

2011

The Impact of Bilingual Treatment on the Math Skills of Hispanic High School Algebra Students

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The Impact of Bilingual Treatment on the Math Skills of Hispanic
High School Algebra Students

by
Robert Kirk

A Dissertation Submitted to the
Gardner-Webb University School of Education
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Education

Gardner-Webb University
2011

Approval Page

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Abstract

The Impact of Bilingual Treatment on the Math Skills of Hispanic High School Algebra Students. Kirk, Robert, 2011: Dissertation, Gardner-Webb University, Mathematics/Bilingualism in Mathematics/Code Switching/Classroom Climate/ESL

This dissertation was designed to measure the impact of instructional techniques in the Foundations of Algebra classroom to bridge linguistic barriers between Hispanic students and the language of teaching. Two consecutive years of failing to meet anticipated yearly growth among Hispanic students in Algebra I, as determined by the North Carolina End of Course exams, indicated a cognitive gap among these students when it comes to learning mathematics.

The writer developed an experiment to be delivered among 9 sections of Algebra in a North Carolina high school. The control group used Microsoft PowerPoint slides created for every lesson plan determined by the school system's pacing guide over the course of one semester, using the adopted Algebra I textbook (Prentice Hall, 2004) as reference. Supplemental worksheets came from the accompanying *Study Guide and Practice Workbook*.

The treatment group used the same Microsoft PowerPoint slides as the control group, with the addition of Spanish subtitles for key words and concepts presented during lesson introduction. The subtitles were a smaller font and in a different color. Upon completion of the instruction, Hispanic students were allowed to form monolingual working groups to delve into application. Their worksheets also came from the *Study Guide and Practice Workbook* but in Spanish.

The researcher examined differences in cognitive domain of both groups using analysis of variance (ANOVA) in pre- and post-test data from the software NovaNet, as well as countywide administered semester final exams. Affective domain changes pertaining to attitudes regarding mathematics as determined by a student questionnaire were compared with frequency distribution on responses. Changes in classroom climate were assessed using the Classroom Environment Scale and teacher interviews.

The treatment group, which exercised the greatest fidelity in experimental guidelines, showed greatest gains in math application skills, while expressing feelings of stronger class affiliation, teacher support, and rule clarity.

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Chapter 1 – Introduction

Background

A popular adage maintains that mathematics is a universal language, an idea that perhaps springs from 13th Century English philosopher Roger Bacon's (n.d.) assertion, "The knowledge of mathematical things is almost innate in us. This is the easiest of sciences, a fact which is obvious in that no one's brain rejects it." By extension, the teaching of "almost innate" mathematics should easily transcend linguistic and cultural barriers for homogeneity among students in learning mathematics concepts in a bilingual and multicultural environment. Gorgorió and Planas (2001) opine that, "even if the mathematical language can be considered universal, the language of 'doing mathematics within the classroom' is far from being universal" (p. 7).

During the course of the past several years, this researcher taught in secondary mathematics classrooms where students whose language of learning was Spanish constituted about 23% of the population (a breakdown of 29/118, 26/112, 20/105 over three years), most of them having completed only two years of English as a Second Language (ESL) classes. The inherent difficulties of teaching "mathematically challenged" Foundations of Algebra and Algebra I classes (high school students who had failed their eighth grade Mathematics End of Grade [EOG] exam or carried low to failing mathematics grades through middle school) were exacerbated by the addition of bilingual and bicultural students to the mix. The 'doing mathematics' gap was twofold in planning for native-speaking English and acquired-English students in the same classroom; the first challenge involved the lack of basic mathematics content knowledge by many in the class, and the second dealt with the lack of metacognitive skills on the part of students

who were more comfortable in their native Spanish language when presented with English-only mathematics instruction.

During a December 2009 interview with the Director of Federal Programs for the county school system, the director commented on the challenges to learning mathematics in a bilingual setting: “For two consecutive years now, the only group within the English as a Second Language (ESL) categories that missed the target was High School Mathematics - and this was also the subgroup that missed AYP (Adequate Yearly Progress). Our Hispanic population really needs some help when it comes to math” (Dr. Marion Bish, personal interview, December 8, 2009). Irrespective of ethnicity, failure to master mathematic concepts invokes repercussions beyond test scores and state-level sanctions. Lynn Steen (2007) asserts that within the traditional classroom, insufficient emphasis is being placed on the areas of communication, connections, and contexts.

Effective communication in the job force requires employees who can “synthesize information, make sound assumptions, capitalize on ambiguity, and explain their reasoning. Employers seek graduates who can interpret data as well as calculate with it and who can communicate effectively about quantitative topics” (Steen, 2007, p. 11). This calls for students to be able to communicate mathematically in both math classes and in classes of other disciplines, which call for quantitative arguments (Steen).

Unless students see teachers of all subjects using more mathematics in their courses, exhortations of the usefulness of math will appear self-serving (Steen, 2007). For effective mathematics mastery to take place, there must be a schoolhouse commitment to numeracy as there is to literacy by administrators and cross-disciplinary teachers; “If each content-area teacher identifies just a few units where quantitative

thinking can enhance understanding, students will get the message” (Steen, p.11).

One of the common criticisms of classroom mathematics is that it focuses too much on process (algorithms) at the expense of understanding (Steen, 2007). This is especially true in the areas of fractions and algebra, because both represent a level of abstraction well beyond simple integer arithmetic. According to Steen, “Without reliable contexts to anchor meaning, many students see only a meaningless cloud of abstract symbols” (p. 12). As level of abstraction increases, so do the number of formulas, and the tie-in to meaning fades. The key to making math count in pedagogical activity is that of connecting meaning to numbers in “authentic contexts, such as history, geography, economics, or biology – wherever things are counted, measured, inferred, or analyzed” (Steen, p.12).

Conceptual Framework

Within an educational setting where discipline-specific content is delivered in the English language, contextual queues and clues are derived from American social mores, and where even written symbols are often cultural (Short, Vogt, & Eschevaria, 2008), it should not come as a surprise that mathematics mastery poses a struggle for the English Language Learner. The treatments undertaken by this research are designed to provide a bridge for some of the potential gaps defined above.

For the purpose of this study, the terms, *English as a Second Language (ESL)*, *Hispanic*, *English Language Learners (ELL)*, and *Latino*, will narrowly refer to those students who have identified themselves upon enrollment in the school system as having come from a Latin American extraction. This self-declared ethnicity is used by the state of North Carolina in defining subgroups within the end of course testing categories.

As reported by the NC Department of Public Instruction [NCDPI] (2008), disaggregated data of a medium-sized North Carolina Piedmont county school system captured in Table 1 shows the Hispanic student subgroup performance on Algebra I EOC scores over the past three years among four high schools, where the largest concentration of Hispanic students attend.

Table 1

End of Course Number and Percent of Hispanic Students At or Above Achievement Level III in Algebra I

School	2005-2006		2006-2007		2007-2008	
	Valid scores	Percent at or above Level III	Valid scores	Percent at or above Level III	Valid Scores	Percent at or above Level III
A	25	64.0	40	55.0	44	47.7
B	34	79.4	42	50.0	40	45.0
C	45	73.3	46	58.7	33	72.7
D	17	64.7	28	53.6	41	51.2

Note. Hispanic students' Algebra I EOC trend over three years among four high schools.

These four high schools were selected for their comparable number of Latino students in the student body for the 2007-2008 school year. Table 2 reflects the overall demographic breakdown at each of the high schools by gender and as a percent of total student population.

Table 2

Demographic Breakdown at Each High School – Spring 2010

School	Am Indian			Asian			Hispanic			Black			White			Multi- Racial			Total
	M	F	%	M	F	%	M	F	%	M	F	%	M	F	%	M	F	%	
A	1	3	0.4	2	3	0.4	84	45	11.5	120	107	20.2	372	352	64.4	22	13	3.1	1124
B	2	1	0.3	6	5	1.0	90	83	15.4	147	144	25.8	319	295	54.5	19	15	3.0	1126
C	2	1	0.2	17	19	2.4	79	95	11.7	140	129	18.0	501	469	65.0	25	16	2.7	1493
D	3	0	0.3	11	16	2.3	47	43	7.8	121	90	18.4	407	372	67.8	17	22	3.4	1149

Note. Demographic data by male (M), female (F), and percent of total population (%).

Contextualized Demographics

The school system web site, accessed July 2009, showed an enrollment across most county schools reflecting the multicultural diversity of its surrounding population. The following breakout of the ethnic composition can be seen: American Indian/Alaska Native at 0.3%; Asian/Pacific Islander at 1.4%; Hispanic at 9.4%; Black at 17.4%; White (non-Hispanic) at 71.5%. Three high schools carry a disproportionate percentage of Hispanic students (NCDPI, 2008).

From 2000 to 2007, North Carolina saw a 68% increase in resident Hispanic population (The Pew Hispanic Center, 2009). A diverse local economy has contributed to making the county attractive to businesses. Throughout the 20th Century, textiles formed the driving engine for the local economy. Toward the last quarter of the 20th Century, the addition of a large tobacco plant added depth and variety to the economic base. Supporting the gradual development of the county, such institutions as a large regional medical center, NASCAR's motor speedway, a county convention center and visitor's bureau, a coffee plant and others began adding jobs, calling for an expanded labor pool. The construction of a regional airport along with existing rail and trucking terminals,

allowed the county commissioners and city councils to offer more benefits to businesses looking to move into the county.

International textile business pressures began forcing plant shut-downs in the late 20th Century, releasing over 4,000 employees into the market place, most of whom did not have a high school education. A large tobacco plant moved to another state, which added 2,500 laborers in need of new employment, along with a loss of 13.4% of the county's tax base. This glut in the labor pool of employees lacking a high school education increased the competition for lesser-paying, menial labor positions in the marketplace. The impact on the county continued to be felt, with a 10.8% unemployment rate for June, 2010. The need for an educated work force is a priority concern for the Regional Chamber of Commerce according to J. Cox, President & CEO of Economic Development for Regional Chamber of Commerce (personal communication, July 8, 2010).

Early into the 21st Century, a significant research campus was erected. Situated in the heart of the county, it began to fill its more than 3,600 jobs ranging from grounds maintenance to security guards to pharmacists to genetic physicists to accelerometer technicians, among others. This research campus will continue to provide jobs to fuel the local economy, inviting further immigration to the county.

Purpose of Study and Research Questions

The purpose of this study was to examine the effects on mathematics scores by using bilingual treatment with Hispanic high school students in Algebra I classes in a central North Carolina school. Additionally, this research examined the effects on classroom climate brought about by the bilingual treatment. With minimal alteration in

math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests. The teacher was not required to be bilingual, the classrooms were taught by mathematics teachers in English, and the Hispanic class language-mix was random, reflecting the student population within the county. This study was designed to answer the following research questions regarding bridging linguistic barriers inherent to Hispanic-English language learners in an Algebra classroom:

- R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?
- R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?
- R3. What impact does bilingual treatment have on the classroom climate?

The treatment upon which the study rests is simple: that the teacher using a Microsoft PowerPoint presentation during the introduction of a math topic will include, in smaller font and in different colored letters, the same math terms in Spanish. This visual aid will serve as a bridge to prior knowledge and link the Spanish-labeled algorithms to the now English-taught algorithms. Following the lesson that reveals a new concept, students will break up into monolingual collaborative groups to work on math worksheets in their language of dominance. Current high school math books provide both English and Spanish components to their textbooks, worksheets, reviews and key concepts, eliminating the need for the teacher to speak any Spanish or be conversant in Spanish math terminology.

Problem

The National Council of Teachers of Mathematics [NCTM] published both *The Professional Standards for Teaching Mathematics* (NCTM, 1991) and the *Assessment Standards for School Mathematics* (NCTM, 1995), which brought into focus the needed changes in practice to reach all students as well as the use of equitable assessment methods (Davidenko & Tinto, 2003, p.85).

The mathematics classroom has undergone serious shifts in the classroom setting, and Davidenko and Tinto (2003) addressed the changes, as suggested by the Standards, in the following:

Toward classrooms as mathematical communities - away from classrooms as simply a collection of individuals; toward logic and mathematical evidence as verification - away from the teacher as the sole authority for right answers; toward mathematical reasoning - away from merely memorizing procedures; toward conjecturing, inventing, and problem solving - away from an emphasis of mechanistic answer-finding; toward connecting mathematics, its ideas, and its applications - away from treating mathematics as a body of isolated concepts and procedures. (p. 86)

In order to accommodate these shifts, the challenge was defined for the mathematics teacher as the ability to reach a classroom with the language of mathematics in English to a subgroup that is just beginning to make connections with the simple English. The researcher believed the introduction of some form of bilingual treatment during the presentation of mathematics algorithms to a group of English language learners could provide that needed bridge between English and Spanish.

Much of the research undertaken in the late 1980's to early 21st Century addressed the mental processes an ELL student adopts in order to enfold the new cultural and linguistic messages to his or her existing framework of understanding. From code switching (Moschkovich, 2005) to symbology manipulation (Gutiérrez, 2002) to semiotic processes (Sáenz-Ludlow, 2003), much has been accomplished and substantiated in the way of adaptive behaviors embraced by students learning in their adopted language in classrooms across many disciplines and across many languages.

A key component to the literature review included focusing on specific learning modalities for ELL students in a mathematics classroom setting, as they address the “double jeopardy” these students face while learning a foreign language (the language of math) in a foreign language (English). Studies that examined the secondary school experience were also of significant concern. The focus on Hispanic ELL students was driven by the fact that there is more impact in U.S. public education with that cultural group than with any other single language study, as this ethnic group is one of the fastest growing school-age populations in the United States (NCES, 2008).

Lessons drawn from reading studies were omitted, as were many, though not all, of the bilingual education studies, since this research scenario was specifically intended as a bilingual mathematics classroom experiment. This research was designed to fill the void of previous research, recognized by Rochelle Gutierrez (2002), which has tended to focus on elementary and middle school math students in a bilingual setting while not addressing Latino students in high school settings in a largely English-dominant classroom.

This study tied in with the current literature as it provided data at the high school

level to validate statements such as the following:

The language of mathematics is a complex mixture of words and symbols integrated across registers and dialects against a backdrop of different linguistic interpretations. To assume a "business as usual" approach to teaching mathematics in a monolingual, English speaking setting can wreak havoc in building both procedural and conceptual mathematics knowledge. Lack of sensitivity to the particular student needs found in a multilingual classroom setting could disrupt the learning environment even more so. (Sáenz-Ludlow, 2003)

When planning for teaching mathematics to a bilingual Hispanic/English audience, available tools such as bilingual overhead slides, Spanish worksheets, and monolingual work groups need to be part of the teaching schema (Gutiérrez, 2002). Assessing mathematical knowledge must entail more than standardized, English-only multiple-choice tests. Creative techniques in oral assessment, mapping strategies and interpretations using native language explanations and translations need to be incorporated in secondary mathematics classrooms (Secada, 1991).

Cultural differences need to be viewed as a means of deepening mathematics understanding in a bicultural classroom, not a dilution of the mathematical experience. Algorithms originating from a different perspective can enrich, not impoverish, the learning arena in any classroom where the language of mathematics is being discovered in its fullest (García, Jensen, & Scribner, 2009).

Best practices, those instructional approaches and strategies for teaching and learning that make for a differentiated classroom environment, invite teachers to list key

words and concepts that will be introduced to students throughout the presentation prior to the start of the lesson (Armstrong & Savage, 2002). These are noteworthy and a good tip for students to ensure they jot down the terms and concepts when presented during the topic-discovery phase of instruction. This study proposed that when the key terms or concepts were displayed to the class, their Spanish counterparts were also displayed, using a slightly smaller font and in a different font color than the English.

Keep in mind that this was a normal English-speaking class (not bilingual), taught in English, and while directed at the English-speaking audience, the instructor also acknowledged the significant presence of the Hispanic minority in the classroom. High school scheduling counselors were precluded from placing an ELL student in Algebra I until the student demonstrated a Level 3 or higher competency in the World-Class Instructional Design and Assessment (WIDA) Placement Test (WAPT) for Assessing Comprehension and Communication in English State to State (ACCESS) – more commonly known as WAPT/ACCESS – for English language learners. Cultural awareness can be viewed as cultural valuing and appreciation of diversity in the mathematics classroom.

This review examined the constructs of language as both the social tool within the mathematics classroom and the means of scaffolding for developing mathematical knowledge (Gorgorió & Planas, 2001; Raiker, 2002; Sáenz-Ludlow, 2004; Setati & Adler, 2000). In a bilingual classroom setting, the practice of code switching – moving across discourses and language – is seen as a means of enhancing the mathematics learning process for most students whose original language is not English (Setati & Adler, 2000; Moschkovich, 2005). Supplementing the language of mathematics is the

use of symbols. Mathematicians, most teachers, and students view symbols with a lack of uniformity in their application and interpretation (Sáenz-Ludlow, 2003). Inherent in the argument of language and symbology interpretation in the mathematics classroom are the semiotic processes, i.e., the human brain's interaction with signs and sign usage.

According to Sáenz-Ludlow, “The semiotic process is measurable in that it is demonstrated by higher order learning as students move from symbolic reflex – the ability to only manipulate and react to signs, to symbolic initiative – the ability to spontaneously create and use signs” (p. 36).

North Carolina state end of course exam results recorded a downward trend among Hispanic mathematics students in the four high schools examined, reflecting that a learning gap exists between current classroom teaching practices and the learning processes among this population. This research collected performance data on Hispanic Algebra I students over the course of a semester to support or refute the effectiveness of a specifically defined bilingual treatment. The treatment consists of two parts: 1) incorporating Spanish subscripts to key English terms and concepts on a Power Point lesson presentation and 2) allowing for monolingual small group algorithm discussion and assimilation upon completion of the lesson.

Additionally, data was collected from administering the Classroom Environment Scale (Trickett & Moos, 2002) surveys to assess impact upon classroom climate, as perceived by both student and teachers.

Limitations

The researcher acknowledges the presence of confounding factors which impact student performance in a mathematics classroom over which there was no control. While

not an exhaustive list, some of these include: the Hispanic student's actual grasp of the English language, national biases and culture-of-origin appreciation for education, student's cognitive skills developed in the language of learning, student's reading skills in Spanish, and the use of technology in lesson presentation.

Organization of Remaining Study

The remaining parts of this study were organized by chapters. Chapter 2 is a detailed literature review on topics associated with language of learning as it applies to English Language Learners (ELL). The literature review helped identify common problems found in classrooms where the language of learning was not the language of teaching and associated coping mechanisms to overcome these natural barriers. The literature review also further discusses the topics listed in the theoretical framework for this study. Chapter 3 describes the methodology used by the researcher to obtain data for this study as well as detailed information of the instrumentation used in data collection. The researcher uses Chapter 4 to provide data analysis and report findings as related to the research questions. Finally, in Chapter 5, the researcher gives recommendations for future studies that may help expand the scope of research available on the topic of effective bilingual lesson delivery to Hispanic students in Algebra classrooms and help answer new questions that may arise from this study.

Summary

This past decade has seen a large shift in the demographics and ethnic composition of the United States, more notably, an expansion of the Hispanic population in the Southern states. As these students find their way into the classroom, the need to meet the requirements of No Child Left Behind legislation has called into play the need

for strong educational pedagogy to bridge the linguistic barriers for English Language Learners.

At the secondary high school level, norm-referenced testing on End of Course (EOC) exams for the state of North Carolina showed that the Algebra I scores for Hispanic students are lagging those of other ethnic backgrounds and that the trend continues to show a widening gap in the discipline of mathematics.

This study was designed to help answer questions surrounding what can be done at the lesson delivery and algorithm assimilation levels in the Algebra I classroom. In completing this study, the researcher measured the effect that bilingual power-point slides as a bridging treatment, coupled with monolingual collaborative groups, had on the Hispanic students' abilities to acquire math computational skills and math application skills. Additionally, the researcher measured the impact of these treatment methods on student self-efficacy as reflected by classroom climate surveys. The researcher hoped that this study would expand the body of literature on the topic of bilingual lesson delivery and monolingual collaborative groups and give rise to similar studies that can help alleviate the number of Hispanic students who struggle to learn the language of math in a foreign language, and when unsuccessful, drop out of high school.

The next chapter will provide the linguistic framework for how an English Language Learner adapts to learning the language of mathematics in his or her non-native idiom.

Chapter 2: Review of Literature

Background

The purpose of this study was to examine the effects on mathematics scores by using bilingual treatment with Hispanic high school students in Algebra I classes in a central North Carolina school. Additionally, this research examined the effects on classroom climate brought about by the bilingual treatment. With minimal alteration in math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests. According to the National Center for Education Statistics [NCES] (2008),

In 2005, minorities made up 33 percent of the U.S. population. Hispanics were the largest minority group, representing 14 percent of the population. Minorities are predicted to represent 39 percent of the total population by the year 2020.

Much of the recent rise in minority enrollment in elementary and secondary school may be attributed to the growth in the number of Hispanic students.

Hispanic students have retention and suspension/expulsion rates that are higher than those of Whites, but lower than those of Blacks. Hispanic students have higher high school dropout rates and lower high school completion rates than White or Black students. Over one-half of Hispanic students speak mostly English at home. (p. 72)

In the South, for grades K-12, Hispanic minorities made up 20% of the enrolled public school students (NCES, 2008). As the influx of immigrants continues, with relaxation of restrictions on Hispanic traffic across the United States border with Mexico as provided by the North American Free Trade Agreement (NAFTA) and as the U.S.

economy continues to be interlaced with foreign interdependencies, the reality of multicultural communities and schools is upon us. In light of growing ethnic diversity in societies around the world, irrespective of geographic locale, Gorgorió and Planas (2001) maintained that the educational system is "differentially effective for students depending on their social class, ethnicity, language background, or other demographic characteristics" (p. 8).

In January 2011, the University of North Carolina at Chapel Hill's Frank Hawkins Kenan Institute of Private Enterprise released James Johnson and John Kasarda's study entitled *Six Disruptive Demographic Trends: What Census 2010 Will Reveal*. It listed two of the six leading disruptive demographic trends emerging from the U.S. Census 2010 as "The South Has Risen – Again" and "The 'Browning' of America." The study went on to explain that the U.S. population growth in the past ten years was seen primarily in the South, with slightly more than half (51.4%) of the 24.8 million additional people concentrated there. Under girding the rapid geographical redistribution of the U.S. population are dramatic changes in the complexion of U.S. society, driven by immigration and rapid non-white population growth. In 1995, whites constituted 75% of the U.S. population. Ten years later, in 2005, the white share of the total population had dropped to 67% of the total. By 2009, the non-Hispanic white share of the U.S. population had declined by another two percent, representing an estimated 65% of the total. Emblematic of this emerging racial adjustment, the Asian, black, and Hispanic population of the United States increased by an estimated 31%, 10%, and 36%, respectively (Johnson & Kasarda, 2011).

Classroom Implications for Demographic Shifts

Johnson and Kasarda (2011) asserted that the primary-age and secondary-age school children most at risk of falling through the cracks of the public school systems are predominantly non-white – mainly black and Hispanic – a product of the “browning” of America. They claimed that “allowing these students to languish in under-resourced and low-performing schools is not just an ethical or moral issue; rather, of more importance, it is a competitiveness issue” (Johnson & Kasarda, p.15).

