THE EFFECTS OF ENGLISH VOCABULARY MASTERY ON GEOMETRY ACHIEVEMENT

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Abstract

This study examines socioeconomic status (SES), English language proficiency (ELP), vocabulary proficiency (VP), and math proficiency (MP) of students to determine if SES, as determined by the Free and Reduced Lunch Program (FRL), as well as English language proficiency (ELP) and vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, impacts math performance on the geometry EOC exam scale scores. An ex-post facto multiple regression study is conducted using secondary data from a random stratified sample of a population of students from four school districts across southwest Florida. The study utilizes ELL groups which differed on independent variables (SES and CELLA scale scores and subtests) and test hypotheses about differences on dependent variables (geometry EOC scale scores). The ex post facto research begins with the results of geometry EOC scale scores, working backward to attempt to identify why students earned the CELLA scale scores and subtest results. Comparisons are made among the ELL students on SES and different subtests of the CELLA exams. Subtests include data on speaking, reading, writing and listening skills. These results could possibly help explain why students struggle with vocabulary and math performance.
Chapter One

Introduction

Background

In the past, there have been a number of educational reform measures aimed to improve academic standards and achievement in the United States, particularly with at-risk populations and in neighborhoods that have experienced downturns due to harsh economic times. Bracey (2009a) noted that some of the programs have been related to No Child Left Behind (NCLB) and increased statewide testing, including The Florida Comprehensive Academic Test (FCAT) and End of Course (EOC) exams which are aimed at testing Florida’s Next Generation Sunshine State Standards (NGSSS) and Common Core State Standards (CCSS). The aim of these programs has been to improve instruction, prepare students for standardized testing, and ultimately allow them to make achievement gains in subject areas such as math. In addition, (Response to Intervention (RTI), and Positive Behavioral Systems (PBS) provide some mixed academic results, although funding continues for many of these programs (Bracey, 2009b).

Past research shows that achievement in American schools increased only slightly over the past several years (National Center for Education Statistics, 2011). The National Assessment for Educational Progress (NAEP) shows that performances of American students in math only showed gains in two of the eighteen districts from 2009 to 2011 (NCES, 2011). Students from twenty one urban districts participated in the NAEP Trial Urban District Assessment (TUDA) in mathematics. The results of the TUDA show that students from urban districts increased their scores slightly, but those students still
struggle in reading and math assessments. Some tests, such as the NAEP, the Program for International Student Assessment (PISA), and the Trends in Mathematics and Science Study (TIMSS) show that performances of students from the urban districts in math only showed gains in two of the twenty one districts tested from 2009 to 2011 (NCES, 2012). Bracey (2009a) noted that increases in math performance for all districts should be higher due to the technology programs and educational reform efforts, such as NCLB, that continue to be implemented. Despite spending 2.3% more this year, up to an average of $10,826 per student, the United States continues to lag behind other nations in math and reading achievement (NEA, 2011).

**Brief summary of the literature review**

Bracey (2009a) discussed the basic reading vocabulary level on U.S. National Assessment of Educational Progress (NAEP) reports, by the U.S. National Assessment Governing Board (NAGB) for all urban and non-urban school districts. Results from the 2011 administration of NAEP suggested that 75% of fourth and eighth graders in all districts scored at or below the lowest proficiency level and that basic reading vocabulary and math skills decreased since the study began in 2009. Skill levels are established by the NAEP and NAGB, based on adherence to national reading and math standards.

The NAEP report in 2011 showed that only about 23% of students in all urban and non-urban districts achieved the highest levels of proficiency in reading vocabulary, a figure that is down from 25% in the 2009 report, suggesting that the language arts skills of students decreased (NCES, 2011). When looking at the same students in the NAEP report, only about 20% of those students achieved the highest levels of proficiency in
mathematics in 2011, down from 22% in 2009, suggesting that the math skills of students in all districts decreased (NCES, 2011). The performances of students in each urban district were compared to the performances of public school students in the nation and in large cities. A comparison to the nation's large cities is made because students in these cities represent a peer group with characteristics that are more similar to the characteristics of students in the twenty one TUDA districts. Based on the results of the NAEP report, comparisons in performance over time are made for those districts and show that students in the urban districts struggled in both vocabulary and math, although they were considered to have no language barrier. Examining these two results together suggested that American students in urban and non-urban districts experienced decreases in both vocabulary and math proficiency.

The TIMSS 2011 administration compared mathematics achievement of eighth-graders among 48 participating countries (NCES, 2011). The average mathematics scores of both U.S. fourth and eighth grade students were statistically significantly higher than the TIMSS scale averages. U.S. fourth-graders scored 529 on average in mathematics, which was higher than the TIMSS scale average of 500. The average mathematics score of U.S. eighth-graders scored 508, on average, in mathematics, which was higher than the TIMSS scale average of 500. The average mathematics score of U.S. eighth-graders was higher than those in 37 of the 47 other countries, lower than in five countries (Chinese Taipei, Republic of Korea, Singapore, Hong Kong SAR, and Japan; all in Asia), and not measurably different from the average scores of students in the remaining five countries (Hungary, England, Kazakhstan, Latvia, and Netherlands). Although it appeared that U.S. students were performing at adequate levels, the Asian
countries outperformed American students. In an increasingly more technological and
global economy, Bracey (2009a) suggested that the U.S. needed to keep up with these
other countries to remain competitive in the global marketplace.

Bracey (2009b) reported that despite many educational efforts to increase
vocabulary performance in the U.S, the results from international large-scale assessments
suggest that although the U.S students outperform most countries in mathematics,
American students still lag behind their Asian counterparts. At the national level,
evidence showed that a large percentage of fourth and eighth graders performed at the
lowest levels of math proficiency and that math and vocabulary skills decreased within
the last three years (Bracey, 2009b). Since vocabulary proficiency was the foundation for
understanding concepts in other subject areas, students who struggled with vocabulary
experienced difficulties in other subjects. Struggles with vocabulary skills can affect
comprehension of concepts and materials, decreasing academic achievement. Bracey
(2009b) stated that when students struggle with basic skills, then they cannot master more
difficult subject content material. The author implied that this phenomenon affected
millions of students. This suggested that some ELL and lower SES students may have
lower vocabulary proficiency and ability, and therefore, they may be less successful in
math performance.

Martiniello (2008) suggested that poor math performance can result from
vocabulary difficulty, and over 10% of American students were designated as English
Language Learners (ELL) or were of immigrant descent whose parents speak a language
other than English. The English proficiency of these students was lower than those of
their American counterparts whose parents speak English at home. Prior to NCLB, ELL
and special education students were excluded from large scale assessments. With the inception of NCLB, ELL students then had to be included in large-scale assessments. Therefore, their inclusion may have lowered the U.S.'s overall performance in international assessments and may have resulted in vocabulary and math performance decreases at home. Although decreases in performances were not encouraging, for the first time in history educators and researchers had an opportunity to examine problems faced by ELL students and to devise strategies to help them achieve. Martiniello (2008) stated that educators had an opportunity to investigate how the linguistic load in math word problems, especially geometry, posed constraints to ELL students, and these results may suggest how to help ELL, Exceptional Student Education (ESE), children from lower socioeconomic status (SES) families, and general education students in their vocabulary and math performance.

Also, Martiniello (2008) studied the linguistic complexity of math word problems that were found to exhibit differential item functioning (DIF) for ELL students and non-ELL students taking the Massachusetts Comprehensive Assessment System (MCAS) fourth-grade math test. Martiniello (2008) suggested that greater linguistic complexity increased the difficulty of English-language math items for ELL students compared to non-ELL students of equivalent math proficiency. Through textual analyses, Martiniello (2008) described the linguistic features of some of the 2003 MCAS math word problems that posed disproportionate difficulty for ELL students. Martiniello (2008) also used excerpts from children's think-aloud transcripts to illustrate the reading vocabulary comprehension challenges these features pose to Spanish-speaking ELL students.
Through both statistics and the voices of children, inferences about ELL students' math knowledge based on linguistically complex test items were questioned.

Beal, Adams, & Cohen (2010) focused on the relationship of English language vocabulary proficiency and math performance in a sample of high school students, which included 47% ELL students. Data sources included state math test scores, study-specific pre- and post-test scores, problem solving in an online math tutorial, and responses to a self-report assessment of mathematics self-concept. Results indicated that math performance for the ELL students increased with English vocabulary proficiency. ELL students' English vocabulary proficiency predicted math test scores, progress in the online math tutorial, and math self-concept. This suggested a possible link between math performance and vocabulary proficiency. Student vocabulary ability was correlated to the mastery that students had with the language. Language proficiency may influence successful vocabulary ability.

Yang (2003) applied two-level structural equation modeling techniques and examined the dimensionality of socioeconomic status (SES) and its relationship with mathematics and science performance at student and school levels. Data samples were drawn from populations of 17 countries in the Third International Mathematics and Science study (TIMSS). A set of items about the ownership of household materials was used to measure the dimensions of SES. For most of the countries, a general economic dimension and a cultural dimension were identified at the student level. The cultural dimension had the greatest impact on students' mathematics and science achievement. At the school level, however, only a general economic dimension was found in most countries. This dimension was interpreted to represent community wealth. It was found to
be highly related to school mean math and science achievement, except for the countries where an additional cultural dimension is identified. This cultural dimension was interpreted as the community cultural resources and atmosphere, and is strongly related to average school mathematics and science achievement. Yang (2003) confirmed that the ownership of a set of household materials can be used as SES indicators in exploring its multifaceted feature at both individual and school levels. A similar model structure was found in different countries by applying these indicators, despite the fact that the content of the set of household possessions is different. The findings show that the latent structure of SES at individual level is different from that at the school level, and that SES dimensions have different effects on mathematics and science achievement at individual and school levels.

Jimerson & Egeland (1999) explained that education is typically a cumulative process, wherein the early elementary school lessons provide a basis for subsequent knowledge acquisition. They noted that failure to acquire basic skills and to achieve academically is a problem for many children from poverty backgrounds. Yang (2003) illustrated that children from disadvantaged backgrounds fall further behind as they pass through the elementary years. Using data from a longitudinal study of high-risk children, Jimerson & Egeland (1999) examined deviations from predicted achievement scores on the basis of the discrepancy of observed scores from an established regression line, from first to sixth grade and first grade to tenth grade. Years in special education and socioeconomic status (SES) were related negatively to changes in math achievement between first and sixth grades, whereas SES, child behavior problems, and quality of home environment were related to deviations in achievement from first grade to tenth
grade. The environmental factors, quality of home environment, parent involvement, and SES were related to improved achievement across time. Early school, family, and home environments, as well as child factors were important predictors of academic achievement deviations in late elementary and high school.

Martiniello (2008) and Bracey (2009) suggested that poor math performance can result from vocabulary difficulty. The English proficiency of ELL students was lower than Native English Speakers (NES) due to the fact that many of the NES students’ parents speak English at home. With the inception of NCLB, ELL students are being evaluated with the same standards as NES students, resulting in vocabulary and math performance decreases. Although decreases in performances were not encouraging, for the first time in history educators and researchers had an opportunity to examine problems faced by ELL students and to devise strategies to help them achieve. Martiniello (2008) and Bracey (2009) stated that educators had an opportunity to investigate how vocabulary in math word problems, especially geometry, posed potential problems to ELL students, and these results may suggest how to help ELL, children from lower socioeconomic status (SES) families, and general education students in both vocabulary and math proficiency.

Capraro & Capraro (2006) analyzed how one teacher used contemporary children's literature to supplement middle-grades geometry. The teacher's students were matched to students in other classes on general reading, general mathematics, and geometry. Student and teacher interviews, observation notes, and video tape recordings provided insights into fluency and flexibility with mathematical vocabulary. On the three outcome measures, all of the students showed little change in general reading and a
modest increase in general mathematics abilities. In contrast, the students in the children's literature group showed markedly improved performance in geometry. Analyses indicated these students showed fluency with geometry vocabulary, demonstrated flexibility in the application of geometry concepts, explained formulae with rich descriptions, and outperformed the non-story group on geometry ability when controlling for pretest performance.

Driscoll, Heck, & Chval (2009) discussed strategies for engaging ELLs in oral and written production in the classroom. They hypothesized about the knowledge that teachers of mathematics need in order to support the learning of ELLs. Teachers need to use strategies for scaffolding and structuring mathematics tasks to heighten access for ELLs, without diluting the cognitive challenges in the tasks, facilitate productive peer interactions, and negotiate meanings. According to Driscoll et al (2009), instruction should include knowledge of at least some basic ways in which language is implicated in the learning of mathematics, including awareness that words like ‘same’ and ‘any’ underscore the importance of precision in mathematical language, as well as the privileged meaning of some words and phrases in mathematics. The authors also suggest that it is necessary to have knowledge of how to interpret gestures and other non-verbal modes of expressing mathematical thinking, as well as how to assess and interpret oral and written mathematical work by ELLs, to see both evidence of mathematical thinking and evidence related to academic language development. Mathematical tools, such as technology, manipulatives, and symbolic representations, support ELLs in mathematical investigations and communication of their thinking.
Problem statement

Research on the relationship between vocabulary and math performance showed that math word problems, particularly in Florida, had a high linguistic load. Nunnery, Kaplan, Owings, & Pribesh (2009) examined approximately 6,500 Florida students' vocabulary and mathematics performance when taught by teachers who focused on language arts skills. Results indicated that students served by these teachers performed about equally well in vocabulary and achieved a small but statistically significant advantage in mathematics when compared with all teachers but achieved substantially and statistically significantly higher in both vocabulary and mathematics when compared with teachers matched by subject and teaching experience. These results suggested that vocabulary abilities were related, to some extent, to math performance. When teachers focused on vocabulary proficiency and strategies while teaching mathematics, students performed better in math.

In 2010, the National Council of Teachers of Mathematics (NCTM) proposed the Common Core State Standards for Mathematics (CCSSM). New math standards were more conceptual than skill-based. The integration of language arts and mathematics may be required to aide students in acquiring the (CCSSM), which specified that students should be able to express mathematical ideas in both verbal and written formats. Pascopella (2010) interviewed Hank Kepner, the president of the National Council of Teachers of Mathematics (NCTM), and he stated that the organization had shifted its focus in terms of mathematics problem solving. Kepner (2010) described mathematics concepts that students in the U.S. should know, including new approaches to teaching students to use thinking and new concepts compared to just knowledge of skills to make
advances in mathematics. Shaughnessy (2010), the president of NCTM, stated that the new standards focus on mathematical thinking and reasoning. Shaughnessy (2010) also commented that CCSSM focus on oral and written communication of mathematical concepts to construct arguments.

