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TEACHER PROFILES AND HIGH SCHOOL MATHEMATICS ACHIEVEMENT: WHAT DO WE KNOW ABOUT THE TEACHERS OF LATINO AND ELL HIGH SCHOOL STUDENTS?

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Abstract

Teacher Profiles and High School Mathematics Achievement: What Do We Know About the Teachers of Latino and ELL High School Students?

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Educational researchers have long sought to identify, measure, and explain the pathways to becoming a high-quality teacher, but specifying the precise admixture of preparation, knowledge, and policies remains elusive. Few studies link teacher qualities to student achievement, despite state and national calls for teacher accountability of their students' test scores (Guarino, Hamilton, Lockwood, & Rathbun 2006). Analyzing the characteristics of mathematics teachers whose students are achieving may help to diminish the long-standing opportunity gap in US schools between the large population of underserved students and those of the dominant culture and language. The persistent underperformance of Latino students, many of whom are also English Language Learners, is of particular concern.

The present study explored the qualities of teachers whose Latino and ELL students achieve in mathematics, and was guided by the following research questions: a) what are the characteristics of prevailing profiles of US 10th grade mathematics teachers; b) what are the predominant characteristics of students who are assigned to 10th grade mathematics teacher profiles; c) which teacher profiles, if any, are more likely to have Latinos or ELLs; and d) what combinations of matching students with teachers might predict better success for Latinos and ELLs in high school mathematics?

Using the ELS 2002-2004 longitudinal data set, a cluster analysis revealed five groups of teachers by their survey responses within a data set of over 4000 mathematics teachers. Results indicate that teachers whose students perform best in mathematics are primarily White, female, highly educated, regularly certified, and have many years of experience. Latinos and ELLs are significantly more likely to have newer, alternatively certified teachers who are Latinos themselves. For Latino and ELL students who scored well in mathematics, these newer, seemingly less prepared teachers may be best for them, but only if students are enrolled in high-tracked rigorous courses.

The results suggest more than one model of a high-quality teacher. Teachers should be highly educated in mathematics, but also highly prepared to teach special populations of students and to use the most recent technology in pedagogically appropriate ways. More importantly, students not enrolled in high-tracked, honors, AP, or college preparatory courses struggle in mathematics, regardless of their teachers' background or preparation.

Dedication and Acknowledgements

It doesn't matter where you are, you are nowhere compared to where you can go--Bob Proctor.

There are many people who have supported me and my dissertation work--some even long before I entered a Ph.D. program. I'll start by thanking all of my former students, who have also been my teachers, supporters, and inspiration. Six years before starting my Ph.D. work, I already had some algebra students in Houston lovingly calling me "Dr. Thompson", because when I told them about my educational goals, they emphatically believed I would get there. I still have unwavering support from Taiwan as well, from former students with English names Rex Chin, Hank Lee, Tim Chien, David Liu, Isaac Lin, and others. They give me a living example of what it means to have high expectations of an emerging scholar, throughout my struggles.

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I: INTRODUCTION

Some teachers are more effective than others are. No thoughtful educator, researcher, or policymaker would disagree on this point. The pervasive measuring and comparing of teachers (both preservice and inservice) as well as the designing of methods to improve the teaching profession through professional development offers evidence that we believe that good teachers can made (or at least selected) and that even good teachers can significantly improve their instruction. Strong evidence points to the fact that the distribution of highly qualified teachers in US schools is not even or random. Policymakers and researchers are particularly concerned about shortages of highly qualified teachers in hard-to-staff school districts (Howard 2003; Ng 2003). Fewer well-prepared teachers and teachers with many years of experience work in schools with students who are immigrant, economically disadvantaged, or of non-dominant ethnicities. Through research, many educators hope that they can design methods to improve the effectiveness of all teachers.

1.1 Statement of the problem

Knowing what makes some teachers highly effective in their profession would be helpful to teachers, administrators, policymakers, and teacher educators in their quest to improve teacher quality. Attempts to define teacher effectiveness include research on teacher beliefs, teacher education (both preservice and inservice), teacher demographics, teacher experience, school organization and resources, and student test scores. Sometimes educators use the results of this large body of research to design curriculum for teacher education and professional development, as well as to make policies about job requirements and teaching standards.

In the past four decades, much of the research that tries to link student achievement to teacher attributes has been inconclusive (See Fetler 1999; Goldhaber and Brewer 2000; Guarino, Hamilton, Lockwood, Rathbun 2006; and Monk 1994 for examples). In this dissertation, I describe a different approach to analyzing a large data set for teacher effectiveness, as well as the need to continue and expand upon quantitative research on teachers that links teacher qualities to student achievement. I show that not just one model characterizes an effective teacher, but rather, there exist a number of "teacher types", some of which are associated with student achievement in mathematics for Latinos and ELLs.

In the literature review, I show that the efforts of policymakers and researchers to provide opportunity for high quality instruction and rigorous education to Latinos and English learners have been grossly insufficient. Educational policy and research findings often delineate a single definition that characterizes a high-quality teacher. Instead of researching for one set of characteristics that describes a high-quality teacher, classroom, policy, and curriculum to educate best the underserved population in US schools, we need to look for patterns and groups in large data sets of teachers and student achievement that are successful. In other words, there exists more than one model of effective teaching, and we might be able to use large data sets to suggest what models of teachers are more likely to be successful with various students, schools, and environments.

1.2 Definition of Key Terms

ELL

ELL stands for English language learner, and refers to a population of US K-12 students who speak another language at home, and have not yet acquired sufficient skills in listening, reading, speaking, and/or writing in English to acquire or demonstrate their content area knowledge. Although ELLs may have been in the United States for some years and speak conversational English without any struggle, they may not be proficient in the academic language required in school. These emerging bilinguals have a transitory status: educators expect that during their time as a student they will eventually acquire the status of "English fluency". ELLs are sometimes referred to in research as LEPs (limited English proficiency students), ELs (English learners), ESL (English as a second language) students, or L2 (second language) learners. Some of these terms may be suggestive of a deficit model: that these students are somehow "limited" in their language ability. While ELL students may have special needs to succeed in school while they acquire academic language, they are not in fact deficient in their ability to learn difficult and rigorous content or in their language ability.

Academic language

Academic language refers to the idea that the language required in classrooms, schools, and on assessments is different in many ways from the language used outside of school. This specialized language is content and topic specific, and dynamically evolving over time, space, and regions. Academic language is more than the proverbial "bold-faced terms" that are defined in the glossary of a textbook: it has a distinguished syntax, style, and formatting that is situational and content-specific. Having the ability to understand and produce academic language is usually a gatekeeper to higher education and many professional opportunities (see Bailey, 2007 for example).

Latino

For the purpose of consistency, I use the term Latino to refer to people in the US who are part of a large ethnic group that includes origins in Spain and Latin American countries such as Mexico, Cuba, Colombia, Dominican Republic, Puerto Rico, El Salvador, and Spanish speaking countries (Gutierrez, 2007). Many sources of media often contain erroneous summaries of Latinos as a homogeneous group of people sometimes characterized by Spanish-sounding family names, the ability to speak Spanish, and phenotypic characteristics. In fact, some Latinos have resided in the land currently known as the United States for six or more generations, and may not speak Spanish at all. Latino children come to US schools with diverse language, culture, and educational experiences (Tellez, Moschkovich, & Civil, 2011), but schools often fail to identify these distinctions. All Latinos have a rich cultural diversity and history that cannot be condensed to names, languages, or any other immediately evident characteristics.

Mathematics achievement

Mathematics achievement refers to the idea that a student has attained some specific competency in mathematics that is both demonstrable and measurable.

Teachers try to measure mathematics achievement using student homework grades, test scores, math grades on transcripts, or project performance on specified math tasks. For the purpose of this study, I measure mathematics achievement by improvement on the mathematics scores reported on the Education Longitudinal Study (ELS) data set. Improvement may be determined by a student's test score in relation to other students in the ELS: 2002-2004 data set taking the same test (for example, their quartile rank), and also by their comparable standardized scores, proficiency level, and IRT[1] estimated number correct gain from the base year to the first follow up. In the first follow-up year, the same ELS participants took another mathematics assessment (not the same one).

Although researchers recommend additional measures of mathematics achievement to more accurately determine what students know and can do, (i.e. multiple measures as opposed to a single or pair of assessment scores), in a national data set it is not possible to compare grades or course-taking as these are not consistent. Other measures such as performance assessments or graded homework are not included in the ELS. With the ELS data, the best measure is the idea of growth from Test 1 to Test 2. Although the tests are not identical, they are products of the same research group, ensuring alignment in many ways that two "random" mathematics assessments would not.

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[1] IRT is "item response theory": a group of probabilistic mathematical models that try to find the correspondence between the test result of a candidate and their level of knowledge. These models are based on the principle that the prospective performance

http://www.nyak.hu/nyat/doc/AK2010-eng/glossary.asp

Teacher quality

Synonyms for quality sometimes include "superior" or "excellent". However, in this study, a teacher quality is synonymous with a "teacher characteristic", referring to an attribute that some teachers possess. For example, some teachers often use graphing calculators during mathematics instruction. In this study, teacher quality is not valued as good or bad. Likewise, use of the term teacher quality in this study does not presume to characterize a teacher as good or bad. Rather, they are characteristics, facts, and information I use to describe teachers in detail. In this sense, teacher quality is not the same as teacher qualifications. In other words, the teacher qualities in this study are not prerequisite skills or abilities required to be a teacher or to acquire a job as a teacher.

Teacher profile

Using a large quantitative data set, I created teacher profiles that place teachers in exactly one of several groups of teachers that they share the most teacher qualities with. However, these teacher profiles are limited by the survey questions asked at the time of data collection. Therefore, the teacher profiles I create and describe only exist within this data set, or rather, they might only exist for teachers whose qualities are characterized by the survey questions used in the ELS data set. When I discuss teacher profiles in this study, I refer to the idea that the classification system I developed helps me to better describe the distinctiveness of the teachers assigned to each group in my analysis.

1.3 Purpose and Significance

I assume in this study that some teachers have greater success in mathematics achievement with Latinos and ELLs. In searching for evidence that not just one set of characteristics defines an ideal, highly-qualified mathematics teacher, I expect my study may be useful for further research in several ways. My findings provide: a) a model for future data that links student mathematics achievement to student qualities and their teacher qualities, b) evidence on how to better understand the needs of Latino and ELL students in US K-12 schools, and c) evidence that suggest teachers should not be held immediately accountable for the test performance of their students.

First, this research provides a model for collecting and managing data at both the state and national level that links student achievement to teacher characteristics over time. Since state policies currently mandate frequent multi-subject testing, linking teacher qualities to the students' test scores and following those students over time (over years of annual testing) is not so cumbersome or expensive as it would be if these practices were not already in place. If more linked data sets were available, teacher educators and policy makers would have a lot more information available about many teachers that would enable them to better certify and prepare new teachers.

In addition, this research adds to the knowledge base about equitable practices in K-12 schooling. I show that in some instances the students with the greatest needs are paired with the least prepared teachers (as is commonly reported in research). However, my findings also contribute to a better understanding of the needs of Latino and ELL students, the teacher qualities that may be beneficial for them in a learning environment, and another way to go about tackling the ever-present opportunity gap in mathematics education between students of the dominant language and culture and those of various underserved populations.

Finally, this research provides evidence that helps to move the focus of educational reforms away from the punitive practices of either punishing or threatening to fire teachers whose students did not perform sufficiently well on state-mandated tests. Because the data is longitudinal, I offer evidence to suggest that several years of academic growth and measurement is necessary in order to determine (if at all possible) that a teacher had a positive impact on mathematics achievement.

1.4 Research questions

In order to address the idea that some mathematics teacher profiles might have characteristics more suitable to teach Latinos and/or ELLs, I explore in this dissertation the following research questions:

> Question 1: What are the characteristics of teacher profiles of US 10th grade mathematics teachers?
>
> Question 2a: What are the predominant characteristics of students who are assigned to various teacher profiles of 10^{th} grade mathematics teachers?
>
> Question 2b: Which teacher profiles, if any, are more likely to have Latinos or ELLs?
>
> Question 3: What combinations of matching students with teachers might predict better success for Latinos and ELLs in high school mathematics?

II: LITERATURE REVIEW

Guarino, Hamilton, Lockwood, and Rathbun (2006), point out the few studies linking student achievement with characteristics of teachers, in spite of the abiding interest in holding teachers, their qualifications, and their instruction accountable for student achievement. The following sections in review the extant studies on US policy and student achievement, underserved students in mathematics (and in particular Latinos and ELL students), teacher-student pairings, and a brief review of quantitative research on teachers, mathematics assessments, and other research using the ELS: 2002-2004 data set.

2.1 US policy and student achievement

While educational policy aims to streamline operations, reduce costs, and increase quality, it decades of research show that a factory model or one-size-fits-all model of education does not work for many students (Callahan, 1962; NCEE, 1983; Rogoff, 1994; and Serafini, 2002, for examples). Children enter schools with widely varying backgrounds, experiences, understandings, strengths, cultural beliefs, languages, and personalities that make it virtually impossible to come up with one set of policies and procedures that will benefit all kinds of students. Global policies tend to motivate educators to treat students as if they were all the same, which is not the same thing as treating students with equity. Diverse students have diverse needs, so that trying to provide all students with exactly the same resources is not likely to be helpful for every student. At the same time, researchers hope to find ways that can improve educational practices, especially for culturally and linguistically underserved populations.

One thing that has become clear from large-scale assessment data is that a large and growing group of students does not perform well on assessments or in school. These students are most often of non-white and non-Asian ethnicity, they attend schools that are resource-poor, and many of the students speak a non-English language at home. The score differences between successful students and those sometimes referred to as 'underserved populations' are large, significant, and sustained over time. Educational researchers sometimes refer to this pronounced difference as "the achievement gap" (Haycock, 2001). However, recent publications point to the idea that the distribution of "achievement", as measured on high stakes assessments, does not indicate an actual gap between students of the dominant culture and language and those who are in one or more ways part of the underserved group: the range of scores has a large overlap (Gutierrez, 2008). Furthermore, Gutierrez points out that focusing on the differences in achievement takes a view of the students as being somehow deficient. In this paper, I point to the idea that students of low-income and linguistic, cultural, and ethnic diversity have not received the same economic or educational resources or opportunity to learn as high-achieving school populations. To that end, I refer to this much-discussed gap as the opportunity gap (Flores, 2007).

Individual states and the US Department of Education have enacted many policies and policy revisions in an effort to reduce or eliminate the opportunity gap.

Federal enactments include Title I, Improving America's Schools, No Child Left Behind (NCLB), and most recently Race to the Top (Miller, Linn, & Gronlund, 2009). Through these and other policies, some children have benefited through programs such as Headstart, sheltered instruction for English learners, and special testing accommodations for students with special needs. Our underserved students in US schools represent a very rich and diverse population and therefore, they have diverse educational strengths and needs. However, programs that try to meet some of these needs are often temporary, under-funded, in constant flux, and are implemented by people who may not have a clear idea of how to provide the resources that are needed in the quantities, regions, and qualities that are required (Flores, 2007). The opportunity gap has thus far remained.

2.2 Underserved students and school achievement

Educational demographers label underserved or marginalized populations (of students) as such because of their historic and ongoing poor performance in US public schools (Hunsaker, 1994). Gutierrez (2009) defines them as “African American, Latina/Latino, American Indians, working class students, and English language learners” (p. 9). Data taken from the National Center for Educational Statistics (NCES, 2004) reveal that almost 44% of K-12 students in the US are from a non-white ethnic background. The report lists nearly half of that group as "Hispanic", comprising over 10 million students. "Although the limited availability of disaggregated data often leads researchers to treat Hispanics as if they were a homogeneous group, the US Hispanic population is diverse," including Mexican

Americans, Puerto Ricans, Cubans, and others (Llagas 2003). These students include recent immigrants as well as Latinos who have been in the United States for many generations. Some Latino students are bilingual or monolingual English speakers, while others are part of a rapidly growing ELL population: More than 5 million students (1 out of 9) in US classrooms are ELLs (Pitoniak et al., 2009). By 2025, population demographics projections predict that 1 out of 4 US students will be ELLs. While the ELL population represents over 400 different home languages, 80% of them are native speakers of Spanish. Many Latinos and ELLs are also part of a large group of students with a low socio-economic status. Twenty million K-12 students are eligible to receive free or reduced lunch (NCES 2004). Given that many underserved students are simultaneously Latino, ELL, and of low socio-economic status (SES), they are at a much greater risk than students who are either of the dominant culture and language, or only possess one of the risk factors associated with underserved students.

A review of research indicates that students in underserved populations perform statistically significantly lower in all subject areas and at all grade levels (Berends, Lucas, Sullivan, & Briggs, 2005). This difference has been long-standing and largely resistant to pedagogical, policy, and curricular efforts to reduce or eliminate it (O'Rourke, 2008). For example, Lee (2002) explores the National Assessment of Educational Progress (NAEP) data and the sustained opportunity gap between Whites and African Americans as well as between Whites and Latinos over a 30-year period (1970-2000) on several measures. To support his evidence, he includes an appendix that describes a number of "gaps" that may contribute to an underserved student's decreased access to educational opportunities. These include what he refers to as gaps in NAEP scores, SAT scores, high school achievement, single parent household, mother's educational attainment and salary, and others.

2.3 Why study Latino and ELL mathematics achievement?

According to 2010 US census data (US Census, 2010), Latinos represent 16% of the total US population, while the black population is 13%. The school-aged Latino population in the US is higher, at about 21%. In 2000, Latino students comprised 42% of all students in the top 10 largest public school districts (Llagas 2003). As recent literature predicted, Latinos now make up the largest minority group (Pitoniak et al., 2009, Llagas 2003). Furthermore, 80% of English learners in US K-12 schools speak Spanish as their home language (NCES, 2004), indicating they are most likely ELL and Latino. The plight of Latinos and ELLs in US schools is well summarized by Tellez, Moschkovich, and Civil (2011).

This large and growing population of students in K-12 schools has been found to have the lowest achievement in mathematics (NCES, 2004), the highest dropout rate (Llagas 2003), and is the least likely to be enrolled in high-tracks, honors, or advanced placement courses in mathematics and science (Mosqueda, 2007). Furthermore, although the US Department of Education has initiated a number of policies and programs with the hope of closing the opportunity gap that separates a large portion of Latinos from ethnic groups who receive more resources and rigorous educational opportunities, four decades of research indicates the gap is stable and in some aspects widening (Lee, 2002). In sum, the Latino and ELL population in the US is currently the largest group of underserved students, the most poorly resourced, and as a result, the most disenfranchised from their pursuit of education and its culminating benefits.

One topic of heated debate is that of English language learners and NCLB's state mandated testing. Part of the controversy is over the idea that bilingual students, while they might be proficient in conversational or everyday English, may not have had adequate access to the academic language used on assessments and in school (Scarcella, 2003). If immigrant students have not had adequate access to academic English, it is likely to have a negative effect on their test scores on a test conducted entirely in English. In an effort to promote equitable practices and fairness to all students, NCLB requires that ELLs participate in state mandated testing after just one year of sheltered instruction, such as SDAIE (Cline & Necochea, 2003). Contrarily, "research indicates that it takes up to seven years for ELLs to acquire the academic language that is needed in learning academic knowledge from English-based sources" (Young et al., 2000, p. 173). The length of time needed (5-7 years) to acquire academic English proficiency is supported by Collier, (1987); Hakuta, Goto and Witt, (2000); and others. Abedi and Dietel (2004) state that in order "to make the substantial gains required by NCLB, schools will need to identify superlative ELL teaching practices and teachers, using that knowledge to help other schools" (p. 5). Researchers need to look for examples of success, both qualitatively and quantitatively, to better inform policy makers, educators, test designers, teachers, and others how to better meet the needs of this rapidly growing population.

2.4 Classification and Assessment of ELL students

US policies define and classify English language learners at the state level, allowing individual states to best determine how to meet the needs of their student population. In a national data set, it does not make sense to ask schools to provide numeric information about the demographics, numbers, and levels of proficiency in their ELL students, as these students do not have consistent labeling across states. Even at the state level Duran writes,

> ELLs participating in state large-scale assessments are in effect a policy construction, a category of students established by individual states to satisfy their education laws to deal with a growing group of students from non-English backgrounds who show some evidence of limited familiarity with English, patterns of low school achievement, low assessment scores in English, and propensity to drop out of school... (2008, p. 300).

Aware of classification inconsistencies and the fallacy of attributing a student's mathematical ability to a single test score, Coltrane (2002) warns that "high-stakes decisions should not be made regarding a program, school, or district with high numbers of ELLs based solely on test data (p. 2). Research suggests that inconsistent identification and labeling of ELLs occurs within states, districts, and schools as well (Duran, 2008, Menken, 2000, and Abedi, 2008).

One reason for inconsistencies in ELL classification is frequently changing policies at the state and national level. However, an inconsistency more difficult to detect lies with immigrant parents' beliefs about how they should inform schools of the language abilities of their children. As described by Duran (2008), all states rely on some form of a home-language survey when a bilingual or ELL student enrolls at a K-12 school. However, because some states have severe laws and enforcement that jeopardizes the financial security and well-being of families with undocumented workers, some parents will inaccurately state that their home language is English to draw attention away from their immigrant status. Other immigrant parents, whose children may live in a fully bilingual or English-dominant household, allude to the idea that their children may need English language support. Parents may be doing this because they believe that their children will receive more resources and better-qualified teachers if they state that their children need language services (Abedi, 2004).

Membership of ELL-classified students is in constant flux: once an immigrant student can successfully navigate mainstreamed classes and display achievement on assessments, state policy removes them from the ELL group and replaces them with new, mostly low-performing students (Kim & Herman, 2009). This further confounds analysis of ELLs in large-scale assessment data. In other words, the group called "ELLs" does not contain the same members over time because once students are doing "well" in school, they are removed, and thus collecting and analyzing ELL data over a period of years will not usually produce valid results. Some research suggests many schools erroneously never promote ELLs to bilingual status, even after 10 years (see Kim & Herman, 2009 for a review).

Some states use content-assessment scores to help determine if a student is (still) struggling with the academic language required. However, Abedi (2008) warns that "classifying language proficiency by arbitrarily setting a cut-off point on standardized academic achievement test scores... is not a good practice since there are large numbers of native English speakers who score below these cutoff points (p. 21). In order to classify ELL students more accurately, Abedi recommends an augmented-classification approach. The classification begins with determining through the home language survey if a student speaks another language at home. If so, the next step is to evaluate the student's language proficiency test to determine if the student is not fluent in English. Finally, those students are classified as ELLs if their standardized achievement test score also falls below a fixed percentile. While the great diversity of bilingual and ELL students and their backgrounds may cause an analyst to continue inconsistently labeling some students, the multi-layered approach increases the likelihood of correctly classifying and identifying ELLs. The augmented-classification approach holds great promise in classifying ELL students in national data sets particularly where all students have scores from the same assessments.

2.5 Quality teachers and Teacher-student pairing

A series of papers by Clotfelter, Ladd, and Vigdor (2005, 2006, and 2007) explore the patterns of matching teachers to students and the analysis of student achievement based on teacher quality. They find that "more highly qualified teachers tend to be matched with more advantaged students, both across and within schools" (2006, p. 778), and that this positive matching lends bias to analyses of the effects of teacher quality on student achievement. Their data set of over 3000 North Carolina teachers provides strong evidence that in most of those schools, the assignment of teachers to students is not random, and that teachers with higher teacher licensing scores and more experience are most often matched with high achieving students. These findings are supported by Rockoff (2004), and Rivkin, Hanushek, and Kain (2005), who found that there is substantial within school variation in teacher quality. In 2007, Clotfelter et al. found that teacher's experience, National Board Certification, and teacher licensing scores all have positive effects on student achievement, especially in mathematics.

In a relevant paper on the distribution of novice and experienced teachers to White and African American students, Clotfelter, Ladd, and Vigdor (2005) found that African American 7th graders in North Carolina are 54 percent more likely to have a novice mathematics teacher than Whites, and 38 percent more likely to have a novice English teacher than Whites. Furthermore, they found that "almost two-thirds of the overall Black-White difference in exposure to novice teachers reflects patterns within, rather than across school districts" (p. 390). While some educators interpret these findings as racial bias, the authors found other possible explanations, such as the constraints possibly placed on administrators by high-achieving (White) students as well as the preferences of experienced teachers in working with "easy-to-educate" students.

While it may not be interesting or surprising that students who have the greatest educational needs are often paired with teachers and schools who are least prepared to teach them, it is interesting to study those patterns to get a clearer picture of what is happening and possibly how to move forward to improve conditions. Crosnoe (2005) examined relationships between school conditions, student demographics, student mental health (as measured by a teacher's evaluation), and mathematics achievement (from the ECLS data) for kindergartners. Crosnoe found that first- and second-generation Latino immigrants were much more likely to attend a more poorly equipped school, even when compared with other underserved populations of the same SES. His research indicates "schools are still highly segregated along racial/ethnic lines" (p. 272). He calls for additional research about the mental health, mathematics achievement, and schooling conditions for Latino immigrants to more clearly understand their relationships. Since it is not clear how informative standardized mathematics assessments are for very young school-aged children (Thorndike, 2005), it would be interesting to examine the characteristics of schools, teacher, student demographics, and mathematics achievement scores for an older group of students.

Administrators generally do not permit teachers in US K-12 public schools to choose their students, and most of those students do not get to choose their teachers. At the same time, the selection process is not random: less experienced mathematics and science teachers are more likely to teach remedial classes, and are rarely offered honors or Advanced Placement (AP) level courses (Clotfelter, Ladd, & Vigdor, 2007; Mosqueda, 2007; Cullen, Jacob, & Levitt, 2004). Remedial classes often have larger numbers of English language learners, even if the teachers of remedial classes may not have taken courses on bilingual or second-language pedagogy (Lewis et al., 1999). Some research also indicates that schools of lower-than-average performance and lower SES are more likely to have uncertified or alternatively certified teachers (Goldhaber & Brewer, 2000). As lower performing schools also have a tendency to have a much higher teacher turnover rate, the average number of years of teaching experience is much lower (Lewis et al.).

Several researchers have considered the possible effects of mathematics achievement scores by the qualifications of their teachers (e.g., Goldhaber & Brewer, 2000, 2001; Darling-Hammond, Berry, & Thoreson, 2001; Clotfelter, Ladd, & Vigdor, 2005, 2006, 2007, and Rivkin, Hanushek, & Kain, 2005). In most research, qualifications refer primarily to type of teacher certification, the number of years teaching experience, and whether the teacher has a degree in the content area she teaches. However, the amount of variance explained on a large data set of mathematics achievement scores by whether the teacher went through a "normal certification process" is small and contested. Research has shown that teachers with more years of experience and a degree in the content area they teach usually have students with higher test scores. However, Flores, (2007) suggests teachers with more years of experience often get better choices as to what subjects and times of day they teach when compared to their newly hired peers.

Research by Rivkin, Hanushek, and Kain (Rivkin, Hanushek, & Kain, 2005; Hanushek, Kain, & Rivkin, 2004) explains that students are assigned to schools and teachers that are not random, and that there is a wide variation in teacher quality within and across schools. However, they suggest that "observable school and teacher characteristics explain little of the between-classroom variation in achievement growth despite the fact that a substantial share of the overall achievement gain variation occurs between teachers" (2005, p. 421). In other words, instead of characterizing effective teachers by experience and education, they claim the qualities of effective teachers are not directly observable. By using a very large data set that follows teachers, students, and student achievement longitudinally for five years and with several cohorts, they measure for the effects of teachers on achievement by holding constant student, school, SES, and classroom variation. They found that a teacher's effect on achievement to be large, and that "classroom gains for individual teachers tend to be highly correlated across different groups of students" (p. 424).

Other research has suggested that teachers who are similar to their students are somehow better equipped to establish rapport with their students (matching gender and ethnicity, for example). However, current evidence does not indicate these matches improve test scores (Darling-Hammond, 1994; Martin, 2007). Instead of researching categories of demographic characteristics about teachers and their students, such as gender/ethnicity matching or languages spoken, it would be informative to create profiles that describe large subgroups of teachers included in a large data set. These profiles might include information such as whether and how often teachers contact parents, teacher beliefs about mathematical ability, and preferred teaching style. An analysis of these profiles may reveal patterns of how teachers with certain practices or beliefs might be more or less frequently matched with certain demographic types of students. Hill (2010) agrees: "Principals and district officials may also benefit from knowing whether any of these background characteristics and/or self-reports can help identify mathematically knowledgeable teachers" (p. 517). Although a large data set cannot guess what rules or procedures are in place when schools go through the annual process of assigning students and teachers into classes together, an analysis might be able to show some of the most common patterns that occur. Further, it may be possible to make some inferences about what kind of matching is more likely to be a successful combination for underserved students.