In response to the obvious implications of multiculturalism in classrooms, the National Council of Teachers of Mathematics [NCTM] (2003) addressed *The Equity Principle* with the following admonition,

Some students may need further assistance to meet high mathematics expectations. Students who are not native speakers of English, for instance, may need special attention to allow them to participate fully in classroom discussions. Some of these students may also need assessment accommodations. If their understanding is assessed only in English, their mathematical proficiency may not be accurately evaluated. (p. 13)

Further, under the heading of “The Assessment Principle” in *Principles and Standards for School Mathematics*, the NCTM (2003) also asserted,

Teachers must ensure that all students have an opportunity to demonstrate clearly and completely what they know and can do. For example, teachers should use English-enhancing and bilingual techniques to support students who are learning English. (p. 24)

The mathematics gap is readily noticeable by early elementary school when

reliable testing instruments are applied, usually at third grade (Dossey, Mullis, Lindquist, & Chambers, as cited in Secada, 1991). Resultant classifications of these students as low achievers requiring compensatory educational programs have seen the emergence of mathematics education for these groups which addressed basic mathematic skills to the virtual exclusion of higher order thinking and on-grade-level math content (Cole & Griffin, as cited in Secada, 1991). Bresser (2003) asserts,

Computational fluency is rooted in an understanding of arithmetic operations, the base-ten number system, and number relationships. Communicating mathematical ideas is fundamental to developing computational fluency. When students share their solution strategies with others, they learn that there are many ways to solve problems and some strategies are more efficient than others. (p. 294)

What do educators need to know in order to help Hispanic ESL students learn the language of mathematics?

The Language of Math

While there are many similarities between linguistic features of everyday English and those of mathematics discussed in a classroom, "mathematical language is thought to have its own unique characteristics. If mathematical language – word problems especially – is derived from ordinary language, then access to that language and its discourse is mediated by mastery of the language from which it is derived" (Secada, 1991, p. 218).

Gorgorió and Planas (2001) saw this mediation of language mastery affecting both the cognitive domain in acquiring mathematical practices as well as the affective domain in fitting in to the cultural mores of the larger classroom setting and asserted,

When minority language students join a mathematics class, they often find different norms, regulating both the social dynamics of the mathematics classroom and the mathematical practices. Discontinuities in understanding new words and meanings can turn into a wide variety of cultural conflicts and disruptions of the learning process. (p. 12)

As a coping mechanism for these discontinuities in understanding, bilingual students have undertaken the practice of code-switching. Setati and Adler (2000) claimed,

Code-switching in a classroom...usually refers to bilingual or multilingual settings, and at its most general, entails the switching by the teachers and/or learners between the Language of Learning and Teaching (LOLT) and the learners' main language. Code-switching is a practice that enables learners to harness their main language as a learning resource. (p. 243)

Code-switching is viewed by sociolinguistics as the use of more than one language within the transmission of a single communicative episode during conversation (Moschovich, 2005). Note that this is not merely code-switching within oneself as a soliloquy or a self-contained translation exercise, but takes place orally within a framework of teacher/student and student/student dialogue in a classroom setting.

In the findings of Secada, "A significant relationship [exists] between the development of language and achievement in mathematics. In particular, oral proficiency in English in the absence of mother tongue instruction was negatively related to achievement in mathematics" (as cited in Setati & Adler, 2000, p. 245). Supported in a range of recent studies focusing on code-switching by Adler, Arthur, Khisty, Moschovich and Setati, Setati, and Adler assert "the significant, positive impact of using the learners'

main language in the developing proficiency in the language of learning and teaching as well as learning mathematics” (p. 246). With the increasing numbers of Hispanic students in the public school system, textbook editors and publishers are reacting by providing entire curriculum support tools, from worksheets to textbooks to overhead transparencies – in Spanish. This kind of practical support enables English-only speaking teachers to build a lesson plan whereby the English terms and concepts are shadowed by their Spanish equivalent.

Code Switching and Dialect

When dealing with differences in meaning, the barriers to code switching become more onerous as not only must the student switch from instructional language to native language for linguistic meaning, but also there are difficulties posed by contextual and cultural reference points. Gorgorió and Planas (2001) asserted, "...[creating meaning] means being able to activate a different communication system, with new symbols, new figures, new words, and also with words and figures which exist in both systems but which may also represent different things depending on the system" (p. 14). Take as an example, the symbol for the decimal place. The code switching for marking the decimal place is the period “.” for English speaking students, but the comma “,” for Central and South American students. Not surprising, the degree of bilingualism allowed in a classroom is positively related to cognitive ability (Hakuta, 1987), which in turn impacts the clarity and alacrity of code switching among Hispanic students (Gorgorió & Planas, 2001). Within many of the classrooms visited by this researcher, an “English only” policy is imposed by the teacher, with outright prohibitions against such code-switching. This *de facto*, not *de jure*, posture attests to some educators’ personal feelings regarding how

this might be perceived as lack of classroom management or failure to require the English Language Learner to learn English.

Compounding the dilemma of words and associated meaning is the existence of two varieties of language essential to communication: dialect and register (Sáenz-Ludlow, 2003, p. 255). According to Sáenz-Ludlow, "Dialect is described as a variety of language according to *user*. Dialects reflect not only regional origin but also index a multitude of linguistic and socio-cultural realities. In contrast, register is described as a variety of language according to *use*" (p. 256). Cobb further differentiates the registers used in a mathematics classroom setting as being either calculational discourse or conceptual discourse. He defines the former as discussions involving process, the latter as discussions involving the rationale behind the calculations (as cited by Setati & Adler, 2000).

Armed with this foreknowledge, is teaching mathematics merely adopting a simplistic delivery model for a mixed language class, where English mathematics discourse needs to be watered down? Raiker (2002) warned that precision in mathematical meaning, not simplification, is critical to understanding sound concepts and subsequent development of mathematical thinking. Yet in this effort to be technically correct, mathematically precise, and conceptually accurate, the very vehicle teachers have for conveying these ideas is replete with pitfalls. Shuard and Rothery (1984), as cited by Sáenz-Ludlow (2002), observed there is an overlap in the technical language of mathematics with everyday English words. They go on to delineate three types of categories for mathematical words:

Technical words - words which have a meaning only in mathematical English, for

example division axis, square centimeters; lexical words - words which have, amongst others, a similar meaning in mathematical English as in everyday English, for example, remainder, origin, altogether; everyday words - words which occur both in everyday English and mathematical English but which can have similar and different meanings in mathematical English from their meaning in everyday English, for example points, change, difference. Taking words one step further, Sáenz-Ludlow (2003) argued that humans and other creatures have the capacity to perceive and react to species-specific signs. Humans not only react to signs but also have the capacity to both modify the perceived signs and to create new signs, changing their worlds and satisfying their needs.

Against this backdrop of sign interactivity, Sáenz-Ludlow (2003) continued her argument that, "the learning of mathematics is a complex semiotic activity that requires both the interpretation of mathematical notation and the construction of mathematical meanings" (p. 33). Expanding Reikers' (2002) listed three categories of *word* types, Sáenz-Ludlow allowed for the following *sign* types, which embraced some of the differentiation held by Reiker: natural signs – natural language used as one of the main mediums for communicating; register signs – natural language used in an informal manner to express mathematical meaning (mathematics register); formal signs – conventional mathematical notation or diagrams used to convey meanings in a standardized manner (Anderson et al., 2003, p. 271).

It is within this framework of linguistic and sign assimilation paradigms, that not only must native English-speaking students learn the language of mathematics, but also bilingual students must cope as well. The construct of mathematical meaning, according to Piaget (1970),

Evolves in a continuous manner, a manner resulting from the individual's exposure to a variety of closely interrelated experiences within mathematical, logical, social, and physical contexts. In such experiences, language, gestures, mental imagery, and evolving interpretations combine to build up knowledge. (as cited by Anderson, et al., 2003, p. 254).

This crisscrossing cognitive activity in the construction of knowledge is what Piaget (1973) called "the semiotic function of intelligence" (Anderson, et al., 2003, pp. 255-256).

Where Raiker (2002) called for a tighter definition of terms and interpretations on the part of teacher and learner, Sáenz-Ludlow (2003) allowed for more subjectivity regarding linguistic and nonlinguistic idiosyncratic signs, permitting them to be used to express mathematical meanings in more personal ways. This sets the stage for a conundrum in teaching the language of mathematics in a bilingual classroom setting.

The tendency for teachers to simplify their language register in multilingual settings is natural, following the Sheltered Instruction Observation Protocol Model (SIOP) (Short et al., 2008). The tradeoff is that in simplifying the communicative form, the mathematical function and process are lost to the learner. In Gorgorió and Planas' (2001) article "Teaching Mathematics in Multicultural Classrooms," they asserted,

It is necessary to reach a point where the language of learning helps the acquisition of school mathematics and vice versa. Even if learners have difficulties in verbalizing a mathematical process, the teacher can promote the mathematical thinking by distinguishing the talk from the thinking. (p. 15).

Davidenko and Tinto (2003) reported that while analyzing their transcripts from

Latino students' interviews, there were English words interspersed with their Spanish. While some words were used interchangeably such as "homework" and the equivalent " *tarea*," there were words describing new concepts for which they knew no Spanish equivalent - such as slope or degree of a polynomial. According to conclusions drawn by Davidenko and Tinto, "These examples show that the students had learned the *concepts* slope and degree along with their mathematical registers in context. The English register had become part of the student's conceptual network of that concept, as in the case for English speaking students in the classroom" (p. 104). Echoes of this assertion come from Moschkovich (2005) who argued that such code-switching should not be viewed as a learning deficit but should be tapped as a source for improved communications in a mathematical setting with bilingual students.

Five Variables for Teaching ESL Students

Gersten and Baker (2000) made a telling discovery on the literature surrounding experimental and quasi-experimental intervention studies and descriptive studies (both qualitative and quantitative) dealing with classroom observations on methodologies that would prove potentially beneficial to English Language Learners: they found nine intervention studies and 15 descriptive studies that analyzed classroom instruction. Due to the paucity of existing studies with sufficient control as well as a lack of studies that were conducted spanning a wide range of grade levels, Gersten and Baker conducted a qualitative, multivocal research synthesis as described below. Ogawa and Malen (1991) described the multivocal research synthesis as a process in which researchers evaluate the methods and results across several documents and use rigorous qualitative processes to analyze "the diverse writings, as well as a deliberate analysis of the findings reported in

empirical observations” (p. 265). According to Oganwa and Malen, multivocal synthesis is a useful tool in areas “characterized by an abundance of diverse documents and a scarcity of systematic investigations” (p. 266).

Gersten and Baker (2000) conducted a series of five professional work groups comprised of practitioners and researchers across Virginia, California, Washington, DC, Florida, and Arizona. All participants were professionals – researchers, teachers, administrators, psychologists, and staff development specialists. The sessions lasted between five and seven hours, and built upon consensus established at the prior working group session. The purpose of the sessions was to gain some insight into what practitioners and researchers saw as promising and productive practices, identify recurring pitfalls in current practices, and become familiar with terms used in the field to define certain practices. Supplementing the working groups was the data source from existing descriptive studies of effective instruction for English Language Learners, focusing on those students in kindergarten through eighth grade. Additionally, data was extrapolated from documents, which included instructional guidelines and curriculum frameworks from school districts with large number of English-language learners such as Denver, Albuquerque, Los Angeles, San Diego, and El Paso, and Federal policy documents from the Office of Civil Rights of the U.S. Department of Education. Gersten and Baker devoted four years to their multivocal synthesis.

At the conclusion of their research, Gersten and Baker (2000) identified five specific variables that hold potentially significant impact for instruction in a bilingual setting: 1) building and using vocabulary as a curricular anchor, 2) using visual aids to reinforce concepts and vocabulary, 3) implementing cooperative learning and peer-

tutoring strategies, 4) using native language strategically, and 5) modulating of cognitive and language demands.

What specific evidences of obstacles to teaching and learning exist in a classroom where there is no mastery of the language of instruction? Gorgorió and Planas (2001) shared three observations: not knowing everyday language interferes with work on mathematical activities, teachers find difficulty in understanding students' thinking processes, and students experience difficulties with the meaning of mathematical words or symbols. Raiker (2002) added a fourth in that rigid assessment techniques do not adequately capture student knowledge or understanding. These studies translated into meaningful applications in a mathematics classroom where bilingual students have to learn mathematics in a language other than their native one through several options.

Classroom teachers need to structure and allow for monolingual working groups (Gorgorió & Planas, 2001). An Hispanic work group is given a Spanish worksheet in which all terms and concepts are presented in Spanish and, as a collaborative team, these students work on the same problem set as their English-speaking counterparts. At the end of the work session, each group reports their solutions and concomitant strategies for problem solving to the class in English. Gorgorió and Planas' observations in their own studies supported the propensity for success in these smaller groups:

Our observations made it clear that the learners who benefited... generally liked being in linguistically homogeneous groups. The minority language students that we observed remained silent in class discussions, but participated in small group discussions and, ...could partially follow the whole group discussion. Most of minority language students developed a positive attitude towards the possibility of

using their main language during mathematics lessons. (p. 27)

Not only is identification of key vocabulary words and concepts crucial in lesson planning, but also equally important is the specific detail for conveying these ideas to English learners as well as to English as Second Language Learners (Raiker, 2002). As the National Council of Teachers of Mathematics (2003) recommended, teachers need to enhance their concept presentations with bilingual enhancing techniques.

Teachers need to have new terms written and plainly visible throughout lesson presentation, where they can be referred to on a frequent basis. Once introduced, use of mathematical terms has to be ongoing until they become assimilated into the students' known mathematical vocabulary (Raiker, 2002). This can be done through collaborative learning groups, in either a monolingual or a bilingual setting.

While the number of English language learners enrolled in the public school system in North Carolina has increased significantly from 56,232 in 2000-01 to 152,605 in 2008-2009, ESL certification is not required for teachers in this state (NCDPI, 2009). States with a history of ESL involvement like California, Texas, and Florida require extensive training in ELL strategies, above and beyond core subject competencies (Rodriguez, Ringler, O'Neal, & Bunn, 2009). The education of ELLs continues to pose unique social, political, and educational problems for schools in North Carolina; Rodriguez et al. concluded, "Social and educational opportunities are typically hindered by frequent moves, poverty, gaps in previous schooling, and language and cultural barriers" (p. 513).

The Department of Public Instruction in North Carolina adopted the Sheltered Instruction Observation Protocol (SIOP) model as the recommended model for teacher

professional development in this arena (Rodriguez et al., 2009). SIOP training helps teachers plan and deliver instruction for ELL students and is composed of 30 features grouped into eight components designed to make content comprehensible for English learners:

Lesson preparation (content objectives and language objectives); building background (concept explicitly linked, links explicitly made, and key vocabulary); comprehensible input (speech, explanation of academic task, and techniques); strategies (scaffolding, interaction, grouping configurations); interaction (extensive oral language practice, intonation, and fluency); practice and application (hands-on, apply content and language knowledge); lesson delivery (content objectives, students' engagement, and pacing); and lesson review and assessment (review key vocabulary, review of key content concepts, feedback, and assessment). (Short et al., 2008, p. 33-35)

Rodriguez et al. noted, "While SIOP training and other workshops concerning the teaching of ELLs are helpful, the brevity of training limits what teachers can reasonably be expected to learn and accomplish afterward" (p. 519).

Classroom Climate and Student Self-Efficacy

Along with these pedagogical applications for student engagement, the National Research Council and the Institute of Medicine (2004) maintained that the characteristics of the educational context within which students learn has a strong affect on the students' active engagement in schooling. According to Doll, Spies, Leclair, Kurien, and Foley (2010), "School learning research indicates that classroom characteristics in the affective domain rival traditional instructional and cognitive characteristics as it pertains to

influencing student learning” (p. 203). The complex structure of the affective domain rests upon four pillars: emotions, attitudes, beliefs, and values (Nicolaou & Phillippou, 2007, p. 48). This suggests that applying a program geared to engender both academic competence and confidence provides a beneficial impetus to the student and gives credence to the contention of social cognitive theory that to increase achievement, educational efforts need to be directed toward raising student dispositions towards self-efficacy (Alfassi, 2003).

Perceived academic self-efficacy is defined as “personal judgments of one’s capabilities to organize and execute courses of action to attain designated types of educational performances” (Bandura, 1997, p. 3). Perceived self-efficacy beliefs have been found to be a strong predictor of performance in the math classroom while problem posing is considered fundamental in mathematical learning (Nicolaou & Phillippou, 2007). This research considers both of these in the analysis of the students’ computational skills, execution of the process and the applications skills – problem posing and solving.

Reformed mathematics education adopted a view that knowing mathematics is identified as “doing” mathematics and learning mathematics is equivalent to constructing meaning for oneself and the ability to handle non-routine problems. In this context, problem posing comprises a primary factor that enhances the student’s ability to solve mathematical problems. Problem posing involves one’s ability to generate new problems or what many math teachers would call “setting up the problem,” in order to make the solution more accessible (Nicolaou & Phillippou, 2007, p. 49). Some problems require greater semantic-structural complexity, such as compare/equalize; problems that involve rate, proportion, and conditional problems fall in this category. Others that are less

language-rich involve basic change, group-part-part-whole, and division problems (Nicolaou & Phillippou).

To help sustain the student's level on engagement in the classroom, many teachers rely on interpersonal communication frameworks. Communication studies and education research together identify classroom goal structure, instructional strategies, teacher immediacy, and classroom environment as established social influences on students' learning motivations (Kerssen-Griep, Hess, & Trees, 2003). Classroom social environments motivate learning when they are autonomous, competent, and related. That is, when the classroom climate helps students feel that they self-initiate and self-regulate their own actions (are autonomous), understand and feel efficacious about performing learning activities (are competent), and develop secure and satisfying connections with others (are related) (Kerssen-Griep et al., p. 359). Deci, Ryan, and Williams (1996, as referenced by Kerssen-Griep, et al.) concluded

Such states are nurtured in classroom environments that offer optimal challenge, interpersonal involvement, acknowledgment of feelings, choice making opportunities, chances to evaluate their own and others' learning, and informational, mastery-oriented, "non-threatening" feedback. (p. 360)

Impact of Face on Classroom Climate

Eric Goffman (1967) introduced the term "face" to refer to the desired self-image that individuals seek to both present and maintain in interaction with others. Since this is a symbiotic relationship, Goffman argued that conversational partners want to respect the face of others so that others will do so for them. This translates into the classroom for teachers and students into three categories of facework: solidarity (strategies attending to

fellowship face or the desire to be included), approbation (strategies attending to competence face), and tact (strategies attending to communication behaviors that indicate a respect for the others' autonomy) (Goffman). Seen through this lens of socially negotiated motivation, learning activities rooted in students' collaboration, or interests, or presented using immediacy behaviors may motivate in part because they help students feel affiliated with each other and with the class (Kerssen-Griep et al., 2003).

Research completed by Kerssen-Griep et al. (2003) supported the view that students' perceptions of instructional facework behaviors will help sustain their involvement and intrinsic learning motivations (read "academic self efficacy") by respecting their autonomy, competence, and fellowship identity needs in classroom interaction (p. 370). A student-perceived solidarity framework during instructional feedback was the most consistent predictor of classroom outcomes, since it may cast the teacher as an ally who helps students tackle problems posed by their schooling and fosters the perception of teacher support. Unlike communication intended to attract liking, this solidarity dynamic instead "may encourage the productive teacher-learner relationship described as grounded in conversations about ideas rather than affection" (Kerssen-Griep et al., p. 365).

Research on students' academic engagement described the classroom competencies that engender students' successes in school, over and above cognitive-intellectual ability (Doll et al., 2010). John L. Byer (2002) further explained students' perceptions of classroom involvement as referring to "the extent to which students perceive attentive engagement in classroom activities" (p. 3). It is this engagement, this level of classroom involvement, which has caused researchers to identify the variable

features of classrooms that promote a classroom climate conducive to student achievement. Various overarching categories have been identified that capture these classroom traits for analysis: classroom relatedness, or the degree to which teachers and classmates foster a socially supportive community; perceived competence in the classroom, or the degree to which students expect to be successful in their learning; and classroom supports for autonomy, or the degree to which students' learning is self-directed (National Research Council and the Institute of Medicine, 2004).

Pickett and Fraser (2010) defined the idea of classroom climate in terms of both teachers' and students' shared perceptions in that environment, which enables characterizing the setting through the eyes of the actual participants and avoiding missing components that an outside observer might overlook or consider unimportant. Combs (1982, as referenced by Byer, 2010) described perceptions as personal meanings that people develop from interacting with environmental circumstances. A variety of applicable questionnaires are available for assessing student perceptions, including the following, all referenced in Aldridge and Fraser (1997) and Pickett and Fraser (2010): My Class Inventory [MCI] (Sink & Spencer, 2005), the Classroom Environment Scale [CES] (Moos & Trickett, 2002), the What Is Happening in this Classroom? Survey [WIHIC] (Fraser, McRobbie & Fisher, 1996), Learning Environment Instrument [LEI] (Fraser, Anderson, & Walberg, 1982), and ClassMaps Survey [CMS] (Doll et al., 2007), to name a few.

Classroom Environment Scale (CES)

For purposes of this research, Trickett and Moos Classroom Environment Scale (CES) was selected, since its design focus was on assessing middle and high school

students' learning environments as well as focusing on the classroom traits most impacting classroom climate and student self-efficacy. The nine CES subscales assess three underlying domains of relationship dimension, personal growth or goal orientation dimension, and system maintenance or change dimension (Trickett & Moos, 2002).

The subscales for the relationship dimension include involvement, affiliation, and teacher support. Involvement reflects the extent to which students are attentive and interested in class activities, participate in classroom discussions, and do additional work on their own. Affiliation reflects the friendship students feel for each other, as expressed by getting to know each other, helping each other work with homework, and enjoying working together. Teacher support reflects the help and friendship the teacher shows towards students; how much the teacher talks openly with students, trusts them, and is interested in their ideas (Trickett & Moos, 2002).

The subscales for the personal growth/goal orientation dimension include task orientation and competition. Task orientation reflects the emphasis on completing planned activities and staying on the subject matter. Competition reflects how much students compete with each other for grades and recognition and how hard it is to achieve good grades (Trickett & Moos, 2002).

The subscales for system maintenance and change dimension include order and organization, rule clarity, teacher control, and innovation. Order and organization reflect the emphasis on students behaving in an orderly and polite manner and on the organization of assignments and activities. Rule clarity reflects the emphasis on establishing and following a clear set of rules and on students knowing what the consequences will be if they do not follow them--the extent to which the teacher is

consistent in dealing with students who break rules. Teacher control reflects how strict the teacher is in enforcing the rules, the severity of punishment for rule infractions, and how much students get in trouble in the class. Innovation reflects how much students contribute to planning classroom activities, and the extent to which the teacher uses new techniques and encourages creative thinking (Trickett & Moos, 2002).

Thomas Diamantes 2002 classroom environmental study sampled students who were diverse in terms of racial and ethnic background and who were academically at-risk for poor standardized test scores, English language proficiency, and socio-economic status. Upon analysis of results, the teachers implemented environmental improvement strategies, which included

Varying classroom grouping practices (to raise cohesiveness), redirecting competition from individual to between groups only (to lower competitiveness), formation of discussion groups to foster social skills and conflict resolution (to raise cohesiveness), and small group meetings to identify learning activities and projects that would raise levels of cooperation and understanding (to lower friction). (Diamantes, 2002, p. 279)

Whereas the purpose of this research was not to create interventions designed to improve perceived classroom climate, the Diamantes research suggested that classroom climate does impact behaviors, which affect the learning environment.