Rodriguez (2012) examined the relationships among Comprehensive English Language Learning Assessment (CELLA) and Florida Comprehensive Assessment Test (FCAT), comparing language (CELLA) and content (FCAT). Language proficiency (CELLA) is reflective of the language associated with content, where academic achievement (FCAT) determines the knowledge and skills associated with the content. Florida uses the CELLA to measure the growth of students classified as ELLs in mastering the skills in English needed to succeed in school. The CELLA is a four-skill (listening, speaking, reading & writing) language proficiency assessment, providing program accountability in accordance with Title III of NCLB.

In 2009, 1,557,280 children, in grades 3-10 took FCAT reading and math exams. Of those students, English language learners accounted for 7% of FCAT’s test-takers. Student achievement among ELLs for FCAT reading in 2009 showed a 1% gain. In mathematics there was no gain. ELLs showed proficiency in FCAT reading of 36% in 2009, and 38% in FCAT math.

Annual Measurable Achievement Objectives (AMAOs) are measures of accountability for ELLs, required under NCLB, as measured by annual performance targets that must be met by all Title III-funded Local Education Agencies (LEAs). School year 2006-07 was the first year districts receiving Title III were held accountable for
meeting the three AMAOs. Levels of AMAO represent annual educational progress. AMAO 1 equals adequate progress; percent of K-12 ELLs making gains, which means moving up a proficiency level or showing proficiency in each of the CELLA domains (listening, speaking, writing and reading). AMAO 2 equals proficiency; the percent of each grade cluster of students (K-2, 3-5, 6-8, and 9-12) who score proficient in all CELLA domains. AMAO 3 equals proficiency in math and reading as measured by FCAT Annual Yearly Progress (AYP).

Rodriguez (2012) encouraged districts to Utilize Title III funding for professional development with content area math and science teachers, by enhancing the development of academic language, especially among middle and secondary school ELLs. Administrators may analyze multiple data sources to drive ELL instruction, sustain academic rigor, and utilize CELLA by adhering to measurable student performance targets. With these adjustments, Rodriguez (2012) anticipated that ELLs will show more proficiency in FCAT reading and math.

Rockhold (2011) examined why students struggle with reading and math FCAT exams and the related subtests of the reading and math FCAT exams. He suggested that language proficiency might affect how ELL students perform on the reading and math FCAT exams. The vocabulary subtest may rely more heavily on language than do information, literature, main idea, comparisons, and research, where the differences were lower. Relying heavily on language may put ELL students at a disadvantage.

Rockhold (2011) found that language proficiency correlates to how students score in reading and math FCAT exams. There was a moderate positive correlation among the
reading FCAT scale and subtest scores and math FCAT scale and subtest scores for ELL students. There was a moderate positive correlation among the reading FCAT scale and subtest scores and math FCAT scale and subtest scores for NES students. Reading performance on the FCAT had somewhat of a different predictive value of math FCAT performance for non-ESE NES students than for non-ESE ELL students. The exact reading performance predictive value of math FCAT performance could not be determined, but there seemed to be a connection between reading and math performance. The regression coefficient of reading FCAT scale scores and math FCAT scale scores was slightly higher for NES students than then regression coefficient for ELL students. Normally, this would have created a larger disparity between the math FCAT scale and subtest scores for ELL and NES students. One possible reason that the differences were not as large as expected could be that the ELL population of students has language proficient individuals that are ready to exit the ELL program, and therefore cannot truly be classified as ELL students. As with any sample of students, there were both high-achieving and low-achieving students in each group.

Bracey (2009a) noted that just because a student is language proficient does not mean that the student necessarily will score higher on standardized exams, because the student may lack the necessary language skills to achieve academically. On the converse, just because a student is not proficient in language does not mean that the student necessarily will score lower on standardized exams.

Rockhold (2011) noted that in a culture of accountability, legislators want to know why students are not performing better on standardized reading and math exams. They want to know why students are not learning and gaining knowledge effectively.
Rockhold (2011) outlined some possible causes for students struggling, particularly for students who are not proficient in the English language. Though findings in Rockhold’s (2011) study have meaning in terms of educational policy and practice as well, they were limited in terms of classifying ELL students.

Also, Rockhold (2011) noted that a possible limitation of the ex-post-facto correlational research design was the difficulty in finding statistically similar groups within the samples of ELL and NES students. In this study, it was difficult to statistically compare ELL and NES students. Reading and math performances of these two groups were compared, but there were factors other than language proficiency that could have caused differences in the performance of the two groups, which were not controlled for in the analyses. Performance differences may have violated assumptions of group homogeneity that are required to statistically compare groups. It may be helpful to have more accurate classifications of ELL students and to investigate differences by language proficiency level rather than grouping all the ELL students together. One of the reasons only small differences were found was because all ELL students were grouped together. The results might have changed with a comparison between Limited English Proficient (LEP) to Native English Speaking (NES) students. Results could look differently with a comparison among the different classifications of ELL students.

Given the findings, Rockhold (2011) concluded that future research should be conducted to add to the body of literature and support for the connections between reading and math performance. Several authors, including Bracey (2009), Martiniello (2008), and Fuchs (2008), have discussed the link between how students learn reading and math concepts. More research is required to show why students struggle with
learning the language, absorbing main idea, gathering information, and applying these concepts to learning other subjects, such as mathematics.

**Statement of purpose**

The purpose of this study is to ascertain the relationships among English language proficiency (ELP) vocabulary proficiency (VP), socioeconomic status (SES), and math performance (MP) on the geometry end of course (EOC) exam for English language learner (ELL) students. Specifically, the extent to which ELP, VP and SES can contribute to performance on the geometry EOC exam will be investigated. It was also examined whether VP and SES have a different predictive value for math performance, particularly in geometry, for higher SES ELL students than for lower SES ELL students.

**Major hypotheses and research questions**

Questions investigated through the course of the research are: 1) What is the strength of the relationship between English language proficiency (ELP) and math performance (MP) on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores and subtests? 2) What is the strength of the relationship between vocabulary proficiency (VP) and math performance (MP) on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores and subtests? 3) For all ELL students, how much of the variance in math performance (MP) is explained by English language proficiency (ELP) and vocabulary proficiency (VP)?

The hypotheses tested in this study are: 1) For all ELL students, there is significant predictability between English language proficiency (ELP), as measured by CELLA scale scores and subtests, and math performance (MP) as measured by geometry
EOC scale scores. 2) For all ELL students, there is significant predictability between vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, and math performance (MP) as measured by geometry EOC scale scores. 3) The multiple regression coefficients of English language proficiency (ELP) and vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, regressed on math performance (MP) as measured by geometry EOC scale scores is greater for higher SES ELL students than for lower SES ELL students.

**Definition of terms and variables**

English language proficiency (ELP) is defined as how well students meet or exceed the Next Generation Sunshine State Standards (NGSSS) in listening and speaking language arts and will be measured by the scale scores and subtests of the Comprehensive English Language Learning Assessment (CELLA), a tool to measure the progress of ELL students’ proficiency in English, helping to ensure the attainment of skills needed in school to achieve at high academic levels. States are required to administer an annual assessment that measures the English language proficiency of English Language Learners (ELLs) in grades K-12. The CELLA was administered to all ELLs in the state beginning in the fall of the 2006-07 school years, and administered annually, to meet this requirement and to assist districts and schools in determining English proficiency attainment in listening, speaking, reading, and writing. Vocabulary proficiency (VP) is defined as how well students meet or exceed the Next Generation Sunshine State Standards (NGSSS) in reading and writing language arts vocabulary and will be measured by the scale scores and subtests of the Comprehensive English Language Learning Assessment (CELLA).
Florida school districts currently use instruments for program entry and exit that provide a common basis for determining the English language proficiency of students or the progress students are making toward this goal. The purpose of the CELLA is to provide a statewide assessment for students, schools, and districts that will meet the requirements of NCLB for students covered under Title III. CELLA was developed through extensive collaboration with Educational Testing Services (ETS), Accountability Works, and five states (Florida, Maryland, Michigan, Pennsylvania, and Tennessee). CELLA was designed to produce an assessment of English language proficiency with four test levels, two forms per level in four skill areas (reading, writing, listening, and speaking). Each skill area is assessed using a variety of multiple-choice and/or constructed-response items and three scales of measurement, referred to as Annual Measurable Achievement Objectives (AMAOs) in the four areas of the CELLA (reading, writing, listening, and speaking) created using item response theory. Moreover, the three scales of measurement are linked vertically such that all four CELLA levels share a common scale.

Socioeconomic status (SES) is measured by inclusion in the Free and Reduced Lunch (FRL) program. The National School Lunch Program, established in 1946 under the National School Lunch Act, provides free and reduced-price lunches to school children from economically disadvantaged families. The program operates in all 50 states and the District of Columbia, as well as in Guam, Puerto Rico, the U.S. Virgin Islands, and Department of Defense schools. Each year, the United States Department of Agriculture publishes income guidelines for program eligibility that factor household income and size in relation to federal poverty guidelines.
Florida Statutes define an English language learner (ELL) as an individual who was not born in the United States and whose native language is a language other than English; an individual who comes from a home environment where a language other than English is spoken in the home; or an individual who is an American Indian or Alaskan native and who comes from an environment where a language other than English has had a significant impact on his or her level of English language proficiency; and who, by reason thereof, has sufficient difficulty speaking, reading, writing, or listening to the English language to deny such individual the opportunity to learn successfully in classrooms where the language of instruction is English. States and local school districts receive federal aid under Title III, also known as the English Language Acquisition, Language Enhancement, and Academic Achievement Act, of the No Child Left Behind Act of 2001 to assist in implementing education programs for English Language Learners. National leadership in ELL education is administered by the Office of English Language Acquisition of the U.S. Department of Education.

Math performance (MP) is defined as how well students meet or exceed the Next Generation Sunshine State Standards (NGSSS) and Common Core State Standards (CCSS) in math and is measured by the geometry End of Course (EOC) scale scores and subtests. The Florida Department of Education is transitioning to EOC assessments for certain high school courses. In the spring of 2012, students throughout the state participated in the Geometry EOC Assessment. The Geometry EOC Assessment measures student achievement of the Next Generation Sunshine State Standards (NGSSS), as measured by scale scores and subtests.
Geometry EOC data was obtained from a data warehouse in each school district, which contains all test data and is available to teachers. CELLA scale scores and subtests, as well as geometry EOC scale scores and subtests, represented the skill levels in language arts vocabulary and math for the academic year 2011-2012, measured how well the students learned vocabulary and math skills, and indicated the levels of student mastery of the subject material. The geometry EOC scale scores consist of criterion-referenced measures on geometry. The scores are indications of how well the students mastered the NGSSS in math, particularly geometry, from the State of Florida.

**Significance of this study**

Lubienski (2007) investigated the link between vocabulary and math performance for ELL students. Research suggested that most students generally struggle with language intensive math problems such as word problems and geometry (NAEP, 2011). It was shown that that there may be a link between vocabulary performance and geometry performance, particularly for those students without language proficiency. With an understanding of this relationship, teachers can improve their instruction, prepare our students more effectively for standardized tests, and have our students enjoy larger learning and achievement gains in geometry scale scores. Educators need to identify which students struggled with geometry because of vocabulary difficulties. The integration of language proficiency and vocabulary strategy instruction with geometry instruction may help ELL and low SES students overcome their struggles in solving geometry problems and understand more of the geometry concepts. Only then will teachers be able to implement adequate interventions and plans to improve mathematics performance.
Bracey (2009b) suggested that teachers may need to instruct their students in academic vocabulary, using basic vocabulary models to scaffold into higher levels of instruction, and integrate cognates and sentence starters into a vocabulary rich curriculum that addresses better cognition of the subject material. Identifying the possible strategies that support solving academic language intensive math problems will clarify for teachers the importance of integrating language proficiency, vocabulary, and geometry instruction, and will enable students to acquire the necessary knowledge and skills that will propel them forward in their educational, personal, and professional goals and pursuits.

**Brief summary of the proposed study**

The study examines socioeconomic status (SES), English language proficiency (ELP), vocabulary proficiency (VP), and math proficiency (MP) of students to determine if SES, as determined by the Free and Reduced Lunch (FRL) Program, as well as ELP and VP, as measured by CELLA scale scores and subtests, impacts performance on the geometry EOC exam scale scores. An ex-post facto multiple regression study is conducted using secondary data from a random stratified sample of a population of students from several school districts across the state of Florida. The study utilizes ELL groups which differed on independent variables (SES and CELLA scale scores and subtests) and test hypotheses about differences on dependent variables (geometry EOC scale scores). This study is an ex post facto design because data was used after the students had taken the CELLA and geometry EOC tests. The ex post facto research begins with the results of geometry EOC scale scores, working backward to attempt to identify why students earned the CELLA scale scores and subtest results. Comparisons are made among the ELL students on SES and different subtests of the CELLA exams.
Subtests include data on speaking, reading, writing and listening skills. These results could possibly help explain why students struggle with vocabulary proficiency and math performance.

The CELLA exam was given to students in 2011, while the geometry EOC exam was administered in the spring of 2012, and all of the students took the CELLA and geometry EOC tests. The results of the CELLA and geometry EOC tests was provided through data transferred from a data warehouse in the four school districts, then to a Microsoft Excel file, and finally to an SSPS file. The data had CELLA scale scores and subtests, which classified students in several categories of an ELL status identification variable. A single variable indicated inclusion in the Free and Reduced Lunch (FRL) Program, which allowed for the students to be put into an appropriate SES category. All of the students took the tests in 2011 or 2012. Tests were scored by the state, including open response questions. The state requires the school districts to keep all of the data in warehouses. CELLA and demographic data were provided. Student data was de-identified and identification numbers were assigned to each case. The data came directly from the district data warehouse, so no one altered or changed any of the data from the CELLA and geometry EOC scale scores and subtests, FRL and SES status information. Names of students were erased and each student was assigned a number. The identities of all students were hidden in the process of the research and throughout the analyses and discussion of the results.