A more recent vein of research on quality teachers and teacher effectiveness relates to a teacher's ability to employ modern technology in the classroom with sound pedagogical techniques. One might assume that younger and newer teachers (who may have grown up with more technology) more frequently use technology in the classroom. However, Pierce and Ball (2009) found no association between a teacher's age or years of teaching experience and classroom technology use. Instead, they found that technology use was highly related to a teacher's internal belief and motivation about the effectiveness of using technology for the increased achievement of her students. Drent and Meelissen (2008) describe teachers who are effective users of classroom technology as entrepreneurs of pedagogy, curriculum, and technology. To contrast with teachers who resist the use of technology, Pierce and Ball found "evidence that those teachers who perceived that students must learn mathematics by-hand (pen and paper) first may see teaching students to use technology as an extra, time-consuming task” (p. 313-314). Salvidar et al. (2012) found evidence that some teachers specifically employ classroom strategies with technology teach more effectively their English learners as well as students who struggled with the reading material found in the text.

2.6 Background for the ELS data set

Educators and researchers sometimes criticize large assessment data sets for their inability to provide explicit information about an individual's mathematical abilities, because they reduce achievement to a single number (Kohn, 2000). Although a large data set might not provide sufficient detail about an individual's ability in specific objectives and concepts in mathematics, an analysis of characteristics and conditions about a very large number of test takers can be powerful in helping to determine what kinds of students are doing well. The predictability of standardized test scores is even more powerful with several scores collected from the same students several years apart, as in a longitudinal data set. With two or more scores from each student separated over a period, analysts have an opportunity to look for characteristics and conditions in various groups of students that may be stronger and longer lasting predictors of successes or struggles. Characteristics about students, their schools, and their teachers that predict success might help to describe recommended best practices and educational designs, as suggested by Abedi and Dietel (2004).

2.6.1 General information about the ELS: 2002-2004 Longitudinal Data Set[2]

The ELS is the fourth of a series of longitudinal studies conducted by NCES. Beginning in 1972, the three completed studies are called the National Longitudinal Study 1972 (NLS-72), the High School and Beyond 1980 (HS&B), and the National Education Longitudinal Study 1988 (NELS:88). In each study, NCES researchers selected a representative group[3] of US students with the intent to follow their educational progress and career path until about the age of 30. As stated in Ingels, Pratt, Rogers, Siegel, and Stutts (2004) "the aim of this continuing program is to study the educational, vocational, and personal development of students at various stages in their educational careers, and the personal, familial, social, institutional, and cultural factors that may affect that development" (pp. 1-2). While each study has some differences in the focus and survey questions, all are designed with the student as a unit of analysis.

Like its predecessors, the ELS longitudinal data set has two distinctive features that enhance the possibilities for analysis and study:

> First, it is a longitudinal study, which means that the same individuals are surveyed repeatedly over time. Second, it is a multilevel study, which means that information is collected from multiple respondent populations that represent students, their parents, their teachers, their librarians, and their schools (NCES 2002).

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[2] For the purpose of brevity, I will hereafter abbreviate the ELS 2002-2004 longitudinal data set as simply the ELS.

[3] Asian and Latino students and private schools were intentionally oversampled (Ingels et al., 2004).

Populations in the ELS data set include:

- -15,362 students
- -752 public, Catholic, and other private schools
- -13,488 parents
- -7135 teachers (mathematics and language arts)
- -743 principals
- -718 librarians (Ingels et al. 2004, p. 12)

The ELS has a lengthy codebook: the public-release data has over 2600 variables available that provide information about each student. The purpose of including student test scores with personal, parent, teacher, principal, and school data in the design was "to provide trend data about critical transitions experienced by students as they proceed through high school and into postsecondary education" (p. 2, ELS Guide, NCES). Participant students in the initial year included over 15,000 high school sophomores from a sample of 752 public and private schools. Two years later, NCES collected follow up data, including twelfth-grade mathematics scores as well as another student survey. For those students who had transferred, dropped out, graduated early, or switched to home schooling, researchers made efforts to track them down and include their data with a customized questionnaire based on the data they provided in the base year.

The ELS includes three assessments: a reading and mathematics assessment given in the base year (2002) when the participants were in 10^{th} grade, and a follow-up mathematics assessment given in the first follow-up year (2004), when the students were most likely in 12^{th} grade. A summary of the content and specifications for all three assessments may be found in Appendix C.

Ingels and Scott (2004) introduce the newest educational longitudinal study by summarizing the base year description of the data and preliminary results. With respect to demographics, the approximately 15,000 students measured consist of about 60% Whites, 3% of whom do not speak English as their first language, 14% African American, 3% of whom do not speak English as their first language, and 16% Latino, 52% of whom do not speak English as their first language. The remaining 10% consist of Asian, multiracial, and Native American subgroups (See Table 2.1 below). With respect to family composition, 57% of students live with both of their biological or adoptive parents; 22% live in a single-parent household, and 4% have some other arrangement, although it is not clear if some two-parent households include a stepparent. The basic unit of analysis for this data set is the student, so that survey responses from principals, teachers, parents, and librarians are all linked to a corresponding student. Mathematics achievement scores had five levels of proficiency; 92% of all sophomores met or exceeded level 1, the lowest level, while only 1% had mastered level 5. Reading achievement scores had 3 levels of proficiency; 89% of all sophomores tested met or exceeded level 1, while only 8% met or exceeded level 3[4].

[4] As stated by NCES (2002), math and reading proficiency levels are of different scales, and therefore not comparable. However, research has shown that reading ability has an effect on math scores, since a mathematics assessment requires a student to read math assessment items (Abedi & Hejri, 2004).

Table 2.1: Student demographics in the ELS by ethnicity and home language.

Ethnicity	Percent of total	non-English first language
White	60%	3%
African American	14%	3%
Latino	16%	52%
Asian, multiracial, other	10%	unknown

2.6.2 Teacher data in the ELS

As stated above, 7135 teachers were included in the ELS. Teachers included in the study are the mathematics and language-arts teachers of the students in the data set at the time that the students were sophomores. "The teacher questionnaire was designed to illuminate questions of the quality, equality, and diversity of educational opportunity by obtaining information in two content areas: "teacher evaluations of students, and teacher background" (p. 29). Survey items for teacher background included basic demographics, years teaching and teaching at that school, full time or part time, certification-type, subjects taught, degrees, job satisfaction, professional development, and use of computers, technology, and Internet for work-related tasks. Teacher evaluations of students included questions about a particular student's work habits and behavior in class, attendance, and the nature and number of phone calls to parents on behalf of that student. NCES has a standard minimum response rate of 85%; however, "no parent or teacher questionnaire items fell below 85% response" (Ingels et al. 2004, p. 71). Teachers in the ELS data set have between 1 and 16 students that are also part of the ELS. Therefore, teachers were required to fill out the student section of the survey up to 16 times; once for each student participant.

As I stated previously, the unit of analysis for the ELS is the student. Because of the way the data was coded, teacher survey responses are linked directly to anywhere from one to sixteen students via a student id code. As a result, it is not possible to scan the data and determine immediately how many mathematics teachers are in the data set. The teacher data was not designed to be analyzed in isolation from the students; it also cannot be directly determined how many teachers are female, how many are Latinas, how many have a degree in mathematics, etc. Rather, the data will indicate how many students have a female mathematics teacher, how many students have a Latina mathematics teacher, etc.

> The teacher questionnaire was designed to provide data that can be used in analyzing influences on student sample members. The design of the component does not provide a stand-alone analysis sample of teachers--either of teachers in the nation, or of teachers in the school" (Ingels et al. 2004, p. 29).

In spite of this caveat, I developed a procedure that allows me to correctly determine and identify the mathematics teachers in the data set.

NCES cautions that although they feel researchers may use data on the schools and students as a representative sample of 10th grade students in the US, the teachers may not be a representative sample of mathematics and language-arts teachers of 10th graders. One reason is private schools along with Latinos and Asians were intentionally oversampled. I analyze the teacher data, not as a stand-alone data set, but as a large section of the whole data set that may be used to help explain some of the variance in student achievement in mathematics. Therefore, it is important to know some of the descriptive statistics of the teacher sample, and to be able to identify individual teachers. In the next section, I use other data sets that help describe a representative sample of US teachers to help me determine if the teachers in the ELS are similar in demographics, qualifications, and other characteristics.

2.6.3 Other large data sets and teachers

Using a variety of data sources, including the Schools and Staffing Survey (SASS), NAEP, NELS:88, the Common Core of Data (CCD), the Recent College Graduates Study (RCG), and the National Study of Post-Secondary Faculty (NSOPF), Choy et al. (1993) give a comprehensive profile of US teachers as of 1987. Recent data from SASS and CCD indicate the trends listed below have not changed much (see Henke et al. 1997; Glazerman et al., 2010). As of 2004, 83% of teachers in all US K-12 schools are non-Hispanic White, 75% are female, and the average teacher age is about 43 years (Strizek et al., 2007). Perhaps it is not surprising that:

> On a number of dimensions—including several measures of teachers' qualifications, teachers' salaries and their satisfaction with them, teachers' perceptions of the availability of necessary materials, the difficulty filling teaching vacancies, the severity of student and family problems that affect teachers' work with students— public schools with relatively more low-income students and the teachers in those schools were less well off than more affluent schools and their teachers. (Henke et al. 1997, p. 115)

An analysis by Comman, Johnson, Zhou, Honegger, and Noel (2010) indicates teacher salaries vary greatly, depending on a teacher's state, highest degree earned, and years of experience. The average public school teacher base salary was $43,814 as of 2007, according to Cornman et al. Teacher's salaries in private schools are much lower (Ingersoll & Alsalam, 1997).

Because of a perceived high teacher turnover rate[5], some studies have addressed teacher job satisfaction (McMillen, 1988; Ingersoll & Alsalam, 1997; Perie, Baker, & Whitener, 1997; and others). McMillen compared teacher job satisfaction in public versus private schools. On most measures, teachers in private schools had a higher job satisfaction and lower attrition rate compared to public schools. This supports the findings of Perie et al., who found that on average, the most satisfied teachers were from private elementary schools, and that those teachers described their workplace as having a "supportive, safe, autonomous environment" (p. 32). Furthermore, Perie et al. found that salary, class size, and school size were not factors of job satisfaction. What was important for job satisfaction in teachers of all grades and schools was a teacher's sense of autonomy, a professional work environment, and desirable working conditions, regardless of the teacher's background characteristics or the school's demographics (Perie et al., 1997; Ingersoll & Alsalam 1997).

Researchers measure quality and quality teacher education in a variety of ways. Despite the large body of research with diverse research methods, Guarino, Hamilton, Lockwood, and Rathbun (2006) explain that "studies that have examined available indicators of teacher preparation or quality--such as academic ability,

[5] According to Henke, Peter, Li, and Geis (2005), "new college graduates' attrition from teaching is no more frequent than their attrition from other occupations held within the first year of completing the bachelor's degree (p. vii)

certification status, subject-matter expertise, and experience--offer mixed findings, suggesting that there is not yet a consensus as to what characteristics influence achievement" (p. 3). At this time, most professional development research has failed to find conclusive evidence of lasting significant results on student achievement and improved classroom practice. For example, Yoon, Duncan, Scarloss, and Shapley (2007) reviewed 1300 studies measuring the effects of professional development and student achievement, and found just nine that met an established standard of evidence.

Glazerman et al. (2010) conducted a comprehensive study on an intense 2-year teacher induction/support program that included 13 states and 418 elementary schools. Support included weekly meetings, classroom observations, and reflective activities between a new teacher and a master teacher educated to coach new teachers at one of two institutions: Educational Testing Service (ETS), and the New Teacher Center of the University of California, Santa Cruz. As is often the case with teacher preparation research, Glazerman et al. found no significant impact on teacher satisfaction, feeling of preparedness, retention or mobility patterns, or student achievement in the first two years when compared to teachers who were from the same schools but not included in the teacher induction program.

In a comprehensive study that tried to match course content and credit hours between traditional certification and alternative certification, Constantine et al. (2009) found no statistically significant differences in teacher effectiveness, student achievement, or teacher retention. Rivkin (in Constantine et al. 2009) explains that "previous nonexperimental research suggests that although teachers have a 'powerful' effect on student achievement, very little of the effect can be explained by observable teacher characteristics, such as education, training, or experience" (p. 5). Constantine et al. state that "their experimental and nonexperimental findings together indicate that although individual teachers appear to have an effect on students' achievement, we could not identify what it is about a teacher that affects student achievement" (p. xxx). They did not find a strong link between variation in student achievement and the teachers' chosen preparation route, or to other measured teacher characteristics. This research supports my contention that searching for one description of an ideal quality teacher is perhaps not the best approach; that a one-size-fits-all approach does not measure or take advantage of the individual and diverse strengths in teachers and students.

2.6.4 Other research using the ELS

There are several studies on the nature of high school dropouts using the ELS. Dalton, Glennie, and Ingels (2009) examined characteristics of students who dropped out of high school late, defined as sometime after their 10^{th} grade year. Although 27% of students from the base year had dropped out of high school by 2004, 73% of those students had earned or were working on a high school diploma or GED by the year 2006, and thus were no longer dropouts. The characteristics of students more likely to drop out are not surprising, and can be summarized as follows: a) they are slightly more likely to be male, b) they are more likely to be African American or Latino, and less likely to be Asian, c) they are more likely to have been at least 17 years old as a sophomore, d) they are more likely to have parents who did not graduate from high school, and e) they are more likely to be of low SES. A shocking 32% of sophomores whose 10th grade math teachers expected them to drop out did drop out, while only 2% of students whose math teachers expected them to get a bachelor's degree dropped out, evidence supporting the recommendation that teachers should have high expectations for all students. Hampden-Thompson, Warkentien, and Daniel (2009) studied dropouts with respect to course selection and course credit accrual. As one might expect, students who were more likely to drop out of high school had accumulated fewer high school credits than did on-time graduates within each year of high school, and the course credit accrual gap increased with each year of high school. Dalton et al.'s research also supports these findings.

Sciarra and Seirup (2008) analyzed how a student's level of school engagement, as measured on three dimensions, might predict mathematics achievement scores. They defined a behavioral dimension of engagement measured by 14 Likert-scaled items from ELS survey data. The items included came from the student's 10th grade mathematics and English teachers as well as eight individual responses and dealt with attendance, disciplinary actions, and extracurricular activities. The emotional dimension consisted of 24 items dealing with the quality of relationships with people at school, school safety, and racial harmony at school. Students' 12th grade mathematics achievement scores measured the cognitive dimension. The differences between racial subgroups were small but significant, and could help predict mathematics achievement.

While it is fairly well established that parents with lower levels of education tend to have adolescents who score lower on achievement tests and are generally less successful in school (Berends et al, 2005; Mosqueda, 2007; O'Rourke, 2008), the ELS data set includes other information about parents, such as their level of participation with the school and the overall family structure. Lee, Kushner, and Cho (2007) analyzed parent-child relationships of varying gender combinations when the student lived in a single-parent home. Although they found that in most instances parent gender and child gender did not have a significant effect on level of school involvement or on achievement scores, they did find that "academic achievement variables were positively affected only when single fathers were highly involved in their daughters' school activities" (p. 153). In other words, mothers of either gender and fathers of sons did not show any significant differences in student achievement with varying levels of school involvement. However, when a father was more involved with his daughter's school, her achievement was significantly higher on test scores. It might be interesting to know more about parental involvement in school from both parents in two-parent households. However, because the ELS research team collected survey data from exactly one parent, it is impossible to determine from this data set.

In Mosqueda's (2007) review of literature on high school tracking, he found that ELLs were more likely to be in low track high school mathematics courses, and that students tend to stay in that low track once placed there. Being in these low-tracked classes, students were disproportionately disadvantaged in mathematics achievement. He believes that many ELLs are misplaced in low-tracked mathematics classes, stating that "according to prior research, ELs have done well in rigorous mathematics courses when native language support was provided for them during instruction" (p. 72). He calls for a scrutinization of educational practices including tracking, qualifications for teachers whose students are ELLs and consistency in labeling/categorizing levels of English proficiency for ELLs.

Nelson and Gastic (2009) looked for patterns of after-school participation in 10th grade students using student surveys from the ELS. Using cluster analysis, they described five participation portfolios based on eighteen out-of-school activities. Interestingly, they found that, contrary to prior research, all students are highly engaged in after-school activities. The varying demographics within each group led them to a number of interesting implications. For example, a group they labeled as “Social” includes students that spend a lot of after-school time on the phone, hanging out with friends, and driving or riding around. Members of the Social group contained significantly higher numbers of White females. Although research does not usually identify this demographic of students as "at risk,” Social group members also had significantly higher than average truancy and delinquency.

Another pertinent finding comes from the group Nelson and Gastic called “All Around”. Students in this group were significantly higher than average in all after-school activities except employment. Although research has shown the benefits of after-school participation in activities such as sports and clubs, this group was actually significantly lower than average in mathematics achievement. The authors suspect that "these students may overextend themselves. Their extensive out-of-school time involvements may be taking a toll on their academic work"(p. 1182).

Latinos were overrepresented in both Nelson and Gastic's “Study” group and the “Employed” group. Students in the Study group spent more time doing unstructured after-school activities, including not only studying but also listening to music and using computers or reading for fun. The Employed group contains a high percentage of males, and these students are far less likely to participate in school-sponsored after-school activities. The authors suggest that many after-school activity choices may be unavailable to employed students because of a required time commitment. They suggest that "drop-in" community service or after-school programs might serve these students better with their after-school schedules.

Although no large-scale studies exist as of yet focusing expressly on the teacher survey data on the ELS data set, these recent studies help add to the information available for the continued analysis of this very large amount of information.

III: RESEARCH DESIGN

As in previous studies by NCES (such as NLS72, HS&B and NELS88), the goal of the ELS team is to collect a large amount of career, education, and lifestyle longitudinal data on a nationally representative set of US students over a period of at least 10 years. For this study, I used student and mathematics teacher data collected in 2002, and also mathematics test scores and student data collected in the first follow-up year, 2004. This data is publicly available through the NCES website. In the following sections, I demonstrate how I prepared the data using SPSS, and then how I used SPSS and the ELS to address each of my research questions. Chapter IV contains a detailed explanation of my findings for each research question.

3.1 Preparing the data

To begin a quantitative analysis, data must be prepared so that the software can accurately read and compute statistical tests. This includes ensuring that all data selected for analysis is valid (not missing or incorrectly coded), and that the variables are coded such that the statistical tests to be performed will correctly execute in SPSS. Below I describe how I determined which students are ELLs, and how I identified the mathematics teachers.

3.1.1 Classifying ELL students

ELL status is normally determined at the state level, although research indicates these determinations are somewhat subjective and applied inconsistently within a state, and even within a district or a single school. In a national data set, I can more consistently apply an ELL classification to students based on their own survey responses and the responses of their teachers. I believe that many bilingual students are often incorrectly categorized as ELL students (see Abedi 2004, 2008; Duran 2008), and so my methodology for finding the ELLs in the ELS data set is conservative. This happens in part because schools often do not have the resources, knowledge, or time to painstakingly test each non-native English speaker that enrolls in listening, reading, speaking and writing in both languages and all subject areas. Duran (2008) recommends post-assessment questionnaires that collect information on "time lived in the United states, language spoken at home, and self-ratings of understanding English at school" (p. 309). I combined his idea of self-ratings with Abedi's (2008) recommendation of augmented classification. After recoding into dummy variables to eliminate missing fields, I computed the following:

> 1. It MUST be true that English is not the student's native language and
> 2. It MUST be true that the student has not indicated he is fluent in English
> Then, at least two of the following must be true:
> A. Student was enrolled in an ESL class at some time in the past
> B. Student feels he does not listen well in English*
> C. Student feels he does not speak well in English*
> D. Student feels he does not read well in English*
> E. Student feels he does not write well in English*
> F. Mathematics teacher has indicated "student is behind as a result of LEP"
> (See teacher survey questions in Appendix A and student survey questions in Appendix B.)

Some students (even monolingual English speakers) are not confident about their academic language ability. Therefore, I required that at least two of the last six variables indicated the student was ELL. I found 266 ELL students. This number is

* These questions were asked in the context of "as a result of not being fluent in academic English.

much below what I would expect from a "nationally representative" data set; only 1.6% of the total. However, by 10th grade, many immigrant students have been in the US long enough to achieve bilingual status. I also suspect that some ELLs were not able to complete the very lengthy survey, and thus left questions blank. Although some literature recommends a cutoff score in reading, mathematics, or both, I felt I did not have enough information to determine what that cutoff score should be, particularly since these students are a national sample, and therefore have been subjected to diverse curricula, courses, and rigor by 10th grade. Table 3.1 shows the students I classify as ELL by ethnicity. Note that 86 students are both Latino and ELL. The total number of ELL students in the table (191) reflects the fact that I deleted all students whose mathematics teacher survey data was entirely composed of non-response codes. A description of the process is in the next section. Such a low number might urge NCES to oversample for ELLs in the US, especially given that their educational needs are poorly understood. However, without a national definition of ELLs, the best way to get a larger sample may be to oversample all non-native English speakers, and to offer student and parent surveys in their home languages.

Table 3.1 ELL students by ethnicity

Ethnicity of ELLs	n	%
American Indian/ Alaska	1	0.5
Asian, Hawaii/Pacific Islander	77	40.3
Black or African American	10	5.2
Latino	86	45.1
More than one race	6	3.1
White	11	5.8
Total	191	100

3.1.2 Identifying mathematics teachers

Because I am interested in the mathematics teacher data, I began by removing any students that do not have mathematics teacher survey responses from the data set. Examining frequencies of each variable from the mathematics teacher survey responses indicate 3007 non-respondents, 179 "legitimate skips", and a number of missing or otherwise invalid responses. While the "missing" frequency differs for each variable, these 3007 and 179 appeared consistently throughout the mathematics teacher survey variables. I deselected these students through the "select cases" function, and then deleted them from the data sample. I then compared the frequencies and central measures of my new data sample and determined that they are nearly identical to the entire ELS data. However, the number of ELL students dropped from 266 to 191. This is a substantial reduction in the population targeted in my study.

According to the new frequencies, 12972 students remain whose teachers filled out at least part of the survey. Some variables still have 'missing' and 'legitimate skip' codes. The items coded for "legitimate skip" indicate that the survey question did not apply to that teacher. For example, a teacher who has not earned a four-year post-secondary degree does not have a response to the question asking for the subject area of her bachelors major and minor, or her graduate degree. For most items, the number of missing codes is less than 100, which amounts to less than 1% of the sample. The ELS data does not contain any missing fields; rather, special codes indicate if the survey response was missing or invalid. These codes were easily identified as they are negative numbers; usually -4, -8, or -9, depending on the reason for a non-response.

To "find" the mathematics teachers among the 12972 students, I performed a duplicate search on 60 of the variables included in the mathematics teacher survey responses. I used only variables that the teacher answered about herself (i.e., I did not use variables from the section where a teacher is asked the same survey questions about each of her individual students). The SPSS function found 4123 primary cases. As a check, I determined that none of the primary cases was duplicated more than 15 times. I expected this because in the description of the data set, it explains that no more than 16 students per mathematics (or language arts) teacher would be selected for the study. Once I felt confident that I had accurately "found" all the mathematics teachers, I created a new data file containing exactly one case for each mathematics teacher. I used this data file to analyze information about the teachers, to create profiles, and to compare these profiles, as I describe next.

3.2 Clustering teachers

To address my first research question, What are the characteristics of prevailing profiles of US 10th grade mathematics teachers?, I performed a cluster analysis on the mathematics teacher data set. A cluster analysis requires that no values are missing in variables used to form clusters (Banks, House, McMorris, Arabie, & Gaul, 2004). Fortunately, there were no survey questions from the ELS teacher survey with less than an 85% response rate. To begin preparing the data, I ensured that all teachers and survey question variables used to perform a cluster analysis contained valid responses. In fact, there are no "missing" values in the data set as NCES prepared the public-release data by filling in missing, non-response, or other invalid responses with special codes. All of the cells that might otherwise be empty contain negative numbers that specify the type of non-response indicated.

Statistical texts contain descriptions of many theoretical and mathematical approaches to cluster analysis, a systematic way to find groups in data (Everitt, Landau, & Leese, 2001). Although research articles generally describe the one clustering algorithm that was ultimately employed in an analysis (Nelson & Gastic, 2009, for example), texts recommend running a cluster analysis with two or more models, followed by a comparison to find which model best fits a researcher's data and questions (see Everitt, Landau, & Leese, 2001, Lawal, 2003, and Kaufman & Rousseeuw, 2005, for examples).

> It is permissible to try several algorithms on the same data, because cluster analysis is mostly used as a descriptive or exploratory tool...We do not wish to prove (or disprove) a preconceived hypothesis; we just want to see what the data are trying to tell us (Kaufman & Rousseeuw, p. 37).

To prepare the data for clustering, I made dummy variables of most items from the teacher surveys. I did this to eliminate the missing or non-response codes, and to strengthen the contrast. By strengthening the contrast, I mean that there may be very little difference between responders on a Likert-scale variable who answered "Extremely important" and "Very important". On a Likert-scale survey, it may be impossible to determine the subjective and subtle difference between two respondents who may have felt the same (perhaps in-between 4 and 5), but in fact gave different responses. By using dummy variables, I put teachers who responded to a Likert-scaled item positively into one category, and those who responded negatively into another. The remaining cases consist of those who gave a neutral response or an indeterminate response. The complete list of clustering codes is in Table 3.2.

Several variables were ordinal values, such as the number of hours a teacher has received in special education instruction, and the year the teacher was born. Running ordinal variables through a cluster analysis alongside binary variables inaccurately causes the program to measure ordinal variable distances as much greater than those with only two values do. As an example, teachers indicated how many hours in special education instruction they had received, but only “yes” or “no” as to whether they had received 8 hours of ELL instruction. These ordinal-valued variables were recoded so that they had similar weight in the clustering algorithm.

The teacher survey included 19 items related to computer and Internet use. Thinking that these questions might be redundant, I selected only a few of them for clustering variables. However, after running multiple variations of cluster analysis, I found that the clusters determined by SPSS were not very strong. Specifically, I found that the distinctions between clusters were small, and not much greater than the within-group variation. To try to get more information and to see if SPSS could define better clusters, I dummy coded all of the computer and Internet use variables to include as clustering variables. As I describe later, I found that for at least two of the clusters, computer and Internet use was task specific. Therefore, by including all of these variables, I added important information to my model.

Table 3.2 Cluster codes for cluster analysis

Code #	Description
CC01	If starting over whether would be a teacher again
CC02A	Importance of home background to student success positive
CC02B	negative
CC03A	Importance of intellectual ability to student success positive
CCO3B	negative
CC04A	Importance of student's enthusiasm to student success positive
CC04B	negative
CC05A	Importance of teacher's attention to student success positive
CC05B	negative
CC06A	Importance of teaching methods to student success positive
CC06B	negative
CC07A	Importance of teacher's enthusiasm to student success positive
CC07B	negative
CC08A	People can learn to be good at math positive
CC08B	negative
CC09A	People must be born with math ability positive
CC09B	negative
CC10A	Highest degree is education specialist or bachelors
CC10B	Highest degree is masters
CC10C	Highest degree is PhD or first professional
CC11A	Total years teaching 20+
CC11B	Total years teaching 0-5
CC12A	Regular certification
CC12B	Alternative or temporary certification
CC13A	Has 1 bachelors degree in a STEM field
CC13B	Has a major and minor bachelors degree in a STEM field
CC13C	Has a bachelors major or minor in education
CC14A	Has a masters degree in a STEM field
CC14B	Has a masters degree in education
CC15A	Has taken 10 or more undergraduate math courses
CC15B	Has taken 10 or more graduate math courses
CC16	Has taken 1-9 graduate math courses
CC17	Has taken more than 10 hours on teaching special ed
CC18	Has had 8 hours training on teaching LEP
CC19A	Number of days missed last semester is 0-4
CC19B	Number of days missed last semester is more than 4
CC20A	Holds additional FT or PT job summer only
CC20B	Holds additional FT or PT job during school year or all year
CC21	Job is related to education

Code #	Description
CC22A	How often use computer to create materials often
CC22B	seldom
CC23A	How often use Web sites to plan lessons often
CC23B	seldom
CC24A	How often use model lesson plans from Internet often
CC24B	seldom
CC25A	How often use Internet for research on teaching often
CC25B	seldom
CC26A	How often take pd courses via Internet often
CC26B	seldom
CC27A	How often use Internet for colleague discussions often
CC27B	seldom
CC28A	How often download instructional software from Internet often
CC28B	seldom
CC29A	How often use computer to give class presentations often
CC29B	seldom
CC30A	How often use computer for administrative records often
CC30B	seldom
CC31A	How often use computer to prepare multimedia presentations often
CC31B	seldom
CC32A	How often use computer to communicate w/parents often
CC32B	seldom
CC33A	How often use computer to communicate w/students often
CC33B	seldom
CC34A	How often use computer to post homework/information often
CC34B	seldom
CC35	Received training in basic computer skills
CC36	Received training in software applications
CC37	Received training in use of Internet
CC38	Received training in use of other technology
CC39	Received training in integrating technology in curriculum
CC40	Received follow-up or advanced training
CC41A	Teacher is White
CC41B	Teacher is Hispanic
CC42	Teacher is male
CC43A	Teacher is older, born 1935-1949
CC43B	Teacher is younger, born 1968-1979

Four survey items relate to teachers' paid work outside of school. The items are: if the teacher has an additional part time job, if that job is related to education, if the teacher has an additional full time job, and if that full time job is related to education. Teachers also indicated if their job(s) took place during summer only, during the school year only, or all year round. To simplify these responses, I created one variable to indicate if the teacher has a job during the summer only (CC20A), if the teacher has a job during the school year or all year (CC20B), and if the job is related to education (CC21).