Summary

The purpose of this study was to examine the effects on mathematics scores by using bilingual treatment with Hispanic high school students in Algebra I classes in a central North Carolina school. Additionally, this research examined the effects on

classroom climate brought about by the bilingual treatment. With minimal alteration in math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests. This study was designed to answer the following research questions regarding bridging linguistic barriers inherent to Hispanic-English Language Learners in an Algebra classroom:

- R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?
- R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?
- R3. What impact does bilingual treatment have on the classroom climate?

The literature addressed research needs within the delivery of mathematic instruction to English Language Learners. Specifically:

What intervention math strategies supported by the elementary and middle school bilingual research could be effectively implemented in high school mathematics classes?

Is it possible to distinguish the impact to mathematics scores attributable to the linguistic interventions versus those due to technology use and level of teacher competence?

Do systemic prohibitions against code-switching inhibit any bilingual student setting, beyond the Hispanic population?

What specific classroom climate dimensions are most impacted in a bilingual instructional setting?

Chapter 3: Methodology

Background

The purpose of this study was to examine the effects on mathematics scores by using bilingual treatment with Hispanic high school students in Algebra I classes in a central North Carolina school. Additionally, this research examined the effects on classroom climate brought about by the bilingual treatment. With minimal alteration in math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests.

Research Questions

- R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?
- R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?
- R3. What impact does bilingual treatment have on the classroom climate?

Participants

Participants selected for treatment in this study were Hispanic students selected from the Algebra I classroom population of a central North Carolina high school. Since Algebra I is a year-long course, the first semester is referred to as Foundations of Algebra. It was this first semester Algebra population that was the focus for this research. The participating high school scheduled eight Algebra I classes during the fall semester, enabling half of the sections to receive the proposed treatment and the other half to serve as the control group. The sample treatment population was 30 Hispanic Algebra I

students out of a total of 60 in the Foundations of Algebra fall 2010 cohort, whose data were compared with the Algebra I classes in the control group. Every Algebra I classroom in the experimental group received the same bilingual slide treatment. The control group received the same Microsoft PowerPoint slides without the Spanish subtitles.

Students considered Hispanic for the purposes of this research were those English Language Learners who have been placed in an Algebra class due to demonstrating a Level 3 or higher competency level in the World-Class Instructional Design and Assessment (WIDA) Placement Test (WAPT) for Assessing Comprehension and Communication in English State to State (ACCESS), more commonly known as WAPT/ACCESS, for English Language Learners. Students who had already exited the program were also considered Hispanic for treatment purposes. The state-wide student database, NCWISE, generated Algebra I rosters designating the ESL population in each of eight classes, thereby defining the research population.

The school system web site, accessed 15 July 2009, reflected an enrollment across most county schools with similar multicultural diversity of population as the corresponding environments. The following ethnic composition applied: American Indian/Alaska Native, 0.3%; Asian/Pacific Islander, 1.4%; Hispanic, 9.4%; Black, 17.4%; and White (non-Hispanic), 71.5%.

Data Collection and Instrumentation

The primary data collection instrument in the cognitive domain for this study was the Basic Achievement Skills Inventory (BASI) test, carrying a copyright date of 2005 by Pearson Education, Inc. The computerized, server-based software that delivered the

testing was called NovaNET. This instrument delivered both pre- and post-test assessment across all Algebra I classes. County-designed mid-term tests were used to monitor growth and provide iterative assimilation assessment. Finally, the county-wide semester Foundations of Algebra final exam was used as yet another data collection and assessment tool for comparative purposes.

Formative assessments that evaluate mathematics skills mastery, fluency in numeracy, calculational discourse, and conceptual application were delivered through quizzes, tests, homework assignments, and oral participation, all in English. The only Spanish worksheet used was the one distributed to the monolingual, collaborative groups following the algorithm introduction, to help absorb the lesson into the Spanish metacognitive framework (Moschkovich, 2005). These worksheets were provided in Spanish by the Algebra I textbook vendor and were the identical problems provided by the English worksheets. All subsequent work, both oral and written, was in English.

This study made no distinction whether the assessment was generated by the teacher, professionally-generated by the textbook publisher, generated by mathematics computer software assessments, or whether assessment was generated by any of the state or Federally-mandated high-stakes tests. Assessment data was collected for comparative and trend analysis. Since classes were taught by teachers in an Algebra I Professional Learning Community, all formative assessments were generated by the collaborative group and were the same across the research classes.

Student attitudes and perceptions regarding learning mathematics were also measured, relying upon surveys led by school counselors at each of the four high schools – treatment and control classes. Since each survey group was no larger than six students

each, surveys were conducted with no more than four separate sessions for each of the pre- and post-test group sessions, allowing approximately 10 minutes per group. Using a pre- and post-test Likert scale, the questionnaire (Appendix A) helped assess if there were changes in attitudes towards mathematics learning due to a perceived invitational, dominant-language atmosphere during monolingual, collaborative groups in the classroom. The questionnaire was developed specifically for this research and was assessed for internal validity and reliability by several colleagues in graduate classes during the spring, 2010 semester, by several high school mathematics teachers, and by the staff at the county's Welcome Center for English Language Learners.

The impact on the classroom climate was measured by periodic questionnaires of both student and teachers, using the Classroom Environment Scale (CES) instrument (Trickett & Moos, 2002). CES classified human environments into three dimensions: relationship, personal development, and system maintenance and change (Adelman & Taylor, in press).

In order to establish a mathematics cognitive baseline, the researcher used the NovaNET BASI (A) pre-test. The BASI test was developed by Achilles N. Bardos, PhD., Professor of School Psychology at the University of Northern Colorado. It is a series of multilevel, group or individually administered, norm-referenced achievement tests that measure reading, written language, and math skills. Strengths experienced with this test include: finding a student's academic strengths and weaknesses; diagnosing reading, math, or spelling disabilities; designing interventions; and estimating yearly progress for NCLB.

The BASI was standardized during the 2002-2003 academic year and was

matched to the 2000 U.S. Census using a stratified sample based upon gender, race/ethnicity, parental education, and geographic region. The standardization included children in Grades 3-12; 2,439 children for Form A and 2,130 children for Form B. The results of each individual in the standardization sample were weighted to ensure a closer match to the U.S. Census (Bardos, 2004).

In regards to his research procedures, Bardos (2004) explains,

The reliability of the BASI test was determined using a number of methods.

Cronbach's alpha coefficients were calculated to estimate the test's internal consistency reliability and to determine standard errors of measurement. The stability of scores over time was examined with a test-retest study. Finally, a study was conducted to investigate the alternate-forms reliability of the BASI test. (p. 27)

For the purposes of this research, the instrumentation data presented focused on the Math Computation, Math Application, and Math Total for BASI Test Form A and Form B. BASI Form A was administered to establish the baseline of skills the individual student possesses. BASI Form B was used to measure individual student growth over time. Additionally, the instrumentation data as applies to 9th grade only will be addressed.

Cronbach's Alpha Internal Consistency Reliability Coefficients are presented below:

BASI Form A (9 th grade, n = 217): Math Computation	.84
Math Application	.78
Math Total	.89
BASI Form B (9 th grade, n = 154): Math Computation	.93
Math Application	.85

	Math Total	.93
Standard Errors of Measurement	$SEM = SD_x \sqrt{1 - r_{xx}}$	
BASI Form A Standard Scores:	Math Computation	6.18
	Math Application	6.79
	Math Total	5.04
BASI Form B Standard Scores:	Math Computation	4.09
	Math Application	5.61
	Math Total	4.02

Concerning evidence of validity, according to Bardos (2004), “the BASI test as a comprehensive achievement test includes evidence of its content validity, relationships to other group-administered achievement tests, relationships to individually administered tests, performance of students with learning impairments, and performance of bilingual students” (p. 32).

Content Validity

Concerning the validity of the content, Bardos (2004) asserted the following:

The content of each BASI subtest was determined using a test blueprint that was developed and further refined in consultation with content experts using the Model Curriculum and Assessment Database (MCAD) - an amalgamation of local, state, and national educational standards from U.S. schools. Content area standards were selected for each BASI subtest across grades 3 through 12. (p. 32)

When obtaining parental permission to test students, the consent form asked if the child spoke another language in addition to English. Bardos’ (2004) data showed, “A total of 402 students (194 [48.3%] males, 208 [51.7%] females) in grades 3-12 were

reportedly bilingual. For these bilingual students, BASI Level 1 was administered to 130 (32.3%), Level 2 to 95 (23.6%), Level 3 to 71 (17.7%) and Level 4 to 106 (26.4%)” (p. 50).

The majority of the students 246 (61.2%) were Hispanic/Latino, 83 (20.6%) were white, 9 (2.2%) were African Americans, 5 (1.2%) were American Indian, 44 (10.9%) were Asian American, 2 (0.5%) were Pacific Islanders, 8 (2.0%) were “other,” and 5 (1.2%) were missing data on race/ethnicity. Overall, the sample earned scores in the average range, suggesting that the BASI test is suitable for bilingual students (Bardos, 2004). The information below captures these average ranges for both math computation and application, with no skewness in the distribution.

BASI Form A Means and Standard Deviation of Bilingual Students

	Mean	Standard Deviation
Math Computation	102.1	14.3
Math Application	98.9	13.7
Math total	99.7	13.6

The BASI was developed to have a low floor (low basal level) and a high ceiling and is available for four grade-specific levels. This research used four levels:

Level 1 for grades 3-4

Level 2 for grades 5-6

Level 3 for grades 7-8

Level 4 for grades 9-12

With Pearson Assessment software (NCS Pearson, Inc., 2004), users can administer the BASI test via computer. The software then scores the test and generates a

score report. No test booklets or answer sheets are needed when computer administration and scoring are used. The software was available at the high school targeted in the research and was used to help place students in developmentally-appropriate math classes.

The BASI test uses a multiple-choice item format and can be administered to groups or individuals. The BASI test can be administered in two hours, with six subtests that can be administered independently. The subtests can be administered untimed, to yield criterion-referenced performance information:

Vocabulary (10 minutes)

Spelling (10 minutes)

Language Mechanics (10 minutes)

Reading Comprehension (30 minutes)

Math Computation (20 minutes)

Math Application (35 minutes)

While there are a number of scores that can be used to interpret an individual's performance on the BASI test, the category of "Standard Scores" was used; an examinee's raw score was transformed into a standard score with a mean of 100 and a standard deviation of 15. This standard score indicates the position of an individual's score or test performance relative to the scores of others in the test's normative sample, which in the case of the BASI test was designed to represent the general population of U.S. students at the same grade level as the examinee.

For each BASI subtest and total score, the estimated true score is calculated according to a method proposed by Dudek (1979) and Glutting, McDermott, and Stanley

(1987) (as referenced by Bardos, 2004). The estimated true score is obtained by the following formula: “Estimated True Score = $100 + r_{xx}(x - 100)$ where x is the standard score obtained and r_{xx} is the internal consistency reliability coefficient of that subtest or total score at the examinee’s grade level” (Bardos, 2004, p. 12).

Data analysis consisted of ANOVA pre- and post tests (NovaNet BASI Forms A and B) as well as the common mid-term assessments and system-generated final exam relative to Foundations of Algebra. Since research participants were randomly assigned to each control and experiment group, the groups had equivalent mean pretest scores and t tests could be used to measure the statistical significance of the mean gain scores. This researcher rejected the null hypothesis if the t value reached a significance level of $p < .05$. The SPSS data analysis software was used for student measure of comparison for those Hispanic students’ grades in the experimental group versus those in the control group for both ANOVA statistical analysis and frequency distribution in the student survey for mathematics class attitudes.

Classroom teachers and students were given the opportunity to participate in several CES survey forms, to ascertain individual’s ideal classroom setting, expected classroom setting, and the perceived, real classroom setting. Environmental scale scores were developed and changes assessed as the semester evolved, for both control and experimental groups. Teacher interviews were conducted twice or three times for subjective assessments on classroom climate and perceived impact on their respective students. Transcriptions of the teacher interviews were collated and analyzed for qualitative value on the impact to classroom climate.

Design and Procedure

During the summer term of 2010, the researcher coordinated with the county office to present and obtain permission to conduct this experimental research within the target school. The affected principal was briefed along with the respective Assistant Principal of Instruction (API). During the research phase, the school API was the key point of contact and clearing house for research questions, clarification, and coordination with the researcher. Following the administrative team brief, the math department head and Algebra I Foundations teachers met with the researcher to discuss the treatment concept and obtain buy-in to the process.

During the first week of school, all Hispanic Algebra I students' parents/guardians in the experimental classes were asked to sign permission slips, allowing their student to participate in the research (Appendix D). The week following, all Hispanic Foundations of Algebra students in both control and experimental group were given the BASI Test Form A on NovaNET to establish baseline subject mastery for the research. At midterm (nine weeks), a common assessment was administered, graded, and compared contributing to the on-going assessment of the Hispanic population subject mastery. Prior to the end-of-semester exam, the same population was given the BASI Test Form B on NovaNET as the post-test. Finally, the semester final exam results were collected and used for data analysis and comparison purposes, again comparing statistical differences in group mean with ANOVA statistical parameters.

To make this palatable for teachers and maximize internal and external validity, the researcher provided the Microsoft PowerPoint lesson plans for the entire semester, following the North Carolina Standard Course of Study for Algebra I and the county

Algebra I pacing guide (Appendix E). Those slides with Spanish subtitles were for the treatment group and those slides without Spanish subtitles were for the control group (Appendix F). Prior to the new school year beginning, the research coordinator held training for the teachers involved with the treatment, modeled bilingual slides and provided guidance on classroom presentation and worksheet application within monolingual, collaborative learning groups.

There existed the possibility of a sampling error, if within the experimental group there was a large percentage of Hispanics possessing a higher degree of English fluency. Irrespective of English fluency levels, the treatment targeted growth and subject mastery and the pre- and post-test assessments addressed this possibility.

The introduction of visual technology can, in itself, enhance a learning environment. Its impact on the research outcome cannot be discounted, above the bilingual treatment assumptions.

The same can be said of collaborative learning groups. The monolingual groups that met following content discovery, to apply the lesson and codify learning, enhance subject mastery in both English and Spanish, and as such enhance content assimilation. The attribution of improvement to discussion groups can be best ascertained from a qualitative study.

Instructional styles and teacher experience are additional factors over which the researcher had no control. The four teachers participating in the experiment ranged from two years to 24 years of experience in the mathematics classroom.

Both cognitive and affective domain data, along with classroom climate changes, were presented to the mathematics department and administration at the participating

high school. Comparing responses from the survey questionnaire, both pre- and post-test Likert scale thematic results were compared on frequency distribution of response and presented to participating school staffs. The two affective domain themes addressed by the student survey were: 1) student attitudes toward numeracy and computational skills and 2) student attitudes toward mathematical discourse in Language of Learning.

The same was true in the cognitive domain, as BASI-A and BASI-B ANOVA and *t*-Tests results compared gain scores. The Foundations of Algebra final exam test scores across all eight classes were also compared. As the semester wore on and the common midterm exam was administered, results were tabulated and trend analysis examined.

Selecting a mixed-method study, group comparisons for both the quantitative and qualitative research at hand, provided the requisite rigor and validity posed by a mixed population across several academic settings. Applying analysis of variance, *t* tests enabled the use of mean gain scores between the experimental and control groups in the Algebra I classes. Methodology addressed the impact of the treatment in both cognitive and affective domains of learning, as well as changes to classroom climate.

Summary

This study was designed to help answer questions surrounding what can be done at the lesson delivery and algorithm assimilation in the Algebra I classroom. In completing this study, the researcher measured the effect that bilingual power-point slides as a bridging treatment coupled with monolingual collaborative groups had on the Hispanic students' ability to acquire math computational skills and math applications skills. Additionally, the researcher measured the impact of these treatment methods on student self-efficacy as reflected by classroom climate surveys.

This study was designed to answer the following research questions regarding bridging linguistic barriers inherent to Hispanic-English Language Learners in an Algebra classroom:

- R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?
- R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?
- R3. What impact does bilingual treatment have on the classroom climate?

Chapter 4: Results

Purpose of Study and Research Questions

The purpose of this study was to examine the effects on mathematics scores by using bilingual treatment with Hispanic high school students in Algebra I classes in a central North Carolina school. Additionally, this research examined the effects on classroom climate brought about by the bilingual treatment. With minimal alteration in math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests.

This research study was designed to answer the following questions in regards to Hispanic Algebra I students' levels of performance with bilingual interventions:

- R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?
- R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?
- R3. What impact does bilingual treatment have on the classroom climate?

The following points are results from research studies by Gorgorió and Planas (2001), which translate into meaningful applications in a mathematics classroom where bilingual students have to learn mathematics in a language other than their native one.

1. Monolingual working groups. A Hispanic work group is given a Spanish worksheet in which all terms and concepts are presented in Spanish and, as a collaborative team, these students work on the same problem set as their English-

speaking counterparts. At the end of the work session, each group reports to the entire class its solutions and concomitant strategies for problem solving in English. Gorgorió and Planas' (2001) observations in their own studies supported the propensity for success in these smaller groups:

Our observations made it clear that the learners who benefited... generally liked being in linguistically homogeneous groups. The minority language students that we observed remained silent in class discussions, but participated in small group discussions and, ...could partially follow the whole group discussion. Most of minority language students developed a positive attitude towards the possibility of using their main language during mathematics lessons. (p. 27)

2. Not only is identification of key vocabulary words and concepts crucial in lesson planning, but also of equal importance is the specific detail for conveying these ideas to English learners as well as to English as Second Language Learners (Raiker, 2002). As the National Council of Teachers of Mathematics recommends, teachers need to enhance their concept presentations with bilingual enhancing techniques (NCTM, 2003).

3. Teachers need to have new terms written and plainly visible throughout lesson presentations where students can refer to them on a frequent basis. Once introduced, use of mathematical terms has to be ongoing until they become assimilated into the students' known mathematical vocabularies (Raiker, 2002). This can be done through collaborative learning groups, in either monolingual or bilingual settings.

Overview

Nine Algebra I classes participated in the research, three of which were

designated as the treatment group (Hispanic $n = 28$), and six classes were designated as the control group (Hispanic $n = 29$). To measure the cognitive domain, each member of both control and treatment groups participated in the norm-referenced Basic Assessment of Skills Inventory (BASI) Test A as a pre-test within the first week of the semester, and subsequently the BASI Test B as a post-test at week 15 of the 18-week semester.

Additionally, school-generated common mid-term exams were given at week eight of the semester, with a county-wide, common summative assessment at week 18.

Two mechanisms for measuring the affective domain were administered. A researcher-generated “Mathematics and Me” survey undertaken by the end of the second week of the semester assessed attitudes towards mathematics as well as the students’ predominant language of learning. A subsequent post-survey at week 17 measured any changes in attitudes due to experimental treatment. At week 11 of the semester, every student (Hispanic and non-Hispanic) and teacher across all nine Algebra I classes participated in a “Classroom Environment Scale” (Trickett & Moos, 2002) survey to assess the perceptions of classroom climate across nine domain areas: involvement, affiliation, teacher support, task orientation, competition, order and organization, rule clarity, teacher control, and innovation.

Results in the Cognitive Domain

BASI assessment measures two major areas of mathematical skills involving mathematical computation and mathematical application. BASI Computation subsumes the skills involving whole numbers, fractions, decimals and percents, integers, and basic algebra. BASI Application includes word problems, geometry, higher algebra and statistics (Bardos, 2004).

Prior to applying statistical analyses to the research questions, assumptions of independent observations, homogeneity of variances, and normal distribution of the dependent variable were examined. No significant violations were found that would impair inferences to be drawn from the analyses used to examine the research questions.

Separate univariate Analysis of Variance analyses were conducted to examine if differences existed in growth (change scores) over time in math application and computation skills between the treatment and control conditions. As noted in Table 3, no significant differences were found in math computation change scores for participants in the treatment conditions ($M = 2.96$, $SD = 14.67$) versus control conditions ($M = 2.96$, $SD = 6.82$), where $F(1, 49) = 3.545$, $p = .066$.

Table 3

Univariate Analysis of Change Scores for Pre- and Post-Test BASI Computation Assessments as a Function of a Second Language Intervention

Variable	Df	MS	F
BASI Computation			
Condition	1	445.5	3.545
Error	49	125.7	

Note. * $p < .05$, ** $p < .001$

Along a similar trend (see Table 4), no significant differences were found in math application change scores for participants in the treatment conditions ($M = 2.67$, $SD = 13.48$) versus control conditions ($M = 0.44$, $SD = 15.20$), where $F(1, 49) = .302$, $p = .585$.

Table 4

Univariate Analysis of Change Scores for Pre- and Post-Test BASI Application Assessments as a Function of a Second Language Intervention

Variable	Df	MS	F
BASI Application			
Condition	1	62.75	.302
Error	49	207.88	

Note. * $p < .05$, ** $p < .001$

The overall descriptive statistics for the Hispanic population involved in the treatment and control group is reflected in Table 5. Across all nine sections of Algebra I, the mean for Hispanic skills in both computation and application showed growth.

Table 5

Overall Descriptive Statistics for the Data Gathered on the Hispanic Population Participating in the Treatment and Control Classrooms

Measures	N Statistic	Range Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std. Error
Pre Computation	57	70	76	146	103.74	1.967
Post Computation	55	54	76	130	107.85	1.497
Pre Application	57	70	67	137	97.26	2.049
Post Application	55	93	45	138	99.44	1.903
Change Computation	51	74	-48	26	2.96	1.554
Change Application	51	76	-46	30	1.49	2.005
Valid N (listwise)	51					

Since R1 and R2 ask whether treatment makes a difference in growth, data provided by Tables 6 and 7 break out change in mathematics computation and application by control and treatment groups.

Table 6

Overall Descriptive Statistics for the Data Gathered on the Hispanic Population Participating in the Six Control Classrooms

	N	Range	Minimum	Maximum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Pre Computation	29	51	79	130	105.38	2.422
Post Computation	29	38	90	128	109.66	2.079
Pre Application	29	61	76	137	98.86	3.050
Post Application	29	91	45	136	100.31	2.974
Change Computation	27	32	-18	14	2.96	1.312
Change Application	27	73	-46	27	.44	2.925
Valid N (listwise)	27					

Examining the summary descriptive data for the six control classrooms is captured in Table 7 below.

Table 7

Overall Descriptive Statistics for the Data Gathered on the Hispanic Population Participating in the Three Treatment Classrooms

	N	Range	Minimum	Maximum	Mean	
Measures	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Pre Computation	28	70	76	146	102.04	3.136
Post Computation	26	54	76	130	105.85	2.129
Pre Application	28	66	67	133	95.61	2.745
Post Application	26	55	83	138	98.46	2.329
Change Computation	24	74	-48	26	2.96	2.994
Change Application	24	56	-26	30	2.67	2.752
Valid N (listwise)	24					

The above tables capture the fact that the mean of the treatment groups for computation pre-test (102.4) and post-test (105.85) lagged those of the control group computation pre-test (105.38) and post-test (109.66); both groups demonstrated equal growth in change for computation (2.96).