CELLA scale scores and subtests, SES, and geometry EOC scale scores for ELL students were examined. During the study, it was examined if there was predictability between CELLA scale scores and subtests and geometry EOC scale scores for all ELL
students. Also, it was determined if there was predictability between SES status and geometry EOC scale scores for all ELL students. There was a comparison made to ascertain if the multiple regression coefficients of CELLA scale scores and subtests on geometry EOC scale scores were greater for higher SES ELL students than the regression coefficient for lower SES ELL students.

Regression analysis is a process to determine a relationship between criterion variables and predictor variables. In the case of this study, the independent criterion variables were CELLA scale scores and subtests and SES, while the dependent predictor variables were geometry EOC scale scores. There were efforts made to determine if there was predictability between CELLA scale scores and subtests and geometry EOC scale scores for all ELL students. Through the research, geometry EOC scale scores for ELL students may be able to be predicted.

In defining the relationship, three equations were used in the form \( y = a + bx \). Equations represented all ELL students, higher SES students, and lower SES students. The first equation showed where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean geometry EOC scale scores), ‘\( b \)’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized \( b \)), and \( x \) was the independent variable (CELLA scale scores). The second equation showed where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean geometry EOC scale scores), ‘\( b \)’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized \( b \)), and \( x \) was the independent variable (CELLA reading subtest scores). The third equation showed where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean
geometry EOC scale scores), 'b' was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized b), and x was the independent variable (CELLA scale scores and CELLA reading subtest scores).

An ex post facto multiple regression research design was used, which was useful in identifying why the students earned the CELLA scale scores and subtests and geometry EOC scale scores. The credibility of the testing results was not compromised due to improper handling of the data from the state or from the school district. A possible limitation of the ex-post-facto multiple regression research design was the difficulty in finding statistically similar groups within the samples. In this study, it was difficult to statistically compare higher SES ELL and lower SES ELL students. Vocabulary and math performance of these two groups were compared, but there may be factors other than vocabulary proficiency that could possibly cause differences in the performance of the two groups. Performance differences may violate assumptions of group homogeneity that were required to statistically compare groups.

Multiple regression research is a process to attempt to show the relationships among variables, in this case, SES, CELLA scale scores and subtests, and geometry EOC scale scores. Multiple regression analysis helped to compare CELLA scale scores and geometry EOC scale scores of ELL students. One reason that some ELL students may struggle with CELLA scale scores and geometry EOC scale scores and subtests could be their command of vocabulary. Similarly, some ELL students could struggle less with CELLA and geometry EOC scale scores and subtests.
There were some threats to internal validity. The possible relationships among ELL status, SES, CELLA scale scores and subtests and geometry EOC scale scores could be the result of other characteristics from which cannot be accounted. This included some examples of extraneous variables in the study such as limited data, the inability to explore other relationships, and prior subjects of the students, including the quality of education prior to this year or study and individual subject characteristics. These extraneous variables could provide alternative explanations as to why there would be differences between ELL students, other than language proficiency.

External threats to validity could include the fact that the results of the study may not be able to be generalized to other populations of students. The comparisons among students in this study and other students might be limited to districts in the states with similar demographics.
Chapter Two  

Literature Review

Research among language proficiency, SES, vocabulary, and math performance showed that math word problems tended to have a high linguistic load. Prior research results from Lubienski (2007) suggested that vocabulary, language abilities, and SES were related, to some extent, to math performance. When teachers focused on language and vocabulary skills while teaching mathematics, students performed better in math.

The link between vocabulary ability and math achievement

Several researchers investigated the link between vocabulary proficiency and performance in math. Lubienski (2007) investigated the achievement gaps in mathematics among several different groups of students. She showed that student scores in high school varied mostly by students’ responses to math word problems. Minority students and those from lower SES groups tended to use common sense more than math or vocabulary skills to answer the word problems. The scores of these students were usually a standard deviation below acceptable levels. On the other hand, students from other racial and SES groups used math techniques to solve the same problems and performed at higher levels than did students who did not use these strategies. The students who did not use the appropriate math or vocabulary strategies to solve the problems correctly did so because they did not have confidence in their abilities in following proper reasoning skills to fully understand the problems and answer the questions correctly. This study suggested that there appeared to be a link between the
ability to read and understand vocabulary in word problems to apply appropriate reasoning skills and performance on math word problems.

Chen (2008) indicated that changes to the math standards could potentially pose difficulty for students with low vocabulary proficiency, particularly for ELL and low SES students. The language load of the new math standards was more demanding than the old standards. The shift from a skills base to conceptual base required students to be more linguistically proficient because conceptual knowledge based problem solving required more developed written and oral academic language proficiency. This suggested that new math assessments required better vocabulary proficiency. ELL and low SES students may not be prepared for such a high linguistic load.

Also, Chen (2008) suggested that ELL and low SES students may perform better in solving problems in pure numerical format versus word problem format. For example, Chen (2008) showed that these students' performance in solving arithmetic problems was poorer with word problems presented in either the first or second language than the case with the same problems presented in a purely numeric format. Moreover, Chen (2008) found that ELL students had better comprehension of the word problems when they were written in their first languages.

According to NCTM standards (2012), students are now expected to communicate mathematically, both orally and in writing, and to participate in mathematical practices such as, explaining solution processes, describing conjectures, proving conclusions, and presenting arguments. Chen (2008) stated that vocabulary understanding and comprehension skills were only limited to basic knowledge which was
not enough for bilingual students’ mathematics learning. The relationships between vocabulary proficiency and mathematics education were more complicated, and researchers now tended to address how ELL students were affected by this emphasis on mathematical communication and how classroom instruction supported these students’ learning to communicate mathematically. Chen (2008) summarized that learning to communicate mathematically was now seen as a central aspect of what it meant to learn mathematics, and language, particularly vocabulary, was taken to play an important role in shaping students’ mathematics thinking.

Chen (2008) suggested that students who struggled with the command of a language and vocabulary tended to have difficulty learning. Students who struggled with language had linguistic difficulties that resulted from not having proficiency in vocabulary, comprehension, and communication areas. Most students who had trouble with English as a first or a second language experienced difficulties in making meaning of complex language in their classes. Given that the new mathematics standards required a higher proficiency of verbal and written English language vocabulary skills, it was important to further study the possible link between language complexity in word problems along with ELL and low SES students’ performance in mathematics.

Bracey (2009b) discussed that despite many educational efforts to increase vocabulary performance in the U.S, results from international large-scale assessments suggest that, although the U.S students outperform most countries in mathematics, American students still lag behind their Asian counterparts. At the national level, evidence shows that a large percentage of fourth and eighth graders perform at the lowest levels of proficiency in math and that math and vocabulary skills have decreased within
the last three years (Bracey, 2009b). Since vocabulary skills are the foundations for understanding concepts in other subject areas, students who struggle with vocabulary experience difficulties in other subjects. Struggles with vocabulary strategies can affect comprehension of concepts and materials, decreasing academic achievement. Bracey (2009b) stated that when students struggle with basic skills, then they cannot master more difficult subject content material. The author implied that this phenomenon affects millions of our students. This suggests that some ELL students have lower language proficiency and vocabulary ability, and therefore, they are less successful in math performance.

Pape (2004) found that many children read mathematics word problems and directly translated them to arithmetic operations. He found that more sophisticated problem solvers transformed word problems into different models. In one model the students used objects or manipulatives to solve the problems. Another model had students who used more mental skills. Subsequent solutions were often qualitatively different because these models differentially supported cognitive processing. Ninety-eight sixth and seventh grade students' problem-solving behaviors were described and classified into five categories. Nearly 90% of problem solvers used one behavior on a majority of problems. Pape (2004) discovered that the use of context such as units and relationships, recording information given in the problem, and provision of explanations and justifications were associated with higher vocabulary and mathematics achievement scores, greater success rates, fewer errors, and the ability to preserve the structure of problems during recall.
Also, Pape (2004) discovered that new math standards were more conceptual than skill-based. The integration of language arts and mathematics were required to aide students in acquiring the new math standards, which specified that students should express mathematical ideas in both verbal and written formats. There were new approaches to teaching students to use thinking and new concepts compared to just knowledge of skills to make advances in mathematics.

**Effect of culture on learning**

Bankston & Zhou (1995) identified the major theoretical perspectives on native-language literacy including forcible assimilation, reluctant bilingualism, and linguistic pluralism, and reports on a case study of the role of such literacy in the academic achievement of 387 Vietnamese high school students in New Orleans. They found that literacy in Vietnamese is positively related to identification with the ethnic group and to academic achievement. The authors maintained that ethnic language skills contributed to academic achievement by the community-level sociological means of providing access to social capital, as well as by the individual-level psychological means of cognitive transference. They concluded that ethnic language skills may not always be a hindrance to the social adaptation and upward mobility of young members of an ethnic immigrant group and that these skills may actually contribute to the goals of mainstream education, rather than compete with them.

Ogbu (1995) discussed how the role of culture in the education of minority children was given greater emphasis within the context of a growing desire for multiculturalism. Many scholars were concerned with obtaining a more inclusive
curriculum. However, an old issue that also deserves consideration relates to how cultural differences make it difficult for minorities to achieve in school. Case studies of African- and Chinese-Americans illustrated how voluntary minorities were better able to overcome cultural barriers than blacks who have an oppositional frame of reference. Both groups must deal with cross-cultural misunderstandings, communication difficulties, conceptual knowledge differences, different teaching and learning styles, white cultural hegemony, and the employment of alternative cultural frames of reference. Chinese-Americans see a problem, such as not speaking standard English, as a disadvantage they must overcome to get ahead. However, African-Americans view differences in group identity as something that should be preserved.

**Brain research and the effect on learning**

Van Steenbrugge, Valcke, & Desoete (2010) presented research that built on teachers' professional knowledge about mathematics learning difficulties and brain research. Based on the input of 918 primary school teachers, an attempt was made to develop an overview of difficult curriculum topics in primary school mathematics. The research approach built on new conceptions about the professional identity of teachers and earlier conceptions that point at the critical relevance of teachers' pedagogical and brain-based instruction of content knowledge. Research indicated that students learn mathematics at different stages depending on interventions made between the ages of three and five years old. Primary school mathematics used scaffolding techniques to build upon prior knowledge of the students to make learning gains.
Chadwick (2002) presented views on why computers are failing in the education of the children today. According to the author in his research of the brain, computers expanded the capacities of the people in the areas of logic and mathematics. This occurred at the cost of other forms of thinking, such as intuition, emotions, and spiritual beliefs. Computers were unable to make an important contribution to education because people did not know how to use the computer technology, adequately interpret the information, and apply it at the right place.

Sternglass & Bell (1983) linked the sharp decline in SAT scores during the 1970s with the fallout from nuclear bomb testing during the 1950s and early 1960s. The authors contended that nuclear radiation from fallout acts on the thyroid gland of the fetus or infant at a time when the thyroid is known to control the development of the brain. The evidence presented involved the temporal and geographical patterns of the changes in SAT scores which followed the pattern of nuclear bomb tests 17 to 18 years earlier. As in the earlier article, the authors presented, through a series of charts and statistics, the correlation which shows that: the steady decline in SAT scores began in 1963, 18 years after 1945, the year in which the first atomic bombs were detonated; the rate of decline accelerated sharply for students born in the early 1950s when bomb tests were begun in Nevada; the decline suddenly slowed in 1977–1978, exactly 18 years after the 1959 moratorium temporarily halted atmospheric bomb testing. Additional evidence presented linking fallout with declining SAT scores comes from geographical data which show that the greatest decline in test scores has occurred in those states in the Far West closest to the Nevada, Pacific, and Siberian test sites. In 1982 when the U.S. as a whole showed a rise in test scores, the 8 states that showed declines in both verbal and math scores were
all located in the West. Nevada and Utah had the greatest declines with Utah from the Nevada test showing the largest decline ever reported. According to the authors, the implications of all these findings indicate that the intellectual abilities so essential to any modern society would be seriously impaired by even a limited nuclear war.

Weinstein (1980) presented preliminary evidence suggesting that many of the children who had difficulty with arithmetic suffered from a neurological development lag rather than an underlying deficit. Such pupils appeared to favor the right cerebral hemisphere, which serves spatial functions, rather than the left, analytic half of the brain.

Smith & Miller (1994) discussed two studies that were conducted to investigate the effect of images on the vocabulary retention of left- and right-hemispheric-preference thinkers in college developmental studies reading classes. In each study, two groups of students were each given a list of unfamiliar words and definitions and student retention was compared. One group of students received sentences using the unknown vocabulary words, while the other group received the same sentences, as well as drawings, depicting the ideas in the sentences. In the first study, students copied the images from an overhead projector, whereas in the second study, the images were supplied on handouts. Both studies included equal numbers of nouns, verbs, and adjectives to investigate whether nouns were more easily learned than other parts of speech. Findings indicate that left-brain preference thinkers benefited more than right-brain preference thinkers from the inclusion of images, that copying the images was more beneficial than studying a supplied handout, and that nouns, verbs, and adjectives were learned equally well by students in all groups.
Miller & Tallal (2006) studied how the role of experience-dependent learning on the learning of language, reading, and math in secondary schools. Neuroscience research has shown that the brain is a "plastic" organ and can be modified throughout life. Neuroscience research related to the language and reading components of phonology, morphology, semantics, syntax, and pragmatics is discussed and applied to classroom teaching techniques.

**Learning styles and differences in how people comprehend material**

McCarthy (1990) explained how the 4MAT System was developed to help teachers organize their teaching based on differences in the ways people learn. 4MAT is an eight step cycle of instruction that capitalizes on individual learning styles and brain dominance processing preferences. Designed to raise teacher awareness as to why some things work with some learners and not at all with others, 4MAT is based on research from the fields of education, psychology, neurology, and management. As a learner focused model for adapting curriculum and instruction to the diverse needs of students, 4MAT benefits teachers by giving them a framework to design learning activities in a systematic cycle. However, 4MAT allows administrators to use the four 4MAT quadrants to sketch out the desired outcomes of staff development. Each lesson was to be developed using all four quadrants so that all learner needs would be met. By examining the primary characteristics in each quadrant of the cycle, the role shifts of teachers and learners become apparent. Each quadrant has a different emphasis; in Quadrant One, for example, the emphasis is on meaning, or how the material to be learned is connected to learners’ immediate lives. The emphasis in Quadrant Two is on content and curriculum and the importance of delivering instruction through an integrated approach.
**Socioeconomic status related to vocabulary and math skills**

Keane (2011) explored the differences between two groups of students, those trying to access learning opportunities and traditional entry students. He examined the differentiated behaviors of these two groups based on a three-year constructivist grounded theory study with 45 undergraduates at an Irish university. The participant groups behaved significantly differently within their own social realm, trying to put distance between themselves and individuals from the other group. They were motivated by a desire to self-protect and based on perceived relative social positioning. Keane illustrated some ways in which both disadvantage and privilege were performed at the post-entry stage in a widening participation context. The 'closure' behaviors of class-based groups constrain the building of social capital by working-class students, thus potentially limiting the ability of widening participation policies in achieving equality goals.