A number of survey questions relate to the degrees teachers have. This includes whether or not the teacher holds an associate's degree, bachelor's, master's, or PhD, the highest degree held, and the major and minor subject areas of each degree held. I determined that I needed to distinguish the teachers by the degrees they held since teachers with a bachelor's major and minor in addition to a master's degree would be included simultaneously into several groups. To simplify these teachers, I first created dummy variables to represent the highest degree held for each teacher, as follows:

CC10A	highest degree is education specialist or BA
CC10B	highest degree is masters
CC10C	highest degree is PhD or first professional degree

Next, I coded to find which teachers had a bachelor's degree (major or minor) in mathematics/science and which had a bachelor's degree in education. Some teachers had both a major and minor in a mathematics or science degree, so I created a code to indicate they had two degrees in a science, technology, engineering, or mathematics (STEM) field. I did the same thing for master's degrees, as follows:

CC13A	has a bachelor's degree in STEM
CC13B	has two bachelor's degrees in STEM
CC13C	has a bachelor's degree in education
CC14A	has a master's degree in STEM
CC14B	has a master's degree in education

Because there were so few teachers with PhD degrees, it did not seem necessary to discriminate among the degrees further.

3.2.1 Selection of Codes to Use for Clustering

Table 3.2 contains the complete list of re-coded variables for clustering. I anticipated finding revealing data in teacher's responses to survey questions on their philosophy of teaching (codes CC01-CC09). However, these codes were actually the least discriminating for cluster selection. Repeated trials using all of the available SPSS clustering algorithms and variations of the recoded variables revealed that the negatively-coded dummy variables were frequently not significant, and that most teachers had a code of 0 (indicating that they had not marked "not very important" or "not at all important" on the item). After many attempts to find the best possible model, I found that clustering was stronger and more distinct when several of these codes were not used as clustering variables. Specifically, the best model for choosing clusters excluded variables measuring teachers who indicated that home background, student enthusiasm, teaching methods, and teacher's enthusiasm were not important to student success (codes CC02B, CC04B, CC06B, and CC07B).

Teacher responses to two survey questions about the nature of mathematical knowledge were a bit confounding (codes CC08 and CC09). Code CC08 asks if people can learn to be good at math. This question implies that mathematical ability is not an inherent trait, and that it is possible for anyone to be good at math. Code CC09 asks if it is true that people must be born with mathematical ability. This is a dichotomous/opposite question, implying that not all people have the ability to be good at math because one must be born with that ability. While I believe I understand the purpose of these questions, a number of teachers answered positively to both questions, or negatively to both questions. This could imply that teachers have conflicting beliefs, or perhaps that the questions were not understood, or understood differently than what they were intended to measure. Furthermore, most teachers answered positively to "people can learn to be good at math". As a result, this question did not add any information to my cluster analysis, and I decided to exclude codes CC08A and CC08B.

Finally, the number of days missed during semester one did not discriminate well between teachers. It seems reasonable to assume there may be little difference in the quality of instruction that a student receives if their regular teacher is present on all days, or has missed only a few days, and this represents more than 75% of the population. Over 90% of the population missed five or fewer days. Because this variable (code CC19A and CC19B) did not seem to add useful information to the model, I excluded it for clustering.

3.2.2 Choosing the best clustering model

K-clustering

K-clustering is a type of partitioning in which a researcher specifies the number of clusters desired. After running the algorithm, every cluster will have at least one object (teacher) in it, and every teacher will be in no more than one cluster. Both SAS and SPSS have the ability to run the algorithm multiple times with different possible values of k (the number of clusters). Thus, this technique will ensure that every teacher fits into exactly one cluster, with no overlap.

I specified that none of the clusters should contain less than 100 teachers, and that the number of clusters should be somewhere from three to twelve. Having clusters containing less than 100 teachers from a set of thousands may begin to resemble outliers, and having more than twelve groups may be too cumbersome to describe and distinguish. K-clustering is attractive for this data set because it is not necessary to specify in advance the number of clusters. Therefore, the researcher can run the k-clustering algorithm several times with different values of k in order to find a best-fitting model.

Two-Step Clustering

SPSS describes a two-step clustering method for very large data sets. Using this SPSS function, SPSS will first pre-cluster the data into many small sub-clusters, thus enabling the software to handle much larger data sets (SPSS, 2001). In the second stage, the pre-clusters are clustered until a specified number of groups are achieved. According to SPSS, if the optimal number of final clusters is unknown, SPSS software can make that determination through repeated iterations. The two-step clustering method may be the easiest to execute with my data and questions. After experimenting with k-means and two-step cluster analysis, I chose the best model to address my research questions.

After removing all of the variables that did not add information to the model, I tried both two-step and k-means cluster analysis in SPSS. The two-step cluster analysis suggested three clusters, and these clusters offered better fit after removing codes that did not contribute well to clustering, although they were still in a "poor" range of strength. To consider other options, I tried various values of k for a k-means cluster.

Below are tables showing the distances between clusters for various values of k (See Figure 3.1). The variables I used were binary (dummy variables). Based on the ANOVA table included with cluster results, a distance between clusters of at least 2.00 shows significant contrast. In other words, when describing the differences between two clusters, distances of less than 2.0 are groups that are somewhat similar to each other, while distances of 2.0 or more show observable differences in responses to at least some of the survey questions.

Figure 3.1 k-means clustering matrices for various values of k

Three Clusters:

	1	2	3
1		2.071	1.645
2	2.071		1.911
3	1.645	1.911	

Four Clusters:

	1	2	3	4
1		1.812	1.806	1.975
2	1.812		2.161	2.244
3	1.806	2.161		1.648
4	1.975	2.244	1.648	

Five Clusters:

	1	2	3	4	5
1		1.466	1.733	2.010	1.997
2	1.466		1.600	2.251	2.051
3	1.733	1.600		2.349	2.842
4	2.010	2.251	2.349		1.634
5	1.997	2.051	2.842	1.634	

Two Clusters:

	1	2
1		1.659
2	1.659	

Six Clusters:

	1	2	3	4	5	6
1		2.611	1.950	2.128	2.218	1.668
2	2.611		2.881	2.043	1.936	2.174
3	1.950	2.881		1.449	2.414	1.925
4	2.128	2.043	1.449		1.854	1.688
5	2.218	1.936	2.414	1.854		1.793
6	1.668	2.174	1.925	1.688	1.793	

In choosing the optimal number of clusters, I looked for the most distinguished groups (i.e. the matrix with the greatest distances between cluster centers as shown in the matrix cells in Figure 3.1). I also examined the model as a whole to see if the individual variables were significantly different measures by cluster. The matrices for five and six clusters both show substantial variation between cluster centers; better than those for two, three, or four clusters. Specifically, with five clusters, clusters 1 and 2 are the most similar to each other (distance of 1.466), and clusters 1 and 5 are the most distinct from each other (distance of 2.842). Furthermore, the five-cluster model shows nearly every variable is significant at the $p < .001$ level (See Table 3.4). The six-cluster matrix shows several cluster pairs that appear to suggest a good model. However, the clustering algorithm as a whole had many individual variables that were not statistically significant.

Because the 5-cluster model had both good discrimination of clusters and an overall statistically significant model, I chose this k-means classification to address my research. Since I recoded all of the variables as binary, the mean of each variable within each cluster also represents the percent of teachers who possess that characteristic. Table 3.4 shows the cluster membership, the mean response for each clustering variable (which is also a percent), and the F-values in the ANOVA table produced in SPSS as a part of the clustering procedure.

Only two variables were not statistically significant: "teaching method is important to student success", and "teacher's enthusiasm is important to student success". Most teachers answered positively to these survey questions, and therefore, the F-value is low. All other variables listed are significant to the $p \leq .001$ level. Chapter IV has a complete description of the final teacher clusters by their distinctive features. Table 3.3 shows the percent and number of teachers in each cluster. Each cluster contains at least 15% of the sample.

Table 3.3 Mathematics teacher membership by cluster

	Sample	1	2	3	4	5
n	4123	653	1148	612	667	1043
%	100	16	28	15	16	25

As expected from the matrix table for five clusters found in Figure 3.1, the cluster numbers that appear to be most similar to each other are 1 and 2, 2 and 3, and 4 and 5. The clusters that appear to be most distinctive are 3 and 5, 3 and 4, and 2 and 4. Because the number of variables used for clustering was too large to fit easily onto a page, I created two tables. Table 3.4 contains general information about teachers, their education, beliefs, and demographics. The second page of Table 3.4 contains 19 variables related to technology use in the classroom. Some variable codes come from Likert-scale survey responses, and so they show both the teachers who responded positively and negatively to the prompts.

Table 3.4 Cluster codes with means (%) and F-values[6]

Code	Sample	1	2	3	4	5	F
n	4123	653	1148	612	667	1043	df = 4118
If starting over whether would teach	68	72_{45}	70_{45}	74_{45}	59_{123}	65_{123}	10.844***
Home background important to students	95	96_{4}	95_{5}	94_{5}	93_{15}	98_{234}	6.585***
Intellectual ability important to students	80	80_{345}	78_{45}	75_{145}	85_{123}	84_{123}	9.442***
no	18	19_{45}	21_{45}	23_{45}	13_{123}	15_{123}	9.310***
Student enthusiasm important to students	98	98_{5}	99_{45}	97_{5}	97_{25}	100_{1234}	4.770***
Teacher attention important to students	86	86_{3}	87_{34}	92_{1245}	83_{23}	84_{3}	7.154***
no	12	12_{3}	12_{35}	5_{1245}	14_{3}	16_{23}	9.866***
Teaching methods important to students	94	95	95	94	93	94	1.143
Teacher enthusiasm important to students	96	97	97	96	95	96	2.069
Highest degree is ed. specialist or BA	51	61_{2345}	99_{1345}	54_{1245}	33_{1235}	0_{1234}	1251.404***
Highest degree is Masters	48	38_{2345}	0_{1345}	44_{1245}	64_{1235}	99_{1234}	1208.848***
Highest degree is PhD	1	1_{34}	0_{34}	2_{12}	2_{125}	1_{4}	4.564***
Teaching 20+ years	33	23_{45}	20_{45}	22_{45}	56_{1235}	47_{1234}	112.348***
Teaching 0-5 years	25	30_{2345}	37_{145}	38_{145}	11_{123}	10_{123}	96.377***
Regular teaching certification	82	79_{35}	79_{345}	72_{1245}	83_{235}	92_{123}	32.338***
Alternate or temporary certification	12	14_{345}	16_{45}	19_{145}	7_{123}	5_{123}	31.212***
Has 1 BA in STEM	64	70_{34}	69_{34}	55_{125}	53_{125}	67_{34}	22.491***
Has a major and minor BA in STEM	11	9_{5}	8_{45}	10_{5}	12_{2}	14_{123}	6.023***
Has a BA in education	29	28_{24}	33_{14}	30_{4}	23_{1235}	30_{4}	6.127***
Has a master's degree in STEM	20	15_{245}	11_{1345}	14_{245}	23_{1235}	44_{1234}	201.073***
Has a master's degree in education	28	21_{245}	2_{1345}	24_{245}	30_{1235}	62_{1234}	321.779***
10 or more undergrad math courses	57	59_{345}	59_{345}	51_{1245}	45_{1235}	66_{1234}	23.989***
Taken ten or more grad math courses	12	10_{25}	4_{1345}	11_{25}	13_{25}	23_{1234}	47.793***
Taken 1-9 grad math courses	41	39_{5}	34_{345}	41_{25}	40_{25}	49_{1234}	12.618***
10+ spec. ed prep.	18	16_{3}	17_{35}	35_{1245}	13_{3}	13_{23}	39.058***
At least 8 hours ELL preparation	12	15_{345}	12_{345}	21_{1245}	5_{1235}	9_{1234}	24.061***
Holds 2nd FT or PT job summer only	20	23_{45}	24_{45}	23_{45}	15_{123}	16_{123}	9.944***
2nd FT or PT job school year/all year	30	31_{3}	28_{3}	37_{1245}	30_{3}	29_{3}	4.414***
Job is related to education	31	35_{24}	28_{13}	36_{245}	27_{13}	31_{3}	5.449***
Teacher is White	83	80_{345}	82_{35}	73_{1245}	85_{135}	89_{1234}	18.280***
Teacher is Latino	5	5_{345}	6_{345}	9_{1245}	2_{123}	2_{123}	13.557***
Teacher is male	43	42_{4}	41_{4}	43_{4}	53_{1235}	40_{4}	8.684***
Teacher is older: born 1935-1949	25	17_{45}	15_{345}	19_{245}	45_{1235}	33_{1234}	75.808***
Teacher is younger: born 1968-1979	29	38_{245}	43_{1345}	37_{245}	8_{1235}	17_{1234}	98.322***
People must be born with math ability	10	9_{4}	10_{34}	7_{245}	14_{123}	11_{3}	4.421***

[6] Subscripts indicate cluster numbers that are significantly different at the $p < .05$ level. For example, cluster 3 has significantly more Latino teachers than groups 1, 2, 4, and 5. For the model, all codes are significant at the $p < .001$ level, except "Teaching methods important to students" and "Teacher enthusiasm important to students".

Table 3.4 Continued: Cluster codes of computer/Internet use with means and F-values

Code	Sample	1	2	3	4	5	F
n	4123	653	1148	612	667	1043	df = 4118
Uses computer to create materials often	63	71_{234}	62_{1345}	91_{1245}	24_{1235}	68_{234}	203.839***
seldom	13	8_{34}	8_{34}	1_{1245}	47_{1235}	7_{34}	256.941***
Uses Web sites to plan lessons often	19	8_{345}	10_{34}	78_{1245}	3_{1235}	12_{134}	650.745***
seldom	51	51_{234}	57_{1345}	1_{1245}	83_{1235}	52_{234}	289.528***
Uses lesson plans from Internet often	6	0_{3}	1_{3}	34_{1245}	0_{3}	1_{3}	372.492***
seldom	77	89_{345}	88_{34}	12_{1245}	95_{1235}	86_{134}	778.628***
Uses Internet: teaching research often	6	1_{3}	1_{3}	34_{1245}	0_{3}	1_{3}	347.566***
seldom	77	87_{34}	86_{34}	14_{1245}	95_{1235}	85_{34}	637.369***
Takes PD courses via Internet often	2	1_{3}	2_{3}	6_{1245}	0_{3}	1_{3}	20.379***
seldom	95	97_{3}	97_{3}	85_{1245}	98_{3}	97_{3}	44.849***
Uses Internet: colleague contact often	7	6_{34}	4_{34}	21_{1245}	1_{1235}	4_{34}	66.730***
seldom	86	87_{234}	90_{134}	59_{1245}	97_{1235}	89_{34}	125.493***
Downloads instructional software often	3	1_{3}	0_{3}	15_{1245}	1_{3}	1_{3}	116.358***
seldom	86	89_{2345}	94_{13}	47_{1245}	95_{135}	92_{134}	296.191***
Computer: class presentations often	6	9_{2345}	1_{135}	20_{1245}	1_{135}	4_{1234}	85.909***
seldom	80	70_{2345}	92_{135}	46_{1245}	94_{135}	85_{1234}	203.248***
Computer: administrative records often	80	95_{2345}	87_{14}	89_{14}	33_{1235}	87_{14}	382.092***
seldom	13	3_{245}	7_{134}	4_{24}	53_{1235}	6_{14}	385.170***
Computer: multimedia presentations often	6	11_{2345}	1_{135}	20_{1245}	1_{135}	4_{1234}	89.913***
seldom	80	71_{2345}	91_{135}	42_{1245}	95_{135}	85_{1234}	243.872***
Computer to communicate w/parents often	21	31_{2345}	17_{134}	36_{1245}	3_{1235}	20_{134}	72.839***
seldom	56	41_{245}	58_{1345}	37_{245}	87_{1235}	53_{1234}	111.525***
Computer to communicate w/students often	23	77_{2345}	8_{134}	38_{1245}	4_{1235}	10_{134}	618.242***
seldom	64	7_{2345}	83_{1345}	40_{1245}	91_{1235}	76_{1234}	590.902***
Uses computer to post homework often	22	87_{2345}	4_{135}	33_{1245}	5_{13}	8_{123}	1034.094***
seldom	69	2_{2345}	91_{135}	50_{1245}	91_{135}	85_{1234}	970.128***
Basic computer skills training	81	82_{45}	82_{45}	85_{4}	60_{1235}	88_{124}	60.678***
Software applications training	82	85_{45}	86_{45}	88_{45}	47_{1235}	93_{1234}	191.275***
Use of Internet training	79	82_{45}	79_{345}	86_{24}	53_{1235}	88_{124}	92.153***
Other technology training	42	50_{2345}	40_{134}	70_{1245}	13_{1235}	42_{134}	122.912***
Integrating tech. in curriculum training	77	82_{345}	79_{345}	89_{124}	42_{1235}	89_{124}	176.307***
Follow-up or advanced training	46	49_{2345}	41_{1345}	73_{1245}	11_{1235}	54_{1234}	162.325***

3.2.3 Testing cluster legitimacy with discriminant analysis

Much of what we know about cluster analysis comes from fields outside of the social sciences, including diverse subjects such as biochemistry, economics, computer science, and medicine. Research that includes k-means clustering for data analysis sometimes includes a post-hoc discriminant analysis, to help validate the clusters and the strength of the clustering variables selected (Ding & Li, 2007; Ye, Janardan, Park, & Park, 2004). However, Burns and Burns (2008) explain, "techniques for determining reliability and validity of clusters are as yet not developed" (p. 558). In the following pages, I provide additional evidence for the legitimacy of my clusters based on a discriminant analysis.

To conduct a discriminant analysis, I used all variables listed in Table 3.4 as my predictor variables. Because the ELS data set I use is large, with many cases and variables, the output was enormous, including several hundred pages of print and individual tables that would take up many pages to display. In the interest of space, my results are in summary form.

Table 3.5 is a small piece of the 67x67 pooled within-groups correlation matrix. The full table has 2211 unique 2-variable correlation cells. Almost every cell contains an absolute value near 0, indicating low intercorrelations. The table below highlights most of the higher values, many of which are expected. For example, it is not surprising that age and the number of years' teaching experience have a positive relationship. Not included in the table is the negative relationship between highest degree earned (masters or bachelors), and the negative relationship for the two race categories (White and Latino). These mutually exclusive variables should produce negative correlations. The remaining cells give evidence that almost all variables act independently in the data, supporting the use of them in my clustering model.

Table 3.5 Partial results for pooled within-groups matrix of predictor variables

	student enthusiasm important	teaching methods important	teaching 20+ years	teaching 0-5 years	has 2nd job during school	use Web for model plans	computer to present in class seldom	basic computer PD	software PD
teachers enthusiasm important	**0.405**	**0.499**	0.027	-0.008	-0.022	0.020	0.013	0.026	0.035
Job is ed related	0.004	0.002	-0.026	0.014	**0.589**	-0.007	-0.040	0.018	0.047
use web for research often	0.036	0.023	-0.006	0.003	-0.007	**0.434**	0.022	-0.001	-0.016
use computer for multimedia often	0.009	0.021	-0.007	-0.019	0.026	0.052	**-0.394**	0.001	0.010
software PD	0.059	0.019	0.053	-0.044	0.017	-0.030	-0.039	**0.460**	1.000
internet PD	0.048	0.035	0.099	-0.088	0.020	-0.025	0.001	**0.515**	**0.424**
teacher is old 53-67	0.014	0.021	**0.467**	-0.218	-0.038	0.015	-0.041	0.056	0.052
teacher is young 23-34	-0.007	-0.014	**-0.395**	**0.496**	0.030	-0.029	0.042	-0.051	-0.045

The Box's M test (table 3.6) tests the null hypothesis that the sum of cross products across groups is homogeneous. This test's result should be not significant, although the table indicates highly significant results. Burns and Burns (2008) state, "with large samples, a significant result is not regarded as too important" (p. 598).

Table 3.6 Box's M results

Box's M		51706.396
F	Approx.	7.726
	df1	6435
	df2	14315665.838
	Sig.	.000

Eigenvalues, as shown in Table 3.7, indicate the strength of the relationship for each of the four discriminant functions in predicting group membership. In this case, all four functions show a strong canonical correlation and can predict a significant amount of the variance, although function 1 is the best predictor, explaining 44.7% of the variance in the model. The canonical correlation refers to the multiple correlations between each discriminant function and the predictors. Again, all four functions have a high canonical correlation, with function 1 as the highest. The significance of each of the four functions is given by Wilks' lambda, as shown in Table 3.8. All four functions are highly significant.

Table 3.7 Eigenvalues for the four discriminant functions

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3.028	44.7	44.7	.867
2	1.560	23.0	67.7	.781
3	1.286	19.0	86.7	.750
4	.901	13.3	100.0	.688

Table 3.8 Wilks' lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 4	.022	15540.294	260	.000
2 through 4	.090	9845.697	192	.000
3 through 4	.230	6004.195	126	.000
4	.526	2625.627	62	.000

Table 3.9 is a partial structure matrix table showing the pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. The predictor variables are resorted so that they are displayed by absolute size of correlation within each function, starting with function 1. An asterisk (*) in a row indicates the largest absolute correlation between each variable and any discriminant function. In other words, the table shows the best predicting variables in order for function 1, then functions 2, 3, and 4 successively. As previous tables show, function 1 has the most variables that have the largest absolute correlation compared to the other functions. Strong predictors for function 1 include a) uses Web for model lesson plans seldom, b) uses Web for research seldom, c) uses Web to create lesson plans often, and d) uses computer to communicate to students seldom. Strong predictors for function 2 include a) uses computer to post homework often, b) uses computer to communicate to students often. Strong predictors for function 3 include a) highest degree is education specialist or BA, b) highest degree is masters, c) has a master's degree in education, and d) has a master's degree in a STEM field. Strong predictors for function 4 include a) uses computer for records often, b) has taken software PD, c) creates class materials with computer seldom, and d) has taken a PD integrating math and technology. Some of the least predictive variables (the highest absolute correlation is <.1 are omitted.

Table 3.9 Partial structure matrix table

Function	1	2	3	4
use Web for model lesson plans seldom	.404*	.398	.022	.123
use web for research seldom	.373*	.349	.018	.094
use web to create lesson plans often	-.370*	-.366	-.020	-.095
use computer to communicate students seldom	.335*	-.291	-.275	.076
use web to create lesson plans seldom	.277*	.161	-.009	-.096
use computer for multimedia seldom	.260*	.102	-.094	.069
download ed software seldom	.260*	.214	-.028	.111
computer to present in class seldom	.238*	.079	-.099	.065
technology PD	-.185*	-.030	.014	.125
web for colleague contact seldom	.180*	.123	-.004	.016
use computer to communicate parents seldom	.163*	-.035	-.041	-.161
use computer for multimedia often	-.157*	-.045	.070	-.056
download ed software often	-.155*	-.149	-.001	-.082
computer to present in class often	-.152*	-.064	.066	-.048
use computer to communicate parents often	-.144*	.019	.044	.076
web for colleague contact often	-.132*	-.084	.003	-.028
PD on web seldom	.100*	.090	-.001	.031
use computer to post homework often	-.350	.515*	.378	-.203
use computer to post homework seldom	.380	-.435*	-.374	.183
use computer to communicate students often	-.307	.362*	.272	-.132
use Web for model plans often	-.271	-.280*	-.018	-.133
use web for research often	-.265	-.266*	-.018	-.125
highest degree is ed specialist or BA	-.172	.365	-.831*	-.180
highest degree is M	.171	-.350	.817*	.202
masters in ed	.082	-.170	.404*	.204
masters in STEM	.084	-.126	.317*	.150
teaching 0-5 years	-.121	.056	-.186*	-.013
teaching 20+ years	.135	-.095	.170*	-.056
teacher is young 23-39	-.115	.097	-.170*	.066
ten or more grad math courses	.032	-.068	.156*	.072
teacher is old 53-67	.104	-.089	.127*	-.093
use computer for records seldom	.225	-.097	.037	-.476*
use computer for records often	-.223	.129	-.028	.464*
software PD	-.126	.019	-.008	.391*
create materials with computer seldom	.196	-.023	.045	-.380*
integrate math and tech training PD	-.144	-.002	.025	.345*
internet use PD	-.100	-.002	.028	.255*
create materials with computer often	-.219	-.032	.017	.237*
advanced PD	-.183	-.071	.049	.224*
basic computer PD	-.071	.003	.010	.220*
ten or more undergrad math courses	.003	.026	.021	.155*
has a STEM BA	.001	.074	-.017	.120*

Figure 3.10 is a territorial map. "The territorial map graphically illustrates the decision or classification rule that is used to predict group membership for individuals based on their scores on the discriminant functions" (Warner, 2008, p. 690-691). The numbers 1-5 on the map are placed such that they represent the boundaries for the region of probability for belonging to each corresponding cluster group. Cluster 1 has boundaries that run generally left to right above all other clusters, with cluster 2 mostly right beneath it. Cluster 3 runs largely top to bottom along the left side of the map, while cluster 4 does the same thing on the right side of the map. Cluster 5 is bounded on the left by cluster 3, on the right by cluster 4, and on top by cluster 2. An asterisk (*) followed by a cluster number indicates the centroid for that cluster.

Table 3.11 is a classification results table. This table indicates how well the discriminant functions correctly classify teachers into the five cluster groups. According to the table, 90.5% of the original cases were correctly classified, and 89.2% of the cross-validated cases were correctly classified. The original percentages of correctly classified teachers show the predictive accuracy of the discriminant function, and are referred to as "hit ratios". According to Burns and Burns (2008), an acceptable hit ratio is 25% larger than that due to chance. Given that there are five clusters, the chance of correctly classifying a teacher is 1/5, or 20%. An acceptable hit ratio, therefore, is 25%. As table 3.11 shows, the percentages of correctly classified teachers are much higher. Teachers in clusters 1, 2, and 5 are correctly classified over 90% of the time, while clusters 3 and 4 are correctly classified 87% and 79% of the time. The results are quite strong.

Figure 3.10 Territorial map for clusters with functions 1 and 2

```
(Assuming all functions but the first two are zero)
Canonical Discriminant
Function 2
      -8.0      -6.0      -4.0      -2.0        .0       2.0       4.0       6.0       8.0
        +---------+---------+---------+---------+---------+---------+---------+---------+
   8.0 +                                                                       144       +
       I                                                                      14         I
       I                                                                     14          I
       I                                                                   114           I
       I                                                                  144            I
       I                                                                 14              I
   6.0 +          +         +         +         +         +         +  114    +          +
       I                                                               144               I
       I                                                             114                 I
       I                                                            124                  I
       I                                                          1124                   I
       I                                                        112224                   I
   4.0 +          +         +         +         +         +  1122 24+         +          +
       I                                                    1122  24                     I
       I                                                  1122   24                      I
       I111                                             1122    24                       I
       I3331111                                       1122      24                       I
       I   3333111                       *1          122       24                        I
   2.0 +       3331111      +         +         + 112     +  24     +         +          +
       I          33331111                      1122        24                           I
       I              3333111                 1122         24                            I
       I                  3331111           1122           24                            I
       I                     33331111     1122          2224                             I
       I                         33331111122      *2 2225554                             I
    .0 +          +         +        33322      + 222555  54        +         +          +
       I                                32     222555     54*4                           I
       I                                 32 222555   *5    54                            I
       I                                  32555            54                            I
       I                                   35              54                            I
       I                        *3         35              54                            I
  -2.0 +          +         +         +     35  +         + 54      +         +          +
       I                                    35              54                           I
       I                                    35              54                           I
       I                                     35             54                           I
       I                                     35             54                           I
       I                                      35             54                          I
  -4.0 +          +         +         +       35+         +  54     +         +          +
       I                                      35             54                          I
       I                                       35            54                          I
       I                                       35             54                         I
       I                                        35            54                         I
       I                                        35            54                         I
  -6.0 +          +         +         +         +35       +   54    +         +          +
       I                                         35            54                        I
       I                                         35            54                        I
       I                                          35           54                        I
       I                                          35           54                        I
       I                                           35          54                        I
  -8.0 +                                           35           54                       +
        +---------+---------+---------+---------+---------+---------+---------+---------+
      -8.0      -6.0      -4.0      -2.0        .0       2.0       4.0       6.0       8.0
                              Canonical Discriminant Function 1
```

Table 3.11 Discriminant analysis classification results

	Cluster Number		Predicted Group Membership					Total
			1	2	3	4	5	
Original	Count	1	609	21	5	0	18	653
		2	37	1081	9	20	1	1148
		3	20	37	534	0	21	612
		4	11	46	3	526	81	667
		5	22	3	15	21	982	1043
	%	1	93.3	3.2	.8	.0	2.8	100.0
		2	3.2	94.2	.8	1.7	.1	100.0
		3	3.3	6.0	87.3	.0	3.4	100.0
		4	1.6	6.9	.4	78.9	12.1	100.0
		5	2.1	.3	1.4	2.0	94.2	100.0
Cross-validated	Count	1	602	22	8	1	20	653
		2	41	1069	13	22	3	1148
		3	23	39	526	1	23	612
		4	13	53	3	509	89	667
		5	26	3	16	28	970	1043
	%	1	92.2	3.4	1.2	.2	3.1	100.0
		2	3.6	93.1	1.1	1.9	.3	100.0
		3	3.8	6.4	85.9	.2	3.8	100.0
		4	1.9	7.9	.4	76.3	13.3	100.0
		5	2.5	.3	1.5	2.7	93.0	100.0

The discriminant analysis above offers strong evidence that my cluster analysis is reasonable. Although there are a few instances where my model does not correctly meet all assumptions (as shown in Table 3.5 and 3.6), these results are acceptable because the data set and the number of predictive variables are sufficiently large (Burns & Burns, 2008; Warner, 2008). Based on these findings, I am confident in the cluster model, and will proceed with statistical tests and evidence to address my remaining research questions.