When examining the mean of the treatment group for application pre-test (95.61) and post-test (98.46), these also lagged those of the control group application pre-test (98.86) and post-test (100.31). However, the change in application for the treatment group (2.67) exceeded the change for treatment group (0.44) per Table 8.

Table 8

Between-Subjects Factors Where Change in Application Scores is the Dependent Variable

Condition	Mean	Std. Deviation	N
Control	.44	15.200	27
Treatment	2.67	13.480	24
Total	1.49	14.317	51

Tests of between-subjects effects resulted as follows, with R Squared = .006, with adjusted R Squared = -.014 (Table 9). There were no differences between conditions on BASI Applications as noted by the p value of .585. This means there was no correlation among the sample population in terms of matching or selection criteria – the groups were truly independent.

Table 9

Tests of Between-Subject Effects Where the Dependent Variable is Change in Application

Source	Type III Sum of Squares	df	F	Sig.		Partial Eta Squared
Corrected Model	62.745 ^a	1	6	.302	.585	.006
Intercept	122.980	1	1	.592	.445	.012
Condition	62.745	1	6	.302	.585	.006
Corrected Total	10248.745	5				

The very low power in the study (.084) restricts the ability to find differences when they may be present (Table 4-8). This was based on $p = .05$.

Table 10

Observed Power of Between-Subjects Effects Where the Dependent Variable is Change in Application

Source	F	Observed Power
Corrected Model	.302	.084
Intercept	.592	.117
Condition	.302	.084

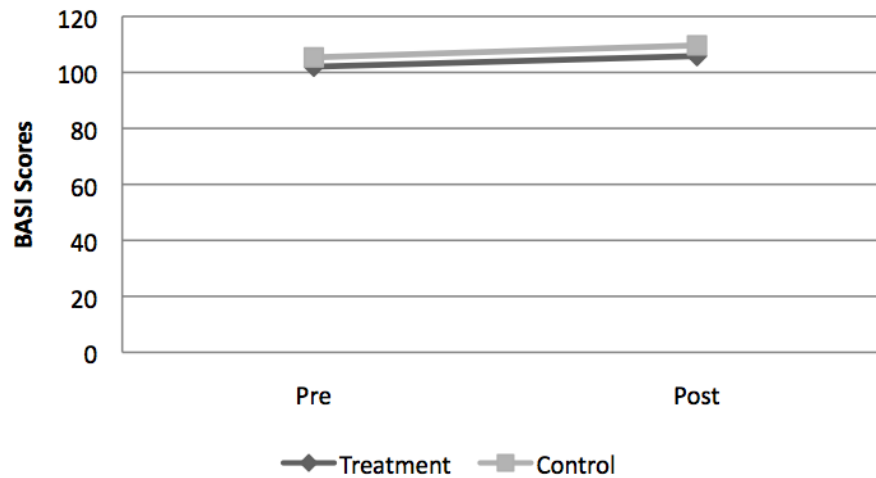


Figure 1 Pre and Post Test Scores on the BASI Computation Subtest by Treatment Condition

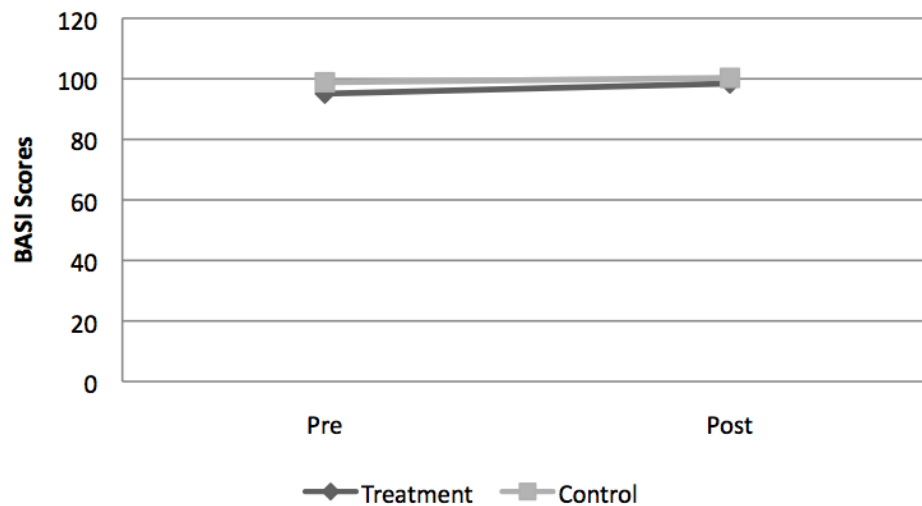


Figure 2 Pre and Post Test Scores on the BASI Application Subtest by Treatment Condition

Figures 1 and 2 represent graphically the data for growth in computation and application when comparing the treatment classes with the control classes. The steeper slope of the treatment group captures the more rapid increase in acquiring language-intensive math skills in the application cognitive domain.

Results in the Affective Domain

Research Question 3 (R3) asked what the impact of the bilingual treatment might

have on the classroom climate, and consequently, what impact the classroom climate might have on the cognitive domain. Table 11 represents the above cognitive domain data, as measured by the BASI Test, alongside the nine areas of classroom climate in the affective domain, as measured by the Classroom Environment Scale (CES) scale (Trickett & Moos, 2002). Hispanic students in both control and treatment classes were included in this survey of classroom climate.

Table 11

Cognitive Domain Pre- and Post-Test Measures Alongside the Nine Classroom Environment Survey Measures for All Hispanic Students

Measures	N	Minimum	Maximum	Mean	Std. Deviation
Pre Computation	57	76	146	103.74	14.853
Post Computation	55	76	130	107.85	11.100
Change in Computation	51	-48	26	2.96	11.098
Pre Application	57	67	137	97.26	15.468
Post Application	55	45	138	99.44	14.113
Change in Application	51	-46	30	1.49	14.317
Innovation	61	2.38	7.75	5.1257	1.58950
Affiliation	61	6.08	7.67	6.7664	.43764
Teacher Support	61	6.29	8.11	7.0980	.51163
Task Orientation	61	5.28	8.86	7.1039	1.29401
Competition	61	5.08	6.38	5.9916	.42662
Order & Organization	61	3.4	9.1	5.626	2.2652
Rule Clarity	61	5.88	8.82	7.5659	.91037
Teacher Control	61	4.4	6.6	5.453	.7681
Innovation	61	3.0	6.0	4.277	.8696
CES Mean	61	5.1	7.2	6.112	.7382
Valid N (listwise)	51				

The above data shows that the three highest-rated environmental factors describing the classroom climate in all nine Algebra I classrooms, as perceived by the Hispanic population, were Rule Clarity, Task Orientation, and Teacher Support.

When examining the treatment class analysis of classroom climate, the following

changes emerged, as captured in Table 12.

Table 12

Cognitive Domain Pre- and Post-Test Measures Alongside the Nine Classroom Environment Survey Measures for Hispanic Students in the Experimental Group Alone

Measures	N	Minimum	Maximum	Mean	Std. Deviation
Pre Computation	28	76	146	102.04	16.592
Post Computation	27	76	130	105.33	10.972
Change in Computation	24	-48	26	2.96	14.669
Pre Application	28	67	133	95.61	14.525
Post Application	27	83	138	98.33	11.662
Change in Application	24	-26	30	2.67	13.480
Innovation	31	3.88	4.46	4.3168	.21485
Affiliation	31	6.16	6.92	6.6665	.32914
Teacher Support	31	6.36	7.04	6.8761	.25052
Task Orientation	31	5.28	6.31	5.9887	.43737
Competition	31	5.08	6.38	6.0077	.50934
Order & Organization	31	3.4	4.0	3.910	.2277
Rule Clarity	31	5.88	7.27	6.8223	.58613
Teacher Control	31	4.4	5.1	4.869	.3283
Innovation	31	4.1	4.9	4.715	.3407
CES Mean	31	5.1	5.8	5.575	.3221
Valid N (listwise)	24				

Within the treatment classroom, Rule Clarity and Teacher Support were still ranked among the top three characteristics of the classroom climate, but classroom Affiliation out-ranked Task Orientation as a leading descriptor of the class. Expanding the test of between-subject effects to include a larger sample size of all classes with covariate environment total mean score, having the dependent variable as change in computation, resulted in Table 11. No significant differences were noted in change scores for Math Computation skills between students in the experimental and control conditions after controlling for classroom environmental factors, $F(1, 48) = 0.403, p = .528$.

Table 13

Tests of Between-Subjects Effects With Dependent Variable as Change in Computation, Having Larger Sample With Covariate of Classroom Environment Total Mean Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	95.091 ^a	2	47.546	.376	.688	.015
Intercept	63.157	1	63.157	.500	.483	.010
CES_Mean	95.091	1	95.091	.753	.390	.015
Condition	50.946	1	50.946	.403	.528	.008
Error	6062.830	48	126.309			
Total	6605.000	51				
Corrected Total	6157.922	50				

Note. Computed using alpha = .05

Performing a univariate analysis of variance for between-subject factors, having the change in application as the dependent variable, yields Table 14.

Table 14

Variance for Between-Subject Factors, With Change in Application as the Dependent Variable

Condition	Mean	Std. Deviation	N
Control	.44	15.200	27
Experimental	2.67	13.480	24
Total	1.49	14.317	51

No significant differences were noted in change scores for Math Application skills between students in the experimental and control conditions after controlling for classroom environmental factors, $F(1, 48) = 2.75, p = .104$ (Table 15).

Table 15

Test of Between Subject Effects, With Change in Application as the Dependent Variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	668.263 ^a	2	334.132	1.674	.198	.065
Intercept	556.519	1	556.519	2.788	.101	.055
CES Mean	605.518	1	605.518	3.034	.088	.059
Condition	548.827	1	548.827	2.750	.104	.054
Error	9580.482	48	199.593			
Total	10362.000	51				
Corrected Total	10248.745	50				

The following two tables, Table 16 and Table 17, use Pearson Correlation (Two-Tailed) methodology for analysis between each of the four BASI measures (pre- and

post-test for computation and application) and each of the nine Classroom Environment Survey measures (involvement, affiliation, teacher support, task orientation, competition, order and organization, rule clarity, teacher control, and innovation) as applied to change in application.

Table 16

Pearson Correlations Across All Nine Classroom Environmental Factors

		Change Application	I	A	TS	TO	C	OO
BASI Pre Computation	Pearson	-.224	-.093	-.343**	-.181	.025	-.305*	-.033
	Correlation							
	Sig. (2-tailed)	.114	.492	.009	.177	.855	.021	.808
	N	51	57	57	57	57	57	57
BASI Post Computation	Pearson	-.125	.040	-.265	-.034	.158	-.237	.074
	Correlation							
	Sig. (2-tailed)	.384	.770	.050	.804	.250	.082	.590
	N	51	55	55	55	55	55	55
Change in Computation	Pearson	.176	.078	.114	.076	.065	.085	.064
	Correlation							
	Sig. (2-tailed)	.217	.587	.424	.594	.650	.551	.654
	N	51	51	51	51	51	51	51
BASI Pre Application	Pearson	-.474**	-.301*	-.393**	-.432**	.084	-.359**	-.165
	Correlation							
	Sig. (2-tailed)	.000	.023	.002	.001	.533	.006	.220
	N	51	57	57	57	57	57	57
BASI Post Application	Pearson	.462**	-.150	-.147	-.155	.046	-.110	-.136
	Correlation							
	Sig. (2-tailed)	.001	.275	.283	.258	.738	.424	.323
	N	51	55	55	55	55	55	55
Change in Application	Pearson	1	.155	.266	.289*	-.075	.272	.025
	Correlation							
	Sig. (2-tailed)		.279	.059	.040	.603	.054	.861
	N	51	51	51	51	51	51	51
Involvement	Pearson	.155	1	.625**	.833**	.691**	.487**	.902**
	Correlation							
	Sig. (2-tailed)	.279		.000	.000	.000	.000	.000
	N	51	61	61	61	61	61	61
Affiliation	Pearson	.266	.625**	1	.691**	.408**	.791**	.521**
	Correlation							
	Sig. (2-tailed)	.059	.000		.000	.001	.000	.000
	N	51	61	61	61	61	61	61
Teacher Support	Pearson	.289*	.833**	.691**	1	.462**	.652**	.663**
	Correlation							
	Sig. (2-tailed)	.040	.000	.000		.000	.000	.000
	N	51	61	61	61	61	61	61

(continued)

		Change Application	I	A	TS	TO	C	OO
Task Orientation	Pearson Correlation	-.075	.691**	.408**	.462**	1	.215	.896**
	Sig. (2-tailed)	.603	.000	.001	.000		.096	.000
	N	51	61	61	61	61	61	61
Competition	Pearson Correlation	.272	.487**	.791**	.652**	.215	1	.286*
	Sig. (2-tailed)	.054	.000	.000	.000	.096		.026
	N	51	61	61	61	61	61	61
Order & Organization	Pearson Correlation	.025	.902**	.521**	.663**	.896**	.286*	1
	Sig. (2-tailed)	.861	.000	.000	.000	.000	.026	
	N	51	61	61	61	61	61	61
Rule Clarity	Pearson Correlation	-.030	.606**	.471**	.518**	.936**	.410**	.779**
	Sig. (2-tailed)	.835	.000	.000	.000	.000	.001	.000
	N	51	61	61	61	61	61	61
Teacher Control	Pearson Correlation	-.145	.315*	.292*	.131	.850**	.119	.578**
	Sig. (2-tailed)	.309	.014	.023	.314	.000	.361	.000
	N	51	61	61	61	61	61	61
Innovation	Pearson Correlation	.310*	-.219	.184	.214	-.632**	.258*	-.529**
	Sig. (2-tailed)	.027	.090	.155	.097	.000	.045	.000
	N	51	61	61	61	61	61	61
CES Mean	Pearson Correlation	.108	.909**	.699**	.794**	.886**	.526**	.939**
	Sig. (2-tailed)	.451	.000	.000	.000	.000	.000	.000
	N	51	61	61	61	61	61	61

Note. ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 17

Correlations – Classroom Environment, Correlations, and Larger Sample With Covariate

Measure		RC	TC	Inn	CES Mean
BASI Pre Computation	Pearson Correlation	.026	.129	-.260	-.102
	Sig. (2-tailed)	.849	.338	.051	.449
	N	57	57	57	57
BASI Post Computation	Pearson Correlation	.143	.194	-.196	.048
	Sig. (2-tailed)	.298	.155	.152	.730
	N	55	55	55	55
Change in Computation	Pearson Correlation	.023	-.022	.092	.085
	Sig. (2-tailed)	.875	.878	.522	.555
	N	51	51	51	51
BASI Pre Application	Pearson Correlation	.099	.349**	-.314*	-.184
	Sig. (2-tailed)	.462	.008	.018	.170
	N	57	57	57	57
BASI Post Application	Pearson Correlation	.113	.259	-.031	-.059
	Sig. (2-tailed)	.412	.057	.819	.666
	N	55	55	55	55
Change in Application	Pearson Correlation	-.030	-.145	.310*	.108
	Sig. (2-tailed)	.835	.309	.027	.451
	N	51	51	51	51
Involvement	Pearson Correlation	.606**	.315*	-.219	.909**
	Sig. (2-tailed)	.000	.014	.090	.000
	N	61	61	61	61
Affiliation	Pearson Correlation	.471**	.292*	.184	.699**
	Sig. (2-tailed)	.000	.023	.155	.000
	N	61	61	61	61
Teacher Support	Pearson Correlation	.518**	.131	.214	.794**
	Sig. (2-tailed)	.000	.314	.097	.000
	N	61	61	61	61
Task Orientation	Pearson Correlation	.936**	.850**	-.632**	.886**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	61	61	61	61
Competition	Pearson Correlation	.410**	.119	.258*	.526**
	Sig. (2-tailed)	.001	.361	.045	.000
	N	61	61	61	61
Order & Organization	Pearson Correlation	.779**	.578**	-.529**	.939**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	61	61	61	61

(continued)

Measure		RC	TC	Inn	CES Mean
Rule Clarity	Pearson Correlation	1	.886**	-.515**	.862**
	Sig. (2-tailed)		.000	.000	.000
	N	61	61	61	61
Teacher Control	Pearson Correlation	.886**	1	-.625**	.630**
	Sig. (2-tailed)	.000		.000	.000
	N	61	61	61	61
Innovation	Pearson Correlation	-.515**	-.625**	1	-.322*
	Sig. (2-tailed)	.000	.000		.011
	N	61	61	61	61
CES Mean	Pearson Correlation	.862**	.630**	-.322*	1
	Sig. (2-tailed)	.000	.000	.011	
	N	61	61	61	61

Note. ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Correlation is most significant among the factors of Rule Clarity, Task Orientation, Teacher Support, Affiliation, and Involvement.

Tables 18 and 19 show the CES scores across the six control group classrooms and the three experimental or treatment classes, respectively. Note that in the control classrooms, Rule Clarity, Task Orientation, and Order and Organization were leading characteristics of the environment. In the treatment classes, Teacher Support replaced Rule Clarity, Rule Clarity replaced Task Orientation, and Affiliation replaced Order and Organization as the top three classroom characteristics.

Table 18

Descriptive Statistics for Classroom Environment Scores for the Six Control Classrooms

Measures	N	Minimum	Maximum	Mean	Std. Deviation
Involvement	6	2.38	7.75	6.1408	1.98319
Affiliation	6	6.08	7.67	6.8989	.52825
Teacher Support	6	6.29	8.11	7.3736	.62311
Task Orientation	6	7.00	8.86	8.2989	.80475
Competition	6	5.38	6.25	6.0042	.33533
Order & Organization	6	3.9	9.1	7.562	2.0927
Rule Clarity	6	7.67	8.82	8.3561	.43616
Teacher Control	6	5.0	6.6	6.047	.6473
Innovation	6	3.0	6.0	3.832	1.0882
CES Mean	6	5.5	7.2	6.724	.6414
Valid N (listwise)	6				

Table 19

Descriptive Statistics for Classroom Environment Scores for Three Treatment Classrooms

Measures	N	Minimum	Maximum	Mean	Std. Deviation
Involvement	3	3.88	4.46	4.1933	.29280
Affiliation	3	6.16	6.92	6.4733	.39716
Teacher Support	3	6.36	7.04	6.7333	.34487
Task Orientation	3	5.28	6.31	5.7833	.51540
Competition	3	5.08	6.38	5.7067	.65126
Order & Organization	3	3.4	4.0	3.810	.3554
Rule Clarity	3	5.88	7.27	6.4767	.71557
Teacher Control	3	4.4	5.1	4.700	.3800
Innovation	3	4.1	4.9	4.607	.4429
CES Mean	3	5.1	5.8	5.387	.3845
Valid N (listwise)	3				

A significant difference emerged between classroom environment scores obtained in the control conditions ($M = 6.72$) and experimental conditions ($M = 5.39$), where $F(1, 7) = 3.574$, $p = .014$. In particular, classroom environments in the control conditions were rated more favorably than those in the experimental conditions. R Squared = .603 (Adjusted R Squared = .546). Table 20 applies.

Table 20

Tests of Between Subjects Effects Where the Dependent Variable is the CES Mean

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.574 ^a	1	3.574	10.634	.014	.603
Intercept	293.346	1	293.346	872.77	.000	.992
Condition	3.574	1	3.574	10.634	.014	.603
Error	2.353	7	.336			
Total	360.672	9				
Corrected Total	5.927	8				

A second ANOVA was run with a smaller sample, drawing on the third treatment class and all other Hispanic control participants. An ANCOVA with classroom environment (e.g., overall classroom mean scores from the CES measure) as a covariate and change scores from BASI application and computation tests as the dependent measures also were run.

Experimental Class III was of special interest to the researcher, as the classroom was a Spanish inclusion class with a population of 19 Hispanic students (out of 29 total students in the class). The classroom culture was more open to natural bilingualism among students, the Hispanic worksheets were used in smaller collaborative monolingual groups, and the treatments were applied with greater fidelity than in any other experimental Algebra I classroom.

Table 21

Condition for Experimental Class III Only

Measures	N	Minimum	Maximum	Mean	Std. Deviation
BASI Pre Computation	17	76	146	96.82	17.103
BASI Post Computation	15	76	130	102.47	12.535
Change in Computation	13	-48	26	5.15	17.902
BASI Pre Application	17	67	133	93.82	15.424
BASI Post Application	15	83	118	99.00	9.710
Change in Application	13	-26	30	5.46	14.286
Involvement	19	4.46	4.46	4.4600	.00000
Affiliation	19	6.92	6.92	6.9200	.00000
Teacher Support	19	7.04	7.04	7.0400	.00000
Task Orientation	19	6.31	6.31	6.3100	.00000
Competition	19	6.38	6.38	6.3800	.00000
Order & Organization	19	4	4	4.00	.000
Rule Clarity	19	7.27	7.27	7.2700	.00000
Teacher Control	19	5.12	5.12	5.1200	.00000
Innovation	19	4.92	4.92	4.9200	.00000
CES Mean	19	5.8	5.8	5.824	.0000
Valid N (listwise)	13				

Experimental Group III still held to Rule Clarity, Teacher Support, and Affiliation as placing highest in their evaluation on the classroom environment scale.

Univariate analysis of variance for between-subject factors for both change in

computation and change in application were conducted, comparing the students in Experimental Group III and the Hispanic students in the control classes (Table 22).

Table 22

Tests of Between-Subjects Effects Where the Dependent Variable is the Change in Computation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	82.164 ^a	2	41.082	.303	.740	.016
Intercept	17.444	1	17.444	.129	.722	.003
CES Mean	40.044	1	40.044	.295	.590	.008
Condition	80.479	1	80.479	.594	.446	.016
Error	5014.611	37	135.530			
Total	5637.000	40				
Corrected Total	5096.775	39				

No significant differences were noted in change scores for Math Computation skills between students in the Experimental Class III and control conditions after controlling for classroom environmental factors, with $F(1, 37) = 0.594$, $p = .446$. (R Squared = .016, adjusted R Squared = -.037).

Table 23

Tests of Between-Subjects Effects for the Smaller Group With No Covariate With Change in Computation as the Dependent Variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	42.120 ^a	1	42.120	.317	.577	.008
Intercept	578.120	1	578.120	4.346	.044	.103
Condition	42.120	1	42.120	.317	.577	.008
Error	5054.655	38	133.017			
Total	5637.000	40				
Corrected Total	5096.775	39				

Testing of between-subject effects for the smaller group with no covariate still shows this is not significant (Table 23).

Table 24 shows no significant differences were noted in change scores for math application skills between students in Experimental Class III and control conditions after controlling for classroom environmental factors, $F(1, 37) 2.585, p = .116$.

Table 24

Tests of Between-Subjects Effects With Change in Application as the Dependent Variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	617.119 ^a	2	308.559	1.417	.255	.071
Intercept	334.175	1	334.175	1.534	.223	.040
CES Mean	396.241	1	396.241	1.819	.186	.047
Condition	563.090	1	563.090	2.585	.116	.065
Error	8059.656	37	217.829			
Total	8849.000	40				
Corrected Total	8676.775	39				

Note. a. R Squared = .071 (Adjusted R Squared = .021)

Smaller sample ANOVA showed no significant differences in change scores for Math Computation skills between students in the experimental and control conditions after controlling for classroom environmental factors, $F(1, 38) = 0.317, p = .577$.