Stanton-Salazar & Dornbusch (1995) explained how the critical role of status attainment was interpreted by members of a socioeconomic group. The authors presented an alternative interpretation based on social reproduction theories and current research on social ties and adult occupational mobility. Using the concept of social capital, defined as social relationships from which an individual is potentially able to derive various types of institutional resources and support, they examined data on the information networks of a selected sample of Mexican-origin high school students. Apart from the influence of parental socioeconomic status, they assessed how students' grades and educational and occupational expectations are related to the formation of relationships with teachers and guidance counselors. Although the authors found some evidence for the relation between
grades and status expectations and measures of social capital, their strongest associations were with language measures, suggesting that bilinguals may have special advantages in acquiring the institutional support necessary for school success and social mobility.

Smith & Wohlstetter (2001) outlined that many educational reforms were implemented on a school-by-school basis in which the individual or the school was often the target of the effort, but the problems of education transcended the capacity of one school working alone. Networking schools with each other or with partner organizations worked to develop social capital, an effective alternative to market-type or hierarchical approaches to reform. In the network model of organizing, authority and accountability were based on the social relationships between network participants. Focusing on new management roles within school networks, the authors' findings suggested that networks promoted community-based collaboration, cost sharing, knowledge sharing, and the involvement of external partners. In contrast, challenges to the network strategy included the need for extensive training in group-process skills and the need for quality information. The authors explained that the language and discourse of networks should be more accessible to education reformers.

Becker (1978) discussed how nine approaches to the education of economically disadvantaged children were evaluated in terms of students' performance levels in basic vocabulary and math skills, cognitive, conceptual skills, and affective outcomes. Five of the programs were designed to foster the unique motivations each individual brings to school; two were oriented to the development of basic reading and math skills one required parents to undertake some teaching activities; and the remaining program focused on the development of bilingualism. The achievements of students in these
programs were compared with that of students in "regular" programs and against national norms. The results were confounded by the possibility that some of the poor outcomes may not be program effects but due to implementation problems, but the research uncovered more information. The Direct Instruction model was more effective in terms of basic academic goals and affective outcomes. The Behavior Analysis model was especially effective in the areas of math computation, reading and spelling, and affective outcomes. The Parent Education and the Bilingual Language models were the only others to show a few positive outcomes.

Yang (2003) applied two-level structural equation modeling techniques and examined the dimensionality of socio-economic status (SES) and its relationship with mathematics and science performance at student and school levels. Data samples were drawn from populations of 17 countries in the Third International Mathematics and Science study (TIMSS). A set of items about the ownership of household materials was used to measure the dimensions of SES. For most of the countries, a general economic dimension and a cultural dimension were identified at the student level. The cultural dimension had the greatest impact on students' mathematics and science achievement. At the school level, however, only a general economic dimension was found in most countries. This dimension was interpreted to represent community wealth. It was found to be highly related to school mean math and science achievement, except for the countries where an additional cultural dimension is identified. This cultural dimension was interpreted as the community cultural resources and atmosphere, and is strongly related to average school mathematics and science achievement. Yang (2003) confirmed that the ownership of a set of household materials can be used as SES indicators in exploring its
multifaceted feature at both individual and school levels. A similar model structure was found in different countries by applying these indicators, despite the fact that the content of the set of household possessions is different. The findings show that the latent structure of SES at individual level is different from that at the school level, and that SES dimensions have different effects on mathematics and science achievement at individual and school levels.

Jimerson & Egeland (1999) explained that education is typically a cumulative process, wherein the early elementary school lessons provide a basis for subsequent knowledge acquisition. They noted that failure to acquire basic skills and to achieve academically is a problem for many children from poverty backgrounds. Yang (2003) illustrated that children from disadvantaged backgrounds fall further behind as they pass through the elementary years. Using data from a longitudinal study of high-risk children, Jimerson & Egeland (1999) examined deflections from predicted achievement scores on the basis of the discrepancy of observed scores from an established regression line, from first to sixth grade and first grade to tenth grade. Years in special education and socioeconomic status (SES) were related to changes in math achievement between first and sixth grades, whereas SES, child behavior problems, and quality of home environment were related to deflections in achievement from first grade to tenth grade. The environmental factors, quality of home environment, parent involvement, and SES were related to improved achievement across time. Early school, family, and home environments, as well as child factors were important predictors of academic achievement deflections in late elementary and high school.
Math word problems and linguistic complexity

Martiniello (2009) examined nonmathematical linguistic complexity as a source of differential item functioning (DIF) in math word problems for ELL students. Specifically, she investigated the relationship between item measures of linguistic complexity, nonlinguistic forms of representation and DIF measures based on item response theory difficulty parameters in a state fourth-grade math test. Martiniello (2009) found that items with greater linguistic complexity had higher item difficulty parameters and non-ELL students performed better on those items than did ELL students, suggesting differential item functioning favoring non-ELL students. However, she found that the impact of linguistic complexity on DIF was important when compared to items with nonlinguistic schematic representations that helped ELLs make meaning of the text. This suggested that language ability was related to performance on math problems, particularly those that are linguistically complex, and including schematic representations help mitigate the negative effect of increased linguistic complexity in math word problems.

Similarly, Powell, Fuchs, Fuchs, Cirino & Fletcher (2009) examined the differential impact of word problem features on problem difficulty as a function of mathematics disability (MD) status. The participants were all in third grade in a Southeastern school district. Results revealed that problem type influenced problem difficulty differentially for MD-only versus mathematic disability vocabulary disability (MDVD) participants.
Powell, Fuchs, Fuchs, Cirino, & Fletcher (2009) also found that there were recent changes to the math standards which potentially could pose difficulty for students from lower socioeconomic status and with low language proficiency, particularly for ELL students. The language load of the new math standards was more demanding than the old standards. The shift from a skills base to conceptual base required students to be more linguistically proficient because conceptual knowledge based problem solving required more developed written and oral academic language proficiency. This suggested that new math assessments required better vocabulary and writing proficiency. Students from lower SES and ELL students may not be prepared for such high linguistic load.

**Math instruction**

Researchers compared instructional methods in the U.S. to those of other countries to attempt to understand American students’ lower math scores in comparison to their foreign counterparts. Hyde (2007) compared methods of mathematics education in the U.S to those of countries with higher math test scores. In contrast to the U.S., Hyde found that countries with the highest math test scores also had a more conceptual and less skill based approach to math instruction where students used integrated additional subject material to understand the lessons. Because of his investigation, Hyde suggested that math teachers in the U.S. incorporate other disciplines into their curriculums.

Xin (2007) examined the potential influence of learning opportunities provided in one U.S. and one Chinese mathematics textbook series on students’ problem-solving performance. The author studied learning opportunities provided in the textbooks by
analyzing word problem distribution across various problem types, as well as the potential influence of learning opportunities on students' ability to solve arithmetic word problems, by determining student success rate in relation to word problem distribution in adopted textbooks. The relation between adopted textbook word problem task presentation and student success in solving problems suggested that the ability of U.S. participants to solve certain problem types better than other problem types may be related directly to the design of U.S. textbooks.

Further, Xin, Wiles & Lin (2008) examined the potential of teaching conceptual model-based word problem (WP) story grammar to enhance mathematics problem solving among elementary school students. Conceptual model-based word problems utilized real-world examples to teach students intended mathematical concepts. Taking the concept of story grammar from reading comprehension literature helped to examine the effect of teaching WP story grammar on arithmetic WP solving that emphasizes the algebraic expression of mathematical relations in conceptual models. Participants were five students in grades four and five who had or were at risk for mathematics disabilities. The authors found that conceptual model-based representation prompted by WP story grammar improved students' performance on arithmetic WP solving and promoted pre-algebra concept and skill acquisition.

Jordan (2007) discussed that students struggled for many reasons. Some students had math difficulties or suffered from math disabilities, such as dyscalculia, in spite of average or above average intelligence. She explained the importance of addressing math difficulties early on in a child's education in order to prevent future failure. Jordan noted common characteristics among struggling students, including weak computational
fluency and deficient number sense. She recommended that the school screen for numeracy problems in kindergarten to the same extent that they screen for literacy problems. Jordan (2007) described a number-sense screening test she and colleagues developed, which covered areas including counting skills, number knowledge, and story problems.

Also, Jordan (2007) determined that students who struggled with the command of a language and reading tended to have difficulty learning. Their linguistic difficulties resulted from not having proficiency in vocabulary, comprehension, and communication areas. Most students who had trouble with English as a first or a second language experienced difficulties in making meaning of complex language in their classes. Given that the new mathematics standards required a higher proficiency of verbal and written English language skills, it was important to further study the possible link between language complexity in word problems and ELL students’ performances in mathematics.

Driscoll, Heck, & Chval (2009) discussed strategies for engaging ELLs in oral and written production in the classroom. They hypothesized about the knowledge that teachers of mathematics need in order to support the learning of ELLs. Teachers need to use strategies for scaffolding and structuring mathematics tasks to heighten access for ELLs, without watering down the cognitive challenges in the tasks, facilitate productive peer interactions, and negotiate meanings. Instruction should include knowledge of at least some basic ways in which language is implicated in the learning of mathematics, including awareness that words like ‘same’ and ‘any’ underscore the importance of precision in mathematical language, as well as the privileged meaning of some words and phrases in mathematics. The authors also suggest that it is necessary to have knowledge
of how to interpret gestures and other non-verbal modes of expressing mathematical thinking, as well as how to assess and interpret oral and written mathematical work by ELLs, to see both evidence of mathematical thinking and evidence related to academic language development. Mathematical tools, such as technology, manipulatives, and symbolic representations, support ELLs in mathematical investigations and communication of their thinking.

**Using vocabulary strategies to teach math**

Some authors discussed using reading strategy models to help teach mathematical concepts. Vacaretu & Stanca (2008) outlined two activities for ninth-grade students that involved using mathematics from an original source and an excerpt from some current print media to show how problem writing enhanced students' awareness of the logical structure of mathematics problems and how such awareness increased success with problem solving. Foster (2007) used the concept of mental modeling to show her students how they could apply their vocabulary strategies to the mathematical problem-solving processes. For the teacher, this technique involved repeating all conscious decisions and steps taken while working out a problem.

Beck & McKeown (2007) discussed studies with kindergarten and first-grade children from a low-achieving elementary school that provided vocabulary instruction by the students' regular classroom teacher of advanced vocabulary words from children's trade books that are typically read aloud. The studies compared the number of sophisticated words learned between children who were directly taught the words and children who received no instruction. The children in the experimental group learned
significantly more words. Another study examined children's learning of words under two different amounts of instruction. The vocabulary gains in kindergarten and first-grade children for words that received more instruction were twice as large. Student vocabulary was assessed by a picture test where students were presented with pictures that represented different words and were asked to identify which picture represented the word that the tester provided. The verbal test was similar but used a sentence description of a scenario instead of a picture. Both studies gave instructional implications for which words to teach and how to teach them to young children.

Depaepe, DeCorte & Verschaffel (2010) reported about a seven-month long video-based study in two regular Flemish sixth-grade mathematics classrooms. The focus was on teachers' approaches towards problem solving. They distinguished between focusing on mathematical structure and focusing on contextual aspects in the problem-solving process. The findings highlighted that the word problem-solving lessons were more dominated by a paradigmatic than a narrative approach and that interventions in which the relation between the mathematics structure and the realistic constraints of the problem context were rare.

Pugalee (2004) investigated the impact of writing during mathematical problem solving. The study involved an analysis of ninth grade algebra students' written and verbal descriptions of their mathematical problem solving processes. The written and verbal data showed a relationship between the number of problem solving strategies tried by students and their success. The majority of problem solving behaviors involved execution actions such as carrying out goals and performing calculations. Pugalee (2004) found that students who constructed global plans were more successful problem solvers.
Students engaged in verification behaviors at various stages of problem solving did not verify their final answers. While both oral and written descriptions served as tools for understanding students' thinking processes, a comparison of the two modes of reporting, using a meta-cognitive framework revealed some important variations. Students who wrote descriptions of their thinking were significantly more successful in the problem solving tasks than students who verbalized their thinking. Differences in meta-cognitive behaviors also supported the premise that writing can be an effective tool in supporting meta-cognitive behaviors.

Also, Pugalee (2004) noted that students need to communicate mathematically, both orally and in writing, to participate in mathematical practices such as explaining solution processes, describing conjectures, proving conclusions, and presenting arguments. The relationships between language proficiency and mathematics education are more complicated, and researchers now tend to address how ELL students are affected by this emphasis on mathematical communication and how classroom instruction can support these students' learning to communicate mathematically.

Capraro & Capraro (2006) analyzed how one teacher used contemporary children's literature to supplement middle-grades geometry. The teacher's students were matched to students in other classes on general reading, general mathematics, and geometry. Student and teacher interviews, observation notes, and video tape recordings provided insights into fluency and flexibility with mathematical vocabulary. On the three outcome measures, all of the students showed little change in general reading and a modest increase in general mathematics abilities. In contrast, the students in the children's literature group showed markedly improved performance in geometry. Analyses
indicated these students showed fluency with geometry vocabulary, demonstrated flexibility in the application of geometry concepts, explained formulae with rich descriptions, and outperformed the non-story group on geometry ability when controlling for pretest performance.

**Links between difficulties in vocabulary and difficulties in math**

Fletcher (2005) addressed issues concerning the measurement of numbers, letters, and words versus cognitive processes in early screening batteries, and associations of vocabulary, math, and attention disorders. Based on vocabulary prediction studies, assessments that include numbers were most predictive of outcomes in math word problems. However, given the association of vocabulary, math, and attention disorders, measures sensitive to vocabulary and attention difficulties may be necessary in early screening batteries for math disabilities.