3.3 Student data within clusters

To address my second research questions, What are the predominant characteristics of students who are assigned to 10th grade mathematics teacher profiles?, and Which teacher profiles, if any, are more likely to have Latinos or ELLs?, I treat each cluster as a nested case, incorporating student data from the ELS data set for the teachers included in each cluster. Using the student and mathematics teacher data that discriminates between clusters, I analyzed the descriptive statistics and frequencies of variables that make students of each cluster number unique when compared to the other profiles and when compared to the data set as a whole. With their 10th grade ELS mathematics assessment scores, I also analyzed the student mathematics achievement by cluster, and how the distribution of mathematics achievement may differ across clusters.

Because my primary interest is in the mathematics teachers of Latinos and ELL students, I first compare the demographics and achievement of the students in each cluster: age, sex, ethnicity/race, and mathematics test scores. However, it may be important to find other ways, if any, that the students of the various teacher clusters may differ. Therefore, I performed an analysis of variance (ANOVA) comparing student survey data across clusters. The student survey (Appendix B) contains 98 questions, including questions on school safety, friendships and relationships, attitudes about academics, after school activities, in-class activities, home environment, and future plans.

I compared students of the five teacher profiles by means and standard deviations on over 300 variables from student survey data. I included some variables from parent survey data, such as household income, parent's highest level of education, and parent’s wishes for their students about attending college. On many codes, students of each cluster were not significantly different from each other or the sample means. This is not surprising, since it would be odd if students had different types of teachers based on, for example, the students' opinions about the school rules, how much they like classes and homework, and what they do in their free time. Table 3.12 has a summary of student characteristics by cluster found to have significant differences between the sample and group means, and some significant differences between clusters. I describe the highlights of these differences in Chapter IV. As in Table 3.4, the superscript numbers indicate cluster numbers that are significantly different at the $p < .05$ level. Students in clusters 1 and 2 are not significantly different from each other on many variables. This is not a surprise, since the teachers of these two clusters are also quite similar to each other in most ways. The main distinctions are in the students of clusters 3 and 5. There were also a few distinguishing features of the students from cluster 4 teachers.

In particular, students in cluster 3 had the lowest mathematics and reading test scores, and a significantly higher percentage of students scoring in the lowest quartile for both the base year and the follow-up mathematics assessments. Table 3.13 shows quartile ranking on assessments by cluster and for Latinos and ELLs. Students in cluster 3 were also significantly more likely to be Latino or ELL[7]. Students in cluster 5 had the highest mathematics and reading test scores, and a significantly higher percentage of students scoring in the highest quartile for both the base year and the follow-up mathematics assessments. Students of both clusters (3 and 5) had a significantly higher use of technology in the classroom when compared to other clusters and the sample. However, cluster 3 was more likely to use computers and graphing calculators in class, while cluster 5 was more likely to use calculators (not graphing calculators) in class. cluster 4 students reported significantly lower use of computers, calculators, and graphing calculators than all other clusters. Comparing clusters 3 and 5 with each other and the sample means reveal many of the most distinctive differences. Chapter IV has a more complete description of the distinctions between the students of each cluster.

The percentage of members (n) in the student sample in each cluster is similar to the percentages of the teachers in each cluster, indicating that, although there may be "teacher types" identified in my research, the average number of students having the same teacher is not affected by cluster assignment. This evidence lends some support to the idea that the teachers in the data set are at least in some ways representative of all 10th grade teachers at the time of data collection.

[7] In the tables and text hereafter, "LELL" refers to the sample of students who are Latino, ELL, or both. Neufeld, Amendum, Fitzgerald, and Guthrie (2006) have also used the acronym LELL.

Table 3.12 Means (%) Student characteristics by cluster

	sample	1	2	3	4	5	LELL
Male	50	51_{2}	48_{13}	53_{245}	49_{3}	50_{3}	50
Student's race: Latino	13	14_{45}	14_{45}	16_{45}	12_{123}	11_{123}	94
Student's race: White	60	58_{5}	60_{3}	56_{245}	60_{3}	62_{13}	0.6
Non-native speaker	15	15	16_{5}	17_{45}	14_{3}	14_{23}	49
Native language: Spanish	6	5_{23}	7_{145}	8_{145}	5_{23}	5_{23}	41
ELL student	1.5	1.1_{3}	2.4	2.9_{15}	1.9	1.4_{3}	10.5
2 parent home	60	60_{3}	61_{3}	57_{1245}	61_{3}	60_{3}	56
Single mother	17	18	16_{3}	20_{24}	17_{3}	18	18
Mom HS or below	38	37_{23}	40_{15}	41_{145}	38_{3}	37_{23}	56
Mom has grad degree	12	13_{2}	11_{15}	11	11	13_{2}	7
Family income <15K	9	9	9_{4}	10_{45}	8_{23}	8_{3}	15
Family income >75K	29	30_{3}	29_{3}	26_{1245}	29_{3}	31_{3}	17
Low SES	22	21_{23}	24_{145}	25_{145}	21_{23}	20_{23}	44
High SES	29	31_{23}	28_{15}	27_{15}	30	30_{23}	16
>50% free lunch	12	11_{3}	11_{3}	15_{1245}	11_{3}	12_{3}	26
Repeated a grade	10	9_{3}	9_{3}	12_{1245}	10_{3}	9_{3}	12
Schooled outside US	5	5_{23}	6_{145}	7_{145}	5_{23}	4_{23}	16
Low home literacy sources	18	17_{3}	17_{3}	21_{1245}	17_{3}	17_{3}	30
2+ academic risk factors	20	19_{3}	20_{35}	23_{1245}	19_{3}	18_{23}	31
Student expects college degree	74	75_{35}	74_{35}	68_{1245}	75_{35}	77_{1234}	66
Plans to continue ed. **right** after high sch.	68	68_{3}	68_{35}	63_{1245}	70_{3}	70_{23}	61
Mother wants college degree for student	68	70_{34}	67_{3}	64_{125}	67_{1}	69_{3}	58
Favorite teacher wants college degree	54	55_{3}	55_{3}	51_{125}	54	55_{5}	50
Family has a computer	79	79_{35}	78_{5}	76_{15}	78_{5}	82_{1234}	65
Family has Internet	74	74_{35}	72_{5}	71_{15}	73_{5}	77_{1234}	59
Has own room	77	77_{3}	75_{5}	74_{15}	76_{5}	79_{234}	64
Often discusses college w/parents	37	39_{23}	36_{13}	33_{1245}	38_{3}	38_{3}	35
School is urban	32	36_{235}	29_{134}	32_{1245}	37_{235}	29_{134}	46
School is in Northeast	18	14_{45}	14_{45}	14_{45}	28_{1235}	19_{1234}	16
School is South or West	55	62_{245}	56_{1345}	61_{245}	48_{1235}	52_{1234}	70
Students friendly w/other races	86	86	87	84	85	85	86
Students disrupt class	69	69_{4}	71_{4}	69_{4}	66_{1235}	69_{4}	72
There are gangs in school	25	24_{3}	26	28_{145}	24_{3}	25_{3}	38
Racial/ethnic groups often fight	20	20_{3}	21_{4}	23_{145}	18_{235}	21_{34}	32
Got into fight at school	3	2_{3}	2_{34}	4_{125}	3_{2}	2_{3}	4
Won an academic honor	34	33_{5}	34_{5}	32_{5}	35	36_{123}	25
Recognized for good grades	48	47	48_{3}	44_{245}	48_{3}	49_{3}	36
Participated in science/math fair	14	15_{23}	12_{14}	13_{14}	15_{23}	14	14
Participated in tech competition	8	8_{4}	9_{45}	8_{4}	6_{123}	7_{2}	7
Often absent from school	14	14	14_{5}	16_{4}	13_{35}	16_{24}	16
Wants to play athletics in college	41	40	42_{3}	38_{24}	42_{3}	40	38
Does what is expected in class	58	57	59_{3}	56_{245}	60_{3}	59_{3}	66

	sample	1	2	3	4	5	LELL
Nothing better to do than school	30	31_{4}	31_{45}	33_{45}	28_{123}	29_{23}	33
Education is important to get job	92	92_{2}	93_{1345}	91_{2}	91_{2}	91_{2}	92
School is a place to meet friends	78	77_{2}	80_{134}	77_{2}	77_{2}	79	76
Plays on a team or club	49	50	50	47_{5}	48_{5}	51_{34}	39
Learns job skills in school	81	79_{2}	83_{1345}	80_{2}	80_{2}	79_{2}	82
Parents expect school success	89	89	90_{345}	88_{2}	88_{2}	88_{2}	88
Seldom uses math books besides text	67	68_{3}	67_{3}	62_{1245}	65_{35}	69_{34}	60
Seldom uses calculators in class	22	23_{45}	22_{45}	23_{45}	27_{1235}	17_{1234}	33
Seldom uses graphing calc. in class	54	54_{345}	55_{345}	50_{124}	61_{1235}	50_{1234}	62
Uses computers in math class	18	19_{34}	17_{34}	24_{1245}	15_{1235}	19_{34}	23
Ever in remedial English	8	8	8	9_{5}	8	8_{3}	10
Ever in remedial math	9	9	9	10_{5}	9	8_{3}	11
Ever in bilingual/bicultural class	29	28	29	26_{45}	31_{3}	30_{3}	29
Ever in ESL class	8	7_{34}	7_{4}	9_{15}	9_{125}	7_{34}	17
Ever in special education	7	6_{3}	6_{3}	10_{1245}	7_{3}	6_{3}	10
Often uses computer for fun	49	49_{3}	50_{3}	45_{1245}	49_{3}	51_{3}	37
Being successful in work important	83	83_{3}	83_{3}	79_{1245}	83_{3}	84_{3}	78
Having happy family important	74	74_{3}	75_{3}	70_{1245}	73_{3}	75_{3}	68
Having lots of money important	39	39	39	41_{5}	38	38_{3}	42
Having strong friendships important	80	80_{3}	81_{3}	76_{1245}	80_{3}	82_{3}	72
Finding steady work important	80	79	81_{3}	78_{25}	79	81_{3}	75
Better opportunities for children important	76	76_{4}	78_{345}	74_{2}	74_{12}	75_{2}	79
Having children important	46	44_{2}	47_{13}	43_{24}	47_{3}	46	40
Getting good education important	79	79_{3}	81_{34}	76_{125}	78_{2}	80_{3}	79
No plans to take SAT or ACT	25	25_{35}	27_{45}	29_{145}	24_{23}	22_{123}	34
Took or plans to take AP test	26	27_{23}	24_{15}	23_{145}	26_{35}	29_{234}	23
Can learn something really hard	46	46_{3}	46_{3}	42_{1245}	46_{3}	48_{3}	39
Can get no bad grades if decides to	50	51_{3}	50_{3}	46_{1245}	50_{3}	52_{3}	42
Keeps studying even if it is difficult	40	41_{3}	40_{3}	36_{1245}	39_{35}	42_{34}	35
Can do excellent on math assignments	37	38	37_{5}	35_{5}	36_{5}	39_{234}	33
Does best to learn what studies	44	44_{3}	44_{3}	41_{1245}	44_{3}	46_{3}	38
Can master math class skills	38	38	37_{5}	36_{5}	37_{5}	40_{234}	32
Expects honors graduation	12	11_{5}	11_{5}	10_{5}	11_{5}	16_{1234}	8
No algebra by 12th grade	4	4_{3}	4_{3}	6_{1245}	4_{3}	4_{3}	6
1+ years general math	20	19_{3}	21_{35}	24_{1245}	21_{35}	17_{234}	23
1+ years pre-algebra	28	29_{5}	30_{45}	29_{5}	27_{25}	25_{1234}	32
1 year algebra I	58	59_{35}	60_{35}	54_{124}	59_{35}	55_{124}	56
1 year geometry	62	64_{3}	63_{3}	55_{1245}	64_{3}	63_{3}	54
1 year algebra II	52	54_{3}	51_{35}	44_{1245}	53_{3}	54_{23}	42
1 year trigonometry	16	17_{23}	15_{145}	14_{145}	17_{23}	17_{23}	10
1 year pre-calculus	21	20_{345}	19_{345}	17_{1245}	23_{123}	23_{123}	14
1 year calculus	12	11_{5}	10_{45}	9_{45}	13_{235}	14_{1234}	7

Several approaches are possible for analyzing "mathematics achievement" in the ELS data set. In the definitions section, I defined mathematics achievement for the purposes of this study as improvement on the mathematics scores reported on the ELS data set. Improvement may be determined by a student's two test scores in relation to other students in the ELS data set taking the same tests (for example, their quartile rank), and also by analyzing the IRT estimated number correct gain from the base year to the first follow up. Standardized scores for the ELS mathematics assessments are less informative as longitudinal data, as the follow-up assessment proved more difficult than the base-year assessment.

In order to compare mathematics scores from 10th to 12th grade, I first removed all students from the data set that did not take both exams. There were 81 students with no base year "BY" mathematics score, and an additional 1926 with no follow-up "F1" score. The remaining data contains 10965 students. For the Latino and ELL students "LELLs", all 1826 students have a BY score, but 374 did not have an F1 score. Analysis of mathematics achievement included the remaining 1452 LELLs.

Table 3.13 shows the number and percent of students scoring in each quartile by cluster. In general, cluster 5 had the most students scoring in the upper quartiles for all three assessments, and cluster 3 had the most students scoring in the lower quartiles. Latinos and ELLs performed significantly lower than all clusters. This finding, along with course-taking in Table 3.12 points to the well-established opportunity gap that disenfranchises Latinos and ELLs from educational and career opportunities.

Table 3.13 Quartiles for base year math, reading, and follow up math by group.

BY	Math n	%	LELL n	%	1 n	%	2 n	%	3 n	%	4 n	%	5 n	%
Q=1	2020	18.40%	489	33.70%	301	16.90%	595	19.10%	325	24.40%	367	18.30%	432	15.80%
Q=2	2491	22.70%	396	27.30%	418	23.50%	766	24.60%	319	23.90%	440	21.90%	548	20.10%
Q=3	3064	27.90%	347	23.90%	527	29.70%	874	28.10%	347	26.00%	573	28.50%	743	27.20%
Q=4	3390	30.90%	220	15.20%	531	29.90%	876	28.20%	343	25.70%	630	31.30%	1010	37.00%
Total	10965	100%	1452	100.00%	1777	100.00%	3111	100.00%	1334	100.00%	2010	100.00%	2733	100.00%
BY	Read n	%	LELL n	%	1 n	%	2 n	%	3 n	%	4 n	%	5 n	%
Q=1	2147	19.60%	524	36.10%	336	18.90%	651	20.90%	333	25.00%	373	18.60%	454	16.60%
Q=2	2490	22.70%	397	27.30%	396	22.30%	737	23.70%	328	24.60%	426	21.20%	603	22.10%
Q=3	2986	27.20%	299	20.60%	500	28.10%	861	27.70%	314	23.50%	557	27.70%	754	27.60%
Q=4	3342	30.50%	232	16.00%	545	30.70%	862	27.70%	359	26.90%	654	32.50%	922	33.70%
Total	10965	100%	1452	100.00%	1777	100.00%	3111	100.00%	1334	100.00%	2010	100.00%	2733	100.00%
F1	Math n	%	LELL n	%	1 n	%	2 n	%	3 n	%	4 n	%	5 n	%
Q=1	2361	21.50%	526	36.20%	344	19.40%	704	22.60%	374	28.00%	409	20.30%	530	19.40%
Q=2	2617	23.90%	404	27.80%	459	25.80%	780	25.10%	329	24.70%	467	23.20%	582	21.30%
Q=3	2853	26.00%	307	21.10%	483	27.20%	847	27.20%	310	23.20%	513	25.50%	700	25.60%
Q=4	3134	28.60%	215	14.80%	491	27.60%	780	25.10%	321	24.10%	621	30.90%	921	33.70%
Total	10965	100.00%	1452	100.00%	1777	100.00%	3111	100.00%	1334	100.00%	2010	100.00%	2733	100.00%

Table 3.14 summarizes standardized score data with the mean and standard deviation of student test scores for math and reading in the base year, and math in the follow up year. The scores show only small differences from one cluster to another. However, the trend is that students in cluster 3 consistently have the lowest scores and students in cluster 5 have the highest.

Table 3.14 Standardized base year and follow up score statistics by cluster

BY math	**sample**	**1**	**2**	**3**	**4**	**5**	**LELL**
n	10965	1777	3111	1334	2010	2733	1452
min	19.38	21.96	19.38	22.61	21.70	21.54	21.96
max	86.68	78.63	80.00	83.27	82.63	86.68	83.27
mean	52.01	52.21	51.46	50.44	52.00	53.28	47.41
std. dev	9.71	9.43	9.46	10.21	9.55	9.87	9.64
BY read	**sample**	**1**	**2**	**3**	**4**	**5**	**LELL**
n	10965	1777	3111	1334	2010	2733	1452
min	22.57	23.80	22.57	24.17	22.94	23.55	23.80
max	78.76	78.76	78.76	77.16	78.76	78.76	75.68
mean	51.75	51.90	51.17	50.34	52.09	52.75	46.90
std. dev	9.81	9.65	9.68	10.21	9.96	9.64	9.69
F1 math	**sample**	**1**	**2**	**3**	**4**	**5**	**LELL**
n	10965	1777	3111	1334	2010	2733	1452
min	22.49	22.49	22.64	24.56	23.26	23.61	22.49
max	79.85	74.97	74.97	74.97	78.76	79.85	74.97
mean	51.16	51.26	50.54	49.44	51.54	52.35	46.78
std. dev	9.96	9.67	9.65	10.43	9.94	10.10	9.70

To address my research question "Which teacher profiles, if any, are more likely to have Latinos or ELLs?", I referred back to the classification system I applied to identify ELLs in the ELS in section 3.1.1. The search for ELLs in the ELS reveals 191 students in the sample. While this number is very small, I feel confident that these 191 students do in fact struggle with high school content because they have not learned enough English to fully benefit from instruction and educational materials delivered in English. Table 3.1 describes the numbers of ELL students by ethnicity, and Table 3.15 describes the numbers of Latino and ELL students in the sample and within each cluster.

Table 3.15 Latino, ELL, non-native English speakers and others by cluster

		sample	1	2	3	4	5
all students	n	12972	2092	3639	1679	2384	3178
	%	100	16	28	13	18	25
Latino	n	1725	294	526	264	286	350
	%	13.3	14.1*	14.5*	15.7*	12.0*	11.0*
ELL	n	191	26	61	34	33	37
	%	1.5	1.2*	1.7	2.0*	1.4	1.2*
non-native	n	1940	304	572	281	343	440
	%	15	14.5*	15.7*	16.7*	14.4*	13.8*
Total LELL	n	1826	307	558	280	307	374
	%	14.1	14.7	15.3	16.7	12.9	11.8
Had Remedial English	%	8.1	8.1	7.9	9.2*	8.3	7.5*
Had Remedial Math	%	9.1	8.9	9.3	10.4*	9.3	8.3*
Had Bilingual Class	%	29	28.1	28.7	26.3*	30.7*	30.1*
Had ESL Class	%	7.6	6.8*	7.3*	8.7*	8.9*	6.8*
Had Special Ed. Class	%	6.8	5.9	6.2	10.1*	6.7	6.3

As shown in Table 3.15, clusters 2 and 3 have significantly more Latinos, and non-native English speakers. Cluster 3 has significantly more ELLs, and clusters 1 and 5 have significantly fewer ELLs. Clusters 4 and 5 have significantly fewer Latinos, and non-native English speakers. The percentage of Latino, ELL, and non-native students in cluster 1 are not significantly different from the sample means. The non-native English speaking students includes students that may be fully bilingual, students identified in my analysis as being ELL, and possibly students who may be ELLs, but were not labeled as such in my study because of missing information. I included non-native students in the table to give additional evidence that it is more likely for linguistically and culturally diverse populations of students to be in some clusters (2 and 3), and not in others (4 and 5).

Sometimes schools view difficult-to-teach students as undesirable in mainstreamed content courses. Because they may have been lumped together in the same classroom, I included variables to show students who had ever been in remedial English, remedial mathematics, bilingual or ESL courses, and special education students. Table 3.22 shows that a significantly higher percentage of students who had been in remedial courses, ESL courses, and special education are in cluster 3, and significantly lower numbers are in cluster 5. Oddly, significantly higher percentages of students in clusters 4 and 5 had been in a bilingual class, even though these clusters had lower percentages of Latino, ELL, and non-native English speakers. In addition, a significantly higher percentage of students in cluster 4 had been in an ESL class. Some of these numbers may be misleading because of the huge variance in state laws about ELL education, bilingual instruction, and sheltered courses.

3.4 Latinos and ELLs within clusters

I use several measures to address my third research question, What combinations of matching students with teachers might predict better success for Latinos and ELLs in high school mathematics? I compare the mathematics quartile increases from 10th grade to 12th grade to analyze if some Latinos and ELLs are succeeding in mathematics achievement, and which clusters are most likely to realize that success. With the student data already reported in the previous section, Latinos, ELLs, and students in cluster 3 scored the lowest on all three assessments compared to all other clusters. This is not surprising, given that these students are also the least likely to be in rigorous mathematics courses, the most likely to have been in remedial or special education, and the least likely to have college plans or expectations. I discuss these findings further in the next chapter.

First, I analyzed the IRT estimated number correct gain by cluster, Latinos, and ELLs. Table 3.16 shows that cluster 4 had the highest number correct gain with a mean of 5.69, and this mean is significantly higher than all other clusters. Cluster 3 had the lowest number correct gains with a mean of 4.97. However, only the gains from cluster 4 were significantly different from other clusters. In other words, clusters 1, 2, 3, and 5 were not significantly different from each other. ELLs had a minimum score that was surprisingly different from all other groups. The sample minimum, Latinos, and all five clusters fell in the range of -39.46 to -25.00. This number implies that the lowest achieving mathematics student was estimated to answer incorrectly up to 39.46 more items on the second test. The ELL minimum score was only -13.35. This may be simply because the number of ELLs is very small: they represent only 1% of the sample.

Table 3.16 Minimum, maximum, mean, standard deviation, and variance of IRT estimated number correct gain by group

	N	min	max	mean	std. dev.	variance
Sample	10965	-39.46	45.42	5.22	6.350	40.316
Cluster 1	1777	-25.00	40.39	5.19	6.399	40.949
Cluster 2	3111	-39.46	44.56	5.15	6.237	38.895
Cluster 3	1334	-33.31	40.54	4.97	6.493	42.164
Cluster 4	2010	-27.39	45.42	5.69*	6.412	41.116
Cluster 5	2733	-32.66	36.83	5.07	6.314	39.871
Latino	1380	-39.46	30.50	4.91	6.500	42.279
ELL	126	-13.35	38.92	4.63	6.586	43.369

As a comparison, I also created a subset of the data that only includes students who had a positive gain for IRT estimated number correct. Table 3.17 shows the minimum, maximum, mean, standard deviation, and variance of IRT estimated number correct gain only for those students whose score gain increased. While the means increased by about two points for each cluster, the general trend is the same: Cluster 4 students had the greatest score gains and these gains were significantly higher than all other clusters.

To find if there exist notable characteristics of students and their teachers who do succeed in mathematics achievement, I created a subset of the data that only includes students who either remained in the top quartile for both the base-year and the follow-up mathematics assessments, or those who increased by one or more quartiles in rank. Tables 3.18 and 3.19 summarize some of the demographic information of the cases included in this subset. Note that the percent values do not add up to 100%, as students were frequently part of more than one group. For example, a student could be male, Latino, ELL, and part of Cluster 2.

Table 3.17 Minimum, maximum, mean, standard deviation, and variance of IRT estimated number correct gain by group for all cases with positive score gains

	N	%	min	max	mean	std. dev.	variance
Sample	9069	100	0.01	45.42	7.14	4.834	23.364
Cluster 1	1466	16	0.02	40.39	7.10	5.073	25.739
Cluster 2	2583	24	0.01	44.56	7.02	4.718	22.264
Cluster 3	1084	12	0.05	40.54	7.08	4.737	22.443
Cluster 4	1694	19	0.03	45.42	7.49*	4.942	24.419
Cluster 5	2242	25	0.01	36.83	7.06	4.759	22.647
Latino	1144	13	0.04	30.50	7.18	4.856	23.578
ELL	101	1	0.39	38.92	6.72	5.355	28.672

Table 3.18 Demographics of students who increased by one or more quartiles or remained in the top quartile in mathematics from 10th to 12th grade

	n	%
Sample	3849	100
non-native English	528	13.7
male	2113	54.9
Native American	11	0.3
Asian	481	12.5
African American	209	5.4
Latino	328	8.5
White	2656	69
ELL	31	0.8
Cluster 1	611	15.9
Cluster 2	985	25.6
Cluster 3	428	11.1
Cluster 4	751	19.5
Cluster 5	1074	27.9
LELL	354	9.2

Table 3.19 Percent students who increased by one or more quartiles or remained in the top quartile in mathematics from 10th to 12th grade by cluster

	Sample	1	2	3	4	5
n	3849	611	985	428	751	1074
BY Math lowest quartile***	7.5	8.5	7.1	9.8	7.7	6.1*
BY Math highest quartile***	68.6	66.1	65.7	65.2	67.5	75.0*
Reading lowest quartile***	6.5	7.9	6.0	9.8	7.6	4.0*
Reading highest quartile***	55.7	55.3	52.6	51.9	55.0	60.6
F1 Math highest quartile***	81.4	80.4*	79.2*	75.0*	82.7*	85.8*
IRT mean score gain***	8.8	8.9	9.0	8.6	9.3	8.17*
ELL	0.8	0.7	1.0	1.2	0.9	0.5
Latino	8.5	7.9	9.6	10.0	8.5	7.2
Native Spanish speaker	3.2	2.5	4.0	4.7	2.9	2.4
LELL	9.2	8.5	10.6	11.0	9.1	7.6
SES quartile lowest*	9.8	10.0	12.0*	10.3	9.2	7.9*
SES quartile highest	48.2	50.9	45.7	50.5	46.2	49.4
Ever in special ed.	3.2	3.4	3.4	3.7	2.9	2.9

This subset contains 3849 students and their 1892 mathematics teachers. A summary of their characteristics is in Tables 3.20 through 3.23. Table 3.20 shows characteristics of the teachers who had mathematics achieving students (those who increased by one or more quartiles in rank or who remained in the top quartile in mathematics) by cluster with some of the characteristics from Table 3.4. Table 3.21 shows the difference in percentages listed in Tables 3.4 and 3.20, to help visualize the degree to which this subset of teachers is different from the original sample of 4123 mathematics teachers. Table 3.15 shows mathematics students who increased by one or more quartiles in rank from the base year to the follow up year, or remained in the top quartile for mathematics by clusters and by characteristics from survey responses. This is similar to Table 3.12, which includes all students in my study. Table 3.23 shows the difference in percentages listed in Tables 3.12 and 3.22 to help visualize the contrast. While the highest numbers of achieving students by this measure are

White, male, of higher SES, and from Cluster 5 (the Scholars), some students succeeded in mathematics achievement in all five clusters, and in all demographics. Negative numbers in Tables 3.21 and 3.23 indicate that the values are lower by the given percentage in comparison to all teachers and students in this study. I did not include the low-use computer codes, as they did not show large differences and were in some ways redundant. Chapter IV contains a more thorough discussion of the findings in these tables.