No significant differences were noted in change scores for Math Application skills between students in the experimental and control conditions after controlling for classroom environmental factors, with $F(1, 38) = 0.993, p = .325$.

A smaller sample ANCOVA with Classroom Environment as a covariate was also examined. After controlling for classroom environment, no significant differences were noted in change scores for Math Computation skills between students in the experimental and control conditions after controlling for classroom environmental factors, with $F(1, 37) = 0.594, p = .446$.

After controlling for classroom environment, no significant differences were noted in change scores for Math Application skills between students in the experimental

and control conditions after controlling for classroom environmental factors, with $F(1, 37) = 2.59, p = .116$.

A larger sample, with ANCOVA controlling for classroom environment, was examined. No significant differences were noted in change scores for Math Computation skills between students in the experimental and control conditions after controlling for classroom environmental factors, with $F(1, 48) = 0.403, p = .528$.

No significant differences were noted in change scores for Math Application skills between students in the experimental and control conditions after controlling for classroom environmental factors, with $F(1, 48) = 2.75, p = .104$.

To mitigate the impact on the data due to the statistically small number of participants in Experimental Class III ($n = 19$), the following graphs capture classroom environmental scores juxtaposed with BASI application and computational growth (Figure 3), application and computational growth (Figure 4), and CES scores for Hispanic students only, superimposed on overall classroom scores (Figure 5).

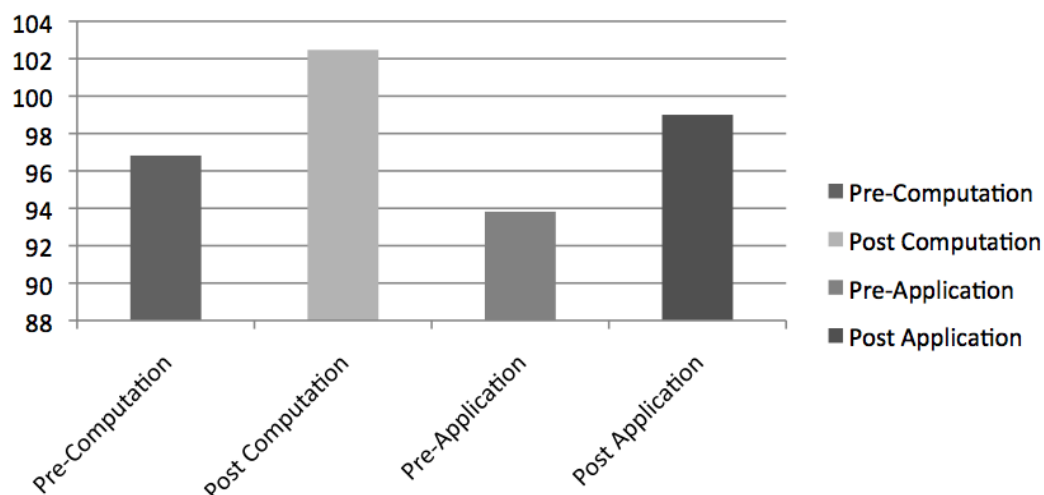


Figure 3 - Experimental Class III Pre and Post BASI Test

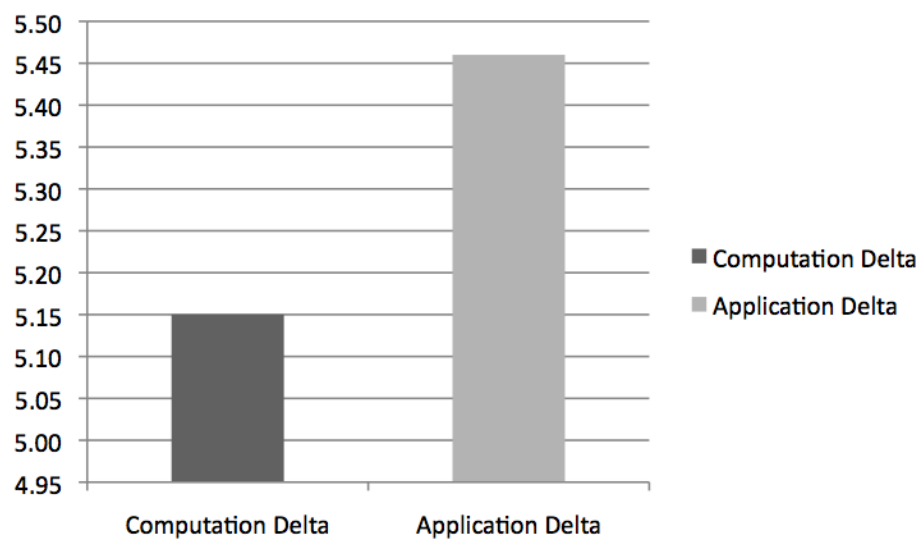


Figure 4 - Experimental Class III Computation and Application Growth

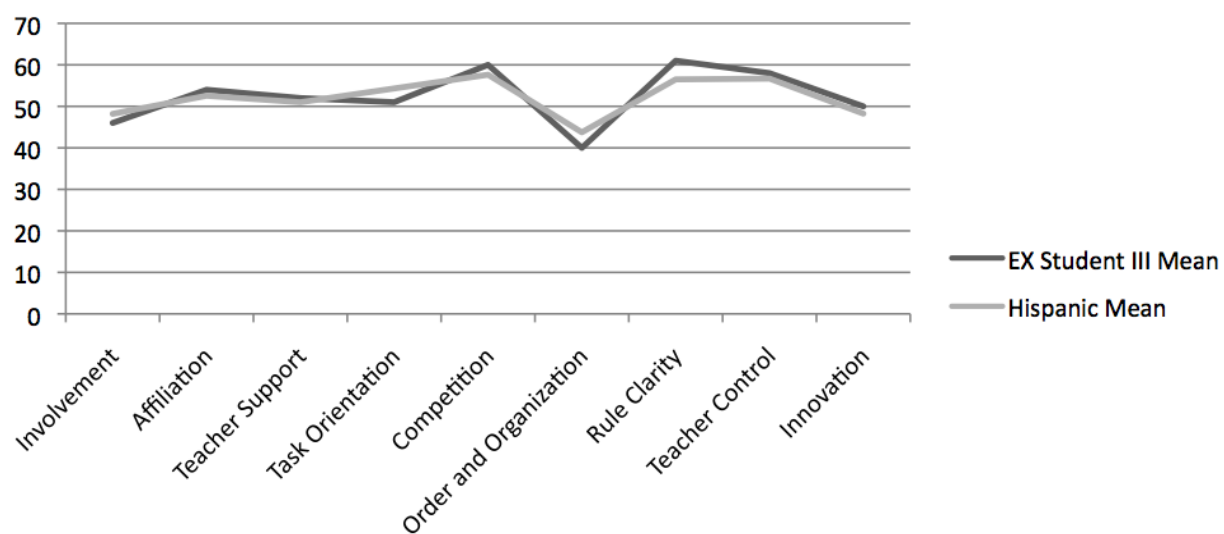


Figure 5 - Experimental Class III Classroom Environmental Scores

Differences in classroom environment between control and treatment conditions as measured by overall mean scores derived from the Classroom Environment scale were noted.

A significant difference emerged between classroom environment scores obtained in the control conditions ($M = 6.72$) and experimental conditions ($M = 5.39$), with $F(1, 7) = 3.574$, $p = .014$. In particular, classroom environments in the control conditions were rated more favorably than those in the experimental conditions.

To evaluate if there was a relationship between participants' satisfaction with math and their exposure to the instructional treatment, an initial Chi-Square was run with all "Math and Me" survey items.

Groups were developed to identify students' levels of participation in the study (experimental or control) as well as their responses to the "Math and Me" survey. Specifically, "Math and Me" responses were grouped according to "high" or "low" outcomes. Results indicate that there is no relationship between participants' treatment conditions and their post-test scores on the Math Satisfaction survey (partitioned into low or high scores), where $\chi^2(2) = .000$ and $p = 1.00$ (Table 25).

Table 25

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.000 ^a	1	1.000		
Continuity Correction ^b	.000	1	1.000		
Likelihood Ratio	.000	1	1.000		
Fisher's Exact Test				1.000	.644
Linear-by-Linear Association	.000	1	1.000		
N of Valid Cases	36				

Note. a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00. – one of the assumptions of Chi-Square was met.

b. Computed only for a 2x2 table

Examining selected items from the “Math and Me” survey revealed small sample sizes hindered performing tests of significance across many of these items. However, a univariate analysis was performed to examine differences between conditions for select questions in the survey.

Survey item 1b asked participants to respond to the phrase, “I like math.” There were no significant differences between conditions on item number one at post-test survey time, with $F(1, 34) = 0.05$, $p = .825$ (Table 26).

Table 26

Tests of Between-Subjects Effects With Item 1b as the Dependent Variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.028 ^a	1	.028	.050	.825	.001
Intercept	330.028	1	330.028	592.308	.000	.946
Condition	.028	1	.028	.050	.825	.001
Error	18.944	34	.557			
Total	349.000	36				
Corrected Total	18.972	35				

Note. a. R Squared = .001 (Adjusted R Squared = -.028)

Survey item 7b, “My math teachers have allowed me to speak Spanish when trying to learn concepts in this class,” revealed no differences between control and experimental groups at post-test for item 7, $F(1, 32) = .856$, $p = .362$ (Table 27).

Table 27

Tests of Between-Subjects Effects With Item 7b as the Dependent Variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.827 ^a	1	.827	.856	.362	.026
Intercept	239.063	1	239.063	247.273	.000	.885
Condition	.827	1	.827	.856	.362	.026
Error	30.938	32	.967			
Total	270.000	34				
Corrected Total	31.765	33				

Note. a. R Squared = .026 (Adjusted R Squared = -.004)

Responses to the “Math and Me” pre- and post-survey administered to the Treatment Group is summarized in Table 28.

Table 28

Treatment Group Responses to “Math and Me” Pre- and Post-Treatment Survey

"Math and Me" Survey	Strongly Disagree	Disagree	Neutral	Agree
1. I like math (pre)		14.3	57.1	28.6
1. I like math (post)	5.6	11.1	61.1	22.2
2. I do well in math (pre)		28.6	57.1	14.3
2. I do well in math (post)	5.6	38.9	50	5.6
3. Prefer to ask in Spanish (pre)	14.3	42.9	42.9	
3. Prefer to ask in Spanish (post)	27.8	61.1	11.1	
4. Spanish primary language (pre)		14.3	28.6	57.1
4. Spanish primary language (post)	11.1	5.6	38.9	44.4
5. Express math in English (pre)		28.6	71.4	
5. Express math in English (post)		22.2	44.4	33.3
6. I think math in Spanish (pre)	14.3	57.1	28.6	
6. I think math in Spanish (post)	22.2	50	16.7	11.1
7. Allowed to speak Spanish (pre)			71.4	28.6
7. Allowed to speak Spanish (post)	6.3	31.3	37.5	25

Cognitive skills were reflected in the final Algebra I exams. An Analysis of Covariance was conducted to examine the differences in math skills across treatment and control conditions after controlling for performance at the final Algebra I exam (Table 29).

Table 29

Descriptive Statistics Having the Final Algebra I Exam as the Dependent Variable

Condition	Mean	Std. Deviation	N
Control	82.33	12.214	24
Experimental	77.64	12.538	28
Total	79.81	12.493	52

Table 30

Tests of Between-Subjects Effects Having the Final Algebra I Exam as the Dependent Variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6104.373 ^a	2	3052.187	80.593	.000	.767
Intercept	96.988	1	96.988	2.561	.116	.050
Mid	5820.058	1	5820.058	153.679	.000	.758
Condition	169.430	1	169.430	4.474	.040	.084
Error	1855.703	49	37.871			
Total	339162.000	52				
Corrected Total	7960.077	51				

Note. a. R Squared = .767 (Adjusted R Squared = .757)

Table 30 above shows that a significant difference is documented between final exam scores for control and experimental conditions with higher scores on final exams emerging within participants in the control condition ($M = 82.33$, $SD = 12.21$) than among participants in the experimental condition ($M = 77.64$, $SD = 12.54$), with $F(1, 49) = 4.74$, $p = 0.040$.

The following graphs summarize the pre- and post-test BASI assessments for

each of the experimental classes, along with growth models for BASI Computation and BASI Application by class, and a class mean for each of the three classroom climate factors with mean Hispanic perceptions plotted against mean class perceptions.

Experimental Class I hosted five self-identified Hispanic students in a class of 30, where one of the Hispanic students did not speak Spanish and the balance had completely exited from the ESL program. Pre- and post-BASI tests showed growth in math computation from $M=105.8$ to $M=111.8$. Pre- and post-BAIS test showed a decrease in math application, from $M=105.2$ to $M=103.4$. Based on the student survey, 80% stated that Spanish was the primary language spoken at home, 80% admitted to liking math, and 100% were allowed to speak Spanish while learning math concepts.

The Classroom Environment Survey (CES) showed that the Hispanic students on the whole scored their teacher more positively than the class average across all nine components except for Teacher Support (Hispanic Average 48, Entire Class Average, 49) and Competition (Hispanic Average 46, Entire Class Average, 48).

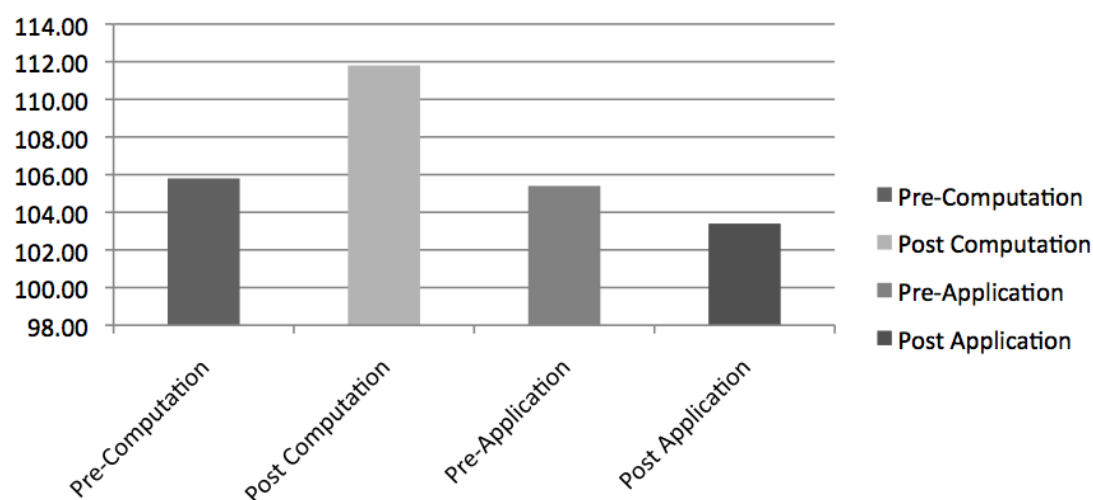


Figure 6 - Experimental Class I BASI Pre- and Post-Test Scores

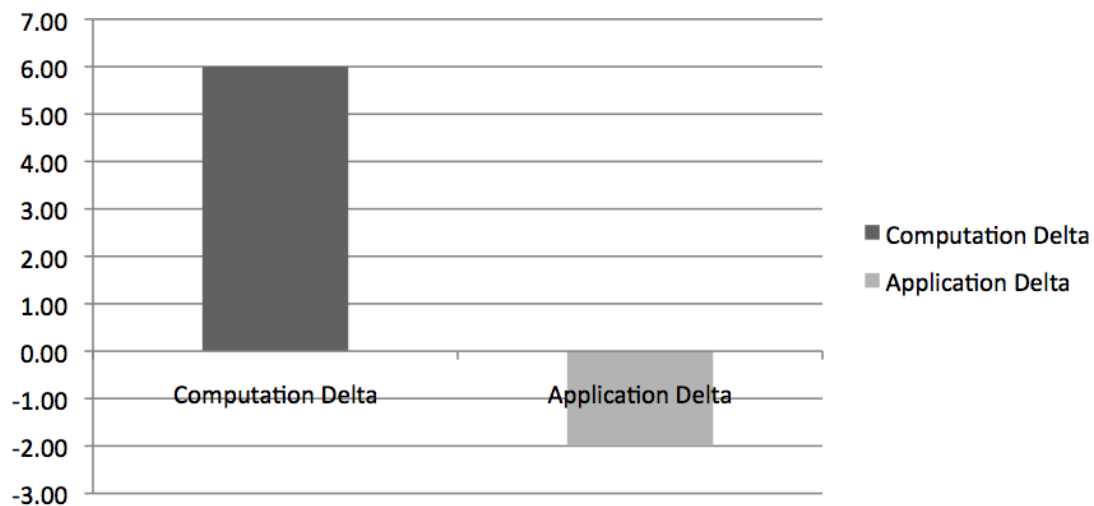


Figure 7 - Experimental Class I Computation and Application Change

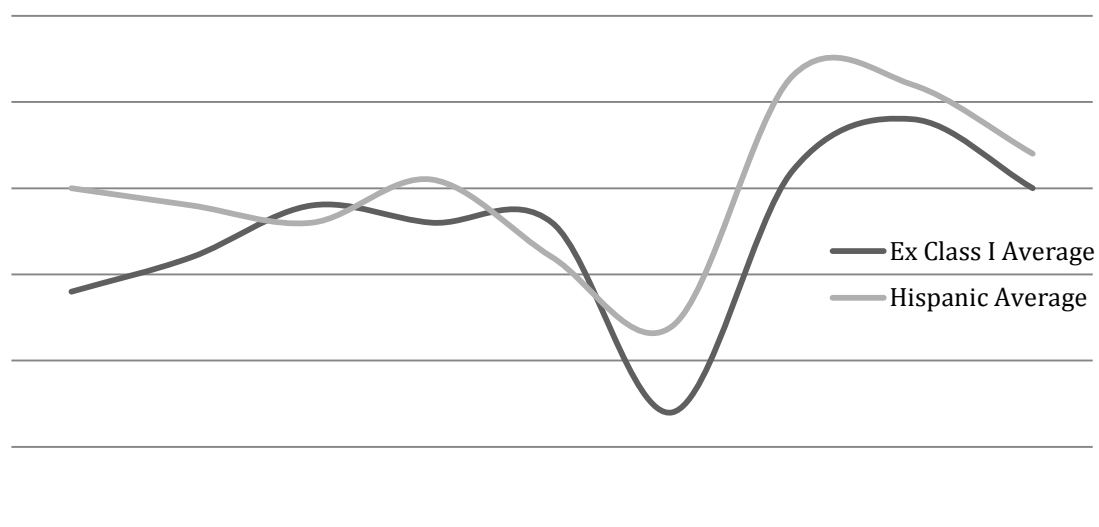


Figure 8 - Experimental Class I Environmental Survey: Hispanic vs. Whole Class

Experimental Class II contained six self-identified Hispanic students in a class of 30 students. Pre- and post-BASI test results showed decrease in math computational skills from $M=113.67$ to $M=106.86$ (-6.81). Pre- and post-BAIS test showed slight increase in math application skills, from $M=92.50$ to $M=93.29$ ($+0.79$). Based on the student survey, 80% stated that Spanish was the primary language spoken at home, 60%

admitted to liking math, and 20% were allowed to speak Spanish while learning math concepts.

The Classroom Environment Survey (CES) showed that the Hispanic students on the whole, scored their teacher more positively than the class average across all nine components except for Involvement (Hispanic Average 43, Entire Class Average, 44) and Affiliation (Hispanic Average 47.8, Entire Class Average, 50).

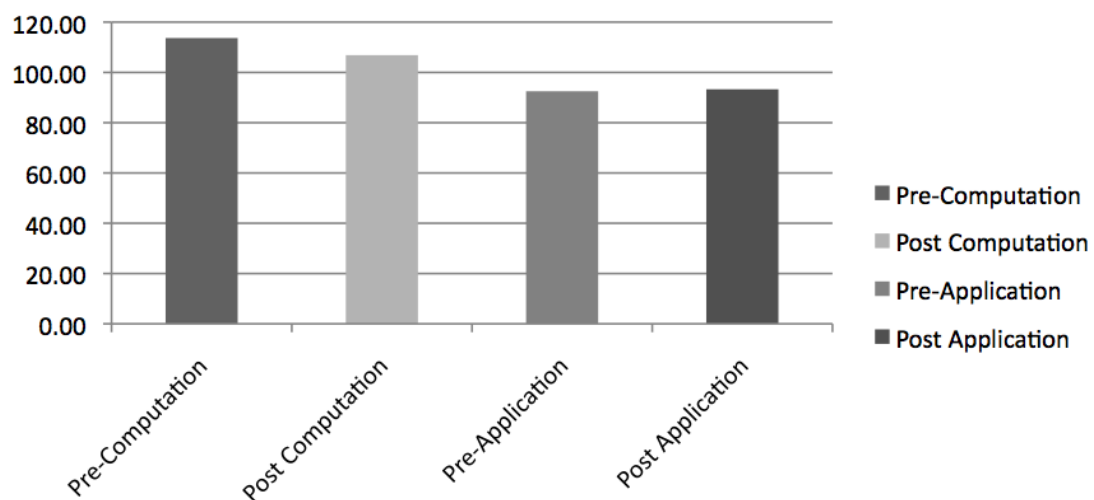


Figure 9 - Experimental Class II BASI Pre- and Post-Test Scores

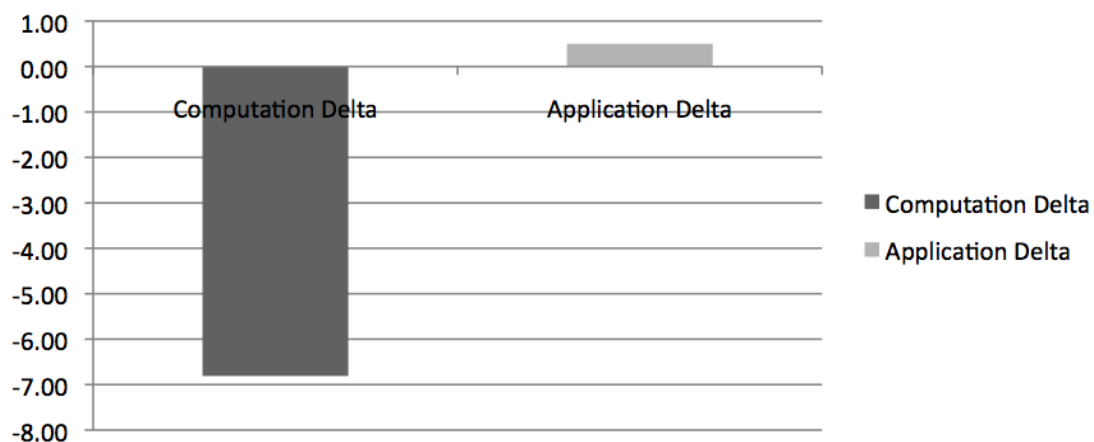


Figure 10 - Experimental Class II Computation and Application Change

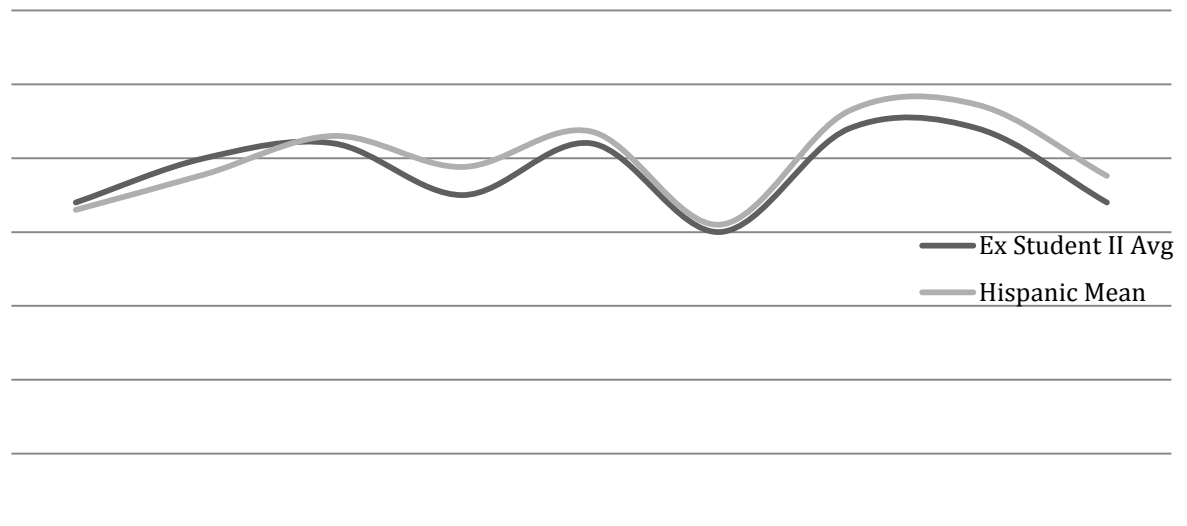


Figure 11 - Experimental Class II Environmental Survey: Hispanic vs. Whole Class

Nineteen self-identified Hispanic students were in a class of 27 students in Experimental Class III. Pre- and post-BASI tests showed an increase in math computational skills from $M=96.82$ to $M=102.47$ (+9.58). Pre- and post-BASI tests showed an increase in math application skills, from $M=93.82$ to $M=99.0$ (+5.18). Based on the student survey, 85% stated that Spanish was the primary language spoken at home, 92% admitted to liking math, and 77% were allowed to speak Spanish while learning math concepts. This class was an ESL inclusion class, hosting four Hispanic students who were in need of strong linguistic help, which merited a bi-lingual, teacher assistant to help with this small population of students.