Abedi (2010) stated however, as most standardized, content-based tests, such as science and math tests, are administered in English and norm-referenced on native English-speaking test populations, they may inadvertently function as English language proficiency tests. Results suggested that ELL students may be unfamiliar with the linguistically complex structure of test questions, may not recognize vocabulary terms, or may mistakenly interpret an item literally. They may also perform less well on tests because they read more slowly.

Further, Abedi (2010) reviewed the literature on the assessment of ELL students that clearly suggests how language factors confound their test results. The largest gap between bilingual and non-bilingual students was in vocabulary. The next largest gaps were in the content areas that appear to have more language demand. Math concepts,
such as estimation, problem solving, and data interpretation, have more language demand than other types of math problems. The results clearly suggested the impact of language factors on students’ performance, particularly in areas with more language demand. With more demanding language, cognitive complexity of test items may also be confounded. That is, items with math calculation may not only have less language demand, but they may also be less cognitively demanding than math problem solving.

Also, Abedi (2010) examined the impact of students’ language background on the outcome of their assessments. The performance difference between ELL and non-ELL students can be partly explained by language factors in the assessment. The linguistic complexity of test items can be a possible source of measurement error and influence the reliability of the assessment. Linguistic complexity of test items can be a possible source of construct-irrelevant variance influence the validity of the assessment. Results from the analyses of data from several locations nationwide indicated that students’ assessment results might be confounded with language background variables. ELL and non-ELL student performance revealed major differences between the performances of the two groups. This showed major differences in performance between students with different language backgrounds. With a higher level of English language complexity in the assessment tool, the greater the performance gap between ELL and non-ELL students. The results of this study suggest that ELL test performance may be explained partly by language factors. That is, linguistic complexity of test items unrelated to the content being assessed may at least be partly responsible for the performance gap between ELL and non-ELL students. There is an impact of language factors on the assessment of ELL students. Psychometric characteristics of assessment tools should be used with ELL
students. In assessing ELL students, student language background can reduce
confounding effects of language background on the assessment outcome.

Abedi (2010) further found that linguistic modification of test items results in
significant differences for mathematics performance. The author discovered that for
word problems with a clear linguistic component, the application of mathematical
knowledge and skills is affected by whether the students are able to understand the
meaning of the words. These studies indicated that students’ vocabulary acquisition and
language comprehension skills are central issues that ELL students need to grapple with
when learning mathematics.

As reported in the NASSP Bulletin (1994) Project Self Help, a family literacy
program in the United States, improved not only vocabulary skills, but also math
performances. The boost was a result of an intensive program aimed at increasing the
language arts skills of students. However, students not only showed progress in
vocabulary abilities, but their math scores increased as well.

Swanson & Beebe-Frankenberger (2004) identified cognitive processes that
revealed individual differences in working memory (WM) and mathematical problem-
solution accuracy in elementary school children at risk and not at risk for serious math
difficulties (SMD). The results were that younger children and children at risk for SMD
performed poorer on WM and problem-solving tasks, as well as measures of math
calculation, reading, and semantic processing. Phonological processing and inhibition in
older children not at risk for SMD and WM predicted solution accuracy of word
problems independent of measures of fluid intelligence, vocabulary skill, math skill,
knowledge of algorithms, semantic processing, speed, and short-term memory. The
results supported the notion that the executive system is an important predictor of children's problem solving.

Fuchs, Compton, Fuchs, Paulsen, Bryant, & Hamlett (2005) examined the efficacy of preventive first grade tutoring in mathematics, estimated the prevalence and severity of mathematics disability, and explored pretreatment cognitive characteristics associated with mathematics development. Tutoring decreased the prevalence of math disability, with prevalence and severity varying as a function of identification method and math domain. Attention accounted for unique variance in predicting each aspect of end-of-year math performance. Other predictors, depending on the aspect of math performance, were nonverbal problem solving, working memory, and phonological processing.

Fuchs, Fuchs, & Prentice (2004) assessed responsiveness to a mathematical problem-solving treatment as a function of students' risk for disability. Interactions among at-risk status, treatment, and time showed that as a function of treatment, mathematics disability risk (MDR) / reading disability risk (RDR), MDR-only, and RDR-only students improved less than no disability risk (NDR) students on computation and labeling, and MDR/RDR students improved less than all other groups on conceptual underpinnings. Exploratory regressions suggested that MDR/RDR students' reading and vocabulary deficits or their underlying mechanisms explained a greater proportion of variance in responsiveness to problem-solving treatment than math deficits or their underlying mechanisms.
Fuchs, Seethaler, Powell, Fuchs, Hamlett, & Fletcher (2008) assessed the effects of preventative tutoring on the math problem solving of third-grade students with math and reading difficulties. Analyses of variance revealed statistically significant effects on a wide range of word problems, with large effect sizes. Findings supported the efficacy of the tutoring protocol for preventing word-problem deficits among third-grade students with math and vocabulary deficits.

Keeler & Swanson (2001) investigated the relationships among working memory (WM), declarative strategy knowledge, and math achievement in children with and without mathematical disabilities (MD). The results showed that after considering the influence of vocabulary, stable strategy choices rather than specific strategy knowledge was related to verbal and visual-spatial WM span in high demand maintenance conditions. Age-matched children's verbal and visual-spatial WM performance was superior to that of children with MD, whereas WM performance was statistically comparable between children with MD and younger children matched on math ability. The selection of expert strategies was related to high WM span scores in the initial conditions. After controlling for vocabulary achievement in a regression analysis, verbal and visual-spatial WM, stable verbal strategy choices, and expert strategy choices related to visual-spatial processing all contributed independent variance to math achievement. Overall, these results suggested that WM and math achievement are related to strategy knowledge.

Several researchers, including Keeler & Swanson (2001) have investigated the link between vocabulary performance on the FCAT and math performance on standardized tests for lower SES students, ELL, and native English-speaking students.
Research suggests that all students generally struggle with math word problems. It has been shown that there may be a link between vocabulary performance and math performance, particularly for those students without language proficiency. Keeler & Swanson (2001) stated that educators need to identify which students struggle with math because of vocabulary difficulties. The integration of vocabulary in math instruction may help ELL students overcome their struggles in solving math word problems and understand more math concepts. Only then will teachers be able to isolate the major causes of the struggles of ELL students and implement adequate interventions and plans to improve mathematics performance. Identifying the root causes of problems in solving word problems will emphasize to teachers the importance of integrating vocabulary and math instruction, which will enable students to succeed. The chapter that follows will discuss the methods that will be used in this study to identify why students struggle with vocabulary and math concepts and ultimately help students improve performance in mathematics.
Chapter Three

Method

Participants

This study examined a stratified random sample of students in high schools from four public school districts in the state of Florida. Within each school district, the study examined students in grades nine through twelve. The school districts serve a large population of students from many different cultural and socioeconomic backgrounds. Hispanic students accounted for sixty-seven percent of the students. African-American students made up twenty-five percent of the students, while Caucasian, Asian, and multiracial students together represented about eight percent of the students.

Description of measures and instruments

A stratified random sample was used from each school district population based on the representative percentages by gender, race, and socioeconomic factors of each district. Outcome variables were math performance (MP), as measured by geometry End of Course (EOC) exam scale scores, while the predictor variables were English language proficiency (ELP) and vocabulary proficiency (VP), both measured by the CELLA scale scores and subtests, and SES, as determined by inclusion in the Free and Reduced Lunch (FRL) program.

Comprehensive English Language Learning Assessment (CELLA), English Language Learner (ELL), and English Language Proficiency (ELP)

The CELLA exam, according to NCES, serves as the instrument to measure scale scores, subtests, English language proficiency (ELP) and vocabulary proficiency (VP) of
ELL students. In the past, ELL students were defined as students who were within the first five years of the process of learning English, but for the purposes of this research study, ELL students were measured by ELP, based on CELLA scale scores and subtests. Subtests include data on speaking, reading, writing, and listening skills. Martiniello (2008) suggested that it takes at least seven years for students to become proficient in a non-native language. Students who are within the five years were generally not considered proficient in the language (Martiniello, 2008). Each ELL student in the state of Florida took the CELLA exam in 2011.

**Vocabulary performance (VP)**

Vocabulary performance (VP) is defined by NCES as how well students meet or exceed the Next Generation Sunshine State Standards (NGSSS) and Common Core State Standards in English Language Arts (CCSSELA) and will be measured by CELLA, a tool to measure the progress of ELL students’ proficiency in English, helping to ensure the attainment of skills needed in school to achieve at high academic levels. States are required to administer an annual assessment that measures the English language proficiency (ELP) of English Language Learners (ELLs) in grades K-12. The CELLA was administered to all ELLs in the state beginning in the fall of the 2006-07 school years to meet this requirement and to assist districts and schools in determining English language proficiency attainment in listening, speaking, reading, and writing.

**Comprehensive English language learning assessment (CELLA)**

The purpose of the Comprehensive English Language Learning Assessment (CELLA) is to provide a statewide assessment for students, schools, and districts that will meet the requirements of NCLB for students covered under Title III, according to NCES.
CELLA was developed through extensive collaboration with Educational Testing Services (ETS), Accountability Works, and five states (Florida, Maryland, Michigan, Pennsylvania, and Tennessee). Also, CELLA was designed to produce an assessment of English language proficiency (ELP) with four test levels, two forms per level in four skill areas (listening, speaking, reading, and writing). Each skill area is assessed using a variety of multiple-choice and/or constructed-response items and three scales of measurement (combined listening/speaking, reading, and writing) will be created using item response theory. Moreover, the three scales of measurement are linked vertically such that all four CELLA levels share a common scale.

English language learner (ELL)

Florida Statutes and NCES define an English language learner (ELL) as an individual who was not born in the United States and whose native language is a language other than English; an individual who comes from a home environment where a language other than English is spoken in the home; or an individual who is an American Indian or Alaskan native and who comes from an environment where a language other than English has had a significant impact on his or her level of English language proficiency (ELP); and who, by reason thereof, has sufficient difficulty listening, speaking, reading, or writing to the English language to deny such individual the opportunity to learn successfully in classrooms where the language of instruction is English. States and local school districts receive federal aid under Title III, also known as the English Language Acquisition, Language Enhancement, and Academic Achievement Act, of the No Child Left Behind Act of 2001 to assist in implementing education programs.
National leadership in ELL education is administered by the Office of English Language Acquisition of the U.S. Department of Education. In 2005-06, according to the National Center for Education Statistics (NCES), more than 4,223,115 students (8.7%) in reporting states and the District of Columbia were English language learners. In the same year, more than 221,705 students (8.3%) in Florida were English language learners. As the fourth most-populous state, Florida’s ELL population is much smaller when compared to the two most populous states, Texas (15.7%) and California (25.1%). Florida’s ELL population is comparable to the third most populous state, New York (7.2%). Except for a slight decrease in 2003-04, the percentage of ELL students in Florida’s public schools continued on a gradual, long-term upward trend for the last decade. The percentage of ELL students in school year 1997-98 was 6.4 percent, increasing to 8.3 percent by school year 2002-03. However, the percentage of ELL students tapered slightly to 7.6 percent in 2003-04 but began increasing again the following year. The ten-year numerical increase during this period amounts to 85,284 students (146,368 in 1997-98 vs. 231,652 in 2006-07), a cumulative increase of 58.3 percent in ten years. Nine districts reported ten percent or more of their enrollment as ELL in 2006-07, as compared to only five districts ten years prior.

**Socioeconomic status (SES)**

Socioeconomic status (SES) is measured, according to NCES, by inclusion in the Free and Reduced Lunch (FRL) program. The National School Lunch Program, established in 1946 under the National School Lunch Act, provides free and reduced-price lunches to school children from economically disadvantaged families. The program operates in all 50 states and the District of Columbia, as well as in Guam, Puerto Rico,
the U.S. Virgin Islands, and Department of Defense schools. Each year, the United States Department of Agriculture publishes income guidelines for program eligibility that factor household income and size in relation to federal poverty guidelines. In 2009-10, a student from a four-person household in Florida with annual household income less than $28,665 is eligible for free lunches. In 2007-08, according to the National Center for Education Statistics (NCES), more than 1.2 million students (45.58%) in Florida were eligible for the free and reduced lunch program. As the fourth most-populous state, Florida’s free and reduced-price lunch figure is comparable with the three most populous states, Texas (47.72%), California (48.86%), and New York (44.12%). Eligibility for free/reduced-price lunch in Florida’s schools continued on a long-term upward trend for several years. The ten-year numerical increase during this period amounts to 339,279 students (1,069,697 in 2000-01 vs. 1,408,976 in 2009-10), a cumulative increase of 31.70 percent in ten years. Forty-nine districts in Florida reported 50 percent or more of their enrollment eligible for free/reduced-price lunch in 2009-10, as compared to only twenty-seven districts ten years prior.

**Math performance (MP)**

Math performance, according to NCES, is defined as how well students meet or exceed the Next Generation Sunshine State Standards (NGSSS) and Common Core State Standards in Math (CCSSM) and is measured by the geometry End of Course (EOC) scale scores. The Florida Department of Education is transitioning to EOC assessments for certain high school courses. In the spring of 2012, students throughout the state participated in the Geometry EOC Assessment. The geometry EOC exam was
administered in April of 2012, and the scale scores consist of criterion-referenced measures on geometry standards.

The Geometry EOC Assessment, according to NCES, measures student achievement of the Next Generation Sunshine State Standards (NGSSS) and Common Core Standards in Math (CCSSM), as outlined in the Geometry course description. The assessment was given in one 160-minute session with a 10-minute break after the first 80 minutes. Students were not allowed to talk during the break. As with FCAT and FCAT 2.0 paper-based administrations, individual breaks may be allowed as needed. Students may not be dismissed during the first 80 minutes; however, after the 10-minute break, they may be dismissed as they complete the test. Although the assessment is scheduled for a 160-minute session, any student not finished by the end of the 160 minutes may continue working. Testing must be completed within the same school day. There are multiple forms of the assessment, with a maximum of 65 items on each test form. Each form of the assessment includes 35-40 multiple-choice and 20-25 fill-in response items. Approximately six to 10 of these items are experimental (field test) items, and are not included in student scores. A scientific calculator is provided in the Test Navigation platform. Students may request the use of an approved, hand-held scientific calculator after they participate in a practice test and determine that they are not comfortable using the online calculator for testing. The FDOE does not provide calculators to districts, but a list approved scientific calculators is provided in the test administration manual. Students are provided a reference sheet containing commonly used formulas and conversions to work the problems. The reference sheet appears in a pop-up window. Schools may make copies of the reference sheet provided in the test administration
manual and distribute them to students if they prefer to use a hard copy. Students are provided four-page, hard-copy work folders to use as scratch paper. Used folders are secure materials that must be collected after testing and stored or securely destroyed according to district assessment coordinators’ instructions.