Table 3.20 Characteristics of mathematics teachers whose students increased a quartile in rank by cluster

Cluster		1	2	3	4	5
n	1892	316	498	221	320	537
If starting over whether would teach	70	71	72	77	66	68
Highest degree is ed. specialist or BA	48	59	99	55	31	1
Highest degree is Masters	51	41	0	44	66	99
Highest degree is PhD	1	1	1	1	2	1
Teaching 20+ years	38	27	23	23	63	49
Teaching 0-5 years	21	25	33	34	10	10
Regular teaching certification	85	83	82	78	88	92
Alternate or temporary certification	9	11	12	16	5	5
Has 1 BA in STEM	70	74	72	69	62	71
Has a major and a minor BA in STEM	11	10	8	12	12	15
Has a BA in education	28	30	31	26	22	29
Has a master's degree in STEM	25	17	1	20	30	50
Has a master's degree in education	29	23	2	24	28	62
10+ spec. ed prep.	12	11	14	22	5	9
At least 8 hours ELL preparation	8	13	10	12	2	6
Holds 2nd FT or PT job summer only	20	20	26	22	13	16
2nd FT or PT job school year/all year	29	29	28	38	28	27
Job is related to education	31	34	30	39	25	31
Teacher is White	87	85	87	79	89	91
Teacher is Latino	3	3	4	8	2	2
Teacher is male	43	42	42	43	54	39
Teacher is older: born 1935-1949	27	18	16	19	49	32
Teacher is younger: born 1968-1979	28	36	41	38	8	19
Uses computer to create materials often	64	75	62	96	25	71
Uses Web sites to plan lessons often	16	6	9	79	2	11
Uses lesson plans from Internet often	4	0	1	32	0	1
Uses Internet: teaching research often	4	0	0	29	0	1
Takes PD courses via Internet often	1	1	1	6	0	1
Uses Internet: colleague contact often	6	6	3	23	2	4
Downloads instructional software often	2	1	0	12	0	1
Computer: class presentations often	7	10	2	20	2	6
Computer: administrative records often	80	96	85	93	36	87
Computer: multimedia presentations often	6	12	2	20	2	5
Computer to communicate w/parents often	23	35	20	46	3	22
Computer to communicate w/students often	23	78	7	42	4	10
Uses computer to post homework often	23	88	4	38	7	7
Basic computer skills training	80	83	83	89	56	87
Software applications training	82	88	88	91	43	93
Use of Internet training	77	83	78	90	49	86
Other technology training	41	49	38	73	12	43
Integrating tech. in curriculum training	77	83	78	94	43	88
Follow-up or advanced training	45	48	41	77	9	54

Table 3.21 Differences between teachers of students whose quartile rank increased and all teachers by cluster

	sample	1	2	3	4	5
If starting over whether would teach	2.1	-1.3	2.4	3.3	6.8	2.7
Highest degree is ed. specialist or BA	-2.7	-2.1	-0.4	1.4	-2.1	0.7
Highest degree is Masters	3.2	3	-0.1	0.2	2.1	0.3
Teaching 20+ years	4.8	3.7	3.5	1.4	7.2	2
Teaching 0-5 years	-4.1	-4.9	-4.3	-4.2	-0.9	0
Regular teaching certification	2.9	3.7	2.6	6.4	4.8	0
Alternate or temporary certification	-2.8	-3.1	-4	-3	-1.6	0.3
Has 1 BA in STEM	6	4.2	2.9	14.1	9.5	3.6
Has a major and a minor BA in STEM	0.4	0.7	0	2.5	-0.3	1.1
Has a BA in education	-1.4	1.8	-2.3	-4.2	-0.5	-0.7
Has a master's degree in STEM	5.4	2.3	-10.3	6.1	6.9	5.9
Has a master's degree in education	1.1	1.6	-0.2	0.3	-1.8	0.5
10+ spec. ed prep.	-6	-5.2	-2.9	-13.1	-8.3	-4.1
At least 8 hours ELL preparation	-4	-2	-2	-9.1	-3.3	-2.8
Holds 2nd FT or PT job summer only	-0.1	-3	2.3	-1	-1.7	0.1
2nd FT or PT job school year/all year	-1.1	-2.4	0.5	1.4	-1.8	-1.6
Teacher is White	4.4	5.2	4.8	5.8	4.3	2.1
Teacher is Latino	-1.6	-2.4	-1.8	-0.8	0.3	-0.4
Teacher is male	0.1	0.3	1.1	0.2	1.1	-0.5
Teacher is older: born 1935-1949	1.8	1.1	1.5	0	3.7	-1
Teacher is younger: born 1968-1979	-1.1	-1.7	-1.9	0.9	-0.4	1.9
Uses computer to create materials often	1.2	4	0	5	1	3
Uses Web sites to plan lessons often	-3	-2	-1	1	-1	-1
Uses Internet: teaching research often	-2	-1	-1	-5	0	0
Takes PD courses via Internet often	-1	0	-10	0	0	0
Computer: administrative records often	0	1	-2	4	3	0
Computer to communicate w/parents often	2	4	3	10	0	2
Computer to communicate w/students often	0	1	-1	4	0	0
Uses computer to post homework often	1	1	0	5	2	-1
Basic computer skills training	-1	1	1	4	-4	-1
Software applications training	0	3	2	3	-4	0
Use of Internet training	-2	1	-1	4	-4	-2
Other technology training	-1	-1	-2	3	-1	1
Integrating tech. in curriculum training	0	1	-1	5	1	-1
Follow-up or advanced training	-1	-1	0	4	-2	0

Negative numbers indicate that the values are lower by the given percentage in comparison to all mathematics teachers. Not all codes are shown.

Table 3.22 Characteristics of mathematics students who increased a quartile in rank by group

	Sample	1	2	3	4	5	LELL
	3849	611	985	428	751	1074	354
Male	55	56	54	61	54	53	52
Student's race: Latino	9	8	10	10	9	7	93
Student's race: White	69	67	69	68	69	71	0
Non-native speaker	15	15	15	15	14	14	42
Native language: Spanish	3	3	4	5	3	2	33
ELL student	1	1	1	1	1	1	9
2 parent home	73	72	72	76	74	71	65
Single mother	13	12	13	12	12	14	18
Mom HS or below	25	22	28	25	26	23	40
Mom has grad degree	16	19	14	16	14	18	10
Family income <15K	3	5	4	2	3	3	6
Family income >75K	44	45	45	43	42	44	32
Low SES	10	10	12	10	9	8	26
High SES	48	51	46	51	46	49	32
>50% free lunch	6	6	6	7	4	5	16
Repeated a grade	4	4	4	5	3	3	6
Schooled outside US	6	6	5	8	5	5	15
Low home literacy sources	12	13	12	14	12	12	25
2+ academic risk factors	11	12	11	11	9	10	19
Student expects college degree	88	88	88	87	89	88	76
Plans to continue ed. right after high sch.	83	82	83	82	82	84	74
Mother wants college degree for student	81	79	82	82	80	81	72
Favorite teacher wants college degree	62	60	63	62	61	61	60
Family has a computer	90	91	89	90	90	90	80
Family has Internet	86	88	85	85	86	87	76
Has own room	83	85	81	84	82	85	74
Often discusses college w/parents	43	45	43	43	45	41	44
School is urban	34	40	31	30	39	31	46
School is in Northeast	20	13	17	15	31	21	16
School is South or West	54	61	54	61	46	51	72
Students friendly w/other races	87	86	89	87	86	86	90
Students disrupt class	63	64	66	64	59	64	71
There are gangs in school	19	19	20	19	18	18	27
Racial/ethnic groups often fight	14	11	15	17	13	14	22
Got into fight at school	1	1	1	1	2	1	3
Won an academic honor	52	50	52	48	53	55	43
Recognized for good grades	68	64	69	64	69	70	56
Participated in science/math fair	17	18	16	15	19	18	16
Participated in tech competition	6	7	8	5	6	4	3
Often absent from school	9	7	8	8	8	11	11
Often got into trouble	2	2	3	2	4	2	4
Does what is expected in class	58	54	60	56	59	58	65
Nothing better to do than school	29	31	30	33	26	26	30

	sample	1	2	3	4	5	LELL
Education is important to get job	93	91	94	96	93	93	94
School is a place to meet friends	84	81	88	86	82	85	82
Plays on a team or club	59	59	59	63	56	59	47
Learns job skills in school	81	78	83	86	80	79	83
Parents expect school success	89	87	92	91	90	88	89
Seldom uses math books besides text	77	75	78	75	72	80	70
Seldom uses calculators in class	15	16	14	15	19	11	24
Seldom uses graphing calc. in class	43	41	46	36	54	36	51
Uses computers in math class	17	19	16	25	12	18	14
Ever in remedial English	6	5	6	5	7	5	5
Ever in remedial math	7	6	8	8	7	6	7
Ever in bilingual/bicultural class	40	38	39	37	39	42	37
Ever in ESL class	4	4	4	6	5	3	11
Ever in special education	3	3	3	4	3	3	4
Often uses computer for fun	60	59	61	60	59	62	53
Being successful in work important	89	89	89	88	90	88	86
Having happy family important	79	77	81	81	80	78	73
Having lots of money important	32	33	33	35	32		35
Having strong friendships important	86	85	87	86	87	86	82
Finding steady work important	83	82	85	84	85	81	82
Better opportunities for children important	74	73	76	76	74	71	81
Having children important	49	45	51	50	51	47	43
Getting good education important	85	84	85	86	85	84	86
No plans to take SAT or ACT	12	13	13	11	12	10	20
Wants to play athletics in college	44	40	46	47	43	44	41
Can learn something really hard	60	60	61	61	60	60	55
Can get no bad grades if decides to	64	63	65	65	63	65	55
Keeps studying even if it is difficult	53	51	55	54	53	52	48
Can do excellent on math assignments	54	53	54	58	51	55	48
Does best to learn what studies	56	55	58	56	56	56	51
Can learn well if wants to	63	61	64	63	64	64	59
Can master math class skills	54	53	56	55	52	56	49
Expects honors graduation	23	21	21	24	19	28	17
No algebra by 12th grade	1	1	1	1	1	1	2
1+ years general math	11	11	11	13	12	9	17
1+ years pre-algebra	16	16	18	18	17	14	23
1 year algebra I	55	55	59	53	60	49	58
1 year geometry	80	81	80	76	81	81	75
1 year algebra II	74	76	74	70	72	77	69
1 year trigonometry	28	30	26	26	28	31	19
1 year pre-calculus	45	43	43	41	48	47	39
1 year calculus	31	30	27	28	31	35	22
Took or plans to take AP test	52	55	45	49	52	57	44

Table 3.23 Differences between students whose quartile rank increased in mathematics and all students by group

	Sample	1	2	3	4	5	LELL
Male	5	5	6	8	5	3	2
Student's race: Latino	-4	-6	-4	-6	-3	-4	-1
Student's race: White	9	9	9	12	9	9	-1
Non-native speaker	0	0	-1	-2	0	0	-7
Native language: Spanish	-3	-2	-3	-3	-2	-3	-8
ELL student	-0.5	0	-1	-2	-1	0	-2
2 parent home	13	12	11	19	13	11	9
Single mother	-4	-6	-3	-8	-5	-4	0
Mom HS or below	-13	-15	-12	-16	-12	-14	-16
Mom has grad degree	4	6	3	5	3	5	3
Family income <15K	-6	-4	-5	-8	-5	-5	-9
Family income >75K	15	15	16	17	13	13	15
Low SES	-12	-11	-12	-15	-12	-12	-18
High SES	19	20	18	24	16	19	16
>50% free lunch	-6	-5	-5	-8	-7	-7	-10
Repeated a grade	-6	-5	-5	-7	-7	-6	-6
Schooled outside US	1	1	-1	1	0	1	-1
Low home literacy sources	-6	-4	-5	-7	-5	-5	-5
2+ academic risk factors	-9	-7	-9	-12	-10	-8	-12
Student expects college degree	14	13	14	19	14	11	10
Plans to continue ed. right after high sch.	15	14	15	19	12	14	13
Mother wants college degree for student	13	9	15	18	13	12	14
Favorite teacher wants college degree	8	5	8	11	7	6	10
Family has a computer	11	12	11	14	12	8	15
Family has Internet	12	14	13	14	13	10	17
Has own room	6	8	6	10	6	6	10
Often discusses college w/parents	6	6	7	10	7	3	9
School is urban	2	4	2	-2	2	2	0
School is in Northeast	2	-1	3	1	3	2	0
School is South or West	-1	-1	-2	0	-2	-1	2
Students friendly w/other races	1	0	2	3	1	1	4
Students disrupt class	-6	-5	-5	-5	-7	-5	-1
There are gangs in school	-6	-5	-6	-9	-6	-7	-11
Racial/ethnic groups often fight	-6	-9	-6	-6	-5	-7	-10
Got into fight at school	-2	-1	-1	-3	-1	-1	-1
Won an academic honor	18	17	18	16	18	19	18
Recognized for good grades	20	17	21	20	21	21	20
Participated in science/math fair	3	3	4	2	4	4	2
Participated in tech competition	-2	-1	-1	-3	0	-3	-4
Often absent from school	-5	-7	-6	-8	-5	-5	-5
Often got into trouble	-3	-2	-2	-4	-1	-2	-3
Does what is expected in class	0	-3	1	0	-1	-1	-1
Nothing better to do than school	-1	0	-1	0	-2	-3	-3

	Sample	1	2	3	4	5	LELL
Education is important to get job	1	-1	1	5	2	2	2
School is a place to meet friends	6	4	8	9	5	6	6
Plays on a team or club	10	9	9	16	8	8	8
Learns job skills in school	0	-1	0	6	0	0	1
Parents expect school success	0	-2	2	3	2	0	1
Seldom uses math books besides text	10	7	11	13	7	11	10
Seldom uses calculators in class	-7	-7	-8	-8	-8	-6	-9
Seldom uses graphing calc. in class	-11	-13	-9	-14	-7	-14	-11
Uses computers in math class	-1	0	-1	1	-3	-1	-9
Ever in remedial English	-2	-3	-2	-4	-1	-3	-5
Ever in remedial math	-2	-3	-1	-2	-2	-2	-4
Ever in bilingual/bicultural class	11	10	10	11	8	12	8
Ever in ESL class	-4	-3	-3	-3	-4	-4	-6
Ever in special education	-4	-3	-3	-6	-4	-3	-6
Often uses computer for fun	11	10	11	15	10	11	16
Being successful in work important	6	6	6	9	7	4	8
Having happy family important	5	3	6	11	7	3	5
Having lots of money important	-7	-6	-6	-6	-6	-8	-7
Having strong friendships important	6	5	6	10	7	4	10
Finding steady work important	3	3	4	6	6	0	7
Better opportunities for children important	-2	-3	-2	2	0	-4	2
Having children important	3	1	4	7	4	1	3
Getting good education important	6	5	4	10	7	4	7
No plans to take SAT or ACT	-13	-12	-14	-18	-12	-12	-14
Wants to play athletics in college	3	0	4	9	1	4	3
Can learn something really hard	14	14	15	19	14	12	16
Can get no bad grades if decides to	14	12	15	19	13	13	13
Keeps studying even if it is difficult	13	10	15	18	14	10	13
Can do excellent on math assignments	17	15	17	23	15	16	15
Does best to learn what studies	12	11	14	15	12	10	13
Can learn well if wants to	13	11	15	17	13	12	16
Can master math class skills	16	15	19	19	15	16	17
Expects honors graduation	11	10	10	14	8	12	9
No algebra by 12th grade	-3	-3	-3	-5	-3	-3	-4
1+ years general math	-9	-8	-10	-11	-9	-8	-6
1+ years pre-algebra	-12	-13	-12	-11	-10	-11	-9
1 year algebra I	-3	-4	-1	-1	1	-6	2
1 year geometry	18	17	17	21	17	18	21
1 year algebra II	22	22	23	26	19	23	27
1 year trigonometry	12	13	11	12	11	14	9
1 year pre-calculus	24	23	24	24	25	24	25
1 year calculus	19	19	17	19	18	21	15
Took or plans to take AP test	26	28	21	26	26	28	10

IV: FINDINGS: DISCUSSION, LIMITATIONS, AND FUTURE DIRECTION

In this chapter, I refer back to my methodology and results tables to describe in detail my findings and their implications. The chapter organization begins with a section for each research question, followed by a discussion of overall implications, limitations, and future research based on these findings.

4.1 Question 1: What are the characteristics of prevailing profiles of US 10th grade mathematics teachers?

In Chapter III, I explained how I arrived at my final clustering of teachers, and the codes that were used to determine cluster membership. Below I describe the distinguishing characteristics for each cluster in detail, referring back to Tables 3.4. I named each cluster of teachers based on some of their defining characteristics.

Cluster 1 (Computer Communicators) makes up 16% of the sample and is especially characterized by significantly higher use of computers, but only for administrative records, communicating with students and parents, and posting homework; much higher than all other clusters. Although these 653 teachers report a significantly higher percentage taking professional development in various pedagogical uses of technology, they are significantly lower than average for most classroom uses of the Internet, such as downloading educational software or lesson plans from websites. Computer Communicators have a significantly higher use of computers (not Internet) for pedagogical purposes, but not as high as clusters 3 or 5. This cluster is also significantly more likely to be younger (average age is 40), to possess a bachelor's degree as the highest degree earned, and to be alternatively certified. On most other codes, such as gender, race, and percentage with a STEM degree, their survey responses were near the sample means, including professional development in ELL and special education instruction.

Although the data is ten years old, I imagine these teachers may have used computers for other communication activities in their free time, such as social networking sites (blogs), chat rooms, and email (see Ferdig, 2007; and McLoughlin & Lee, 2007 for a review of social networking websites and education). The Computer Communicators had about the same percentage of Latino (5%), White (80%), and male (42%) teachers as the sample population.

Cluster 2 (Young Bachelors) makes up 28% of the sample and reports over 99% having a bachelor's degree as the highest degree earned; almost twice the sample average of 50.7%. These 1148 teachers are the youngest group (average age is 38), and have a higher-than-average number of teachers with: a) 0-5 years of teaching experience and b) an alternative or temporary teaching certificate. This group reports near average participation in professional development of the six technology professional development codes, but is lower than average for every type of computer or Internet use except using computers to keep administrative records. It may be surprising that the youngest teachers are not the most active users of technology. However, as Pierce and Ball (2009) found, age and teaching experience are not necessarily associated with technology use in the classroom.

On most other codes, the survey responses were near the sample means, and so they are in many ways similar to the Computer Communicators. The Young

Bachelors had about the same percentage of Latino, White, and male teachers as the sample population.

Cluster 3 (Comprehensives) makes up 15% of the sample and is distinct from the other clusters in many ways: in fact, they have the highest means on over half of the codes. These 612 teachers are the most likely to say that they would still want to be a teacher if starting over, the least likely to say that intellectual ability is important to student success, and the most likely to say that a teacher's attention is important to student success. They have about twice the average number of PhD-degreed teachers, but also have the largest percentage of teachers with just 0-5 years teaching experience. They are younger than average (their average age is 40), and have the highest numbers of alternatively certified teachers and the lowest numbers of regularly certified teachers. They are comparatively hard working and motivated teachers. Interestingly, this cluster has the highest percentage of Latino teachers; almost twice the sample average.

The Comprehensives are the most likely to have an additional job, the most likely to have more than 10 hours of special education preparation, and the most likely to have at least 8 hours preparation in instructing ELL students when compared to all other clusters. I call these teachers the Comprehensives because in addition to these factors, they are higher than average on all 19 computer-use codes, and highest on 13 of them. These teachers are more likely to be using computers and the Internet to enhance their instruction, to develop lessons and curricula, to present information to students, and to keep records. In addition, these teachers are more likely than average to have received professional development on all six technology items on the survey. They are about the same age as the Computer Communicators (average age is 40).

Compared to the sample means and to all other clusters, the Comprehensives seem to have taken advantage of every resource available to them as teachers. In addition, they are more likely to have an additional job both during the school year and in the summer. Furthermore, they seem to have a good attitude about themselves and their students, as shown by their desire to be a teacher and the things they attribute to student success in mathematics achievement.

Cluster 4 (Traditionals) makes up 16% of the sample, and can be described as an older group of teachers that has not embraced technology or participated as much in professional development. This cluster of 667 teachers has a significantly higher percentage of male teachers (all other clusters are near average), and had the lowest means on 18 of the 19 computer/Internet use and professional development codes. These teachers also had the lowest percentage reporting the following factors as important to student success: home background, student enthusiasm, teacher's attention, teaching methods, and teacher's enthusiasm. These teachers were the least likely to say they would become a teacher if they had a chance to start over, and they were the most likely to say that a person must be born with mathematical ability. The Traditionals have the highest percentages of teachers with PhD degrees, teachers who are older (their average age is 50), and teachers with more than 20 years teaching experience. However, this cluster contains lower than average percentages of teachers with additional jobs or preparation in special education or ELL instruction.

Traditionals are primarily older teachers who have not embraced technology. Although they may have been well educated in terms of the degrees they earned before becoming a teacher, many of them have been teaching for more than 20 years. They are significantly less likely to take advantage of professional development in technology or in teaching students who may have special needs (including both ELLs and special education students). They are typically not using computers, the Internet, or calculators for instruction or preparation for class. These teachers may feel their students must learn mathematics by pencil and paper before using technology, and thus do not have time to add technology to their curriculum, as found by Pierce and Ball (2009). Compared to the sample and to the other clusters, the Traditionals seem to be less likely to have high expectations of their students or of their job (as seen by their responses to whether or not they would become a teacher if starting over, and the importance they place on various factors for student achievement).

Cluster 5 (Scholars) makes up 25% of the sample, and is the most educated of the five clusters: 99 percent have a master's degree as the highest degree earned, and 1 percent has a PhD. They have a significantly higher than average percentage of teachers with more than 20 years teaching experience, and they are older than average (their average age is 47). Ninety-two percent of the Scholars have a regular teaching certification (the highest), and 44.1% have a master's degree in a STEM field (the highest). These 1043 teachers also have a significantly higher percentage with a bachelor's major or a major and minor in a STEM field. The Scholars are significantly less likely to have an additional job, and have the highest percentage of White teachers (89%). Unlike the Traditionals, this older group of teachers is highly likely to have received professional development in the use of computers/Internet. Although their computer use is below average on most codes, it is higher than the computer use of the Traditionals, and about the same as the Computer Communicators and the Young Bachelors. Based on the 19 technology and Internet use codes, they are moderate users of these tools. While the Comprehensives are most likely to use graphing calculators during instruction, the Scholars are most likely to use regular calculators (as shown in student Table 3.19).

The Scholars are the best fit for NCLB's definition of a highly-qualified teacher: regular certification and a degree in the subject(s) they teach. Since many Scholars also have a minor or a master's degree in a STEM field, they exceed educational expectations on US policy for high school teachers. However, they are below average in professional development on special education and ELL students.

To connect these five teacher clusters with the defining characteristics of their students, I will now describe the students of the teachers in each of the five clusters. These findings refer to Table 3.19 in Chapter III.

4.2 Question 2a: What are the predominant characteristics of students who are assigned to various teacher profiles of 10th grade mathematics teachers?

As described in section 3.3, I analyzed descriptive statistics and frequencies of over 300 variables from student and parent surveys and mathematics and reading test scores. I then performed a post-hoc one-way ANOVA to determine if the differences between clusters were significant. While it was not surprising that many of these variables did not show significant differences across clusters, it may be important to describe any differences to increase understanding of teacher-student pairings and to help generate other survey questions for future research that would be informative. Table 3.12 has a summary of student characteristics by cluster found to have significant differences for at least some of the clusters.

Students in clusters 1 and 2, who have the Computer Communicator and the Young Bachelor teachers, are not significantly different from each other on almost every variable. For those variables that did show significance, the differences were small. This is not a surprise, since the teachers of these two clusters are also quite similar to each other in many ways. The main distinction for students of the Computer Communicators is that they are significantly more likely to be at an urban school in the South or West, and less likely to be in the Northeast. On all other codes, they are near the sample means. The main distinctions for the students of Young Bachelors is that they are significantly more likely to be of low socio-economic status and more likely to say they are learning job skills at school, and significantly less likely to be at a Northeast school or to take an AP exam.

The main distinctions between student groups are in the Comprehensive and the Scholar clusters, as I describe next. There were also a few significant features of the students with Traditional teachers.

The Comprehensives' students have the highest means of Latino, ELL, lower SES, and special education students. This fact is not surprising, since Comprehensive teachers have a significantly higher percent of teachers with professional development in ELL and special education instruction. Socio-economic status is a composite of a number of variables: total family income, quartile coding of SES, number of academic risk factors, and percent free or reduced lunch. Comprehensive's students were highest on all of these measures. The Comprehensives' students are also the most likely to take less rigorous mathematics courses (i.e. general math, consumer math, or pre-algebra, and the least likely to take Advanced Placement tests or rigorous mathematics courses, such as trigonometry, pre-calculus, or calculus. Compared with all other clusters, the Comprehensive's students had the lowest numbers of two-parent homes, annual family income greater than $75,000, college plans, and confidence in their own mathematics ability. They also had the highest numbers of students eligible for free lunch, and students who had repeated a grade. Based on these findings, it is perhaps not surprising that these students had the lowest mathematics and reading scores on the assessment given, the lowest percentage in the fourth quartile (the highest-scorers), and the highest percentage of students scoring in the first quartile (the lowest scorers). A significant but small percentage of students (6%) had never taken algebra by 12th grade. From the course-taking data, it is evident that more students of Comprehensive teachers were in low track mathematics courses.

Given that Comprehensive students have teachers who report a high use of computers and technology, it is not surprising that the students also had the highest reports of computer and graphing calculator use in the classroom. However, at the same time, this group of students are the least likely to have a computer or Internet access at home. Finally, I was surprised to find that the students of the Comprehensive cluster, with the highest percentage of Latinos and ELL students, had the lowest percentage of students who had ever been in a bilingual or bicultural class.

Scholars' students, in contrast with the Comprehensives' students (and with all clusters), were the most likely to have a computer and Internet access at home. They are the most likely to say they use calculators in math class (not graphing calculators), and they are the most likely group to state they expect to graduate with honors. The students are taking a significantly higher than average number of rigorous mathematics courses and a significantly lower than average number of non-rigorous mathematics courses. They were significantly higher than average in the percentage taking Advanced Placement exams. Many of these students are clearly in high-tracked academic courses. The Scholars' students had the highest mathematics and reading assessment scores, and the highest percentages scoring in the top quartile for each content area. Oddly, although these students had the highest percentage of Whites and the lowest percentage of non-native English speakers, they are most likely to say they had been in a bilingual or bicultural class.

The Traditionals' students were not significantly different from the sample means on most variables. However, they are significantly more likely to be at a school in the Northeast geographic region of the United States, and the least likely to be from the South or West. Perhaps related is the fact that this group of students is also much more likely to report attending an urban school than all other clusters. This seems to indicate that a larger percentage of these students may be from the New England in the Northeast and is more densely populated than most other areas in the US. It is not surprising that this group of students reports the lowest use of calculators, graphing calculators, or computers in class, since their teachers also report the lowest use of technology in the classroom. The students' test scores on reading and mathematics were slightly higher than the sample means, but these differences were not significant.

Somewhat unexpectedly, the Traditionals' students showed the greatest gains using an IRT estimated number correct from mathematics test 1 to test 2. These students, although they were not the top scorers by raw, standardized, or quartile measures on any of the three tests, made slightly but significantly greater gains on the second mathematics test. This may be attributed to the fact that these teachers are highly experienced (though less educated than the Scholars) and least likely to have the populations of students who typically do not perform well on school mathematics assessments (Latino and non-native English speakers).

Table 3.12 also has a column showing the characteristics of students who are Latino, ELL, or both. It is not possible to measure these for significance against the clustering groups since they came from all five clusters. They are for comparison only. Forty-nine percent of the LELL group members are non-native speakers of English, but most of these are bilingual and English-fluent, since only 10.5 percent are ELLs. These students are similar to the Comprehensives' students, but show an even greater degree of an opportunity gap when compared to the numbers from clusters 1, 2, 4, and 5. For example, LELLs have the highest percentage of mothers with an education equivalent to a high school degree or below, the highest numbers of low socio-economic status on all measures, and the highest numbers of students with no college plans or rigorous mathematics course-taking. They also have a much higher percentage in urban schools and schools in the South or West regions of the United States. These students also show the highest percentages of students who say that there are gangs at school, that they had gotten into physical fights, and that racial or ethnic groups often fight at school. It was not part of my analysis to determine if Latinos and ELLs are in the same schools as other students who did not report these findings. However, I suspect students in this cluster may be more aware of racial tensions in their school than students who are more likely to be White and to participate in clubs, sports, and rigorous courses.