The Classroom Environment Survey (CES) showed that the Hispanic students on the whole scored their teacher not as positively as the class average across all nine components. The areas where the Hispanic students scored higher than the rest of the class were Involvement (Hispanic Average 48.19, Class Average 46.00), Task

Orientation (Hispanic Average 54.31, Class Average 51.00), and Order and Organization (Hispanic Average 43.75, Class Average 40.00).

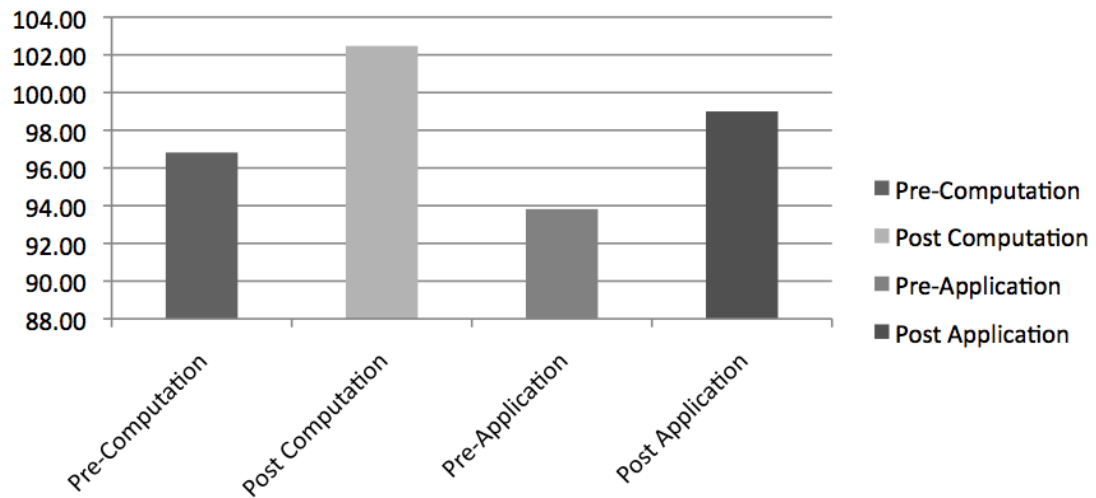


Figure 12 - Experimental Class III - BASI Pre- and Post-Test Scores

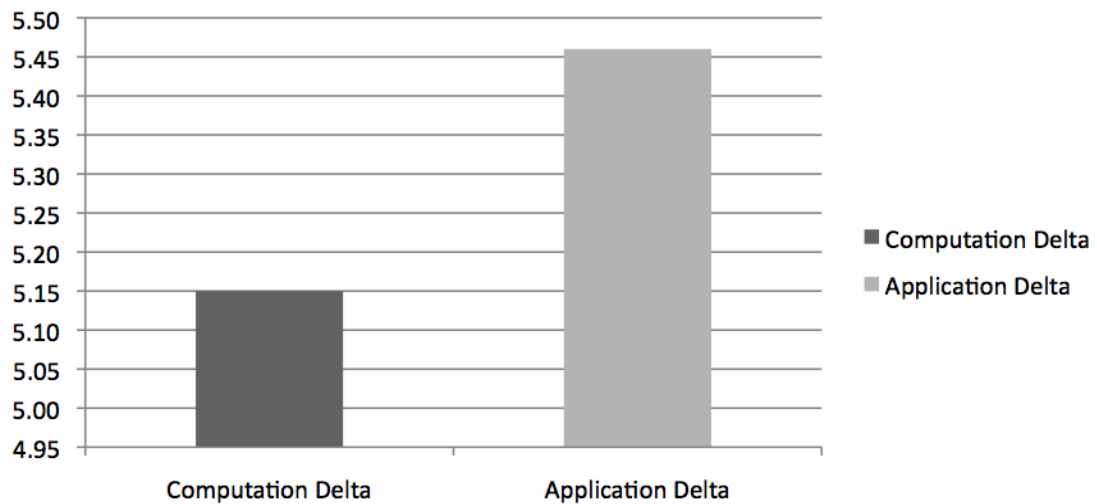


Figure 13 - Experimental Class III Computation and Application Change

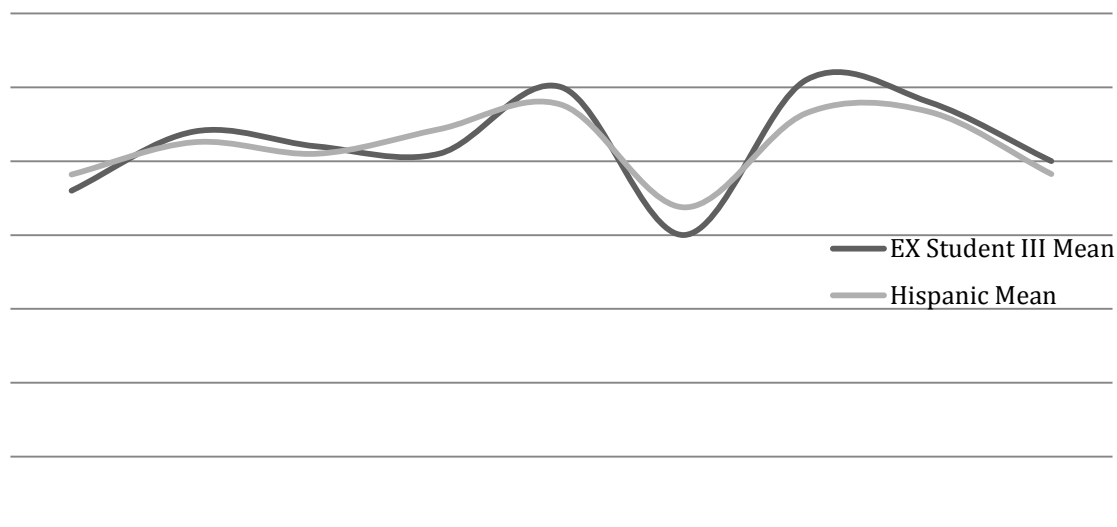


Figure 14 - Experimental Class III Environmental Survey: Hispanic vs. Whole Class

Summary

This chapter presented findings that addressed results from the following research:

- Control group pre- and post-test math computation and application scores
- Treatment group pre- and post-test math computation and application scores
- Change in computation and application skills for all Hispanic Algebra I students
- Self-assessment on personal attitude changes toward math over the semester
- Classroom environmental survey for all students across all nine Algebra I classes
- Hispanic assessment of classroom climate within specific classrooms
- Final Algebra I exam scores across all nine sections for both treatment and control groups

The above data is used in Chapter 5 to support the analysis, conclusions, and recommendations to answer the following Research Questions:

R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?

R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?

R3. What impact does bilingual treatment have on the classroom climate?

Chapter 5: Summary and Conclusions

Introduction

In this chapter, the researcher integrated the components of this study--cognitive domain characteristics, affective domain characteristics, and perceived classroom climate--together with a brief problem overview, implied conclusions that can be made based on data collected and analyzed, extrapolated applications for this study as well as recommend improvements and topics for future studies as a result of this work. The need to close the achievement gap for Hispanic students in mathematics is a national mandate, as this population among high school students seems to be lacking skill sets in both math computation and math application. Although this study was conducted in a central piedmont high school in North Carolina, the increasing number of Hispanic high school math students who are struggling academically in this discipline across America each year lends credibility to a rising and unanswered need in Algebra classrooms.

Problem

A central piedmont school district in North Carolina has documented a failure to make Adequate Yearly Progress (AYP) as set forth by the 2001 No Child Left Behind (NCLB) federal legislation among Hispanic Algebra I students for two consecutive years, the only subgroup not meeting AYP goals. Failure to demonstrate subject mastery in this gateway course has led to a growing number of Hispanic students being retained in the ninth grade, a major factor in the student falling into the at-risk category and a significant contributor to a student becoming discouraged and dropping out of high school.

Purpose of Study

The purpose of this study was to examine the effects on mathematics scores by

using bilingual treatment with Hispanic high school students in Algebra I classes in a central piedmont North Carolina school. Additionally, this research examined the effects on classroom climate brought about by the bilingual treatment. With minimal alteration in math content delivery methods and algorithm assimilation, this research measured the impact on Hispanic students' scores on norm-referenced mathematics tests.

Research Questions

R1. Are Algebra I skills improved among Hispanic students if the visual aids are subtitled with Spanish vocabulary equivalents during lesson presentation?

R2. Are Algebra I skills improved among Hispanic students when algorithm introduction is followed with application in monolingual, collaborative working groups?

R3. What impact does bilingual treatment have on the classroom climate?

Overview of Study

The literature review focused primarily on three key areas to be considered in teaching mathematics within a bilingual classroom setting. Prior studies defined obstacles to be overcome, recommended pedagogy to bridge linguistic barriers, and clarified the impact of classroom climate on student learning.

Where there is no mastery of the language of instruction, Gorgorió and Planas (2001) shared three observations: (a) not knowing everyday language interferes with work on mathematical activities, (b) teachers find difficulty in understanding students' thinking processes, and (c) students experience difficulties with the meaning of mathematical words or symbols. Raiker (2002) added a fourth observation in that rigid assessment techniques do not adequately capture student knowledge or understanding.

Identification of key vocabulary words and concepts is crucial in lesson planning, and equally important is the specific detail for conveying these ideas to English learners as well as to English as Second Language Learners (Raiker, 2002). The National Council of Teachers of Mathematics (2003) recommends that teachers enhance their concept presentations with bilingual enhancing techniques. Teachers need to have new terms written and plainly visible throughout lesson presentations, where terms can be referred to on a frequent basis. Once introduced, use of mathematical terms has to be ongoing until the terms become assimilated into the students' known mathematical vocabularies. This can be done through collaborative learning groups, in either monolingual or bilingual setting (Raiker, 2002).

At the conclusion of their research, Gersten and Baker (2000) identified five specific variables that potentially may significantly impact instruction in a bilingual setting: (a) building and using vocabulary as a curricular anchor, (b) using visual aids to reinforce concepts and vocabulary, (c) implementing cooperative learning and peer-tutoring strategies, (d) using native language strategically, and (e) modulating cognitive and language demands.

The National Research Council and the Institute of Medicine (2004) maintained that the characteristics of the educational context within which students learn has a strong affect on the students' active engagement in schooling. School learning research indicated that classroom characteristics in the affective domain rival traditional instructional and cognitive characteristics as they pertain to influencing student learning (Doll et al., 2010). The affective domain is a complex structural system consisting of four main components: emotions, attitudes, beliefs, and values (Nicolaou & Phillippou, 2007).

Miriam Alfassi (2003) suggested that applying a program geared to foster both academic competence and confidence provides a beneficial synergy to the student and supports the contention of social cognitive theory that to increase achievement, educational efforts need to be directed on raising student self-efficacy.

The researcher used the literature reviewed in this study to help formulate and construct the methodology that would be best suited to answer the three research questions.

Participants

Participants selected for treatment in this study were Hispanic students selected from the Algebra I classroom population in a central piedmont North Carolina high school. Since Algebra I is a year-long course, the first semester is referred to as Foundations of Algebra. It is this first semester Algebra I population that was the focus for the research. The participating high school scheduled nine Algebra I classes during the fall 2010 semester, enabling half of the Hispanic student population to receive the proposed treatment and the other half to serve as the control group. The sample treatment population were drawn from three Algebra I classes ($n = 28$) out of a total 238 students in the Foundations of Algebra fall 2010 cohort, whose data were compared with the Hispanic students in the six Algebra I control group classes ($n = 29$). Every Algebra I classroom in the experimental group received the same bilingual slide treatment and allowed students to use Spanish-language worksheets in collaborative, monolingual working groups immediately following instructional delivery. The control group received the same Microsoft PowerPoint slides without the Spanish subtitles and their work sheets were in English only.

Students considered Hispanic for the purposes of this research were those English-Language Learners who had been placed in an Algebra class due to demonstrating a Level 3 or higher competency level in the World-Class Instructional Design and Assessment (WIDA) Placement Test (WAPT) for Assessing Comprehension and Communication in English State to State (ACCESS)--more commonly known as WAPT/ACCESS--for English-Language Learners. Students who had already exited the program were also considered Hispanic for treatment purposes. The state-wide student database (NCWISE) generated Algebra I rosters designating the ESL population in each of nine classes, thereby defining the research population.

Summary of Results

After quantitative and qualitative analysis of the data collected, the research questions were answered as follows.

Results in the cognitive domain (R1 and R2). The tool used for pre- and post-test baseline and growth was the Basic Assessment of Skills Inventory (BASI) software. This assessment measured two major areas of mathematical skills: one involving mathematical computation and the other, mathematical application. BASI Computation subsumes the skills involving whole numbers, fractions, decimals and percents, integers, and basic algebra. BASI Application includes word problems, geometry, higher algebra and statistics (Bardos, 2004).

Prior to applying statistical analyses to the research questions, assumptions of independent observations, homogeneity of variances, and normal distribution of the dependent variable were examined. No significant violations were found that would impair inferences to be drawn from the analyses used to examine the research questions.

Separate univariate Analysis of Variance analyses were conducted to examine if differences existed in growth (change scores) over time in math application and computation skills between the treatment and control conditions. As noted in Table 3, no significant differences were found in math computation change scores for participants in the treatment ($M = 2.96$, $SD = 14.67$) versus control ($M = 2.96$, $SD = 6.82$) conditions, $F(1, 49) = 3.545$, $p = .066$.

Along a similar trend (see Table 4), no significant differences were found in math application change scores for participants in the treatment ($M = 2.67$, $SD = 13.48$) versus control ($M = 0.44$, $SD = 15.20$) conditions, where $F(1, 49) = .302$, $p = .585$.

If just the statistical data is looked at in the aggregate, one might conclude that the null hypothesis is validated and the treatment made no impact on growth rate in either math computation or application skills when comparing control and experimental classes. At this juncture, it is important to remember the differences between computation and application. Computation is comprised of basic math skills involving whole numbers, fractions, decimals and percents, integers, and basic algebra – all basic number manipulation, symbol recognition, and those components of mathematics that many consider the “universality” of math, much like music notes on a staff, which is not limited by language or cultural expression. The application part of the BASI pre- and post-testing was made up of word problems, geometry, higher algebra and statistics – all language intensive and terminology-specific manipulation of mathematics, where both linguistic specificity and mathematical terminology require a fuller grasp of language and cultural expression.

Experimental Class III was of special interest to the researcher. Made up of 19

Hispanic students (four of which were inclusion ESL students) out of a class size of 28, this treatment group exercised the research with the greatest level of fidelity. Students were engaged by the bi-lingual Power Point slides, readily broken up into Spanish-speaking collaborative work groups (or joined an English-speaking team if their language mastery was not an issue), and the conversations in the room were in both English and Spanish.

The statistical data addressing BASI change in computational growth and application growth for this class may not have had a sample population large enough to capture statistical affect for comparison between treatment and control groups. Yet Figure 1 did look at the math computation trend data over the course of the semester and Figure 2 did look at the math application trend data over the course of the semester. It is significant to note the steeper slope of the treatment group when it came to change in BASI application scores, indicating that this treatment group was growing at a faster rate than those in the control group. Since both control and treatment classes increased in computational skills at the same rate, the growth in application skills appeared to rest in the increased acquisition of the specific language of math in the cultural language of English. Student survey response to the “Math and Me” survey indicated a 33% increase in comfort level with expressing math ideas in English (Question #5, Table 28). These results were supported by both Gregorió and Planas (2001) and Reiker (2002) who asserted that mastering the language of math is key to performance and learning in a math classroom.

In addition to change in BASI scores, final math test scores were also examined for any differences between participants in the treatment or control groups after

controlling for participants' performances at the mid-point (midterm scores) of exposure to the treatment or control conditions. This was the third year (fifth administration) of a common Algebra I county-wide final math assessment.

An Analysis of Covariance was conducted to examine the differences in math skills across treatment and control conditions after controlling for performance at the 9-week mark. A significant difference was documented between final exam scores for control and experimental conditions with higher scores on final exams emerging within participants in the control condition ($M = 82.33$, $SD = 12.21$) than among participants in the experimental condition ($M = 77.64$, $SD = 12.54$), $F(1, 49) = 4.74$, $p = 0.040$. This was not surprising to the researcher, as the control classes started at a higher mean. What is significant is that the growth in class mean between the common mid-term exam and the common final Algebra I exam showed an improvement of 7.17 points for the treatment class when compared to the growth of 1.9 points for the control class growth. As the semester progressed, the curriculum for Foundations of Algebra moved more deeply into math application focus, with word problems, geometry, and basic Algebra skills – all more language intensive. The faster growth in technical language acquisition by the treatment groups over the control groups was evidenced by the faster rate of subject mastery, as measured by both common mid-term and final summative assessment.

Results in the affective domain (R3). Research Question 3 (R3) asked what the impact of the bilingual treatment might have on the classroom climate, and consequently, what impact the classroom climate might have on the cognitive domain. Chapter 4, Table 11, presented the cognitive domain data for Hispanic students in both control and treatment classes, as measured by the BASI Test, alongside the nine areas of classroom

climate in the affective domain, as measured by the Classroom Environment Surveys (CES). This table showed that no significant differences were noted in change scores for Math Computation skills between students in the experimental and control conditions after controlling for classroom environmental factors, $F(1, 48) = 0.403, p = .528$. Additionally, Table 15 showed that no significant differences were noted in change scores for Math Application skills as well between students in the experimental and control conditions after controlling for classroom environmental factors, $F(1, 48) = 2.75, p = .104$.

Differences in classroom environment between control and treatment conditions as measured by overall mean scores derived from the Classroom Environment Scale were noted. A significant difference emerged between classroom environment scores obtained in the control ($M = 6.72$) and experimental ($M = 5.39$) conditions, $F(1,7) = 3.574, p = 0.014$. In particular, classroom environments in the control conditions were rated more favorably than those in the experimental conditions.

Data collected among the Hispanic students in the control groups showed that 16.7% agreed that Spanish was the primary language spoken at home (Question 4), 91.3% disagreed that they think in Spanish when working a math problem (Question 6), and 70.8% disagreed that their teachers have allowed them to speak Spanish when trying to learn concepts in class (Question 7). Where the language of learning is not different from the language of teaching in a given classroom, the treatments designed to bridge linguistic barriers are moot.

Data collected among the Hispanic students in the treatment groups showed that 57% agreed that Spanish was the primary language spoken at home (Question 4), 71.4%

disagreed that they think in Spanish when working a math problem (Question 6), and 37% disagreed that their teachers have allowed them to speak Spanish when trying to learn concepts in class (Question 7). Experimental Class III broke out at 84% with Spanish as the primary language, 61% disagreed that they think in Spanish when working math problems, and 23% disagreed that their teachers have allowed them to speak Spanish when trying to learn concepts in class. For the treatment classes, the focus on conveying the technical language of math in English to a Hispanic English Language Learner using bridging techniques was more sharply defined.

Observations and potential impact. The four Foundations of Algebra teachers decided that after examining the numbers and demographics of each of their respective classes, one teacher would assume ownership of the three experimental classes and the other three teachers the balance of the six remaining control classes. Teacher interviews were conducted at the 12-week mark of the semester to help frame the pedagogical philosophies, attitudes, and dispositions of the teachers involved as well as ascertain classroom climate delimiters inherent to each instructor. Since all experimental classes were taught by the same teacher, it was instrumental to the research in question to delve into the nature of this single instructor, whom we shall identify as Mr. Experimental, or simply, Mr. E.

Mr. E has taught for 17 years in two states, Florida and North Carolina. He has been at this high school for six years, teaching Algebra and Foundations of Algebra, and more specifically inclusion Foundations of Algebra, which puts children from both the Exceptional Children and English as Second Language subgroups in his class. Case-and-point, during the course of this experiment, five of the 19 Hispanic students in Mr. E's

Experimental Group III spoke no English on entry to his class. A second teacher, an ESL teacher, was added to that class to help these students cope with learning English in a classroom setting. Mr. E stated he had spent some time as a teacher with the Sylvan Learning Center, where he gained an appreciation for teaching students the reading skills so important in a math classroom setting. He stated, “We do a lot of word problems now.” Mr. E is the chair of the Algebra I collaborative working group in his department’s Professional Learning Community.

Mr. E’s personal philosophy has been to focus on the individual child to meet his or her needs, something he attributes to the influences of the Sylvan Learning model of one-on-one instruction, as well as a philosophy attributable to the social realities of lack of parental involvement at home and the teachers having to assume in *loco parentis* roles to mold and shape the child. He works on establishing personal relationships with each student and avails himself to his students during and after classes for help with math issues and “life issues.” Mr. E feels comfortable with technology, rues the fact that he only got the laptop and projector as part of an experiment and that he will lose it at the end of the semester, and embraced the bilingual slides as a key element in teaching the language of math and supporting this device to enhance accuracy among his entire Algebra class population – not just the Hispanic students.