Student results from the different test forms must be reviewed and compared to ensure that the difficulty level is the same for each test form. This process, called equating, takes place after testing so that enough student scores are in the system to ensure that a representative sample of student results is available for use in the comparison. Students receive a score on a scale of 20-80. This scale is a special scale known as a T-score scale. On this scale, a score of 50 is at the statewide average. Individual Student Reports (ISRs) will indicate whether the student’s score falls within the high, middle, or low levels as compared to other students in Florida. Geometry scores are released approximately two weeks after the end of the test administration window. For students who entered grade 9 in the 2011-12 school year and are enrolled in Geometry or an equivalent course, each student’s Geometry EOC Assessment score must be used to calculate 30 percent of his/her final grade in the course. The method for applying this requirement is determined and applied by each school district. For the purposes of this research study, the CELLA and geometry EOC scale scores were used instead of developmental scale scores because the emphasis was on comparing students over one year versus over several years.

**Geometry EOC**

The geometry EOC has content validity because of the connection of questions to a benchmark. All test items address specific Next Generation Sunshine State Standards
(NGSSS) and Common Core State Standards in Math (CCSSM) benchmarks. Items are reviewed and evaluated for how well they address the benchmarks for which they were developed. The geometry EOC exam is a standardized test that is used in the state of Florida.

**CELLA**

The CELLA test has content validity because of the connection of questions to a benchmark. All test items address specific Next Generation Sunshine State Standards (NGSSS) and Common Core State Standards in English Language Arts (CCSSELA) benchmarks. Items are reviewed and evaluated for how well they address the benchmarks for which they were developed. The CELLA exam is a standardized test that has been used in the state of Florida for several years.

**Research design**

An ex-post facto stepwise multiple regression study was conducted using secondary data from a random stratified sample of a population of high school students from several school districts across the state of Florida. The study utilized ELL groups which differed on predictor variables (SES, ELP, and VP, as determined by FRL and measured by CELLA scale scores and subtests) and tested hypotheses about differences on outcome variables (MP, as measured by geometry EOC scale scores). This study was an ex post facto design because data was used after the students had taken the CELLA and geometry EOC tests. The ex post facto research began with the results of geometry EOC scale scores, working backward to attempt to identify why students earned the CELLA scale scores and subtest results. Comparisons were made among the ELL students on SES and different subtests of the CELLA exams. These results could
possibly help explain why students struggle with vocabulary proficiency (VP) and math performance (MP).

A stepwise multiple regression research design was used to determine if relationships existed among SES, ELP, and VP, as determined by FRL and measured by CELLA scale scores and subtests, and MP, as measured by geometry EOC scale scores. Fraenkel & Wallen (2003) stated that regression research is done to determine relationships among two or more variables and explore their implications for cause and effect. Multiple regression research is used to help make meaningful and intelligent predictions. Information was collected and then quantitatively analyzed using Statistical Package for the Social Sciences (SPSS). Before the multiple regression coefficients were calculated, descriptive statistics were generated.

Stepwise multiple regression analysis was used to determine if there were relationships among each of the predictor and outcome variables. Sirkin (2006) found that stepwise multiple regression is a procedure in which each predictor variable is added to the regression in a separate step, and the order of entry was based on criteria selected by the researcher. The criterion was the strength of the relationships among the outcome variable and each predictor variable. The SES, ELP, VP, as determined by FRL and measured by CELLA scale scores and subtests, represented the predictor variables, whereas MP, as measured by geometry EOC exam scale scores, represented the outcome variable. A relationship could exist among the predictor and outcome variables.

Stepwise multiple regression is designed to assess the existing degree of implementation of the components of the predictor variables (SES, ELP, and VP, as
determined by FRL and measured by CELLA scale scores and subtests) and the outcome variables (MP, as measured by geometry EOC scale scores). Using the SPSS statistical analysis software package, descriptive statistics and factor analysis was performed. These analyses ensured the established internal consistency and stability.

Fraenkel & Wallen (2003) described descriptive statistics as mathematical techniques for organizing and summarizing a set of numerical data. The ELL students were categorized by SES, ELP, and VP, determined by FRL and measured by CELLA scale scores and subtests. Once organized, math performance comparisons were made. Research quantitative variables were identified in the study. First, SES, ELP and VP will be the predictor variables. Second, MP was the outcome variable. According to Fraenkel & Wallen (2003), predictor variables were presumed to affect, partly cause, or somehow influence at least one other variable known as the outcome variable. Sirkin (2006) described the variable presumed to do the causing or explaining as the predictor variable and the variable being described or explained as the outcome variable.

**Data collection procedures**

The CELLA exam was given to students in the spring or fall of 2011, while the geometry EOC exam was administered in the spring of 2012, and all of the students took the CELLA and geometry EOC tests. The results of the CELLA and geometry EOC tests were provided through data transferred from a data warehouse in the school district to a Microsoft Excel file to an SSPS file. The data had CELLA scale scores and subtests, which classified students in several categories of an ELL and ELP status identification variable. A single variable indicated inclusion in the FRL program, which allowed the
students to be put into an appropriate SES category. All of the students took the tests in 2011 or 2012. Tests were scored by the state, including open response questions. The state requires the school districts to keep all of the data in warehouses. CELLA and demographic data were provided. The data came directly from the district data warehouse, so no one altered or change any of the data from the CELLA and geometry EOC scale scores and SES status information. Names of students were redacted and each student was assigned a number. The identities of all students were hidden in the process of the research and throughout the analyses and discussion of the results.

Geometry EOC data was obtained from a data warehouse in each school district, which contains all test data and is available to teachers. CELLA scale scores and subtests, as well as geometry EOC scale scores, represented the skill levels in English language arts, vocabulary proficiency, and math performance for the academic year 2011-2012, measured how well the students learned vocabulary and math skills, and indicated the levels of student mastery of the subject material. The geometry EOC scale scores consisted of criterion-referenced measures on geometry. The scores were indications of how well the students mastered the NGSSS and CCSSM, particularly geometry, from the State of Florida.

**Data analyses**

CELLA scale scores and subtests, SES, and geometry EOC scale scores for ELL students were examined. The relationship between the CELLA scale scores and subtests and the geometry EOC scale scores for all ELL students was examined. Also, the relationship between the SES status and geometry EOC scale scores for all ELL students
was examined. There was a comparison made to ascertain if the regression coefficient of CELLA scale scores and subtests on geometry EOC scale scores was greater for higher SES ELL students than the regression coefficient for lower SES ELL students.

Questions investigated through the course of the research were: 1) What was the strength of the relationship between English language proficiency (ELP) and math performance (MP) on the geometry EOC exam for ELL students as measured by CELLA and geometry EOC exam scale scores? 2) What was the strength of the relationship between vocabulary proficiency (VP) and math performance (MP) on the geometry EOC exam for ELL students as measured by CELLA and geometry EOC scale scores? 3) For all ELL students, how much of the variance in math performance (MP) was explained by English language proficiency (ELP) and vocabulary proficiency (VP)?

The hypotheses tested in this study were: 1) For all ELL students, there was predictability between English language proficiency (ELP), as measured by CELLA scale scores and subtests, and math performance (MP) as measured by geometry EOC scale scores. 2) For all ELL students, there was predictability between vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, and math performance (MP) as measured by geometry EOC exam scale scores. 3) The regression coefficients of English language proficiency (ELP) and vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, regressed on math performance (MP) as measured by geometry EOC exam scale scores was greater for higher SES ELL students than for lower SES ELL students.
Table 1 presents the outcome variables, data, predictor variables, and statistical method used to determine the strength of the relationships among English language proficiency (ELP) and math performance (MP) on the geometry EOC for ELL students.

**Table 1**

*The Strength of the Relationships among English Language Proficiency (ELP) and Math Performance (MP) on the Geometry EOC for ELL Students*

What was the strength of the relationship between English language proficiency and math performance on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores?

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Data Variable</th>
<th>Predictor Variable</th>
<th>Data Variable</th>
<th>Statistical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry Scale EOC</td>
<td>Subtest</td>
<td>CELLA</td>
<td>Listening</td>
<td>Regression</td>
</tr>
<tr>
<td>(MP)</td>
<td>(ELP)</td>
<td></td>
<td>Speaking</td>
<td></td>
</tr>
</tbody>
</table>


Table 2 presents the outcome variables, data, predictor variables, and statistical method used to determine the strength of the relationships among vocabulary proficiency (VP) and math performance (MP) on the geometry EOC for ELL students.

**Table 2**

*The Strength of the Relationships among Vocabulary Proficiency (VP) and Math Performance (MP) on the Geometry EOC for ELL Students*

What was the strength of the relationship between vocabulary proficiency and math performance on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores?

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Data</th>
<th>Predictor Variables</th>
<th>Data</th>
<th>Statistical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry EOC</td>
<td>Scale</td>
<td>CELLA</td>
<td>Subtest</td>
<td>Regression</td>
</tr>
<tr>
<td>(MP)</td>
<td></td>
<td>Reading</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Writing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(VP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3 presents the outcome variables, data, predictor variables, and statistical method used to determine the variance of math performance (MP) explained by English language proficiency (ELP) and vocabulary proficiency (VP) for ELL students.

**Table 3**

*The Variance of Math Performance (MP) Explained by English Language proficiency (ELP) and Vocabulary Proficiency (VP) for all ELL Students*

For all ELL students, how much of the variance in math performance was explained by English language proficiency and vocabulary proficiency?

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Data Variable</th>
<th>Predictor Variable</th>
<th>Data Variable</th>
<th>Statistical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry</td>
<td>Scale</td>
<td>CELLA</td>
<td>Scale</td>
<td>Regression</td>
</tr>
<tr>
<td>EOC</td>
<td>Listening</td>
<td>and Speaking</td>
<td>and Subtest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(MP)</td>
<td>Writing</td>
<td>(ELP and VP)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stepwise multiple regression analysis is a process to examine predictability between outcome variables and predictor variables by placing the predictor variables into the regression equation one at a time. The predictor variables were CELLA scale scores and subtests and SES, while the outcome variables were geometry EOC scale scores. There were efforts made to determine if there was predictability between CELLA scale scores and subtests and geometry EOC scale scores for all ELL students. Through the research, geometry EOC scale scores for ELL students may be able to be predicted.

In defining the relationship, three equations were used in the form $y = a + bx$. Equations represented all ELL students, higher SES students, and lower SES students. The first equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores). The second equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), $b$ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA reading subtest scores). The third equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores and CELLA reading subtest scores).
Chapter Four

Results

The purpose of this study was to examine the relationships among English language proficiency (ELP), vocabulary proficiency (VP), socioeconomic status (SES), and math performance (MP) on the geometry end of course (EOC) exam for English language learner (ELL) students. Specifically, the extent to which VP and SES contributed to performance on the geometry EOC exam was investigated. It was also examined whether VP and SES had a different predictive value for MP, particularly in geometry, for higher SES ELL students than for lower SES ELL students. The intended outcome of the research was to explain that geometry achievement, above all other math strands, was more directly related to ELP and VP.

Major hypotheses and research questions

Questions investigated through the course of the research were: 1) What was the strength of the relationship between English language proficiency (ELP) and math performance (MP) on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores? 2) What was the strength of the relationship between vocabulary proficiency (VP) and math performance (MP) on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores? 3) For all ELL students, how much of the variance in math performance (MP) was explained by English language proficiency (ELP) and vocabulary proficiency (VP)?

The hypotheses tested in this study were: 1) For all ELL students, there was significant predictability between English language proficiency (ELP), as measured by
CELLA scale scores and subtests, and math performance (MP) as measured by geometry EOC scale scores. 2) For all ELL students, there was significant predictability between vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, and math performance (MP) as measured by geometry EOC scale scores. 3) The multiple regression coefficients of English language proficiency (ELP) and vocabulary proficiency (VP), as measured by CELLA scale scores and subtests, regressed on math performance (MP) as measured by geometry EOC scale scores was greater for higher SES ELL students than for lower SES ELL students.

**Descriptive statistics**

The sections that follow present descriptive statistics for the sample followed by results of the each hypothesis and a conclusion of the findings. Tables 4, 5, and 6 describe the demographic data of the sample of students. Information includes the ethnicity, ELL status, and socioeconomic status of the participants.
Table 4 presents the sample frequencies by ethnicity.

**Table 4**

*Participants by Ethnicity (N = 599)*

<table>
<thead>
<tr>
<th>Ethnicity Status</th>
<th>N</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>396</td>
<td>66.2%</td>
</tr>
<tr>
<td>African-American</td>
<td>150</td>
<td>25.0%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>22</td>
<td>3.6%</td>
</tr>
<tr>
<td>Asian</td>
<td>16</td>
<td>2.7%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>15</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

The students consisted of 307 males and 292 females. The majority of the sample consisted of Hispanic and African-American students (91.2%). There was about two and a half times the number of Hispanic (66.2%) than African-American (25.0%) students. Only 3.6% were Caucasian, while 2.7% of the students were Asian, and 2.5% of the students represented more than one culture or race.
Table 5 presents the sample frequencies by ELL status.

**Table 5**

*Participants by ELL Status (N = 599)*

<table>
<thead>
<tr>
<th>ELL Status</th>
<th>N</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently Enrolled ELL (LY)</td>
<td>515</td>
<td>86.1%</td>
</tr>
<tr>
<td>Exited ELL Follow Up Program (LF)</td>
<td>84</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

There were 86.1% of the students currently enrolled in the ELL program in classes specifically designed for ELL students (LY). Students who have exited the ELL program and are part of a two-year follow up evaluation (LF) account for 13.9% of the students.
Table 6 presents the sample frequencies by socio-economic status (SES).