4.2.1 Mathematics achievement of students by cluster

In this section, I discuss the mathematics achievement of all students and by cluster groups for those who took both the base year and follow-up mathematics assessments. I measured mathematics achievement in several ways, summarized in Tables 3.13, 3.14, and 3.16 in Chapter III. I also included score measurements for Latinos and ELLs, since this is my targeted group of interest.

Table 3.13 summarizes the number and percent of students in each quartile ranking for the sample, by cluster, and for the Latinos and ELLs. All three assessments are included: base-year mathematics and reading, and follow-up mathematics. Note that the sample percents do not show 25% in each quartile as might be expected; this is because I excluded student cases from the original data set if they did not have any mathematics teacher data or if they did not have scores for both mathematics assessments. As expected from the literature, Latinos and ELLs have the largest numbers of students scoring in the lowest quartile for all three assessments. Clusters 1, 2, and 4 students had percents of quartile rankings that were near the sample percents for all quartiles and all assessments. Cluster 3 students had substantially higher percentages of students scoring in the lowest quartiles and lower percentages scoring in the highest quartiles compared to the sample means and the other clusters. Cluster 5 students had the lowest percentages scoring in the lowest quartiles, and the highest percentages scoring in the highest quartiles for all three assessments. The conclusion is that the overall students in cluster 5, who have Scholars for teachers, performed the best on all three assessments. It may not be surprising that students in cluster 3 had the lowest performing students, since they have the highest percentages of Latino, ELL, and special education students. From the previous section, we know that these underserved students were not in rigorous mathematics courses, they may have struggled with the academic language required in content, and as a result, they may not have had adequate access to the material tested.

A second method of determining how students performed on the ELS assessments is to compare the standardized test scores as shown in Table 3.14. While the trends shown are similar to those in Table 3.13, standardized scores also show the mean score differences in all cluster groups are small. For example, on the base year mathematics assessment, the sample mean score is 52.01, the highest scoring group mean is 53.28 (cluster 5), and the lowest scoring group mean is 50.44 (cluster 3). With a sample standard deviation of 9.71, these score differences seem small. As the subscripts show, the differences in clusters 3 and 5 are significant when compared to all other groups. Clusters 1 and 4 are not significantly different from each other. The most notable distinction is the scores of the Latino and ELL group, whose mean is 47.41 on the base-year mathematics assessment, and similarly low for the other two assessments when compared to the sample and cluster group means. The data in Table 3.14 strengthens my findings from the quartile comparison in Table 3.13.

The ELS mathematics assessment scores indicate that the follow-up test in grade 12 was more difficult than the base-year test. One can observe this fact by noting from Table 3.14 that the mean scores by sample and by cluster are lower in the follow-up test than in the base year. For example, the follow-up sample mean standardized score is 51.16, while the base-year sample mean standardized score is 52.01. In order for researchers to have a measure of "growth" in mathematics achievement from the base-year to the follow-up year, NCES conducted an IRT to account for the increased difficulty and to estimate the number correct gain from test 1 to test 2. Table 3.16 summarizes the minimum, maximum, mean, standard deviation, and variance of IRT estimated number correct by sample and by group.

For all groups except the small group of ELLs, the minimum score is very low, ranging from -39.46 to -25.00. This indicates that all groups had at least one student whose mathematics achievement appears to decrease substantially from grade 10 to grade 12. The minimum score for ELLs is only -13.35, but I suspect this is because the sample is too small to have reliable data; there are only 126. Somewhat unexpectedly, students in cluster 4 showed the greatest gains, and these gains were significantly different from all other clusters. Clusters 1, 2, 3, and 5 had gains that were a little lower and not significantly different from each other. In fact, only cluster 4 students had a mean score gain above the sample mean score. I expected cluster 5 to have the greatest gains and cluster 3 to have the lowest, as indicated by previous tables in my study. One possible reason is that there may be a ceiling effect for students in group 5. In other words, group 5 students were already performing well in 10th grade, and continued performing well in 12th grade. Thus, they did not show measurable growth on this IRT estimated score gain variable. I explore this possible ceiling effect further in Section 4.3, where I compare scores and characteristics of only those students who did well on the mathematics assessments.

4.2.2 Question 2b: Which teacher profiles, if any, are more likely to have Latinos or ELLs?

Research indicates that the students with the most needs often have the least prepared teachers. This idea is too simplistic to describe my findings in the ELS data set. All five clustering groups had populations of Latino and ELL students, though the Scholars teachers may have been more experienced and better educated to teach them. Furthermore, it is clear that many Scholars' students who were native English speakers had been in a bilingual or bicultural class, as shown in Table 3.12. The sample non-native English speakers are 15%, while 29% stated that they had been in a bilingual/bicultural class.

To summarize the findings from Table 3.12, clusters 1, 2, and 3, have a significantly higher percentage of Latinos (the highest is cluster 3), while clusters 4 and 5 have a significantly lower percent. Cluster 1 has a small but significantly lower percentage of students who are ELL, non-native English speakers, or had been in an ELS class. Cluster 2 has a significantly higher percentage of non-native English speakers, but a significantly lower percentage of students who had been in an ESL class. Cluster 3 has a significantly higher percentage of students who are ELL, non-native English speakers, students who had been in remedial, ESL, or special education courses, and a lower percentage of students who had been in a bicultural class. Clusters 4 and 5 have significantly fewer Latinos and non-native English speakers, but significantly more students who had been in an ESL class.

It is difficult to explain why students in clusters 4 and 5 appear to have lower numbers of students who are Latino, bilingual, or ELL and at the same time have higher numbers of students who had been in bilingual or ESL classes. Perhaps this is an indication that students in clusters 4 and 5 are more likely to have opportunities to participate in language services and culturally responsive programs at their schools. From Table 3.12, we also know that students in clusters 4 and 5 are on average more likely to be of a higher socio-economic status and less likely to be of a lower socio-economic status. This may imply that parents of clusters 4 and 5 students are better equipped to advocate for their children in choices of schools, course offerings including bilingual programs for native English speakers, and college preparation and entry.

4.3 Question 3: What combinations of matching students with teachers might lead to a better success rate for Latinos and ELLs?

Educational research often finds that the students at highest-risk or with the most needs receive the least prepared teachers and least well-equipped schools (Clotfelter, Ladd, and Vigdor 2006; Llagas, 2003). However, the goal with my third research question is to look for and describe examples of success in mathematics achievement, particularly for Latinos and ELLs. This analysis aims to find where and under what conditions within teacher portfolios Latinos and ELL students are doing well in mathematics. To discuss this question, I refer to Tables 3.18, 3.19, and 3.20. Before describing distinctive features of teachers whose Latino and ELL students show mathematics achievement, I look for distinctive features of all teachers who have achieving students, and all achieving students.

4.3.1 Mathematics teachers of students who show achievement

A test of significance is not appropriate for analyzing the differences between all mathematics teachers in the ELS and only mathematics teachers whose students showed mathematics achievement. This is because a single teacher had up to 16 students, and therefore is likely to be a teacher of both math achievers and non-achievers. My description of the differences between teachers of "achievers" and "non-achievers" is only for getting a better qualitative understanding of how these teachers might be different from those who were excluded because they had no mathematics achievers as defined by increasing in quartile rank or by remaining in the top quartile for both mathematics assessments. A summary of these differences is in Table 3.21.

A sample of 1892 mathematics teachers out of the original 4123 had at least one student who showed success in mathematics achievement. These teachers are more likely to say they would still like to be a teacher if starting over and more likely to be veteran teachers (especially the Traditional teachers). They are also more likely to have a regular certification and to have a bachelor's degree in a STEM field (especially the Comprehensives). The teachers are generally less likely to have a bachelor's degree in education (except the Computer Communicators), and less likely to be novice teachers or to have an alternative certification. Interestingly, they are less likely to have taken professional development in ELL or special education instruction, (especially the Comprehensives). This may be in part because not many ELLs or special education students are included in the set of students showing mathematics achievement.

With respect to demographics, teachers of mathematics achievers tend to have a higher percentage of Whites and lower percentage of Latinos, more males, and more teachers who are older. Because many of the Internet use codes had small percentages by cluster, it is not clear if the differences are meaningful. The Traditionals tend to show even less use of computers, Internet, and technology professional development. The percent differences in the other clusters are small for most codes, except taking professional development courses via the Internet, which is much lower for the Young Bachelors, and using the computer to communicate with parents, which is much higher for the Comprehensives. The Scholars did not show any large differences, especially with the computer use codes.

4.3.2 Mathematics students who show achievement

To better delineate the contrast between characteristics of all students and the characteristics of achieving students, I compare the differences between these groups, as summarized in Table 3.23. With few exceptions, mathematics achievers in the sample and in all clusters and for LELLs had either a higher percentage or a lower percentage for a specific characteristic. With respect to demographics, mathematics achievers are more likely to be male, White, and to live in a two-parent home. They are less likely to be Latino, native-Spanish speaking, to have a mother with an education of high school or below, or to be from a low socio-economic status family. They are more likely to have a mother with a graduate degree and to be in a family with an annual income greater than $75,000. The percentages of non-native speakers, ELL students, and those who had attended school outside the US were about the same.

As might be expected, mathematics-achieving students are more likely to have college plans and are more likely to have taken rigorous mathematics courses, such as AP courses, pre-calculus, and calculus. They are more likely to say they expect to graduate with honors, to have participated in a science fair, and to say they had received recognition for good grades. They are less likely to have been in remedial courses, non-rigorous mathematics such as general math or pre-algebra, special education, or ESL courses. They are also less likely to have participated in a tech competition, or to say they had been often absent or in trouble at school.

Mathematics achieving students are more likely to say they have their own room and that they have a computer and Internet access at home. They are also more likely to play on a team or club at school, to have been in a bilingual or bicultural class, and to use calculators or graphing calculators in class. These students seem to have a good attitude and confidence in their studies: they are more likely to say that getting a good education is important, and that they are good at learning and at learning mathematics. They are more likely to say they would like to play athletics in college, but less likely to say that having lots of money is important.

Very few variables showed differences from one cluster group to another. For example, the differences in percentages were small for school urbanicity and geographic region. There is an increase of students in the Comprehensives and LELLs and a decrease or near-zero change for other clusters for the following three variables: education is important to get a job, learns job skills at school, and giving better opportunities to children important. It is not clear if these variables are an important difference for the Comprehensives, and so I treat this finding as an anomaly in the data.

Since almost all variables increased or decreased for all groups, the implication is that, regardless of what kinds of teachers these students may have, the students themselves play a very important role in driving their own success in school. However, it would be inaccurate to lay blame on those students who are less successful at school, since many of these characteristics are wholly beyond the students' control, such as their access to rigorous courses, the socio-economic status they were born into, and the education of their mothers. The purpose of this data is not to hold any person accountable for the success or failure of students in mathematics, but to find those situations where conditions are working well to promote mathematics achievement.

4.3.3 Latinos and ELLs that show mathematics achievement

As shown in Table 3.12, students in cluster 3 have the highest percentage of Latino and ELL students. I have previously shown that cluster 3 also had the lowest test scores on reading and mathematics. To determine which Latinos and ELL students are achieving in mathematics, I identified Latino and ELL students whose quartile rank increased or remained in the top quartile from 10th to 12th grade. Table 4.1 shows the percent increases in quartile for LELLs by cluster.

In some ways, the most promising cluster is 3, the group whose teachers are the Comprehensives. They show the highest average percent that increased by one quartile rank, and were the only cluster that showed an increase by three quartiles. Cluster 5, students of the Scholars had the lowest numbers of students increasing their quartile ranking from the first test to the second. Since I have accounted for a ceiling effect in the high-achieving Scholars (and all LELLs) by including students who remained in the top quartile for both tests, it appears that the Scholars are not the most effective teachers for Latinos and ELLs. About 15% of students were not available to take the second assessment. This may be because some students had dropped out of school, moved to a new location, or were no longer willing to participate in the study. We know from research that students of immigrant and lower socio-economic status are more likely than average to have a different experience than the more typical four years at the same high school: they are more likely to move or change schools, drop out, or possibly take more than four years to graduate. Further analysis of large-scale mathematics achievement is warranted to determine which students show the most improvement in mathematics from 10th to 12th grade.

Table 4.1 Percent LELL students whose quartile rank in math achievement increased

	LELL	LELL1	LELL2	LELL3	LELL4	LELL5
n	1452	237	458	219	232	306
+1	11.9	11.8	12.2	13.7	12.1	10.1
+2	0.8	0.8	0.7	0.5	1.3	1.0
+3	0.1	0.0	0.0	0.5	0.0	0.0

4.4 DISCUSSION

4.4.1 Which teachers' students are actually succeeding in mathematics education?

Determining whether students are successful in mathematics achievement in school is a complicated question. Qualitative data may be able to offer painstakingly detailed information about how and what a student knows and can do in mathematics, but only for a few students. With large sets of quantitative data such as the ELS used in my research, the mathematical ability of many students may be looked at in several ways, but is ultimately reduced to a single number: their test score. My findings seem to suggest that whether or not students are doing well in mathematics may depend on how it is measured and compared. Below I explain why my results seem to point to several different clusters when looking for examples of mathematics achievement.

Students of the Scholars appear to be performing the best in school: they have the most students scoring in the top quartile for all three tests, and the highest standardized test scores for all three tests. These students are the most likely to take high-tracked mathematics courses, to expect to graduate with honors, and to have college plans. They also have the most experienced, educated, and regularly certified teachers. Students of the Scholars were already doing well in school by the time they enrolled in 10th grade, and they continued to do well as they finished high school in 12th grade. Despite the fact that their teachers are older, (and thus their degrees may have been earned in a time of pre-technology), Scholar teachers are using technology in the classroom and are taking professional development courses to keep up with technological advances for pedagogy. In some ways, the Scholars are the "best" teachers.

An IRT analysis showed that the Traditionals students had the greatest score gains from test 1 to test 2. The implication is that although the Scholars students had been doing well all along, the Traditionals students showed the greatest growth. In many ways, the Traditional teachers are similar to the Scholars: they are older, more experienced, and their students are more often taking rigorous mathematics courses. However, the 10th grade quartile scores show that Traditionals students are scoring more similarly to clusters 1 and 2, students of the Computer Communicators and the Young Bachelors. By the time these students reach 12th grade, their scores are closer to those of the Scholars' students. The implication is that the Traditionals' students showed a greater growth than all others did, in part because they were less likely to be in low-tracked courses and to have highly experienced teachers. Furthermore, since these students were more likely to have been in a bicultural class but less likely to be Latino or ELL, the suggestion is that these students (even monolingual English speakers) have more access to language services. The Traditionals cluster (students and teachers) is much more likely to be from an urban school and/or from a school in the Northeast geographical region, and East-coast schools do tend to do better nationally on achievement measures. Traditionals' students are more likely to be from a higher SES family, which can play a strong role in access to effective schools, teachers, and rigorous mathematics courses.

At the same time, the Traditional teachers were most likely to say they would not become a teacher if they could start over, and they had not embraced technological advancements for use in the classroom. Some of these teachers may be "burned out", but they may be teaching at schools that provide quality academic resources and course offerings to their students. Although most Traditional teachers did not take professional development on the instruction of special education and ELL students, their students were generally doing well in mathematics, and they had few special education, Latino, or ELL students. Since the test was given with paper and pencil, it might be logically assumed that the classroom use of technology was not required for students to perform well.

Comprehensive students showed the lowest mathematics achievement by all measures unless I restricted the data to those students who are Latino or ELL and had increased in rank from test 1 to test 2. From the large body of literature that points to the opportunity gap between Latinos and ELLs and those of the dominant culture and language, it is not surprising that the cluster with the highest numbers of Latino teachers and Latino, ELL and/or special education students show the lowest achievement. The students are clearly not receiving the same opportunities to prepare for college, to take rigorous mathematics courses (or even algebra), or to have access to teachers who are highly educated in a STEM field. At the same time, the Comprehensive teachers appear to be very passionate about their work: they are taking advantage of every professional development provided to them (such as technology, special education, and ELL instruction), and they are passing this knowledge on to their students in the classroom.

I am convinced that the quartile rank improvement of Latino and ELL students is an indication that Comprehensive teachers are good teachers and effective teachers for these populations (See Salvidar et al. 2012). However, through educational policy and the established norms in the school system, their students do not receive nearly enough of what they need. Furthermore, more supports for teachers in economically distressed schools could help these teachers to become more like the Scholars. As they have been shown to be hard-working and open to professional development outside of the classroom, a program providing tuition reimbursement for bachelor's and master's degrees in STEM fields is likely to be attractive to

Comprehensive teachers, and to show measurable improvements in the achievement of their students.

4.4.2 Implications

In some ways, my study adds to the growing research evidence that Latino and ELL students are not receiving the same opportunities as other students in K-12 schools (such as Mosqueda 2007, and Llagas 2003). The evidence of the impact of tracking, mother's education, and socio-economic status is stronger than student or teacher types that may influence mathematics achievement. I assume that limitations on resources available at the schools where Latinos and ELLs more typically attend also played a role in opportunities for mathematics achievement. However, research on the schools included in the ELS was outside the scope of my research questions. The positive finding is that there is evidence of success in mathematics achievement for some Latino and ELL students in all five cluster groups, and more particularly in the Comprehensive cluster.

My findings suggest several implications. First, it is clear that there may be more than one model of a high quality teacher. Or, as found by Hanushek, Kain, and Rivkin (2004), the qualities that make some teachers more effective are not directly observable, although they found that principals are generally accurate in determining which of their teachers are most effective. While all parents and schools want teachers with a high degree of expertise in their subject area (like the Scholars), literature, policy, and funding decisions also clarify that professional development, expertise in special education and ELL instruction, and the use of modern technology in the classroom are highly valued (the Comprehensives). Some teacher profiles may be less desirable according to educational policy, such as teachers who have not embraced technology (Rivkin, Hanushek, & Kain 2005) and who may be dissatisfied with their own career choice (the Traditionals), although some of the students of Traditional teachers are clearly achieving in mathematics as well.

I would venture to guess that the Computer Communicators are the kind of teachers that may like to use computers for email, chatting, and blogging in their free time, but this ability does not appear to benefit their students. The Young Bachelors, whose students did not stand out in any way as mathematics achievers may be a result of the fact that the youngest and least experienced teachers usually get the students and courses no one else wants to teach (the low-tracked courses frequently populated by various students with special needs). The Young Bachelors are probably at the most risk of changing schools or leaving the profession altogether as well (Rockoff 2004).

For those teachers who are taking advantage of technology in classroom practice (primarily, the Comprehensives, and less so, the Scholars), research indicates they have a special characteristic perhaps not directly related to age, education, or experience. Specifically, teachers who readily employ technology for pedagogical purposes have been found to be internally motivated to use technology (Pierce & Ball 2009; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; and Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). In other words, these teachers are using technology because they believe it enhances their teaching and increases the achievement in their students, and not because they have the technology or have been told to use it. These papers all found that technology use for pedagogical purposes was not encouraged or hindered by personal experience with technology or professional development, but rather a personal affinity for the benefits provided by technology. As described by Drent and Meelissen (2008), these teachers are entrepreneurs, creating innovative ways to meet the needs of their students and curricular demands through technology. Saldivar et al. (2012) found technology use to be of particular interest for science teachers of ELLs and students who struggle with reading:

> Teachers reported that they needed to supplement the textbook and other curricular materials provided by the publisher and by DPS for two major reasons. First, teachers with students who were English language learners or who otherwise had below grade level reading skills reported that such students often had difficulty learning course material directly from the text…teachers reported using [technology] to find alternative representations of Earth science phenomena that went beyond the simple graphic or textual descriptions in the text, such as animations of volcanoes erupting or diagrams of geologic structures. These alternative representations also were helpful for students who had adequate reading skills but who nonetheless struggled to comprehend the course material (p. 62).

It is clear from the student characteristics by cluster that students who are Latino, of low SES, or are non-native English speakers have fewer chances to take rigorous mathematics courses. Even if their teachers may have used modern technology in their classrooms, they did not receive adequately challenging curriculum that might have enabled them to perform better on mathematics assessments. My study also provides evidence that punitive measures against teachers whose students do not have adequately high test scores may be misplaced: although the Comprehensives' students did not perform well on the 10th grade mathematics assessment, many of them did show improvement from 10th grade to 12th grade. I believe that the effects (both positive and negative) a teacher may have on a student's achievement may be difficult to measure, and that these effects may take more than one school year to become apparent.

It is also apparent that the students who do succeed in mathematics achievement may have any type of teacher and may be from many diverse backgrounds. I believe that high school students need role models, but also active participants in their preparation and decisions for college entrance. Literature and reactive educational policy informs us that many students arrive at high school ill-prepared to succeed in the curriculum schools and states expect them to take (Rogoff, 1994; and Serafini, 2002). However, no empirical evidence exists to indicate all children are supposed to learn (either naturally or by force) exactly the same content in exactly the same amount of time. Instead of committing children with non-dominant backgrounds or with special needs via tracking and failure, perhaps there exists more than one model of student achievement. Some students may need five years of high school and/or support during the summer (without being humiliated or pressured to "keep up") so that they may also prepare for the same college and career opportunities that high-tracked students get.

Based on these findings, my recommendations are that schools, parents, policy, and teachers need to do whatever is necessary to give all students opportunities to take rigorous courses from mathematics teachers who have degree(s) in a STEM field. Ideally, all teachers should also be remarkably well prepared to teach students with special needs such as special education and ELL students (Kain and O'Brien 1998). These students are mainstreamed into regular content courses, and thus, regular content teachers need to be well-prepared to guide them towards academic achievement in school. Finally, all teachers need to take advantage of professional development in the latest technological pedagogy as well as to use that technology, as it is available to classrooms. In an ideal world, I would want all students to have the education and experience of Scholar teachers combined with the passion, preparation, and diversity of the Comprehensive teachers, and I would want them all to attend the Traditionals' (Northeast urban) schools.

Finally, some implications about the fact that some students who are native English speakers (with Traditional or Scholar teachers) seem to have more access to bilingual programs than ELLs and non-native English speakers. Given that Scholars, Traditionals, and their students tend to be at schools of a higher SES, parents may be able to advocate for their children to be offered these courses. While wealthier parents may have enough cultural capital to value and demand bilingual classes, many (Latino and ELL) students may attend resource-poor schools, where policies may be aimed at extinguishing bilingualism, and parents can do little to help their children with course selection.

4.5 Limitations

The data set has limitations that may reduce the applicability of my findings to other teachers and other data sets. The teacher survey from the ELS gives too much focus on technology. Although my analysis revealed interesting cluster distinctions, the technology available and familiarity with it in 2002 is very different from 2012. In other words, the expectations about whether a teacher uses computers or the Internet to do her job in 2012 may not be a meaningful comparison. Whether or not a teacher takes advantage of computers and technology to do her job well may have been an indicator that she was keeping up with current research in education in 2002, but perhaps less so in 2012. Recent literature on the likelihood of teachers to employ technology for pedagogical purposes in class implies that such teachers may be innovative and internally motivated to use classroom advancements to enhance teaching (see Drent and Meelissen 2008, for example). This finding may be worthy of continued research and for comparison with the findings in this study.

I feel it may have been more informative to find out about the teaching style, classroom management, philosophy, punitive classroom practices, homework and assessment practices, classroom size, and other features from the teachers surveyed. State policy and varying teacher education programs might influence these pedagogical practices, but perhaps also by the teachers of new teachers, who may mold their own identities on the teaching practices they became familiar with as students. In reference to African American students, Martin offers:

> In addition to having mastery of the mathematics they will teach, teachers should (a) develop a deep understanding of the social realities experienced by African American students, (b) take seriously one's role in helping to shape the racial, academic, and mathematics identities of African American learners, (c) conceptualize mathematics not just as a school subject but as a means to empower African American students to address their social realities and life conditions, and (d) become agents of change who challenge research and

> policy perspectives that construct African American children as less than ideal learners (p. 27).

I suggest that asking teachers about these pedagogical practices will have better longevity in educational research, and that a comparison of multiple large data sets with these characteristics would produce valuable insights.

With the data given and the results in this dissertation, I am not confident about making specific recommendations to administrators about which profiles of teachers may be better suited to teach ELL students because the ELS had so few clearly definable ELLs. Part of the problem may be that ELLs severely impacted by English-only assessments may not have been willing or able to complete the ELS tests and survey. Furthermore, it is unlikely a parent of such a child would be successful in completing the parent survey. Although the ELS claims to contain a representative sample of all US students in the 10th grade in 2002, I object to the fact that there is not a representative sample of ELLs. Furthermore, it is absolutely critical that researchers collect and analyze data from this underrepresented, inadequately provided for, and little understood population of students in the US. To help resolve this flaw, I suggest national data sets oversample immigrant and non-native speaking students, and that comprehensive efforts are made to provide students with testing materials and surveys in their home languages as needed.

I do feel that linking teacher data to student scores is worthwhile, at both the state and national level. Large data sets that specifically link teacher characteristics to student achievement are needed, as stated by Guarino, Hamilton, Lockwood, and

Rathbun (2006) to increase our understanding of not only the importance of a teacher's role in student achievement, but in what ways teachers might influence their students in positive ways.

In reporting these results, it is important to convince potential readers that I do not imply that various teacher characteristics and behaviors of teachers are the cause of student achievement. I am not able to ask any participants why they responded the way they did, or what other ideas they may have about survey questions that do not include details about their choices. Furthermore, I do not imply that any of the teachers in their various profiles are "poor" teachers based on their characteristics. It is not possible to determine if any of the teachers or students are "poor", even when they did not show evidence of mathematics achievement. Rather, it is my goal to show with a large data set the trends in groups of mathematics teachers and students, lending predictability to mathematics achievement and similar data sets.

Finally, it is critical that I reiterate a shortcoming of all large data sets: characteristics, scores, and demographics of real humans lose important information when they are reduced to numbers. Specifically, it is not clear what students know and can do in mathematics and reading by a single score given for a single test. More importantly, the group I refer to as LELLs, a combination of Latinos and ELLs is a politically constructed definition. As I stated in the introduction, the students included in this group have little in common with respect to language, family background, or cultural values. The one clear common characteristic is that US K-12 schools do not meet their needs. I acknowledge that these students represent a great diversity in their lives, goals, and families, and that other methods of research must be depended upon to better understand their individual needs.

4.5.1Next Steps

This study adds to the body of knowledge about a large sample of US high school mathematics teachers and their students. Since most states are already conducting mandatory assessments throughout K-12 grades, it would not be prohibitive in cost or time to ask teachers to answer survey questions at the same time. The Texas data analyzed by Kain and colleagues (Hanushek, Kain, & Rivkin 2004, Rivkin, Hanushek, & Kain 2005, and Kain and O'Brien 1998) provide an example of how other states might organize and collect data over time on teacher quality and student achievement. Their analysis might produce many additional findings if data collection included periodic teacher and student surveys. Test data managers can then link teacher survey responses to their students' score sheets. Over time, a massive amount of longitudinal data could be available for many students and their teachers. This may enable analysts and mathematics education researchers to identify common strengths and weaknesses in our education system that could help improve the lives and educational experiences of the students who have the greatest needs.

As I have stated in my introduction, I would like to use my study as a model to link student assessment scores to their teachers, in order to follow students longitudinally over their journey in K-12 schools. Keeping track of students' teachers, schools, parents, courses, and choices could provide a lot of evidence for how things sometimes go wrong in a student's education, but also how sometimes things go right. “A succession of good teachers could, by our estimates, go a long way toward closing existing achievement gaps across income groups” (Rivkin, Hanushek, & Kain, 2005 p. 449).

"Finding" the mobile population of ELL students remains a challenge. Research with large data sets such as the ELS may help us become better at understanding English learners and their needs nationally and by state. State data on ELLs is typically not comparable since each state has its own guidelines for identifying and providing services to ELL students. National data can be more objective, but it is important to use multiple measures to help determine which students may not have acquired all the academic language they need to succeed in school, as recommended by Abedi (2008). I plan to apply my model from this study to other national data sets to increase knowledge about ELL populations in K-12 US schools, and to suggest guidelines and methodology for identifying them and their needs more consistently.

V. CONCLUSION

The long-standing opportunity gap between students who succeed in school and the large and growing population of those who are not offered those same opportunities presents a challenge for all educators. Latinos and ELLs (80% of whom speak Spanish) are the largest group of underserved students, and the least prepared for college and career choices by the time they leave public schools in the US (Llagas, 2003). Despite increased scrutiny of teacher quality and student test scores, the understanding of data, research, and the role an individual teacher contributes towards a student's achievement is still quite limited (Rockoff, 2004). In this study, I examined a large data set that specifically links student achievement in mathematics with characteristics of their teachers. I focused on how teachers with various profiles might contribute to those students who are doing well in high school mathematics, and in particular, those few Latinos and ELLs who are doing well in mathematics.