Experimental class I. Descriptors: Experimental Class I hosted five self-identified Hispanic students in a class of 30, where one of the Hispanic students did not speak Spanish, and the balance had completely exited the ESL program. Pre- and post-BASI test (Chapter 4, Figure 6) showed growth in math computation from $M=105.8$ to $M=111.8$. Pre- and post-BAIS test showed decrease in math application, from $M=105.2$

to $M=103.4$. Based on the student survey, 80% stated that Spanish was the primary language spoken at home, 80% admitted to liking math, and 100% were allowed to speak Spanish while learning math concepts.

The Classroom Environment Survey (CES) (Chapter 4, Figure 8) showed that the Hispanic students on the whole scored their teacher more positively than the class average across all nine components except for Teacher Support (Hispanic Average 48, Entire Class Average, 49) and Competition (Hispanic Average 46, Entire Class Average, 48).

Impact on experimental class I. Students' attitudes regarding math were positive overall and these feelings were enhanced by the teacher friendliness and the students' ability to work together and talk (Student Surveys). It is important to note that there was greater feeling of Affiliation and Involvement by the Hispanic students than their non-Hispanic counterparts in the same class. Coupled with a higher perception level of Rule Clarity, Order and Organization, and Innovation, these students gained in terms of assessment results as the semester wore on, but did not appear to increase their math application skills as measured by the BASI test. Hispanic Experimental Group I class average mid-term Foundations of Algebra exam improved from a score of $M=72.4\%$ to $M=80.6\%$ for the common, county-wide final exam.

Experimental class II. Six self-identified Hispanic students were in this class of 30 students. Pre- and post-BASI test results (Chapter 4, Figure 10) showed a decrease in math computational skills from $M=113.67$ to $M=106.86$ (-6.81). Pre- and post-BAIS tests showed a slight increase in math application skills, from $M=92.50$ to $M=93.29$ ($+0.79$). Based on the student survey, 80% stated that Spanish was the primary language spoken at

home, 60% admitted to liking math, and 20% were allowed to speak Spanish while learning math concepts.

The Classroom Environment Survey (CES) (Chapter 4, Figure 11) showed that the Hispanic students on the whole scored their teacher more positively than the class average across all nine components except for Involvement (Hispanic Average 43, Entire Class Average, 44) and Affiliation (Hispanic Average 47.8, Entire Class Average, 50). Of the three treatment classes, Experimental Group II was the most reluctant to embrace the post-lesson-delivery opportunity to gather in a monolingual working group or to use the Spanish worksheets. Their grasp of English appeared adequate during classroom interactions and the researcher surmised that to opting to engage in this monolingual effort would have singled them out from their classmates, possibly contributing to social isolation. Their corporate decision to not break out from the pack may have contributed to their personal lower ranking of their sense of belonging in the Involvement and Affiliation categories of classroom climate.

Though this group showed a slight decrease in math computation skills and a slight increase in math application skills, Hispanic Experimental Group II class average mid-term Foundations of Algebra exam improved from a score of $M=78.5\%$ to $M=85.33\%$ for the common, county-wide final exam.

Experimental class III. There were 19 self-identified Hispanic students in this class of 27 students. Pre- and post-BASI test (Chapter 4, Figure 12) showed an increase in math computational skills from $M=96.82$ to $M=102.47$ (+9.58). Pre- and post-BAIS test showed an increase in math application skills, from $M=93.82$ to $M=99.0$ (+5.18). Based on the student survey, 85% stated that Spanish was the primary language spoken at

home, 92% admitted to liking math, and 77% were allowed to speak Spanish while learning math concepts. This class was an ESL inclusion class, hosting four Hispanic students who were in need of strong linguistic help, which merited a bi-lingual, teacher assistant to help with this small population of students.

Classroom Environment Survey (CES) (Chapter 4, Figure 14) showed that the Hispanic students on the whole, scored their teacher not as positively than the class average across all nine components. The areas where the Hispanic students scored higher than the rest of the class were Involvement (Hispanic Average 48.19, Class Average 46.00), Task Orientation (Hispanic Average 54.31, Class Average 51.00), and Order and Organization (Hispanic Average 43.75, Class Average 40.00). Student survey comments spoke to the positive feelings of getting together and working in [Spanish] groups, of learning with friends, of the fun teacher, of being able to speak in Spanish to ask for clarification (this last comment written in Spanish on the questionnaire), and of finally being able to learn math. The interview with Mr. E spoke to his perception of improved student engagement using the technology, of the improved student perception that their language and culture were important, and that there was ebb and flow between English-only and Spanish-only student collaborative groups, as some students felt equally comfortable working in either language setting. The researcher noted during classroom observations in Experimental Group III the smooth flow of code-switching and language mixing among the Hispanic students as they discussed certain math problems in their learning groups.

Hispanic Experimental Group III class average mid-term Foundations of Algebra exam improved from a score of $M=68.76\%$ to $M=75.24\%$ for the common, county-wide

final exam.

Unexpected Findings

This research called for a minimal amount of technology in that both a laptop or personal computer and a LCD projector were required to present the lessons using Microsoft's Power Point software. Among the four classrooms, only one teacher (Control Group I) had an interactive Smart Board. The researcher had to provide two of the three remaining teachers with laptop and projector, and the fourth teacher (Control Groups IV, V, and VI) simply used her existing television monitor and an Averkey conversion box to show the power point lessons provided by the researcher on the TV screen, hooked up from her desk-top personal computer.

The apparent comfort level by the teachers with technology was of note. Both the youngest teacher and the most senior teacher did not take to the power point medium naturally. It was the most senior teacher (Control Groups II and III) that embraced the use of technology with most spirit. When in her class, the researcher was amused to find the projection well off the projection screen, taking up most of the classroom wall, but the lesson went on and the visual learners and her EC students appreciated the slides. Several students expressed as much to the researcher, who was introduced to the class as "the guy who made the power point."

The youngest, initially licensed teacher, preferred to propagate the pedagogical style through which she learned mathematics: overhead projector, wet markers and transparencies. The researcher's assumption that this recent college graduate would prefer to adopt the technology tool of projector and screen were not realized in this control group teacher. She stated she did not need a projector and laptop for the purposes

of this experiment. The slides were used *in toto*, but as a means of presenting the lesson overview as well as a review.

The one teacher who already had an interactive board was responsible for delivery to Control Group I. He was the most resistant to the research initially and voiced his concerns. Yet, within a few weeks, had taken the researcher's power point lessons and converted to them to Smart Notebook for a more interactive delivery style. He retained the minimal delivery slides for research fidelity, yet improved upon the pedagogical presentation.

During classroom observations and teacher interviews, the climate in this school's system was in flux as the DuFour Professional Learning Community culture was being introduced and embraced with varying degrees of acceptance. Among these four teachers, the form of collaborative teaching teams was present, but not necessarily the function. The venue of sharing best practices in a monthly meeting could have impacted student performance across all nine classes in a positive way had that spirit of openness prevailed among this group of educators.

The fourth teacher, Mr. E, was most appreciative of the technology and when his projector experienced technical difficulties, worked through his school's technology facilitator to affect immediate repairs.

Conclusions

Data gathered from this research supports the posit that when applied with fidelity, there is a correlation between bilingual treatment of lesson delivery and algorithm assimilation in monolingual working groups, and improvement in mathematics computation and application skills, as measured by BASI testing and in keeping with the

literature review (Gregorió and Planas, 2001). While both control and experimental groups measured increases in performance, the experimental group showed a steeper slope in gains over the control group (Chapter 4, Figure 2).

Bilingual power point slides contributed to learning the language of math, improved accuracy in terminology, and contributed to improved student behavior and engagement (Teacher interviews, December 2010). Visual learners on two separate classroom visits thanked the researcher for creating the power point slides.

Use of bilingualism was perceived by Hispanic students as respecting their culture and was perceived by the Experimental Class teacher as a motivator for students to behave better, remain on task longer, and give extra effort to complete assignments (Student Post-Survey and Teacher Interviews, December 2010). This enhanced the Classroom Environment component of Affiliation and Teacher Support (Trickett & Moos, 2002).

All four participating teachers admitted to not having considered the challenges to their Hispanic population as they impact pedagogical preparations to teach an Algebra concept. This new sensitivity brought home their need to accommodate students across the learning spectrum, not only linguistically but also within the EC community of students (Teacher Interviews, December 2010, and NCTM, 2003).

Student survey comments across two of the three experimental classes lauded the use of small group classroom discussions to improve their math skills and “make math class more fun.” This contributed to the Task Orientation component of Classroom Environment (Trickett & Moos, 2002).

Limitations

1. North Carolina Window on Student Education (NCWISE), the electronic student accountability system for the state of North Carolina, allows for students to self-define ethnicity at enrollment and/or transfer into a school or the school system. This has the potential to add a student to a subgroup – in this case Hispanic – who may be of Hispanic extraction but not necessarily Hispanic in terms of language of choice.
2. BASI pre- and post-test were in English and computer-based. This may have created obstacles to an ESL student unfamiliar with both language and technology.
3. Teen-age reluctance to seem “different” than other classmates may have prevented a full, monolingual collaborative discussion group from becoming the norm among the students in Experimental Group II. Since over half the students in Experimental Group III were ESL, there was no perceived “negative” pressure.
4. Teachers were advised of experiment participation three days before the semester started which provided little time for project buy-in and little time for lesson planning adjustment, during the first two weeks; however, with researcher support, this initial sense of being overwhelmed was reduced and the experiment proceeded as prescribed.
5. Not all teachers were comfortable with power point slides as a medium for delivering instruction, nor were all classrooms equipped with the technology necessary in the form of computer and projector.
6. Seemingly entrenched in the control group was the highly-regimented, seats-in-

rows and students-in-seats classroom environment for traditional math classes.

The attitude of student collaboration was not evident, neither was their much collaboration among the teachers. The experimental class was more free-flowing in terms of student movement, engagement with each other and the teacher, and what the researcher called “the audible buzz of learning, bordering on slight chaos” found primarily in Experimental Class III.

Recommendations

1. A question arising from this research was how much growth in English comprehension throughout the course of the semester accompanied the growth in math terminology? It is recommended that subsequent experiments incorporate pre- and post-testing to ascertain whether or not there is a correlation between English language comprehension growth and improvement in math application scores.
2. Is there correlation between technology use and improvement in math scores, irrespective of language barriers? It is recommended that research be conducted to control for the impact of technology use in a math classroom.
3. What different classroom climate factors impact student self-efficacy when learning a defined skill set (e.g., construction class, math computation) as opposed to working with a more open-ended skill set (e.g., writing a story, creating a painting)? It is recommended that research identify those classroom environment components most conducive to learn math computation and further assess whether these environmental factors differ when addressing learning math application skills.

Summary

Hispanic students in mathematics classes where the language of learning is predominantly English, encounter a two-fold problem: trying to understand the language of mathematics while processing the language of teaching in a language foreign to their own language of learning. North Carolina End of Course (EOC) testing demonstrates the Hispanic subgroup for Algebra achievement continues to be less than their non-Hispanic counterparts. Unless there are changes in mathematics classroom methods of delivery to reach the growing Hispanic population in North Carolina public schools, the gap will continue to widen, with concomitant increase in Hispanic high school dropout rates.

With slight modifications to existing “best practices,” many of the linguistic barriers can be overcome with the Hispanic population, facilitating the learning of math. Word walls, prevalent in elementary school, take the form of bi-lingual key terms and concepts. Collaborative learning groups, already gathering momentum at the high school level with the growing DuFour model, become monolingual collaborative learning groups until concept mastery is achieved. Technology in the form of Power Point and interactive SmartBoard technology erode the “sit and get” stereotype of ineffective teaching. Differentiation takes on one more dimension, as the ESL student is enfolded in lesson preparation.

This study demonstrated that with minimal classroom lesson delivery and application modifications, a significant barrier to learning mathematics in an Algebra classroom has been minimized. A two-step process of bilingual power point slides followed by monolingual working groups using Spanish worksheets activated prior

knowledge, increased accuracy in communicating math concepts, engendered cultural respect, and raised the mean score for all Hispanics in the experimental groups.

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Appendix A

Student Mathematics Attitude Questionnaire in English and in Spanish

Student Mathematics Attitude Questionnaire

Student Name: _____

School: _____

Mathematics and Me

Read the statement. Then circle the number below the statement that describes how you feel about it.

1. I like math.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

2. I usually do well in math classes.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

3. If I have a math question, I prefer to ask my question in Spanish rather than asking the teacher.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

4. Spanish is the primary language spoken at home.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

5. I feel comfortable expressing my math ideas with my classmates in English.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

6. When I am thinking about and working a math problem I think in Spanish.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

7. My math teachers have allowed me to speak Spanish when trying to learn concepts in class.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

8. The thing that would make me enjoy this class more would be [that has made me enjoy this class more has been]:

Student Mathematics Attitude Questionnaire (Spanish)

Nombre del

Estudiante: _____ Escuela: _____

Las Matemáticas y Yo

Leé la oración y luego traza un círculo alrededor de la oración que mejor describe como te sientes acerca de lo siguiente.

Me gusta la matemática.

Completamente en desacuerdo	En desacuerdo	De acuerdo	Completamente de acuerdo
1	2	3	4

Usualmente hago bien en la clase de matemáticas.

Completamente en desacuerdo	En desacuerdo	De acuerdo	Completamente de acuerdo
1	2	3	4

Si tengo una pregunta de matemáticas, prefiero hacer mi pregunta en español mas bien que preguntarle al maestro.

Completamente en desacuerdo	En desacuerdo	De acuerdo	Completamente de acuerdo
1	2	3	4

El lenguaje de Español es la lengua primaria en mi hogar.

Completamente en desacuerdo	En desacuerdo	De acuerdo	Completamente de acuerdo
1	2	3	4

Me siento bien cuando puedo expresar mis ideas de matemáticas en Inglés, con mis compañeros de clases.

Completamente en desacuerdo	En desacuerdo	De acuerdo	Completamente de acuerdo
1	2	3	4

Appendix B

Letter to School System for Research

Dear Dr. Propst:

Recent county-wide trends in our Hispanic student achievement for Algebra I reflect that we need to examine our instructional delivery techniques in an attempt to reach this mathematics subgroup.

In an effort to help stem the tide for our county in this arena and in compliance with the Gardner-Webb University School of Education requirement for the degree of Doctor of Education, respectfully request that you allow me to work with the principals of four high schools – XXXXX High School, XXXXX High School, XXXXX High School and XXXXX High School – to conduct an experiment in bilingual intervention for our Hispanic students. Gardner-Webb University Institutional Research Board has approved this study.

The control group will use Power Point slides that I have created for every lesson plan determined by the school system's pacing guide over the course of one semester, using the adopted Algebra I textbook (Prentice Hall, 2004) as reference. Worksheets will come from the accompanying "Study Guide and Practice Workbook."

The experimental group will use the same Power Point slides as the control group, with the addition of Spanish subtitles for key words and concepts presented during lesson introduction. The subtitles will be slightly smaller and in a different color. Upon completion of the instructional delivery, Hispanic students will be allowed to form monolingual working groups to delve into application. Their worksheets will also come from the "Study Guide and Practice Workbook" but in Spanish.

At the end of the semester, I will examine differences in cognitive domain of both groups using analysis of variance (ANOVA) in pre- and post-test data from the software NovaNet, as well as county-wide administered semester final exams. Affective domain pertaining to attitudes regarding mathematics as determined by a student questionnaire will be compared with chi-squared test on frequency distribution.

Results and conclusions from this experiment will be shared with each principal and staff as requested, following data collection and analysis early in the spring semester, 2011.

With your permission, I would like to meet with above-mentioned high school principals to share the mechanics of this research effort.

Sincerely,

Robert Kirk

Appendix C

Sample Letter to Principals

Dear Principal:

Recent county-wide trends in our Hispanic student achievement for Algebra I reflect that we need to examine our instructional delivery techniques in an attempt to reach this mathematics subgroup.

In an effort to help stem the tide for our county in this arena and in compliance with the Gardner-Webb University School of Education requirement for the degree of Doctor of Education, respectfully request that you allow me to work with your Assistant Principal for Instruction, your Mathematics Department Head and Foundations of Algebra teachers this Fall Semester to conduct an experiment in bilingual intervention for your Hispanic students.

The control group will use Power Point slides that I have created for every lesson plan determined by the school system's pacing guide over the course of one semester, using the adopted Algebra I textbook (Prentice Hall, 2004) as reference. Worksheets will come from the accompanying "Study Guide and Practice Workbook."

The experimental group will use the same Power Point slides as the control group, with the addition of Spanish subtitles for key words and concepts presented during lesson introduction. The subtitles will be slightly smaller and in a different color. Upon completion of the instructional delivery, Hispanic students will be allowed to form monolingual working groups to delve into application. Their worksheets will also come from the "Study Guide and Practice Workbook" but in Spanish.

At the end of the semester, I will examine differences in cognitive domain of both groups using analysis of variance (ANOVA) in pre- and post-test data from the software NovaNet, as well as county-wide administered semester final exams. Affective domain pertaining to attitudes regarding mathematics as determined by a student questionnaire will be compared with chi-squared test on frequency distribution.

Results and conclusions from this experiment will be shared with you and your staff following collection and analysis early in the spring semester, 2011.

With your permission, I would like to meet with your API and Math Department Head to share the mechanics of this research effort.

Sincerely,

Robert Kirk

Appendix D

Letter to Experimental Group Parents

Dear Parents:

As your student is beginning his/her semester in Foundations of Algebra class, we would like your permission to try a different approach in our instructional delivery with your son/daughter.

We are trying to determine if these techniques will enhance your student's learning ability – we are confident they will not hinder your student's success in learning mathematics concepts.

Explanation of Experiment

There will be two types of teaching delivery: one will be called “the control group,” the other called “the experimental group.”

What will be the same: Both groups will receive instruction with the teacher using a lesson created on Power Point computer software, and then projected onto a screen. Both groups will also be given mathematics worksheets to practice their new math skills.

What will be different: The experimental group, for which we would like to use your student, will have the same lesson projected onto the screen as the control group, but their slides will have Spanish equivalent words under key ideas. A second difference will be that the experimental group students will be able to get together with other Spanish speaking students and work the problems on a Spanish worksheet while being able to work in English and in Spanish on the math skills just learned.

Please indicate your permission for your student to participate in the experimental group with your signature. If you would prefer for your student not to be part of the experimental group, we will place him/her in the control group.

☐

I agree for my student to be part of the experimental group

Signature

Date

☐

I prefer my student NOT be part of the experimental group

Signature

Date

Letter to Experimental Group Parents (Spanish)

Estimados Padres:

Al comenzar su estudiante este semestre, con la clase de Fundamentos de Algebra; nos gustaria tener su permiso para intentar un modo diferente de instruccion con su hijo/hija.

Estamos tratando de determinar, si estas técnicas tendrán un efecto favorecedor en la habilidad para aprender del estudiante. Confiamos en que estas no dificultarán el éxito del estudiante en el aprendizaje de conceptos de matemáticas.

Explicación de Experimento:

Habrà dos métodos de enseñanza: A uno se le denominarà el “grupo de control” y al otro “grupo experimental”.

Lo que serà igual:

Ambos grupos recibiràn instruccion de parte del maestro/a, usando una lección creada en un programa de computadora (Power Point), y luego èsta se proyectarà en una pantalla. A ambos grupos se le daràn hojas de trabajo en matemáticas, para practicar las nuevas destrezas que han adquirído.

Lo que serà diferente:

El “grupo experimental” para el cual nos gustaría usar a su estudiante, tendrá la misma lección proyectada en la pantalla que la del “grupo en control”. La diferencia està, en que las diapositivas tendrán palabras equivalentes en Español bajo las ideas claves. Una segunda diferencia es, que al “grupo experimental” de estudiantes, se les permitirá juntarse con otros estudiantes que hablan español y trabajar los problemas en una hoja de trabajo en español, a la vez que se les permíte trabajar usand tanto el Inglés como el español, poniendo en pràctica las destrezas recién adquiridas.

Por favor, indíque abajo con su firma si desea o no, que su hijo/a, participe en el grupo experimental. Si usted prefiere que su estudiante no sea parte del grupo experimental, entonces lo colocaremos en el grupo de control.

☐

Estoy de acuerdo en que mi estudiante sea parte del grupo experimental.

Firma

Fecha

☐

Prefiero que mi estudiante no sea parte del grupo experimental.