Table 6

*Participants by Socio-Economic Status (N = 599)*

<table>
<thead>
<tr>
<th>SES</th>
<th>N</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free and Reduced Lunch Program</td>
<td>431</td>
<td>71.9%</td>
</tr>
<tr>
<td>Not in Free and Reduced Lunch Program</td>
<td>168</td>
<td>28.1%</td>
</tr>
</tbody>
</table>

Most of the students come from lower socio-economic status families as defined by inclusion in the Free and Reduced Lunch Program (71.9%). Students not in the Free and Reduced Lunch Program accounted for 28.1%.
Research findings

The ex-post facto stepwise multiple regression study that was conducted using secondary data from a random stratified sample of a population of high school students from four school districts across southwest Florida demonstrated relationships between socioeconomic status (SES), English language proficiency (ELP), vocabulary proficiency (VP) and math performance (MP). The study utilized ELL groups which differed on predictor variables (SES, ELP, and VP, as determined by FRL and measured by CELLA scale scores and subtests) and test hypotheses about differences on outcome variables (MP, as measured by geometry EOC scale scores). This study was an ex post facto design because data was used after the students had taken the CELLA and geometry EOC tests. The ex post facto research began with the results of geometry EOC scale scores, working backward to attempt to identify why students earned the CELLA scale scores and subtest results. Comparisons were made among the ELL students on SES and different subtests of the CELLA exams.

A stepwise multiple regression research design was used to determine if relationships existed among SES, ELP, and VP, as determined by FRL and measured by CELLA scale scores and subtests, and MP, as measured by geometry EOC scale scores. Information was collected and then quantitatively analyzed using Statistical Package for the Social Sciences (SPSS). Before the multiple regression coefficients were calculated, descriptive statistics were generated.

Stepwise multiple regression analysis was used to determine if there were relationships among each of the predictor and outcome variables. The criterion was the
strength of the relationships among the outcome variable and each predictor variable. The SES, ELP, VP, as determined by FRL and measured by CELLA scale scores and subtests, represented the predictor variables, whereas MP, as measured by geometry EOC exam scale scores, represented the outcome variable. A relationship could exist among the predictor and outcome variables.

Stepwise multiple regressions were designed to assess the existing degree of implementation of the components of the predictor variables (SES, ELP, and VP, as determined by FRL and measured by CELLA scale scores and subtests) and the outcome variables (MP, as measured by geometry EOC scale scores). Using the SPSS statistical analysis software package, descriptive statistics analyses were performed. These analyses ensured the established internal consistency and stability.

**Results for research hypotheses**

The first hypothesis stated that for all ELL students, there is significant predictability between English language proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The sections that follow present descriptive statistics for English language proficiency, CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores for ELL students and also present multiple regression results that tested hypothesis one.

The second hypothesis stated that for all ELL students, there is significant predictability between vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The
sections that follow present descriptive statistics for vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and also present multiple regression results that tested hypothesis two.

The third hypothesis stated that the multiple regression coefficients of English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, regressed on math performance as measured by geometry EOC scale scores is greater for higher SES ELL students than for lower SES ELL students. The sections that follow present descriptive statistics for English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and also present multiple regression results that tested hypothesis three.
Descriptive statistics of CELLA scale scores by ethnicity

Table 7 presents the descriptive statistics of CELLA scale scores by ethnicity

Table 7

**CELLA Scale Scores by Ethnicity (N = 599)**

<table>
<thead>
<tr>
<th>Ethnicity (N)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic (396)</td>
<td>1785</td>
<td>2461</td>
<td>2215.660 (103.320)</td>
</tr>
<tr>
<td>African American (150)</td>
<td>1823</td>
<td>2432</td>
<td>2193.590 (103.424)</td>
</tr>
<tr>
<td>Caucasian (22)</td>
<td>2130</td>
<td>2409</td>
<td>2244.770 (67.073)</td>
</tr>
<tr>
<td>Asian (16)</td>
<td>2092</td>
<td>2338</td>
<td>2202.940 (69.682)</td>
</tr>
<tr>
<td>Multiracial (15)</td>
<td>1884</td>
<td>2320</td>
<td>2144.870 (144.702)</td>
</tr>
</tbody>
</table>

Results suggest that Caucasian students had a mean CELLA scale score that was on average 29 points higher than that of Hispanic students. Hispanic students had a mean CELLA scale score that was on average 12 points higher than Asian students. Asian students had mean CELLA scale scores that were on average 9 points higher than African American students and on average 57 points higher than Multi-racial students. The mean CELLA scale score for Caucasian students was 2244.770 (SD = 67.073) and for Multi-racial students was 2144.870 (SD = 144.702).
Descriptive statistics of CELLA scale scores by SES

Table 8 presents the descriptive statistics of CELLA scale scores by SES.

Table 8

*CELLA Scale Scores by SES (N = 599)*

<table>
<thead>
<tr>
<th>SES Status (N)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRL (431)</td>
<td>1785</td>
<td>2461</td>
<td>2210.240 (106.136)</td>
</tr>
<tr>
<td>No FRL (168)</td>
<td>1865</td>
<td>2422</td>
<td>2261.740 (85.550)</td>
</tr>
</tbody>
</table>

Results suggest that Free and Reduced Lunch students had a mean CELLA scale score that was on average 50 points lower than that of the students not part of the Free and Reduced Lunch Program. The mean CELLA scale score for Free and Reduced Lunch students was 2210.240 (*SD = 106.136*) and for students not part of the Free and Reduced Lunch Program was 2261.740 (*SD = 85.550*).
Descriptive statistics of CELLA reading / vocabulary subtest scores by ethnicity

Table 9 presents the descriptive statistics of CELLA reading / vocabulary subtest scores by ethnicity

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic (396)</td>
<td>605</td>
<td>820</td>
<td>753.580 (38.525)</td>
</tr>
<tr>
<td>African American (150)</td>
<td>605</td>
<td>820</td>
<td>749.010 (38.229)</td>
</tr>
<tr>
<td>Caucasian (22)</td>
<td>740</td>
<td>820</td>
<td>772.830 (23.455)</td>
</tr>
<tr>
<td>Asian (16)</td>
<td>725</td>
<td>790</td>
<td>755.860 (18.513)</td>
</tr>
<tr>
<td>Multiracial (15)</td>
<td>605</td>
<td>820</td>
<td>722.930 (77.281)</td>
</tr>
</tbody>
</table>

Results suggest that Caucasian students had a mean CELLA reading / vocabulary subtest score that was on average 2 points higher than that of Hispanic students and on average 5 points higher than Asian students. Asian students had a mean CELLA reading / vocabulary subtest score that was on average 5 points higher than African American students and on average 32 points higher than Multi-racial students. The mean CELLA reading / vocabulary subtest score for Caucasian students was 772.830 (SD = 23.455) and for Multi-racial students was 722.930 (SD = 77.281).
Descriptive statistics of CELLA reading / vocabulary subtest scores by SES

Table 10 presents the descriptive statistics of CELLA reading / vocabulary subtest scores by SES.

Table 10

*CELLA Reading / Vocabulary Subtest Scores by SES (N = 599)*

<table>
<thead>
<tr>
<th>SES (N)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRL (431)</td>
<td>605</td>
<td>820</td>
<td>751.510 (40.513)</td>
</tr>
<tr>
<td>No FRL (168)</td>
<td>605</td>
<td>820</td>
<td>783.860 (11.231)</td>
</tr>
</tbody>
</table>

Results suggest that Free and Reduced Lunch students had a mean CELLA reading / vocabulary subtest score that was on average 30 points lower than students not part of the Free and Reduced Lunch Program. The mean CELLA reading / vocabulary subtest score for Free and Reduced Lunch students was 751.510 (SD = 40.513) and for students not part of the Free and Reduced Lunch Program was 783.860 (SD = 11.231).
Descriptive statistics of geometry EOC scale scores by ethnicity

Table 11 presents the descriptive statistics of geometry EOC scale scores by ethnicity.

**Table 11**

*Geometry EOC Scale Scores by Ethnicity (N = 599)*

<table>
<thead>
<tr>
<th>Ethnicity (N)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic (396)</td>
<td>20</td>
<td>77</td>
<td>39.670 (12.174)</td>
</tr>
<tr>
<td>African American (150)</td>
<td>20</td>
<td>77</td>
<td>38.970 (10.816)</td>
</tr>
<tr>
<td>Caucasian (22)</td>
<td>33</td>
<td>67</td>
<td>48.550 (9.709)</td>
</tr>
<tr>
<td>Asian (16)</td>
<td>32</td>
<td>80</td>
<td>51.250 (13.757)</td>
</tr>
<tr>
<td>Multiracial (15)</td>
<td>20</td>
<td>56</td>
<td>40.130 (10.967)</td>
</tr>
</tbody>
</table>

Results suggest that Asian students had mean geometry EOC scale scores that were on average two points higher than that of Caucasian students. Caucasian students had mean geometry EOC scale scores that were on average 7 points higher than Multi-racial, Hispanic, and African American students. The mean Geometry EOC scale score for Asian students was 51.250 (*SD* = 13.757) and for African American students was 38.970 (*SD* = 10.816).
Descriptive statistics of geometry EOC scale scores by SES

Table 12 presents the descriptive statistics of geometry EOC scale scores by SES

Table 12

*Geometry EOC Scale Scores by SES (N = 599)*

<table>
<thead>
<tr>
<th>SES (N)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRL (431)</td>
<td>20</td>
<td>80</td>
<td>39.070 (11.870)</td>
</tr>
<tr>
<td>No FRL (168)</td>
<td>20</td>
<td>77</td>
<td>46.980 (10.655)</td>
</tr>
</tbody>
</table>

Results suggest that Free and Reduced Lunch students had a mean geometry EOC scale score that was on average 6 points lower than that of students not part of the Free and Reduced Lunch Program. The mean geometry EOC scale score for Free and Reduced Lunch students was 39.070 (*SD = 11.870*) and for students not part of the Free and Reduced Lunch Program was 46.980 (*SD = 10.655*).
To examine performance differences between higher SES and lower SES students in language proficiency, descriptive statistics were obtained for the content areas assessed in the CELLA exam.

Table 13 presents the descriptive statistics of the CELLA subtest scores for higher SES and lower SES students.

**Table 13**

*Descriptive Statistics of CELLA Subtest Scores for Higher SES and Lower SES Students*

<table>
<thead>
<tr>
<th>CELLA Subtest Scores</th>
<th>HSES (N = 168)</th>
<th>LSES (N = 431)</th>
<th>M_{HSES} (SD)</th>
<th>M_{LSES} (SD)</th>
<th>M_{HSES} – M_{LSES}</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening</td>
<td>749.190 (36.430)</td>
<td>733.120 (44.121)</td>
<td>16.070</td>
<td>2.145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaking</td>
<td>748.880 (35.420)</td>
<td>732.110 (43.678)</td>
<td>16.770</td>
<td>2.239</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>783.860 (11.231)</td>
<td>751.751 (40.513)</td>
<td>32.350</td>
<td>4.127</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing</td>
<td>745.700 (29.100)</td>
<td>726.340 (34.348)</td>
<td>19.360</td>
<td>2.596</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2261.740 (85.550)</td>
<td>2210.240 (106.136)</td>
<td>51.500</td>
<td>2.277</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results suggest that higher SES students had an overall mean CELLA composite score that was higher than that of lower SES students. Overall mean CELLA scale scores for higher SES students were 2261.740 (85.550) and for lower SES students were 2210.240 (106.136). The Reading subtest score showed the largest difference between higher SES and lower SES students (4.127%). The Listening subtest showed the lowest difference between higher SES and lower SES students (2.145%). This suggests that the reading subtest may be more related to SES status than listening, speaking, and writing.
To examine performance differences between higher SES and lower SES students in math, descriptive statistics were obtained for the geometry EOC exam.

Table 14 presents the descriptive statistics of the geometry EOC scale scores for higher SES and lower SES students.

**Table 14**

*Descriptive Statistics of Geometry EOC Scale Scores for Higher SES and Lower SES Students*

<table>
<thead>
<tr>
<th>Geometry EOC Scale Scores</th>
<th>HSES (N= 168)</th>
<th>LSES (N = 431)</th>
<th>M_{HSES} (SD)</th>
<th>M_{LSES} (SD)</th>
<th>M_{HSES} – M_{LSES}</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>46.980 (10.655)</td>
<td>39.070 (11.870)</td>
<td>7.910</td>
<td>16.837</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results suggest that higher SES students had Geometry EOC scale scores that were higher than that of lower SES students. Overall mean and standard deviations of Geometry EOC scale scores for higher SES students were 46.980 (10.655) and for lower SES students were 39.070 (11.870), a percentage difference of 16.837.
Table 15 presents the correlation results of CELLA scales scores and subtests and geometry EOC scale scores for all ELL students.

Table 15

Correlation Matrix of CELLA Scale Scores and Subtests and Geometry EOC Scale Scores for all ELL Students ($N = 599$)

<table>
<thead>
<tr>
<th></th>
<th>CL</th>
<th>CS</th>
<th>CR</th>
<th>CW</th>
<th>CSS</th>
<th>GEOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>1</td>
<td>.850**</td>
<td>.654**</td>
<td>.721**</td>
<td>.901**</td>
<td>.207**</td>
</tr>
<tr>
<td>CS</td>
<td>.850**</td>
<td>1</td>
<td>.650**</td>
<td>.690**</td>
<td>.860**</td>
<td>.220**</td>
</tr>
<tr>
<td>CR</td>
<td>.654**</td>
<td>.650**</td>
<td>1</td>
<td>.680**</td>
<td>.868**</td>
<td>374**</td>
</tr>
<tr>
<td>CW</td>
<td>.721**</td>
<td>.690**</td>
<td>.680**</td>
<td>1</td>
<td>.869**</td>
<td>.293**</td>
</tr>
<tr>
<td>CSS</td>
<td>.901**</td>
<td>.860**</td>
<td>.868**</td>
<td>.869**</td>
<td>1</td>
<td>.305**</td>
</tr>
<tr>
<td>GEOC</td>
<td>.207**</td>
<td>.220**</td>
<td>.374**</td>
<td>.293**</td>
<td>.305**</td>
<td>1</td>
</tr>
</tbody>
</table>

**p < .01

Correlation coefficients ranged from $r = .207 \ (p < .01)$ to $r = .374 \ (p < .01)$ for all ELL students. Note that the strongest correlation between CELLA subtest scores and geometry EOC performance for all ELL students was observed between the Reading / Vocabulary subtests and geometry EOC scale scores, $r = .374 \ (p < .01)$. The weakest correlation between CELLA subtest scores and geometry EOC scale scores for all ELL students was observed between the Listening subtest and geometry EOC scale scores, $r = .207 \ (p < .01)$. 
Regression results for language proficiency, vocabulary proficiency, socioeconomic status and math performance

Once descriptive statistics were examined for English language proficiency, vocabulary proficiency, socioeconomic status, and math performance, regression analyses were conducted among English language proficiency, vocabulary proficiency, socioeconomic status and math performance. Regression analyses were conducted for all ELL students, higher SES students, and lower SES students separately to examine possible differential effects of English language proficiency, vocabulary proficiency, and socioeconomic status on math performance. Results for regression analyses follow.