To understand better the teachers and students who end up together in the same classroom, I performed a cluster analysis on the teacher data from the ELS data set. I found and described five portfolios of tenth grade mathematics teachers. I then analyzed whether the "type" of teacher a student has could help predict some characteristics of their students, and specifically, if teacher characteristics could help predict mathematics achievement in their students. Because my goal was to be able to describe examples of teacher-student pairings that resulted in success in student mathematics achievement, I included an analysis that concentrates on students and their teachers, and in particular Latino or ELL students and their teachers, who did well in mathematics from 10th to 12th grade.

With large, quantitative assessment data, it is often possible to measure test scores in multiple ways. To increase confidence in my findings, I analyzed mathematics achievement from assessment scores in three ways: by looking at changes in quartile rank, changes in standardized test scores, and an IRT estimated number correct score gain from test 1 to test 2. As my results have shown, these three different measures provided different perspectives on how to determine which students are doing well in mathematics, and why.

In the following sections, I summarize findings for each of the four research questions. Next, I revisit the significance of this study and how these findings can inform future research.

5.1 Summary of findings

Below is a summary of my findings for each research question. Table 5.1 has a summary of findings by cluster group.

Table 5.1 Summary of findings

Cluster	1: Computer communicators	2: Young Bachelors	3: Comprehensives	4: Traditionals	5: Scholars
mathematics teachers: 4123	653; 16% of sample -Younger (avg age 40) -Low pedagog comp use -But: Highest comp use communicating to students, parents, homewk & grades -More likely to have BA as highest degree & alt. cert. -Less experienced -Near avg. on other codes	1148; 28% of sample - Youngest (avg 38) -99% have BA as highest degree -Lower than avg computer/Internet use on all codes - Less experienced -Like group 1: near avg on most codes	612; 15% of sample - Younger (avg age 40) -Highest means on over 1/2 of codes -Highest computer/Int. use -Highest ELL & Special Ed. PD -Highest % Latino teachers -Highest % have an addit'l job -Highest means of alt. cert. -Most job satisfaction	667; 16% of sample -Oldest (avg age 50) -More males (53%) -Highest 20+ yrs exp -Lowest comp/Int. use -Lowest ELL & Spec. Ed. PD -Lowest % Latino -More M & Phd degree -Lowest motivation	1043; 25% of sample -Older (avg age 47) -99% have M; 1% PhD -More with 20+ years -Highest reg cert. (92%) -Highest White (89%) -Highest M deg. in STEM (44%) -Comp. use moderate -Low ELL or Spec. Ed. PD
10th grade students: 12972	-More at urban school -Most likely in South or W. -Near avg. on all other codes	-More ELL & native Spanish -Avg math rigor -More students feel ed. Is important for job -Near avg. on all other codes	-Most Latino, ELL, low SES, Spanish, & spec ed -Less rigorous math courses -More using comp/graphing calcs in class -Least to have bilingual class -Least to have comp at home -Least to have college plans	-Most likely at urban school -Most likely in Northeast -Lowest use of all tech in class -More rigorous math	-Most have comp at home -Most likely grad. w/ honors -More rigorous math classes -Highest % Whites & lowest % non-native English -Most likely took a bilingual course -Most have college plans
scores	-Near avg std scores, quartiles, & IRT gains for reading, math1 & math2	-C5Near avg std scores, quartiles, & IRT gains for reading, math1 & math2	-Lowest std scores, quartiles, & IRT gains for reading, math1 & math2 -Highest % Latinos/ELLs quartile increase	-Avg. std scores read, math1 & math2 -Above avg. quartile read, math1 & math2 -Highest IRT gains	-Highest std scores for reading, math1 & math2 -Highest quartile for reading, math1 & math2 -Lower IRT score gains: ceiling effect
implications	-Avg teachers & students -May be bloggers -May not have access to tech for students	-Avg teachers & students -Young, but not tech users -May have higher attrition	-Best tech users -Best for ELL/Latinos -Lowest achievers, but -Best teachers for ELL/Latinos/Spec ed -Teachers & students diverse	-Teachers burned out? -Some students do well; maybe due to higher SES -Greatest IRT gains -Need more PD: tech, ELL & Spec ed.	-Best educated: STEM -Best teachers, but not for ELL/Latinos -Highest achievers -Teachers & students not diverse

5.1.1 What are the characteristics of prevailing profiles of US 10th grade mathematics teachers?

My final cluster analysis model suggests five distinctive teacher portfolios from the ELS data set. Each portfolio has features that distinguish it from both the sample and from the other four clusters. Below is a summary of the defining features of each teacher cluster.

The Computer Communicators are a cluster of younger and less experienced teachers that report high use of computers for communicative purposes: they contact parents and students, keep administrative records, and post homework electronically more than any other clusters. However, they do not as frequently use computers, calculators, or the Internet to design or present instructional materials, to increase professional development in their field, or for any other pedagogical purposes. These teachers report a greater number of teachers with a bachelor's degree as the highest degree earned, and a greater number of alternatively certified teachers. With respect to gender and ethnic demographics, they are an average cluster of teachers. While many Computer Communicators have received professional development on the use of technology in the classroom, most have not received professional development in special education or ELL instruction.

The Young Bachelors are a cluster of the youngest and least experienced teachers. Ninety-nine percent of the Young Bachelors have a bachelor's degree as the highest degree earned. These teachers are similar to the Computer Communicators in many respects, but they report a near-but-below-average professional development or use of technology in the classroom. Many of these teachers have a bachelor's degree in a STEM field, but also report a low percentage that have received professional development in special education or ELL instruction. As the youngest and least experienced cluster of teachers, the Young Bachelors probably had the fewest choices with respect to what schools and what courses they would teach.

The Comprehensives are a very distinct cluster of teachers that appear to be very busy. A much higher percentage of them report having an additional job, both during the summer or during the school year. Some Comprehensives' additional jobs are full-time. They also have the largest number of teachers with an alternate or emergency certification, which means some teachers may be working concurrently on their certification courses. In addition, Comprehensive teachers have taken advantage of every possible professional development or continuing education opportunity available to them outside of their university degree. They are the most highly educated in both special education and ELL instruction as well as the in use of technology for pedagogical purposes. Unlike the Computer Communicators and the Young Bachelors, the Comprehensives are putting their technology-pedagogy education to use: they are the highest users of technology in their classrooms and for instructional planning. The Comprehensives have the highest percentage of teachers who are Latino, and the lowest percentage of teachers who are White.

Perhaps the Comprehensive teachers are not paid highly enough in the schools where they work, prompting them to take additional jobs and professional development courses. Alternatively, they may not be confident in the security of their positions, and so they seek out other jobs and job skills to provide more and better income and job choices in the future.

The Traditionals are the oldest cluster of teachers, the most male, and the most experienced teachers. A high number of Traditionals have a master's degree as their highest degree earned, but the number of degrees earned in a STEM field is near or below average. These teachers were the most likely to say that they would not become a teacher if they could start over and the least likely to say that teacher or student enthusiasm is important to student achievement. Perhaps some of the Traditional teachers are “burned out” after more than 20 years of teaching.

The most striking feature of the Traditional teachers is that they are the least likely to have taken any professional development in technology, special education, or ELL instruction, and the least likely to use computers or the internet for any aspect of their job. This is not surprising, since many of these teachers were born and grown up long before computers were common.

The Scholars are the most highly educated cluster: 99% have a master's degree and 1% have a Ph.D. They are highly experienced, predominantly White, and many have one, two, or three degrees in a STEM field (bachelor's major, minor, and master's degrees). They are moderate users of technology for pedagogical purposes despite the fact that they are near the Traditionals in age. The implication is that, although many of these teachers grew up long before the Internet and personal computers became popular, they have kept up with technology to enhance their instruction. According to Rockoff (2005), these teachers are likely internally motivated to use technology in pedagogically sound ways. A higher than average percent of these teachers have taken professional development courses on integrating technology in the classroom. However, a lower than average percent of the Scholars has taken professional development in special education or ELL instruction.

Since all states mainstream courses for special education and ELL students whenever possible, it is critical that all teachers are well prepared to teach them. US Census projections predict a significant increase in ELL and bilingual students across all regions by 2025. Given these estimations and the current populations of K-12 students, even Comprehensive teachers, with 35% special education and 21% ELL professional development are insufficiently prepared. Furthermore, eight to ten hours of specialized professional development for instruction of these students is grossly inadequate. Professional development for the instruction of special education and ELL students should be compulsory, continuous, and specialized by content area and grade level for all K-12 teachers, regardless of the students that may populate their schools and classrooms this year (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012).

5.1.2 What are the predominant characteristics of students who are assigned to 10th grade mathematics teacher profiles?

When I compared the students that have teachers from the five cluster groups, I found many variables that were not significantly different from one cluster to another. This is not surprising, since it is unlikely that students would be assigned to one teacher profile over another based on characteristics such as the number of siblings a student has, his best friends, or what he may like to do after school.

The students of Computer Communicator and Young Bachelor teachers are not very different from each other or from the sample means on almost all variables. For those few variables that did show differences, it is difficult to suggest implications. For example, the Computer Communicator students are more likely than average to be at an urban school and/or to be from the South or West geographic regions. Students of the Young Bachelors are more likely than average to be of low-socio-economic status. For both clusters, student demographics, family income, and most other variables are about average. The implication might be that, when compared to the teachers and students of the other three clusters, the Computer Communicator and Young Bachelor clusters are a nationally representative set of average teachers and average students (with the exception of ELLs, who are scarce throughout the data (See Kain and O’Brien, 1998)).

The Comprehensives' students have the highest percentage of Latino, ELL, lower SES, and special education students. It is not surprising that the Comprehensive teachers have the most ELL and special education students, since they are the most prepared to teach them. What may be surprising is that these two distinct special needs groups seem to populate my analyses together. Literature documents that school faculty sometimes mislabel ELL students as special education students (see Hanushek, Kain, & Rivkin 2002). I believe that these two groups are sometimes placed together in schools where the populations of ELLs and special education students may be too small to fill a (sheltered) class. This may be happening because schools do not know where to put students that do not fit well with pre-established courses, curricula, and veteran teachers. Special education teachers with sheltered classes may have ELL students in their classroom, and ELL teachers, who sometimes have smaller class sizes, may have to take more or all of the special education students. This tactic, as my measures of mathematics achievement may imply, was not beneficial to either group.

Comprehensives' students are more likely than all other clusters to take remedial mathematics courses, and less likely to take rigorous courses, Advanced Placement courses, or to have college plans. It is not surprising that these students had the lowest scores on all three ELS assessments, since many did not have access to the same mathematics and reading content as students in high-tracked courses.

It is also not surprising that Comprehensives' students report the highest use of graphing calculators at school, since their teachers are the most prominent users of technology in the classroom. However, these students are also the least likely to have a computer or Internet access at home. Perhaps the most surprising feature of the Comprehensives' students is that they have the lowest percentage reporting having been in a bilingual or bicultural class, even though they have the highest percentage of ELL and bilingual students.

The Scholars' students are well on their way to becoming scholars themselves: they are most likely to have college plans and to take rigorous mathematics courses. They are the most likely to say they expect to graduate with honors, the most likely to have a computer and Internet access at home, and, oddly, the most likely to have ever been in a bilingual or bicultural class. This is unexpected since, in contrast to the Comprehensives' students, the Scholars' students are the most likely to be White and the least likely to be non-native English speakers.

The Traditionals' students were not distinctive from the sample on most variables. However, these students are much more likely to be in an urban school and much more likely to be in the Northeast region of the US. Not surprisingly, Traditionals' students report the lowest use of calculators or computers in the classroom, since their teachers are not using these technologies in their instructional practice.

Mathematics Achievement

To summarize mathematics achievement, the Scholars' students scored the highest on all three ELS assessments and the Comprehensives' students scored the lowest. However, when looking explicitly at IRT estimated score gains from test 1 to test 2, the Traditionals' students made the greatest gains This may be due to the fact that their teachers are very experience, and many are in higher SES schools in the Northeast region. Latinos and ELL students performed much worse than even the Comprehensive students, who were the lowest-scoring cluster. It is discouraging to see that the Comprehensive teachers, who appear to be very passionate about the teaching profession, do not seem to make much of an impact on the success of their mathematics students. However, it seems clear from the courses that the Comprehensive students are taking that they do not have access to the same rigorous courses and opportunities that other students enjoy, and this fact may more strongly impact mathematics achievement than the characteristics of their teachers (Mosqueda 2007).

5.1.3 Which teacher profiles, if any, are more likely to have Latinos or ELLs?

The Computer Communicators, Young Bachelors, and Comprehensives all have a higher percentage of Latino students (Comprehensives are the highest) while Traditionals and Scholars have a lower percentage of Latino students. The Comprehensives also have the highest percentage of ELL students, non-native English speakers, students who had been in remedial courses, and special education students. It is notable that the cluster with the highest percentage of Latino teachers also has the highest percentage of Latinos, ELLs, and non-native English speakers (the Comprehensives). What is not clear is if Latino teachers are more likely to take jobs at schools with predominantly Latino populations, or if school administrators are more likely to assign Latinos students to Latino teachers wherever they may work.

5.1.4 What combinations of matching students with teachers might predict better success for Latinos and ELLs in high school mathematics?

A subset of the data that includes only mathematics teachers who had one or more students that were successful in mathematics achievement was different from the data set of all mathematics teachers in many ways. Teachers of mathematics achievers are more educated, (especially with degrees in STEM fields), more experienced, more likely to have a regular certification, and more likely to be White, older, and male. They are less likely to be Latino, alternatively certified, or to have had professional development in special education or ELL instruction. It may seem counter-intuitive that teachers of successful mathematics students are less prepared to teach special education and ELL students. However, fewer special education or ELL students succeeded in mathematics education. The demographics seem to indicate that the teachers most likely to have successful students in mathematics are from the dominant culture and language in the US. However, I think this is just more evidence that the dominant culture and language (White, middle-class, and monolingual English) is being perpetuated and favored in US K-12 schools by providing those students with the most opportunities to have the most rigorous courses taught by the most highly qualified teachers (Flores, 2007; Walston & McCarroll, 2010; and Tellez, Civil, & Moschkovich, 2011).

The students who showed success in mathematics achievement (by either increasing in quartile rank from test 1 to test 2, or by remaining in the top quartile for both tests), were remarkably different from the sample of all students. With respect to demographics, mathematics achievers are more likely to be White, male, native-English speaking, and of a higher socio-economic status. They are more likely to take rigorous mathematics courses, to have college plans, and to expect to graduate with honors, and less likely to be Latino, ELL, or in special education courses.

This paints a rather bleak picture for the large and growing population of Latinos and ELLs, who frequently do not achieve in high school mathematics (Lee, 2002; Scarcella, 2003). The good news is that there were some successful Latino and ELL students in mathematics achievement in all five cluster groups. Though these numbers are small, the information connected to successful Latino and ELL students provides some insight about conditions conducive to mathematics achievement for these students (Sciarra & Seirup, 2008).

When looking at the small group of students that includes only Latinos and ELLs that do succeed in mathematics achievement, the Comprehensive teachers had the highest percentage achieving in mathematics when compared to other clusters. It cannot be determined with any degree of confidence why some students of the Comprehensive teachers may be doing better in mathematics. Perhaps since the Comprehensive teachers are more likely to be Latino and prepared to teach ELL students (Darling-Hammond, 1999), they are sometimes more successful in advocating for their students to take high-tracked courses. However, without also accounting for all the Latinos and ELLs in the Comprehensive cluster and in all groups that did not succeed in mathematics achievement, these hypotheses are merely conjecture. More research is needed, both qualitatively and quantitatively, on teachers and their Latino and ELL students' test scores (Abedi & Hejri, 2004; Young, Cline, King, Jackson, & Timberlake, 2011). Stronger evidence will help determine how, why, and when Latino and ELL students succeed in mathematics, and how we might be able to provide less successful students with the same opportunities to succeed. The use of technology by Comprehensive teachers is a promising practice for Latinos, ELLs, and students who struggle with content-area reading (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Saldivar et al., 2012).

5.2 Significance of findings

In the future I hope large-scale longitudinal assessment data such as the ELS: 2002-2004 will be an established way to follow students as they go through the system of public education, especially at the secondary level, in order to better document the long term effects of characteristics of their schooling, including teachers, school resources, family, technology, and even attitudes. The next NCES longitudinal educational study known as the High School Longitudinal Study of 2009 (HSLS:09) is now processing a second round of data (NCES). NCES states they expect the longitudinal test scores and questionnaire data collected in 2012 to be available for study sometime in 2013. On a smaller scale, the work of Hanushek and colleagues in Texas and Clotfelter and colleagues in North Carolina have set a precedent for examining teacher data with student achievement at the state level (Clotfelter, Ladd, & Vigdor, 2005, 2006, 2007; Rivkin, Hanushek, & Kain, 2005; Hanushek, Kain, & Rivkin, 2004). On a more global scale, the Teacher Education Study in Mathematics (TEDS-M) is an international comparative study of teachers "that pays attention to the links among teacher education policies, practices, and outcomes" (Michigan State University, 2010, p. 1). As of yet, there are no large studies that have successfully followed the mathematics achievement of ELLs and the characteristics of their teachers as they acquire language and advance (or not) through school. Following many individual ELL students longitudinally as they progress through school is critical to increase understanding of the roving population of ELL students, because when comparing any two sets of achievement data for ELLs, the students are not likely to be the same students (Abedi, 2008).

More evidence of the sustained opportunity gap is probably not needed, unless it is to refute journals that publish literature stating it is fictitious or dissolved (Llagas, 2003; Gutierrez, 2008). However, the very fact that the opportunity gap has remained for a number of decades suggests that educators and researchers do not fully understand or know how to react effectively to change it (Berends, Lucas, Sullivan, & Briggs, 2005). Some educators recommend focusing more on evidence of success in mathematics achievement, rather than continuing to point out deficiency models and broken policy enactments (Moschkovich, 2002; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; and Abedi & Dietel, 2004). In my study, I also analyze cases of Latino and ELL students who did succeed in mathematics achievement.

While we cannot determine all the influences that may lead a particular student to answer an item correctly (or incorrectly) on a high-stakes standardized test, keeping track of how students are progressing over years of US public schooling may give researchers a much better idea about the roles that teachers, parents, peers, and schooling play in a student's overall educational development (Guarino, Hamilton, Lockwood, & Rathbun, 2006). More research that specifically connects student achievement (especially for Latinos and ELLs) in mathematics to people, institutions, and other phenomena in their lives may help in designing qualitative and mixed methods research describing high schools that work and best practices (Young, Cline, King, Jackson, & Timberlake, 2011). In addition, we can feel more confident about increases in achievement from one grade to another when scores from two or more tests are from exactly the same students.

Recommendations

So, what are the characteristics of teachers who are the best suited to teach Latinos and ELLs? Based on the findings in this dissertation, the best teachers for Latinos and ELLs have the education and experience of the Scholars: they have multiple degrees in STEM fields and many years of teaching experience. However, these teachers should also have some of the characteristics of the Comprehensive teachers: they should be a diverse population of teachers who show evidence of being hard working, and motivated to teach and teach well. They should be highly educated in ELL and special education as well as in pedagogical uses of the latest classroom technology. They should actually use these pedagogical practices in the classroom. Most importantly perhaps, Latinos and ELLs need teachers who encourage them to enroll in rigorous and high-tracked mathematics courses, especially if the wider school culture offers no such encouragement (Llagas, 2003; Mosqueda, 2007; Gutierrez, 2009). In short, the best teachers are Comprehensive Scholars.

For policy changes, I recommend that teachers in poorer schools receive benefits and monetary incentives to help teachers that are similar to Comprehensives to become more like my proposed blend: Comprehensive Scholars. Specifically, teachers need adequate pay and reasonable job security so that they do not need to take an additional job. More importantly, mathematics teachers in poorer schools should receive tuition reimbursement for pursuing (perhaps multiple, additional) bachelor and master degrees in STEM fields. Scholar teachers, and all teachers, should engage in continuous professional development specifically related to instruction of ELL and special education students, using technology in the classroom, and the latest theory and methods for improving instruction for mathematics achievement in their students (Rockoff, 2004; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010).

Policy for students should include providing for bilingual courses for all students, rigorous mathematics courses, and formative assessments in home languages or both languages for ELL students (Hakuta, Goto, & Witt, 2000).

For preservice teacher education, it is important to recognize that simply offering a course in ELL, special education, or technology instruction is not likely to have a strong impact on actual teaching practice (Henke, Choy, Chen, Geis, & Alt, 1997). As some researchers found, the most important factor that enables teachers to use these pedagogical techniques is a belief that they are effective in mathematics achievement for their students, and therefore they are worth the effort (Pierce & Ball, 2009; Saldivar et al., 2012; Drent & Meelissen, 2008). Collier, Weinburgh, and Rivera (2004) recommend “the absence of stand-alone technology courses in favor of total integration of technology into all courses (p. 466). Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) agree, recommending technology professional development “continually, collaboratively, and on the job” (p. 434), and to use technology for “everyday” professional development activities in wikis and blogs. To make this work, “teacher educators need to act as a cohesive unit…[and] infuse technology education into existing curricular subjects (Collier et al., p. 466).

Similarly, if teacher educators included instruction of special education students and ELLs as a regular part of all education courses and content area methodology, the modeling in teacher education courses would more closely match the experiences new teachers will have in their classrooms with mainstreamed students from these special populations (Martin, 2009; Ng, 2003). This instruction could include a strong focus on pedagogical methods for encouraging student use of content-area academic language (Tellez & Waxman, 2006) as well as specific strategies such as using multiple modalities in mathematics instruction (Moschkovich, 2002).

Final note

Clearly, there is much more work for researchers, teachers, parents, students, and policy-makers in efforts to provide all US students with their rights to an equitable and high-quality education. As Ertmer and colleagues recommend that teachers engage in technology professional development “continually, collaboratively, and on the job” (2012, p. 434), so I recommend that we as researchers work towards equity in mathematics education *continually, collaboratively, and on the job*.

APPENDIX A: The ELS Teacher Questionnaire[8]

Part I: Student information

1. Did you teach this student during the fall of 2001?

2. How well do you remember this student from the fall semester?
V=Very well, W=Well, N=Not well

3. Are you teaching this student during the spring of 2002?

4. Does this student usually work hard for good grades in your class?

5. Does this student seem to relate well to other students in your class?

6. Is this student exceptionally passive or withdrawn in your class?

7. Does this student talk with you outside of class about school work, plans for after high school, or personal matters?

8. Have you communicated with this student's parents this year about the following:
    a. Student's poor academic performance?
    b. Student's disruptive behavior in school?
    c. Student's failure to complete homework assignments?
    d. Student's absenteeism
    e. Student's accomplishments

9. How involved are the parents of this student in his/her academic performance?
    Very involved, Somewhat involved, Not involved, Don't Know

10. Is this class too difficult, the appropriate level, or not challenging enough for this student?

11. In your opinion, does this student have a learning-, physical-, or emotional- disability that affects his/her school work?

12. Has this student fallen behind in school work?

[8] I am including here only the questions from the teacher survey that are available as data on the public release of the ELS. Excluded are instructions and identification questions.

IF YES... Why has this student fallen behind in school work? MARK ALL THAT APPLY

a. health problem
b. Limited proficiency in English language
c. A disciplinary action
d. Lack of effort
e. Some other reason

13. How often does this student complete homework assignments for your class? N=Never, R=Rarely, S=Some of the time, A=All of the time, NHA=No homework assigned, DK=Don't know

14. How often is this student absent from your class?
N=Never, R=Rarely, S=Some of the time, M=Most of the time, A=All of the time, DK=Don't know

15. How often is this student tardy to your class?
N=Never, R=Rarely, S=Some of the time, M=Most of the time, A=All of the time, DK=Don't know

16. How often is this student attentive in your class?
N=Never, R=Rarely, S=Some of the time, M=Most of the time, A=All of the time, DK=Don't know

17. How often is this student disruptive in your class?
N=Never, R=Rarely, S=Some of the time, M=Most of the time, A=All of the time, DK=Don't know

18. Have you spoken to a guidance counselor or other member of the school staff this school year about the following:

a. Student's poor school performance
b. Student's disruptive behavior in school

19. Have you recommended this student for academic honors, advanced placement, or honors classes?

20. How far in school do you expect this student to get?

-Less than high school graduation only
-HS graduation or GED only
-Will attend or complete a 2-year school course in a community or vocational school
-Will go to college but no complete a 4-year degree

-Will graduate from college
-Will obtain a Master's degree or equivalent
-Will obtain a Doctorate, professional degree or other advanced degree
-Don't know

QUESTION 21 IS FOR ENGLISH TEACHERS ONLY:
21. Please rate this student's compositional skills, as exhibited in performance in your English class:
a. Ability to organize ideas logically and coherently
b. Ability to employ the conventions of English grammar and usage
c. Ability to elaborate points with appropriate detail
d. Ability to express analytical, critical, or creative thinking
O=Outstanding, V=Very Good, G=Good, F=Fair, P=Poor

Part II: Teacher Background and Activities

22. What is your sex?

23. Are you Hispanic (or Latino/Latina)

24. Please select on or more of the following choices to best describe your race. Are you...
-White
-Black/African American
-Asian
-Native Hawaiian or Other Pacific Islander
-American Indian or Alaska Native

25. In what year were you born?

26. Counting this year, how many years have you taught at the elementary and secondary level? Please also note the number of years in total.
-Elementary total(K-6)
-Secondary(7-12)
-Total(K-12)

27. Counting this year, how many years in total have you taught in this school?

28. What is your employment status in this school or school system? MARK ONE RESPONSE
-Regular full-time teacher
-Regular part-time teacher
-Long-term substitute teacher

29. In the state in which your school is located, what type of teaching certification do you hold in the field you teach the students named on the student list?

- Regular or standard certification (standard certification offered in your state)
- Probationary certification (the initial certification issued after satisfying all requirements except the completion of the probationary period)
- Temporary, provisional, or emergency certification (require additional coursework before regular certification can be obtained)
- I am not certified in this field, but am currently in a program to obtain state certification in this field

30. What academic degree(s) do you hold? MARK ALL THAT APPLY

- No degree
- Associate degree (A.A., A.S., etc.)
- Bachelor's degree (B.A., B.S., etc.)
- Education specialist/professional diploma
- Master's (M.A., M.S., M.B.A., etc.)
- Doctorate (Ph.D., Ed.D., D.P.H., etc.)
- First professional (M.D., D.D.S., J.D./L.L.B., etc.)

31. What were your major and minor (or 2nd major) fields of study for your bachelor's degree?

- Education
- English
- Mathematics
- History/social studies/social science
- Natural/physical sciences
- Foreign languages
- Physical education
- Vocational education
- Business
- Other
- Does not apply

IF YOUR HIGHEST DEGREE IS A BACHELOR'S DEGREE, SKIP TO QUESTION 33.
IF YOUR HIGHEST DEGREE IS AN EDUCATION SPECIALIST/PROFESSIONAL DIPLOMA OR HIGHER, GO TO QUESTION 32.

32. What were your major and minor (or 2nd major) fields of study for your highest graduate qualification?

- Education
- English

-Mathematics
-History/social studies/social science
-Natural/physical sciences
-Foreign languages
-Physical education
-Vocational education
-Business
-Other
-Does not apply

33. How many undergraduate and graduate courses have you taken in the subject area of the class(es) you teach the students named on the enclosed list? Please report the number of courses, not credit hours.
a. Undergraduate courses in English
b. Graduate courses in English
c. Undergraduate courses in math
d. Graduate courses in math
Does not apply, None, 1-3, 4-,6 7-9, 10 or more, I don't know

34. Suppose you could go back to college and start over again. In view of your present knowledge, would you become a teacher? MARK ONE RESPONSE
-Certainly would
-Probably would
-Chances for and against are even
-Probably would not
-Certainly would not

35. How often do you use a computer at home or in school to… MARK ONE RESPONSE ON EACH LINE
a. Create instructional materials (e.g., handouts, syllabi, tests)?
b. Gather information from Web sites for planning lessons?
c. Access model lesson plans from the Internet?
d. Access research and best practices for teaching from the Internet?
e. Take professional development courses via the Internet?
f. Participate in discussions via the Internet with colleagues?
g. Download instructional software from the Internet to use in class?
h. Give multimedia presentations in class?
i. Keep administrative records (e.g., grades, attendance, lesson plan)?
j. Prepare multimedia presentations?
k. Communicate with colleagues and other professionals through E-mail or listserves?
l. Communicate with students' parents via E-mail or listserves?
m. Communicate with students outside of class hours?

n. Post homework or other class requirements or information?
Never, Less than once a month, Between once a week and once a month, A few times a week, Almost every day, Every day

36. In the last 3 years, how many hours of training or professional development on how to teach special education students have you had? If none, enter 00.