Firma

Fecha

Appendix E

Sample English Power Point Slides

Foundation of Algebra

- Jump Start
- Discovery: Properties of Real Numbers (Chpt 1-8)
- Drill and Grill
- Interactive Chalkboard
- Homework: Workbook pg



Setting goals:

- in this lesson you'll identify properties of addition and multiplication and use these properties to solve problems



Key terms & concepts

- Commutative Property of Addition
- Commutative Property of Multiplication
- Associative Property of Addition
- Associative Property of Multiplication
- Identity Property of Addition



Key terms & concepts

- Identity Property of Multiplication
- Multiplicative Property of Zero
- Inverse Property of Addition
- Inverse Property of Multiplication



Key terms & concepts

- Multiplicative Property of -1
- Distributive Property
- Deductive Reasoning



Commutative Property of Addition

The order in which the numbers are added does not change the sum

$$5 + 3 = 3 + 5$$

For any real number a and b ,

$$a + b = b + a$$



Commutative Property of Multiplication

The order in which numbers are multiplied does not change the product

$$2 \cdot 4 = 4 \cdot 2$$

For any real number a and b ,

$$a \cdot b = b \cdot a$$



Associative Property of Addition

The way in which the addends are grouped does not change the sum

$$(2 + 4) + 6 = 2 + (4 + 6)$$

For any real numbers a , b , and c

$$(a + b) + c = a + (b + c)$$



Associative Property of Multiplication

The way in which factors are grouped does not change the product

$$(6 \cdot 3) \cdot 7 = 6 \cdot (3 \cdot 7)$$

For any real numbers a , b , and c

$$(a \cdot b) \cdot c = a \cdot (b \cdot c)$$



Identity Property of Addition

The sum of an addend and zero is the addend

$$6 + 0 = 6$$

For any real number a ,

$$a + 0 = a$$



Identity Property of Multiplication

The product of a factor and one is the factor

$$6 \cdot 1 = 6$$

For any real number a ,

$$a \cdot 1 = a$$



Multiplicative Property of Zero

The product of a factor and zero is zero

$$5 \cdot 0 = 0$$

For any real number a ,

$$a \cdot 0 = 0$$



Inverse Property of Addition

For every real number n , there is an additive inverse $-n$ such that

$$n + (-n) = 0$$

Examples: $17 + (-17) = 0$

$$-8 + 8 = 0$$



Multiplication Property of Zero

For every real number n , $n \cdot 0 = 0$

Example: $35 \cdot 0 = 0$

$$-35 \cdot 0 = 0$$



Multiplication Property of -1

For every real number n , $-1 \cdot n = -n$

Example: $-1 \cdot 5 = -5$
 $-1 \cdot (-5) = 5$



Inverse Property of Multiplication

For every nonzero real number a , there is a multiplicative inverse $1/a$, such that

$$a \cdot (1/a) = 1$$

Example: $5 \cdot (1/5) = 1$ $-5(-1/5) = 1$



Distributive Property

In words:

The sum of two addends multiplied by a number is the sum of the product of each addend and the number



Distributive Property

In symbols:

For any number a , b , and c

$$a(b + c) = ab + ac \quad \text{and}$$

$$(b + c)a = ba + ca$$



Deductive Reasoning

Deductive reasoning is the process of reasoning logically from given facts to a conclusion

Using deductive reasoning, you justify each step in simplifying an expression with reasons such as properties, definitions, or rules



Appendix F

Sample English Power Point Slides With Spanish Subtitles

Foundation of Algebra

- Jump Start
- Discovery: Properties of Real Numbers (Chpt 1-8)
- Drill and Grill
- Interactive Chalkboard
- Homework: Workbook pg



Setting goals:

- in this lesson you'll identify properties of addition and multiplication and use these properties to solve problems



Key terms & concepts

- Commutative Property of Addition
 - Propiedad Conmutativa de la Adición
- Commutative Property of Multiplication
 - Propiedad Conmutativa de la Multiplicación
- Associative Property of Addition
 - Propiedad Asociativa de la Adición
- Associative Property of Multiplication
 - Propiedad Asociativa de la Multiplicación



Key terms & concepts

- Identity Property of Addition
 - Propiedad de Identidad de la Adición
- Identity Property of Multiplication
 - Propiedad de Identidad de la Multiplicación
- Multiplicative Property of Zero
 - Propiedad Multiplicativa del Zero
- Inverse Property of Addition
 - Propiedad Inversa Aditiva



Key terms & concepts

- Inverse Property of Multiplication
 - Propiedad Inversa Multiplicativa
- Multiplicative Property of -1
 - Propiedad Multiplicativa del Uno Negativo
- Distributive Property
 - Propiedad Distributiva
- Deductive Reasoning
 - Razonamiento Deductivo



Commutative Property of Addition

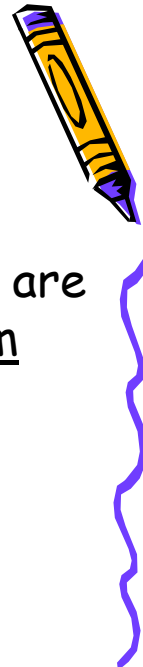
Propiedad Conmutativa de la Adición

The order in which the numbers are added does not change the sum

$$5 + 3 = 3 + 5$$

For any real number a and b ,

$$a + b = b + a$$



Commutative Property of Multiplication

Propiedad Conmutativa de la Multiplicación

The order in which numbers are multiplied does not change the product

$$2 \cdot 4 = 4 \cdot 2$$

For any real number a and b ,

$$a \cdot b = b \cdot a$$



Associative Property of Addition

Propiedad Asociativa de la Adición

The way in which the addends are grouped does not change the sum

$$(2 + 4) + 6 = 2 + (4 + 6)$$

For any real numbers a , b , and c

$$(a + b) + c = a + (b + c)$$



Associative Property of Multiplication

Propiedad Asociativa de la Multiplicación

The way in which factors are grouped does not change the product

$$(6 \cdot 3) \cdot 7 = 6 \cdot (3 \cdot 7)$$

For any real numbers a , b , and c

$$(a \cdot b) \cdot c = a \cdot (b \cdot c)$$



Identity Property of Addition

Propiedad de Identidad de la Adición

The sum of an addend and zero is the addend

$$6 + 0 = 6$$

For any real number a ,

$$a + 0 = a$$



Identity Property of Multiplication

Propiedad de Identidad de la Multiplicación

The product of a factor and one is the factor

$$6 \cdot 1 = 6$$

For any real number a ,

$$a \cdot 1 = a$$



Multiplicative Property of Zero

Propiedad Multiplicativa del Zero

The product of a factor and zero is zero

$$5 \cdot 0 = 0$$

For any real number a ,

$$a \cdot 0 = 0$$



Inverse Property of Addition

Propiedad Inversa Aditiva

For every real number n , there is an additive inverse $-n$ such that

$$n + (-n) = 0$$

Examples: $17 + (-17) = 0$

$$-8 + 8 = 0$$



Multiplication Property of Zero

Propiedad Multiplicativa del Zero

For every real number n , $n \cdot 0 = 0$

Example: $35 \cdot 0 = 0$

$$-35 \cdot 0 = 0$$



Multiplication Property of -1

Propiedad Multiplicativa del Uno Negativo

For every real number n , $-1 \cdot n = -n$

Example: $-1 \cdot 5 = -5$
 $-1 \cdot (-5) = 5$



Inverse Property of Multiplication

Propiedad Inversa Multiplicativa

For every nonzero real number a , there is a multiplicative inverse $1/a$, such that

$$a \cdot (1/a) = 1$$

Example: $5 \cdot (1/5) = 1$ $-5(-1/5) = 1$



Distributive Property Propriedad Distributiva

In words:

The sum of two addends multiplied by a number is the sum of the product of each addend and the number



Distributive Property Propriedad Distributiva

In symbols:

For any number a , b , and c

$$a(b + c) = ab + ac \quad \text{and}$$

$$(b + c)a = ba + ca$$



Deductive Reasoning

Razonamiento Deductivo

Deductive reasoning is the process of reasoning logically from given facts to a conclusion

Using deductive reasoning, you justify each step in simplifying an expression with reasons such as properties, definitions, or rules



Appendix G

Sample English Practice Worksheets

Name _____ Class _____ Date _____

Practice 3-4**Solving Multi-Step Inequalities****Solve each inequality. Graph and check the solution.**

- | | | |
|-----------------------------|--|---------------------------------------|
| 1. $2z + 7 < z + 10$ | 2. $4(k - 1) > 4$ | 3. $1.5 + 2.1y < 1.1y + 4.5$ |
| 4. $h + 2(3h + 4) \geq 1$ | 5. $r + 4 > 13 - 2r$ | 6. $6u - 18 - 4u < 22$ |
| 7. $2(3 + 3g) \geq 2g + 14$ | 8. $2h - 13 < -3$ | 9. $-4p + 28 > 8$ |
| 10. $8m - 8 \geq 12 + 4m$ | 11. $5 + 6a > -1$ | 12. $\frac{1}{2}(2t + 8) \geq 4 + 6t$ |
| 13. $-5x + 12 < -18$ | 14. $2(3f + 2) > 4f + 12$ | 15. $13t - 8t > -45$ |
| 16. $2(c - 4) \leq 10 - c$ | 17. $\frac{1}{2}t - \frac{1}{3}t > -1$ | 18. $3.4 + 1.6v < 5.9 - 0.9v$ |

Write and solve an inequality that models each situation.

19. Ernest works in the shipping department, loading shipping crates with boxes. Each empty crate weighs 150 lb. How many boxes, each weighing 35 lb, can Ernest put in the crate if the total weight is to be no more than 850 lb?
20. Beatriz is in charge of setting up a banquet hall. She has five tables that will seat six people each. If no more than 62 people will attend, how many tables seating four people each will she need?
21. Suppose it costs \$5 to enter a carnival. Each ride costs \$1.25. You have \$15 to spend at the carnival. What is the greatest number of rides that you can go on?
22. The cost to rent a car is \$19.50 plus \$.25 per mile. If you have \$44 to rent a car, what is the greatest number of miles that you can drive?
23. The student council is sponsoring a concert as a fund raiser. Tickets are \$3 for students and \$5 for adults. The student council wants to raise at least \$1000. If 200 students attend, how many adults must attend?

Solve each inequality. Check the solution.

- | | | |
|--------------------------------|---|--|
| 24. $-18 < 2(12 - 3b)$ | 25. $5n + 3 - 4n < -5 - 3n$ | 26. $36 > 4(2d + 10)$ |
| 27. $2(5t - 25) + 5t < -80$ | 28. $3j + 2 - 2j < -10$ | 29. $\frac{2}{5}(5x - 15) \geq 4$ |
| 30. $7(2z + 3) > 35$ | 31. $2(3b - 2) < 4b + 8$ | 32. $\frac{1}{2}y + \frac{1}{4}y \geq -6$ |
| 33. $8(3f - 6) < -24$ | 34. $\frac{3}{4}k < \frac{3}{4} - \frac{1}{4}k$ | 35. $3(4g - 6) \geq 6(g + 2)$ |
| 36. $\frac{1}{2}(2g + 4) > -7$ | 37. $4(1.25y + 4.2) < 16.8$ | 38. $38 + 7t > -3(t + 4)$ |
| 39. $4(2d + 1) > 28$ | 40. $4(n - 3) < 2 - 3n$ | 41. $\frac{3}{4}d - \frac{1}{2} \leq 2\frac{1}{2}$ |

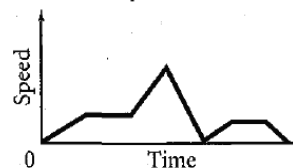
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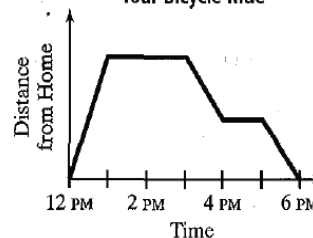
Name _____ Class _____ Date _____

Practice 5-1**Relating Graphs to Events****The graph shows the speed a student traveled on the way to school.**

1. What do the flat parts of the graph represent?
2. Circle the sections of the graph that show the speed decreasing.

Trip to School**The graph shows the relationship between time and distance from home.**

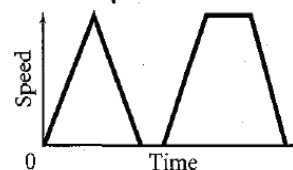
3. What do the flat parts of the graph represent?
4. What do the sections from 3 P.M. to 4 P.M. and from 5 P.M. to 6 P.M. represent?
5. What does the section from 12 P.M. to 1 P.M. represent?

Your Bicycle Ride**Sketch a graph to describe the following. Explain the activity in each section of the graph.**

6. your elevation above sea level as you hike in the mountains
7. your speed as you travel from home to school
8. the height of an airplane above the ground flying from Dallas, Texas to Atlanta, Georgia
9. the speed of a person driving to the store and having to stop at two stoplights

The graph shows the relationship between time and speed for an airplane.

10. Circle the sections of the graph that show the speed increasing.
11. Circle the section of the graph that shows the plane not moving.
12. Circle the section of the graph that shows the plane moving at a constant speed.

Speed vs. Time

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Name _____ Class _____ Date _____

Practice 6-3**Standard Form****Graph each equation using x - and y -intercepts.**

- | | | | |
|--------------------|---------------------|-------------------|---------------------|
| 1. $x + y = 3$ | 2. $x + 3y = -3$ | 3. $-2x + 3y = 6$ | 4. $5x - 4y = -20$ |
| 5. $3x + 4y = 12$ | 6. $7x + 3y = 21$ | 7. $y = -2.5$ | 8. $2x - 3y = 4$ |
| 9. $x = 3$ | 10. $3x - 2y = -6$ | 11. $5x + 2y = 5$ | 12. $-7x + 2y = 14$ |
| 13. $3x + y = 3$ | 14. $-3x + 5y = 15$ | 15. $2x + y = 3$ | 16. $8x - 3y = 24$ |
| 17. $3x - 5y = 15$ | 18. $x + 4y = 4$ | 19. $x = -3.5$ | 20. $y = 6$ |

Write each equation in standard form using integers.

- | | | | |
|---------------------------------------|---------------------------------------|---------------------------------------|------------------------|
| 21. $y = 4x - 11$ | 22. $y = 2x - 6$ | 23. $y = -2x - 3$ | 24. $y = 5x - 32$ |
| 25. $y = \frac{2}{3}x - \frac{25}{3}$ | 26. $y = 43 - 4x$ | 27. $y = -\frac{4}{5}x + \frac{6}{5}$ | 28. $y = -\frac{x}{5}$ |
| 29. $y = \frac{5}{2}x - 22$ | 30. $y = \frac{7}{3}x + \frac{25}{3}$ | 31. $y = -\frac{x}{3} + \frac{2}{3}$ | 32. $y = -6x - 38$ |

33. The drama club sells 200 lb of fruit to raise money. The fruit is sold in 5-lb bags and 10-lb bags.
- Write an equation to find the number of each type of bag that the club should sell.
 - Graph your equation.
 - Use your graph to find two different combinations of types of bags.
34. The student council is sponsoring a carnival to raise money. Tickets cost \$5 for adults and \$3 for students. The student council wants to raise \$450.
- Write an equation to find the number of each type of ticket they should sell.
 - Graph your equation.
 - Use your graph to find two different combinations of tickets sold.
35. Anna goes to a store to buy \$70 worth of flour and sugar for her bakery. A bag of flour costs \$5, and a bag of sugar costs \$7.
- Write an equation to find the number of bags of each type Anna can buy.
 - Graph your equation.
36. You have \$50 to spend on cold cuts for a party. Ham costs \$5.99/lb, and turkey costs \$4.99/lb. Write an equation in standard form to relate the number of pounds of each kind of meat you could buy.

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Appendix H

Sample Spanish Practice Worksheets

Nombre _____ Clase _____ Fecha _____

Práctica 4-4**Resolver desigualdades de varios pasos****Resuelve cada desigualdad. Comprueba la solución.**

- | | | |
|-----------------------------|--|---------------------------------------|
| 1. $2z + 7 < z + 10$ | 2. $4(k - 1) > 4$ | 3. $1.5 + 2.1y < 1.1y + 4.5$ |
| 4. $h + 2(3h + 4) \geq 1$ | 5. $r + 4 > 13 - 2r$ | 6. $6u - 18 - 4u < 22$ |
| 7. $2(3 + 3g) \geq 2g + 14$ | 8. $2h - 13 < -3$ | 9. $-4p + 28 > 8$ |
| 10. $8m - 8 \geq 12 + 4m$ | 11. $5 + 6a > -1$ | 12. $\frac{1}{2}(2t + 8) \geq 4 + 6t$ |
| 13. $-5x + 12 < -18$ | 14. $2(3f + 2) > 4f + 12$ | 15. $13t - 8t > -45$ |
| 16. $2(c - 4) \leq 10 - c$ | 17. $\frac{1}{2}t - \frac{1}{3}t > -1$ | 18. $3.4 + 1.6v < 5.9 - 0.9v$ |

Escribe y resuelve una desigualdad que muestre cada situación.

19. Ernest trabaja en el departamento de envíos llenando cajones con cajas. Cada cajón vacío pesa 150 lb. Si cada caja pesa 35 lb, ¿cuántas cajas puede poner Ernest en el cajón para que el peso total no sobrepase 850 lb?
20. Beatriz está encargada de decorar una sala de banquetes. Ella tiene cinco mesas con capacidad para seis personas cada una. Si no van a asistir más de 62 personas, ¿cuántas mesas con capacidad para 4 personas necesitará?
21. Imagina que la entrada a un parque de atracciones cuesta \$5. Cada paseo en una atracción cuesta \$1.25. Si tienes \$15, ¿cuál es la cantidad máxima de paseos que puedes dar?
22. Alquilar un carro cuesta \$19.50 más \$.25 por cada milla. Si tienes \$44 para alquilar un carro, ¿cuál es la cantidad máxima de millas que puedes manejar?
23. El consejo estudiantil está patrocinando un concierto para recaudar fondos. Los boletos cuestan \$3 para los estudiantes y \$5 para los adultos. El consejo estudiantil quiere recaudar por lo menos \$1000. Si asisten 200 estudiantes, ¿cuántos adultos deben asistir?

Resuelve cada desigualdad y comprueba la solución.

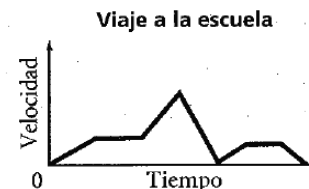
- | | | |
|--------------------------------|---|--|
| 24. $-18 < 2(12 - 3b)$ | 25. $5n + 3 - 4n < -5 - 3n$ | 26. $36 > 4(2d + 10)$ |
| 27. $2(5t - 25) + 5t < -80$ | 28. $3j + 2 - 2j < -10$ | 29. $\frac{2}{5}(5x - 15) \geq 4$ |
| 30. $7(2z + 3) > 35$ | 31. $2(3b - 2) < 4b + 8$ | 32. $\frac{1}{2}y + \frac{1}{4}y \geq -6$ |
| 33. $8(3f - 6) < -24$ | 34. $\frac{3}{4}k < \frac{3}{4} - \frac{1}{4}k$ | 35. $3(4g - 6) \geq 6(g + 2)$ |
| 36. $\frac{1}{2}(2g + 4) > -7$ | 37. $4(1.25y + 4.2) < 16.8$ | 38. $38 + 7t > -3(t + 4)$ |
| 39. $4(2d + 1) > 28$ | 40. $4(n - 3) < 2 - 3n$ | 41. $\frac{3}{4}d - \frac{1}{2} \leq 2\frac{1}{2}$ |

Nombre _____ Clase _____ Fecha _____

Práctica 5-1**Relacionar gráficas con sucesos**

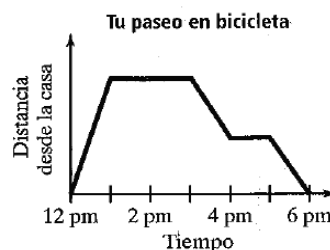
La gráfica muestra la velocidad a la que iba un estudiante camino a la escuela.

1. ¿Qué representan las secciones planas de la gráfica?
2. Encierra en un círculo las secciones de la gráfica que muestran una disminución de velocidad.



La gráfica muestra la relación entre el tiempo y la distancia de casa.

3. ¿Qué representan las secciones planas de la gráfica?
4. ¿Qué representan las secciones de 3 p.m. a 4 p.m. y de 5 p.m. a 6 p.m.?
5. ¿Qué representa la sección de 12 p.m. a 1 p.m.?

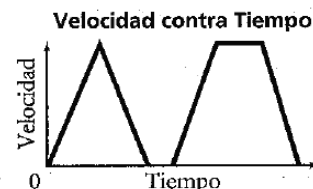


Haz una gráfica para describir lo siguiente. Describe la actividad en cada sección de la gráfica.

6. tu altura sobre el nivel del mar mientras caminas por las montañas
7. tu velocidad al viajar de la casa a la escuela
8. la altura de un avión que viaja de Dallas, Texas a Atlanta, Georgia
9. la velocidad de una persona que maneja a la tienda y tiene que detenerse en dos semáforos

La gráfica muestra la relación entre el tiempo y la velocidad de un avión.

10. Encierra en un círculo las secciones de la gráfica que muestran un aumento de velocidad.
11. Encierra en un círculo la sección de la gráfica que muestra que el avión no se está moviendo.
12. Encierra en un círculo la sección de la gráfica que muestra al avión moviéndose a una velocidad constante.



Nombre _____ Clase _____ Fecha _____

Práctica 6-4

Forma general

Representa gráficamente cada ecuación usando los interceptos x e y .

- | | | | |
|--------------------|---------------------|-------------------|---------------------|
| 1. $x + y = 3$ | 2. $x + 3y = -3$ | 3. $-2x + 3y = 6$ | 4. $5x - 4y = -20$ |
| 5. $3x + 4y = 12$ | 6. $7x + 3y = 21$ | 7. $y = -2.5$ | 8. $2x - 3y = 4$ |
| 9. $x = 3$ | 10. $3x - 2y = -6$ | 11. $5x + 2y = 5$ | 12. $-7x + 2y = 14$ |
| 13. $3x + y = 3$ | 14. $-3x + 5y = 15$ | 15. $2x + y = 3$ | 16. $8x - 3y = 24$ |
| 17. $3x - 5y = 15$ | 18. $x + 4y = 4$ | 19. $x = -3.5$ | 20. $y = 6$ |

Escribe cada ecuación en forma general usando números enteros.

- | | | | |
|---------------------------------------|---------------------------------------|---------------------------------------|------------------------|
| 21. $y = 4x - 11$ | 22. $y = 2x - 6$ | 23. $y = -2x - 3$ | 24. $y = 5x - 32$ |
| 25. $y = \frac{2}{3}x - \frac{25}{3}$ | 26. $y = 43 - 4x$ | 27. $y = -\frac{4}{5}x + \frac{6}{5}$ | 28. $y = -\frac{x}{5}$ |
| 29. $y = \frac{5}{2}x - 22$ | 30. $y = \frac{7}{3}x + \frac{25}{3}$ | 31. $y = -\frac{x}{3} + \frac{2}{3}$ | 32. $y = -6x - 38$ |

33. El club de teatro vende 200 lb de frutas para recaudar dinero. Las frutas se venden en bolsas de 5 y 10 lb.

- Escribe una ecuación para hallar el número de bolsas de cada tipo que el club de teatro debe vender.
- Representa gráficamente tu ecuación.
- Utiliza la gráfica para hallar dos combinaciones diferentes de los tipos de bolsas.

34. El consejo estudiantil está promocionando una feria para coleccionar dinero. Las entradas cuestan \$5 por adulto y \$3 por estudiante. El consejo estudiantil quiere reunir \$450.

- Escribe una ecuación para hallar el número de entradas de cada tipo que deben vender.
- Representa gráficamente tu ecuación.
- Utiliza una gráfica para hallar dos combinaciones diferentes de entradas vendidas.

35. Ana va a una tienda para comprar \$70 de harina y azúcar para su panadería. Una bolsa de harina cuesta \$5 y una bolsa de azúcar cuesta \$7.

- Escribe una ecuación para hallar el número de bolsas de cada tipo que Ana puede comprar.
- Representa gráficamente tu ecuación.

36. Tienes \$50 para comprar carnes frías para una fiesta. El jamón cuesta \$5.99/lb y el pavo cuesta \$4.99/lb. Escribe una ecuación en forma general para relacionar el número de libras de cada tipo de carne que podrías comprar.

Appendix I

Sample Classroom Environmental Scale Questionnaire

For use by Robert Kirk only. Received from Mind Garden, Inc. on August 28, 2010

(Form R)

- | | |
|--|--|
| 61. There are set ways of working on things. | 62. It's easier to get in trouble here than in a lot of other classes. |
| 63. Students are expected to follow set rules in doing their work. | 64. A lot of students seem to be only half awake during this class. |
| 65. It takes a long time to get to know everybody by their first name in this class. | 66. This teacher wants to know what students themselves want to learn about. |
| 67. This teacher often takes time out from the lesson plan to talk about other things. | 68. Students have to work for a good grade in this class. |
| 69. This class hardly ever starts on time. | 70. In the first few weeks the teacher explained the rules about what students could and could not do in this class. |
| 71. The teacher will put up with a good deal. | 72. Students can choose where they sit. |
| 73. Students sometimes do extra work on their own in the class. | 74. There are groups of students who don't get along in class. |
| 75. This teacher does not trust students. | 76. This class is more a social hour than a place to learn something. |
| 77. Sometimes the class breaks up into groups to compete with each other. | 78. Activities in this class are clearly and carefully planned. |
| 79. Students aren't always sure if something is against the rules or not. | 80. The teacher kicks students out of class if they act up. |
| 81. Students do the same kind of homework almost every day. | 82. Students really enjoy this class. |
| 83. Some students in this class don't like each other. | 84. Students have to watch what they say in this class. |
| 85. The teacher sticks to classwork and doesn't get sidetracked. | 86. Students usually pass even if they don't do much. |
| 87. Students don't interrupt the teacher when he or she is talking. | 88. The teacher is consistent in dealing with students who break the rules. |
| 89. When the teacher makes a rule, he or she means it. | 90. In this class, students are allowed to make up their own projects. |