37. In the last 3 years, have you had 8 hours or more of training or professional development on how to teach Limited English Proficient (LEP) students? (An LEP student is an English Language Learner who has limited English skills.)

38. In the last 3 years, have you received training in these areas from any source? MARK ONE RESPONSE ON EACH LINE

a. Basic computer training
b. Software applications
c. Use of the Internet
d. Use of other technology (e.g., satellite access, wireless Web, interactive video, closed-circuit TV, videoconferencing)
e. Integration of computers and other technology into the classroom curriculum
f. Follow-up or advanced training

39. During the first semester of the current school year, how many days of teaching did you miss for any reason?

40. In addition to your duties at this school, do you hold any other paying jobs that are full-time at any time of the year? MARK ONE RESPONSE

No
Yes, summer only
Yes, school year only
Yes, during the entire year

41. Is this full-time work related to the field of education?

42. In addition to your duties at this school, do you hold any other paying jobs that are part-time at any time of the year?

No IF NO, SKIP TO QUESTION 44
Yes, summer only
Yes, school year only
Yes, during the entire year

43. Is this part-time work related to the field of education?

44. When students are successful in achieving intended goals or objectives, it is often attributed to one of the following sources. In your opinion, how important is each source of success? MARK ONE RESPONSE ON EACH LINE

a. Student's home background
b. Student's intellectual ability
c. Student's enthusiasm or perseverance
d. Teacher's attention to the unique interests and abilities of the student
e. Teacher's use of effective methods of teaching
f. Teacher's enthusiasm or perseverance

Extremely Important, Very Important, Not very Important, Not at all Important

QUESTION 45 IS FOR MATH TEACHERS ONLY. IF YOU ARE AN ENGLISH TEACHER, SKIP TO QUESTION 46.

45. How much do you agree or disagree with the following statements? MARK ONE RESPONSE ON EACH LINE

a. Most people can learn to be good at math.
b. You have to be born with the ability to be good at math.

Agree, Strongly Agree, Disagree, Strongly Disagree

APPENDIX B: Student Questionnaire Base Year, 10th Grade[9]

PART I: INFORMATION FOR FUTURE FOLLOW-UP

13. When were you born?

14. What is your sex?

15. Are you Hispanic or Latino/Latina? IF NO, SKIP TO QUESTION 17

16. If you are Hispanic or Latino/Latina, which on of the following are you?
MARK ONE RESPONSE

-Mexican, Mexican-American, Chicano
-Cuban
-Dominican
-Puerto Rican
-Central American (Guatemalan, Salvadoran, Nicaraguan, Costa Rican, Panamanian, Honduran)
-South American (Colombian, Argentinian, Peruvian, etc.)

17. Please select one or more of the following choices to best describe your race.
MARK ALL THAT APPLY

-White
-Black/African American
-Asian
-Native Hawaiian or Other Pacific Islander
-American Indian or Alaska Native

18. If you marked Asian in question 17, which one of the following are you?
MARK ONE RESPONSE

-Chinese
-Filipino
-Japanese
-Korean
-Southeast Asian (Vietnamese, Laotian, Cambodian/Kampuchean, Thai, Burmese)
-South Asian (Asian Indian, Bangladeshi, Sri Lankan)

19. excluded

[9] I have excluded some of the instructions and some questions asking for contact information, which are not available on the public release of the ELS data and are not needed for my research.

PART II: SCHOOL EXPERIENCES AND ACTIVITIES

20. How much to you agree or disagree with each of the following statements about your current school and teachers?
Strongly agree, Agree, Disagree, Strongly Disagree

a. Students get along well with teachers
b. There is real school spirit
c. Students make friends with students of other racial and ethnic groups
d. Other students often disrupt class
e. The teaching is good
f. Teachers are interested in students
g. When I work hard on schoolwork, my teachers praise my effort
h. In class I often feel "put down" by my teachers
i. In class I often feel "put down" by other students
j. I don't feel safe at this school
k. Disruptions by other students get in the way of my learning
l. Misbehaving students often get away with it
m. There are gangs in school
n. Fights often occur between different racial/ethnic groups

21. Thinking about your school over the last year, how much do you agree or disagree with the following statements?
Strongly agree, agree, disagree, Strongly Disagree

a. Everyone knows what the school rules are
b. The school rules are fair
c. The punishment for breaking school rules is the same no matter who you are
d. The school rules are strictly enforced
e. If a school rule is broken, students know what kind of punishment will follow

22. In the first semester or term of this school year, how many times did any of the following happen? Never, Once or twice, More than twice

a. I had something stolen from me at school
b. Someone offered to sell me drugs at school
c. Someone threatened to hurt me at school
d. I got into a physical fight at school
e. Someone hit me
f. Someone used strong-arm or forceful methods to get money or things from me
g. Someone purposely damaged or destroyed my belongings
h. Someone bullied me or picked on me

23. Since starting ninth grade, did you win any of the following awards or were you recognized at school for doing well or participating in certain activities?

a. Won an academic honor
b. Received special recognition for good attendance
c. Received special recognition for good grades or honor roll
d. Received a community service award
e. Participated in a science, math or technology fair
f. Vocational/technical skills competition (e.g., DECA, VICA, FFA, FHA)

24. How many times did the following things happen to you in the first semester or term of this school year? Never, 1-2 times, 3-6 times, 7-9 times, 10 or more times

a. I was late for school
b. I cut or skipped classes
c. I was absent from school
d. I got in trouble for not following school rules
e. I was put on in-school suspension
f. I was suspended or put on probation
g. I was transferred to another school for disciplinary reasons

25. Please write down the names of your best friends at your present school. Please fill in up to three names. If you have fewer close friends, provide less than three names. Then for each friend you named, answer questions 25a through 25g.

a. Is this friend male or female?
b. Is this friend Hispanic or Latino/Latina?
c. What is this friend's race? MARK ALL THAT APPLY FOR EACH FRIEND
d. What grade is this friend in at your school? MARK ONE RESPONSE FOR EACH
e. How important is getting good grades to this friend?
Not at all important, Somewhat important, Very important
f. Do you know either or both of this friend's parents?
g. Does your mother or father know either or both of this friend's parents?

26. If you had to limit yourself to one of the following three choices, which comes nearest to describing your high school program? MARK ONE RESPONSE

-general
-college preparatory (academic)
-vocational (including technical or business)

27. How much to you agree or disagree with the following statements about why you go to school? Strongly agree, agree, disagree, Strongly Disagree

a. I go to school because I think the subjects I'm taking are interesting and challenging

b. I go to school because I get a feeling of satisfaction from doing what I'm supposed to do in class
c. I go to school because I have nothing better to do
d. I go to school because education is important for getting a job later on
e. I go to school because it's a place to meet my friends
f. I go to school because I play on a team or belong to a club
g. I go to school because I'm learning skills that I will need for a job
h. I go to school because my teachers expect me to succeed
i. I go to school because my parents expect me to succeed

28. How much do you like school? MARK ONE RESPONSE
Not at all, Somewhat, A great deal
29. In your current or most recent mathematics class, how often do/did you...
a. Review the work from the previous day
b. Listen to the teacher lecture
c. Copy the teacher's notes from the board
d. Use books other than textbooks
e. Do word problems or problem solving activities
f. Use calculators
g. Use graphing calculators
h. Use computers
i. Explain your work to the class orally
j. Participate in student-led discussions

30. Do/did you use computers in your current or most recent math class?
IF NO, SKIP TO QUESTION 32

31. In your current or most recent mathematics class, how often do/did you use computers in the following ways? Never, Rarely, Less than once a week, Once or twice weekly, Almost every day
a. Review work from the previous day
b. Do word problems or problem solving activities
c. For graphing
d. To practice math drills
e. To analyze data
f. To apply what was learned in class to new situations or problems
g. The teacher uses/used the computer to instruct us individually
h. The teacher uses/used the computer to demonstrate new topics in mathematics

32. Please indicate if you used or are using a computer in class for the following subjects in 9th and 10th grade:
a. 1st semester/term English

b. 2nd semester/term English
c. 1st semester/term science
d. 2nd semester/term science
e. 1st semester/term math
f. 2nd semester/term math
g. 1st semester/term social studies
h. 2nd semester/term social studies

33. Have you ever been in any of the following kinds of courses or programs in high school?

a. Advanced Placement (AP)
b. International Baccalaureate (IB)
c. Courses or a program which you take at a separate area or regional vocational school part-time
d. Remedial English
e. Remedial math
f. Bilingual or bicultural education
g. English as a Second Language (ESL)
h. Dropout prevention, Alternative or Stay-in-School Program
i. Special Education Program
j. Course via distance learning
k. Career academy
l. Special program to help students plan or prepare for college

34. Overall, about how much time do you spend on homework each week, both in and out of school?

__________In school hours _________Out of school hours

35. In your current math course, about how much time do you spend on homework each week, both in and out of school?

__________In school hours _________Out of school hours

36. In your current English course, about how much time do you spend on homework each week, both in and out of school?

__________In school hours _________Out of school hours

37. How important are good grades to you? Not important, Somewhat important, Important, Very Important

38. How often do you come to class without these things? Never, Seldom, Often, Usually

a. Pencil/pen or paper
b. Books

c. Homework done

39. For the following items, intramural means competition between teams or students within the same school. For each sport listed below, indicate whether you participated on an intramural team in this sport during this school year.
School does not have interscholastic team, Did not participate, Participated on a junior varsity team, Participated on a varsity team, Participated as a varsity team captain/co-captain

a. Baseball
b. Softball
c. Basketball
d. Football
e. Soccer
f. Other team sport
g. An individual sport (e.g., wrestling, golf, tennis)
h. Cheerleading, Pompon (Pompom), or Drill Team

40. For the following items, interscholastic means competition between teams from different schools. For each sport listed below, indicate whether you have participated on an interscholastic team during this school year.
School does not have interscholastic team, Did not participate, Participated on a junior varsity team, Participated on a varsity team, Participated as a varsity team captain/co-captain

a. Baseball
b. Softball
c. Basketball
d. Football
e. Soccer
f. Other team sport
g. An individual sport (e.g., wrestling, golf, tennis)
h. Cheerleading, Pompon (Pompom), or Drill Team

41. Have you participated in the following school-sponsored activities this school year? Yes/No

a. Band, orchestra, chorus, choir
b. School play or musical
c. Student government
d. National Honor Society (NHS) or other academic honor society
e. School yearbook, newspaper, literary magazine
f. Service club
g. Academic club
h. Hobby club

i. Vocational education club, vocational student organization (e.g., DECA, VICA, FFA, FHA)

42. In a typical week, how much time do you spend on school-sponsored extracurricular activities (for example, sports, school clubs?) _________hours

43. How much additional reading do you do each week on your own outside of school--not in connection with schoolwork? (Do not count any school-assigned reading) ______hours

44. How often do you spend time on the following activities outside of school?

a. Visiting with friends at a hangout
b. Working on hobbies, arts, crafts
c. Volunteering or performing community service
d. Driving or riding around
e. Talking with friends on the telephone
f. Taking classes: music, art, language, dance
g. Taking sports lessons
h. Playing non-school sports

45. Whether at home, school, or someplace else, how often do you use a computer...
Never, Rarely Less than once a week, Once or twice a week, Every day or almost every day

a. for fun, such as talking to friends or relatives through E-mail, playing games, surfing the Internet, or listening to music?
b. for school work or assignments?
c. as a resource to learn things of interest to you on your own?

46. How many hours a day do you usually use a computer...

a. for school work? _________hours
b. other than for school work? _________hours

47. How often do you use a computer... No computer, Never, Less than once a week, Once or twice a week, Every day or almost every day

a. at home?
b. at school?
c. at the public library (for activities other than catalog searches)?
d. at a friend's house?
e. at another place?

48. During the school year, how many hours a day do you usually watch TV or videotapes/DVDs?

Weekdays ________hours Weekends ________hours

49. During the school year, how many hours a day do you usually play video or computer games such as Nintendo or Play Station?

Weekdays ________hours   Weekends ________hours

50. Does your school have a library or library media resource center?
IF NO, SKIP TO QUESTION 54

51. How often do you use your school library media center for any of the following activities?

a. Course assignments
b. In-school projects
c. Homework (assignments to be completed outside of class time)
d. Research papers
e. Leisure reading
f. Read magazines or newspapers
g. Read books for fun
h. Learn about things that are not course-related, such as sports, hobbies, people or music
i. Use the Internet

52. How useful are the reference materials (books, magazines, newspapers, Internet resources, and databases) available from the school library media center in helping you do your class assignments and research? Very useful, Useful, Not useful, Don't use the school library

53. How helpful is the school library staff with the following?
Very helpful, Helpful, Not Helpful, Don't use the school library

a. Helping you find books, magazines and newspaper articles on a research topic
b. Helping you use online databases or CD-ROMs for research
c. Helping you use the Internet for research

PART III: PLANS FOR THE FUTURE

54. How important is each of the following to you in your life?

a. Being successful in my line of work
b. Finding the right person to marry and having a happy family life
c. Having lots of money
d. Having strong friendships
e. Being able to find steady work
f. Helping other people in my community
g. Being able to give my children better opportunities than I've had
h. Living close to parents and relatives

i. Getting away from this area of the country
j. Working to correct social and economic inequalities
k. Having children
l. Having leisure time to enjoy my own interests
m. Item deleted
n. Becoming an expert in my field of work
o. Getting a good education

55. Have you taken or are you planning to take any of the following tests in the next two years?
I haven't thought about it, No I don't plan to, Yes this school year, Yes next school year, Yes in 12th grade

a. Pre-SAT test (PSAT) or Preliminary American College Testing Test (PACT)
b. College Board Scholastic Assessment Test (SAT) or American College Testing Service (ACT)
c. Advanced Placement (AP) test
d. Armed Services Vocational Aptitude Battery (ASVAB)

56. As things stand now, how far in school do you think you will get?

-Less than high school graduation SKIP TO QUESTION 62
-High school graduation or GED only SKIP TO QUESTION 62
-Attend college, but not complete a 4- year degree
-Graduate from college
-Obtain a Master's degree or equivalent
-Obtain a Ph.D., M.D., or other advanced degree
-Don't know

57. Do you plan to continue your education right after high school or at some time in the future?

-Yes, right after high school
-Yes, after staying out of school for one year
-Yes, after staying out of school for over a year
-Yes, but I don't know when
-No, I don't plan to continue my education after high school SKIP TO QUESTION 62
-I don't know if I will continue my education after high school SKIP TO QUESTION 62

58. Which of the following do you plan to attend?

-Four-year college or university
-Two-year community college
-Vocational, technical or trade school

59. Where have you gone for information about the entrance requirements of various colleges?
MARK ALL THAT APPLY

- -Guidance counselor
- -Teacher
- -Coach
- -Parent
- -Friend
- -Brother or sister
- -Other relative
- -College publications or websites
- -College representatives
- -College search guides, publications, or websites
- -None of the above

60. Would you like to participate in athletics (not intramurals) at the collegiate level?
IF NO, SKIP TO QUESTION 63

61. Do you hope to receive an athletic scholarship to pay for all or part of your college expenses?
SKIP TO QUESTION 63

62. Which of the following are reasons why you have decided NOT to continue your education past high school?

a. I do not like school
b. My grades are not high enough
c. I will not need more education for the career I want
d. I cannot afford to go on to school
e. I'd rather work and make money than go to school
f. I plan to be a full-time homemaker
g. I do not feel that going to school is important
h. I need to help support my family

63. Write in the name of the job or occupation that you expect or plan to have right after high school. ______________________

64. Write in the name of the job or occupation that you expect or plan to have at age 30._______

65. How far in school do you think your mother and father want you to go?

- -Less than high school graduation
- -High school graduation or GED only

-Attend or complete a 2-year school course in a community or vocational school
-Attend college, but not complete a 4-year degree
-Graduate from college
-Obtain a Master's degree or equivalent
-Obtain a Ph.D., M.D., or other advanced degree
-Don't know
-Does not apply

66. What do the following people think is the most important thing for you to do right after high school? Does not apply, Go to college, Get a full-time job, Enter a trade school or an apprenticeship, Enter military service, Get married, They think I should do what I want, They don't care, I don't know

a. Your mother
b. Your father
c. Your friends
d. A close relative
e. School counselor
f. Your favorite teacher
g. Coach

PART IV: LANGUAGE

67. Is English your native language (the first language you learned to speak when you were a child)? IF YES, SKIP TO QUESTION 71

68. What is your native language (the first language you learned to speak when you were a child)? MARK ONE RESPONSE

-Spanish
-A Chinese language
-Japanese
-Korean
-A Filipino language
-Italian
-French
-German
-Greek
-Polish
-Arabic
-Farsi
-Urdu
-Hindi, Tamil or other Indian subcontinent language
-Portuguese
-Vietnamese

-Cambodian
-Other Southeast Asian language
-American Indian language
-Other

69. How often do you speak your native language with...
Never, Sometimes, About half of the time, Always or most of the time, Does not apply

a. your mother?
b. your father?
c. your brothers and sisters?
d. your friends?

70. How well do you do the following? Very well, Well, Not well, Not at all

a. Understand spoken English
b. Speak English
c. Read English
d. Write English

PART V: MONEY AND WORK

71. In which of the following work-based learning experiences have you participated during high school? MARK ALL THAT APPLY

-Cooperative education (work experience that is part of a vocational class and for which you earn class credit)
-Internship (work experience arranged by your school, but not necessarily part of a vocational class)
-Job shadowing or work-site visits (school-arranged visits to work places to observe one worker or many workers)
-Mentoring (a school-arranged match with an adult in your career area for advice and support)
-Community service (volunteer work arranged by your school to support your local community)
-School-based enterprise (working in a business run by students or teachers from your school)
-None of these

72. Have you ever worked or pay, not counting work around the house?

-No SKIP TO QUESTION 81
-Yes and I am currently employed SKIP TO QUESTION 74
-Yes but I am not currently employed

73. When did you last work for pay, not counting work around the house?

Month/Year

74. When did you start your current or most recent job? Month/Year

75. How many hours do/did you usually work each week on your current or most recent job?
_________hours

76. How many of those hours each week are/were on the weekend (Saturday or Sunday)?

77. What kind of work do/did you do for pay on your current job or most recent job? (If you have two or more jobs, answer for the job that pays the most per hour. Do not include work around your own house.) MARK ONE RESPONSE

-Fast food worker, waiter/waitress, host/hostess, dishwasher/busboy
-Babysitter or child care
-Cashier, grocery clerk/bagger
-Salesperson, customer service
-Lawn work or odd jobs
-Camp counselor, lifeguard, coach, umpire, or referee
-Farm worker
-Construction work
-Computer related job (e.g., repair, Web-design, network installation)
-General office or clerical worker
-Warehouse worker
-House cleaning or janitorial work
-Hospital or health worker
-Beautician, hair stylist, barber
-Other

78. Item deleted.

79. How did you get this job?

-School-arranged co-op program
-Other assistance from school or teacher
-Family
-Friends
-Read an ad, sign or notice
-Placed an advertisement
-Other

80. Is this job related to the job you want to have when you have completed your education?
Closely related, Somewhat related, Not related at all

PART VI: FAMILY

81a. What kind of work does your mother normally do? That is, what is the job called? (If she is unemployed, retired, or disabled, answer for her most recent job. If she works more than one job, answer for the job you consider to be her major activity.)

-My mother is a full-time homemaker GO TO QUESTION 82
-Does not apply GO TO QUESTION 82
-
OCCUPATION____

81B. What does she actually do in that job? That is, what are her main duties?_______________

82a. What kind of work does your father normally do? That is, what is the job called? (If he is unemployed, retired, or disabled, answer for his most recent job. If he works more than one job, answer for the job you consider to be his major activity.)

-My father is a full-time homemaker GO TO QUESTION 83
-Does not apply GO TO QUESTION 83
-
OCCUPATION____

81B. What does he actually do in that job? That is, what are his main duties?_______________

83.How far in school did your parents go? Indicate your mother's and father's highest level of education.

-Did not finish high school
-Graduated from high school or equivalent (GED)
-Graduated from high school and attended a two-year school (such as a vocational or technical school, a junior college, or a community college), but did not complete a degree
-Graduated from a two-year school (such as a vocational or technical school, junior college, or a community college)
-Graduated from high school and went to college, but did not complete a four-year degree
-Graduated from college
-Completed a Master’s degree or equivalent
-Completed a Ph.D., M.D., or other advanced professional degree
-Don’t Know
-Does Not Apply

84. Does your family have the following in your home?
- a. A daily newspaper
- b. Regularly received magazine
- c. A computer
- d. Access to the Internet
- e. DVD player
- f. Electric dishwasher
- g. Clothes dryer
- h. More than 50 books
- i. A room of your own
- j. A fax machine

85. How often do your parents do the following? Never, Rarely, Sometimes, Often
- a. Check on whether you have done your homework
- b. Help you with your homework
- c. Give you privileges as a reward for good grades
- d. Limit privileges because of poor grades
- e. Require you to do work or chores
- f. Limit the amount of time watching TV/playing video games
- g. Limit the amount of time going out with friends on school nights

86. In the first semester or term of this school year, how often have you discussed the following with either or both of your parents or guardians? Never, Sometimes, Often
- a. Selecting courses or programs at school
- b. School activities or events of particular interest to you
- c. Things you've studied in class
- d. Your grades
- e. Transferring to another school
- f. Plans and preparation for ACT or SAT tests
- g. Going to college
- h. Community, national and world events
- i. Things that are troubling you

PART VII: BELIEFS, OPINIONS ABOUT SELF

87. How much do you agree or disagree with the following statements?
Strongly agree, Agree, Disagree, Strongly disagree
- a. When I do mathematics, I sometimes get totally absorbed
- b. Because reading is fun, I wouldn't want to give it up
- c. Because doing mathematics is fun, I wouldn't want to give it up
- d. I read in my spare time
- e. When I read, I sometimes get totally absorbed
- f. Mathematics is important to me personally

88. How much do you agree with the following statements?
Strongly agree, Agree, Disagree, Strongly disagree

- a. Most people can learn to be good at math
- b. You have to be born with the ability to be good at math

89. How often do these things apply to you? Almost never, Sometimes, Often, Almost always

- a. I'm confident that I can do an excellent job on my math tests
- b. I'm certain I can understand the most difficult material presented in math texts
- c. I'm certain I can understand the most difficult material presented in English texts
- d. I study to get a good job
- e. When I sit myself down to learn something really hard, I can learn it
- f. I'm confident I can understand the most complex material presented by my English teacher
- g. When I study, I make sure that I remember the most important things
- h. I study to increase my job opportunities
- i. I'm confident I can do an excellent job on my English assignments
- j. When studying, I try to work as hard as possible
- k. I'm confident I can do an excellent job on my English tests
- l. I'm confident I can understand the most complex material presented by my math teacher
- m. I'm certain I can master the skills being taught in my English class
- n. If I decide not to get any bad grades, I can really do it
- o. When studying, I keep working even if the material is difficult
- p. I study to ensure that my future will be financially secure
- q. If I decide not to get any problems wrong, I can really do it
- r. I'm confident I can do an excellent job on my math assignments
- s. When studying, I try to do my best to acquire the knowledge and skills taught
- t. If I want to learn something well, I can
- u. I'm certain I can master the skills being
- v. When studying, I put forth my best effort

90. Among your close friends, how important is it to them that they...
Not important, Somewhat important, Very important

- a. attend classes regularly
- b. study
- c. play sports
- d. get good grades
- e. be popular/well-liked by others
- f. finish high school

g. have a steady boyfriend/girlfriend
h. continue their education past high school
i. item deleted
j. do community work or volunteering
k. have a regular job
l. get together with friends
m. go to parties
n. item deleted
o. item deleted
p. item deleted
q. make money

91. Altogether, how many of your close friends have dropped out of school before graduating? (Do not include those who have transferred to another school.)
None of them, Some of them, Most of them, All of them

92. How much do you agree or disagree with the following statements?
Strongly agree, Agree, Disagree, Strongly disagree
a. It is important that girls have the same opportunity to play sports as boys
b. Some sports should be just for boys
c. Girls should have equal access to sports, but through their own teams
d. For most sports, girls should have the opportunity to be on the same team with boys

93. Item deleted

94. Do you have close friends now who were also your friends when you were in 8th grade?

95. Item deleted

96. During the past year, have you observed high school students placing bets on college or professional sporting events? IF NO, SKIP TO QUESTION 98

97. How were these bets placed? MARK ALL THAT APPLY
-With friends
-With family members
-With a bookie
-With an Internet website
-Other

98. Please fill in today's date.

Appendix C: Summary of Mathematics and Reading Assessments[10]

Assessment Framework for Mathematics

Test specifications for the ELS:2002 base year and first follow-up were adapted from frameworks used for NELS:88. There were two levels to the framework: content areas and cognitive processes. Mathematics tests contained items in arithmetic, algebra, geometry/ measurement, data/probability, and advanced topics (including analytic geometry and precalculus but not calculus). The tests also reflected cognitive process categories of skill/ knowledge, understanding/comprehension, and problem solving. The test questions were selected from previous assessments: NELS:88, NAEP, and PISA. Most of the base-year items were multiple choice (about 10 percent of the base-year mathematics items were open-ended). In the first follow-up, all items were multiple choice.

The ELS:2002 assessments were designed to maximize the accuracy of measurement that could be achieved in a limited amount of testing time while minimizing floor and ceiling effects by matching sets of test questions to initial estimates of students' achievement. In the base year, this was accomplished by means of a two-stage test. In 10th grade, all students received a short multiple-choice routing test, scored immediately by survey administrators, who then assigned each student to a low, middle, or high difficulty second-stage form, depending on the student's number of correct answers in the routing test. In the 12th-grade administration, students were assigned to an appropriate test form based on their performance in 10th grade. Cut points for the 12th-grade low, middle, and high forms were calculated by pooling information from the field tests for 10th and 12th grades in 2001, the 12th-grade field test in 2003, and the 10th-grade national sample.

Table 3. Number and percentage of unique mathematics items in ELS:2002 base year, by content area: 2002

Content area	Number of items	Percentage of items
Arithmetic	19	26.0
Algebra	17	23.3
Geometry/measurement	20	27.4
Data analysis, statistics/probability	9	12.3
Advanced topics[1]	8	11.0

[1] "Advanced topics" includes precalculus and analytic geometry.

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "Base Year, 2002."

[10] From Ingels, S.J., Pratt, D.J., Wilson, D., Burns, L.J., Currivan, D., et al. (2007). ELS 2002 Base Year to Second Follow Up Data File Documentation. Washington, DC: National Center for Education Statistics pp.27-31.

Table 4. Number and percentage of unique mathematics items in ELS:2002 first follow-up, by content area: 2004

Content area	Number of items	Percentage of items
Arithmetic	15	25.4
Algebra	17	28.8
Geometry/measurement	17	28.8
Data analysis, statistics/probability	4	6.8
Advanced topics[1]	6	10.2

[1] Advanced topics includes precalculus and analytic geometry.

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "First Follow-up, 2004."

Table 5. Number and percentage of unique mathematics items per skill/cognitive process area in ELS:2002 base year, by process/skill specifications: 2002

Process/skill specifications	Number of items	Percentage of items
Procedural skills/knowledge	23	31.5
Conceptual understanding	27	37.0
Problem solving	23	31.5

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "Base Year, 2002."

Table 6. Number and percentage of unique mathematics items per skill/cognitive process area in ELS:2002 first follow-up, by process/skill specifications: 2004

Process/skill specifications	Number of items	Percentage of items
Procedural skills/knowledge	17	28.8
Conceptual understanding	26	44.1
Problem solving	16	27.1

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "First Follow-up, 2004."

Assessment Framework for Reading

Reading items were drawn from two sources, NELS:88 and PISA (2000). There are four content areas:

- biographical;
- literary (including both poetry and prose);
- scientific (includes graphical displays as well as prose); and
- social studies.

There are three cognitive process areas: reproduction of detail, comprehension of thought (translating verbal statements into concepts), and inference/evaluative judgment (drawing conclusions based on the material presented). In the reading assessment (conducted in the base year only), there are 51 unique items, 11 of which are used twice (i.e., across two forms).Distribution of unique items (again, some items were repeated, to link forms) across the content areas is summarized in Table 10, while distribution across cognitive process areas is summarized in table 11.

Table 10. Number and percentage of unique reading items in ELS:2002 base year, by content area: 2002

Content area	Number of items	Percentage of items
Biographical	12	23.5
Literary	18	35.3
Scientific	13	25.5
Social studies/other	8	15.7

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "Base Year, 2002."

Table 11. Number and percentage of unique reading items per skill/cognitive process area in ELS:2002 base year, by process/skill specifications: 2002

Process/skill specifications	Number of items	Percentage of items
Reproduction of detail	12	23.5
Comprehension of thought	19	37.3
Inferences/evaluative judgments	20	39.2

NOTE: To provide overlap, some items appear on more than one test form. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Education Longitudinal Study of 2002 (ELS:2002), "Base Year, 2002."

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