Results for research hypotheses

The first hypothesis stated that for all ELL students, there is significant predictability between English language proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The sections that follow present descriptive statistics for English language proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores for ELL students. The following sections also present multiple regression results that tested hypothesis one.

The second hypothesis stated that for all ELL students, there is significant predictability between vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The sections that follow present descriptive statistics for vocabulary proficiency, as measured
by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and also present multiple regression results that tested hypothesis two.

The third hypothesis stated that the multiple regression coefficients of English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, regressed on math performance as measured by geometry EOC scale scores is greater for higher SES students than for lower SES students. The sections that follow present descriptive statistics for English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and also present multiple regression results that tested hypothesis three.
Stepwise multiple regression results for CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS) regressed on geometry EOC scale scores for all ELL students.

Table 16 presents the ANOVA multiple stepwise regression of CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS), regressed on geometry EOC scale scores for all ELL students.

Table 16

ANOVA Multiple Stepwise Regression of the CELLA Scale Scores and CELLA Reading Subtest Scores, Regressed on Geometry EOC Scale Scores for all ELL Students (N = 599)

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSS Regression</td>
<td>9818.217</td>
<td>1</td>
<td>9818.217</td>
<td>80.029**</td>
</tr>
<tr>
<td>Residual</td>
<td>60237.304</td>
<td>598</td>
<td>122.683</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>70055.521</td>
<td>599</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSS Regression</td>
<td>11625.504</td>
<td>2</td>
<td>5812.752</td>
<td>48.746**</td>
</tr>
<tr>
<td>Residual</td>
<td>58430.018</td>
<td>597</td>
<td>119.245</td>
<td></td>
</tr>
<tr>
<td>CRSS Total</td>
<td>70055.521</td>
<td>599</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .01
The difference among the CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores for all ELL students was statistically significant.

Table 17 summarizes the stepwise multiple regression analysis results of CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores for all ELL students.

Table 17

*Summary of Stepwise Multiple Regression Analysis Results of CELLA Scale Scores (CSS) and CELLA Reading Subtest Scores (CRSS), Regressed on Geometry EOC Scale Scores for all ELL Students (N = 599)*

<table>
<thead>
<tr>
<th>CELLA Scale Scores</th>
<th>CELLA Scale Scores and CELLA Reading Subtest Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>b</strong></td>
<td><strong>SE b</strong></td>
</tr>
<tr>
<td>.086</td>
<td>.017</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td></td>
</tr>
<tr>
<td><strong>F</strong></td>
<td></td>
</tr>
</tbody>
</table>

**p < .01
The difference among means was statistically significant at the .01 significance level for all ELL students for the CELLA scale scores ($F = 80.029$, $t = 8.946$), and for CELLA reading subtest scores ($F = 48.746$, $t = 9.359$). CELLA scale scores regressed on geometry EOC scale scores, $b = .086$, $SE b = .017$, $\beta = .291$, $R^2 = .140$. CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, $b = .110$, $SE b = .012$, $\beta = .374$, $b = .114$, $SE b = .012$, $\beta = .387$, $R^2 = .166$.

In defining the relationship, three equations were used in the form $y = a + bx$. Equations represented all ELL students, higher SES students, and lower SES students. The first equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores). The second equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores and Geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA reading subtest scores). The third equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores and CELLA reading subtest scores).

In the case of this particular study, $y(CSS1) = a + b(CSS)x$, $y(CSS2) = a + b(CSS)x$, and $y(CSS, CRSS) = a + b(CSS, CRSS)x$, where $b(CRSS, CSS)$ is higher than
b(CSS2) and higher than b(CSS1) ($b = .086$, $b = .110$ and $b = .114$). The slope of the $y$(CSS, CRSS) line is greater than the slope of the $y$(CSS2) and $y$(CSS1) line. The first equation is $y = 40.140 + .086x$. The second equation is $y = 40.140 + .110x$. The third equation is $y = 40.140 + .114x$.

For CELLA scale scores, CELLA performance explained 13.8% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 16.3% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores.
Graphic depiction of the regression analyses of CELLA scale scores (CSS) and CELLA reading subtests (CRSS), regressed on geometry scale scores for all ELL students.

From a visual standpoint, the slope of the line for CELLA scale scores and CELLA reading subtests, regressed on geometry EOC scale scores is slightly greater than the slope of the second line for CELLA scale scores, which is slightly greater than the slope of the first line for CELLA scale scores. In the first equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 71 at a CELLA scale score of 800. In the second equation, a mean geometry EOC scale score of 40.140, corresponding to a projected mean geometry EOC scale score of 86 at a CELLA scale score of 800. In the third equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 98 at a CELLA scale score of 800. A CELLA scale score of 800 was used because that was the target passing CELLA scale score to demonstrate language and vocabulary proficiency.
Stepwise multiple regression results for CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS) regressed on geometry EOC scale scores for higher SES students.

Table 18 presents the ANOVA stepwise multiple regression of CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS), regressed on geometry EOC scale scores for higher SES students

**Table 18**

*ANOVA Stepwise Multiple Regression of the CELLA Scale Scores (CSS) and CELLA Reading Subtest Scores (CRSS), Regressed on Geometry EOC Scale Scores for Higher SES Students (N = 168)*

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSS</td>
<td>Regression</td>
<td>3735.742</td>
<td>1</td>
<td>3735.742</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>18319.537</td>
<td>157</td>
<td>126.342</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>22055.279</td>
<td>158</td>
<td></td>
</tr>
<tr>
<td>CRSS</td>
<td>Regression</td>
<td>4263.428</td>
<td>2</td>
<td>2131.714</td>
</tr>
<tr>
<td>And</td>
<td>Residual</td>
<td>17791.851</td>
<td>156</td>
<td>123.555</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>22055.279</td>
<td>158</td>
<td></td>
</tr>
</tbody>
</table>

**p < .01**
The difference among the CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores for higher SES students was statistically significant.

Table 19 summarizes the stepwise multiple regression analysis results of CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS), regressed on geometry EOC scale scores for higher SES students.

Table 19

Summary of Stepwise Multiple Regression Analysis Results of CELLA Scale Scores (CSS) and CELLA Reading Subtest Scores (CRSS), Regressed on Geometry EOC Scale Scores for Higher SES Students (N = 168)

<table>
<thead>
<tr>
<th>CELLA Scale Scores and CELLA Reading Subtest Scores</th>
<th>CELLA Scale Scores and CELLA Reading Subtest Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>CELL A Scale Scores</td>
<td>CELL A Scale Scores</td>
</tr>
<tr>
<td>CELL A Scale Scores</td>
<td>CELL A Scale Scores</td>
</tr>
<tr>
<td>b</td>
<td>SE b</td>
</tr>
<tr>
<td>.046</td>
<td>.008</td>
</tr>
<tr>
<td>.098</td>
<td>.021</td>
</tr>
<tr>
<td>R²</td>
<td>.169</td>
</tr>
<tr>
<td>F</td>
<td>29.569**</td>
</tr>
</tbody>
</table>

**p < .01
The difference among means was statistically significant at the .01 significance level for higher SES students for the CELLA scale scores \((F = 29.569, t = 5.438)\), and for CELLA reading subtest scores \((F = 17.253, t = 4.283)\). CELLA scale scores regressed on geometry EOC scale scores, \(b = .046, SE\ b = .008, \beta = .412, R^2 = .169\). CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, \(b = .081, SE\ b = .019, \beta = .726, b = .098, SE\ b = .021, \beta = .825, R^2 = .193\).

In defining the relationship, three equations were used in the form \(y = a + bx\). Equations represented all ELL students, higher SES students, and lower SES students. The first equation shows where \(y\) was the dependent variable (geometry EOC scale scores), ‘\(a\)’ was the constant (mean geometry EOC scale scores), ‘\(b\)’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized \(b\)), and \(x\) was the independent variable (CELLA scale scores). The second equation shows where \(y\) was the dependent variable (geometry EOC scale scores), ‘\(a\)’ was the constant (mean geometry EOC scale scores), ‘\(b\)’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized \(b\)), and \(x\) was the independent variable (CELLA reading subtest scores). The third equation shows where \(y\) was the dependent variable (geometry EOC scale scores), ‘\(a\)’ was the constant (mean geometry EOC scale scores), ‘\(b\)’ was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized \(b\)), and \(x\) was the independent variable (CELLA scale scores and CELLA reading subtest scores).

In the case of this particular study, \(y(CSS1) = a + b(CSS)x, y(CSS2) = a + b(CSS)x, y(CSS, CRSS) = a + b(CSS, CRSS)x\), where \(b(CRSS, CSS)\) is higher than
b(CSS2) and higher than b(CSS1) \( (b = 0.046, b = 0.081 \text{ and } b = 0.098) \). The slope of the y(CSS, CRSS) line is greater than the slope of the y(CSS2) and y(CSS1) line. The first equation is \( y = 40.140 + 0.046x \). The second equation is \( y = 40.140 + 0.081x \). The third equation is \( y = 40.140 + 0.098x \).

For CELLA scale scores, CELLA performance explained 16.4% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 18.2% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores.
Graphic depiction of the regression analyses of CELLA scale scores (CSS) and CELLA reading subtests (CRSS), regressed on geometry EOC scale scores for higher SES students

From a visual standpoint, the slope of the line for CELLA scale scores and CELLA reading subtests, regressed on geometry EOC scale scores is slightly greater than the slope of the second line for CELLA scale scores, which is slightly greater than the slope of the first line for CELLA scale scores. In the first equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 49 at a CELLA scale score of 800. In the second equation, a mean geometry EOC scale score of 40.140, corresponding to a projected mean geometry EOC scale score of 66 at a CELLA scale score of 800. In the third equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 80 at a CELLA scale score of 800. A CELLA scale score of 800 was used because that was the target passing CELLA scale score to demonstrate language and vocabulary proficiency.
Stepwise multiple regression results for CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS) regressed on geometry EOC scale scores for lower SES students.

Table 20 presents the ANOVA stepwise multiple regression of CELLA scale scores (CSS) and CELLA reading subtest scores (CRSS), regressed on geometry EOC scale scores for lower SES students.

**Table 20**

ANOVA Stepwise Multiple Regression of the CELLA Scale Scores and CELLA Reading Subtest Scores, Regressed on Geometry EOC Scale Scores for Lower SES Students ($N = 431$)

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSS Regression</td>
<td>6199.500</td>
<td>1</td>
<td>6199.500</td>
<td>51.035**</td>
</tr>
<tr>
<td>Residual</td>
<td>41787.437</td>
<td>440</td>
<td>121.475</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47986.936</td>
<td>441</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSS Regression</td>
<td>7845.493</td>
<td>2</td>
<td>3922.747</td>
<td>33.519**</td>
</tr>
<tr>
<td>Residual</td>
<td>40141.443</td>
<td>439</td>
<td>117.030</td>
<td></td>
</tr>
<tr>
<td>CRSS Total</td>
<td>47986.936</td>
<td>441</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .01**
The difference among the CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores for lower SES students was statistically significant.

Table 21 summarizes the stepwise multiple regression analysis results of CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores for lower SES students.

**Table 21**

*Summary of Stepwise Multiple Regression Analysis Results of CELLA Scale Scores (CSS) and CELLA Reading Subtest Scores (CRSS), Regressed on Geometry EOC Scale Scores for Lower SES Students (N = 431)*

<table>
<thead>
<tr>
<th>CELLA Scale Scores and CELLA Reading Subtest Scores</th>
<th>CELLA Scale Scores and CELLA Reading Subtest Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>CELL A Scale Scores</td>
<td>CELL A Scale Scores</td>
</tr>
<tr>
<td>CELL A Scale Scores</td>
<td>CELL A Scale Scores</td>
</tr>
<tr>
<td>b</td>
<td>SE b</td>
</tr>
<tr>
<td>.106</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.129</td>
</tr>
<tr>
<td>F</td>
<td>51.035**</td>
</tr>
</tbody>
</table>

**p < .01**
The difference among means was statistically significant at the .01 significance level for lower SES students for the CELLA scale scores ($F = 51.035, t = 7.144$), and for CELLA reading subtest scores ($F = 33.519, t = 7.475$). CELLA scale scores regressed on geometry EOC scale scores, $b = .106$, $SE\ b = .015$, $\beta = .359$, $R^2 = .129$. CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, $b = .109$, $SE\ b = .015$, $\beta = .370$, $b = .111$, $SE\ b = .016$, $\beta = .377$, $R^2 = .163$.

In defining the relationship, three equations were used in the form $y = a + bx$. Equations represented all ELL students, higher SES students, and lower SES students. The first equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores). The second equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA reading subtest scores). The third equation shows where $y$ was the dependent variable (geometry EOC scale scores), ‘$a$’ was the constant (mean geometry EOC scale scores), ‘$b$’ was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized $b$), and $x$ was the independent variable (CELLA scale scores and CELLA reading subtest scores).

In the case of this particular study, $y(CSS1) = a + b(CSS)x$, $y(CSS2) = a + b(CSS)x$, and $y(CSS, CRSS) = a + b(CSS, CRSS)x$, where $b(CRSS, CSS)$ is higher than
b(CSS2) and higher than b(CSS1) \((b = .106, b = .109 \text{ and } b = .111)\). The slope of the y(CSS, CRSS) line is greater than the slope of the y(CSS2) and y(CSS1) line. The first equation is \(y = 40.140 + .106x\). The second equation is \(y = 40.140 + .109x\). The third equation is \(y = 40.140 + .111x\).

For CELLA scale scores, CELLA performance explained 12.7\% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 15.9\% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores.
Graphic depiction of the regression analyses of CELLA scale scores (CSS) and CELLA reading subtests (CRSS), regressed on geometry EOC scale scores for lower SES students

From a visual standpoint, the slope of the line for CELLA scale scores and CELLA reading subtests, regressed on geometry EOC scale scores is slightly greater than the slope of the second line for CELLA scale scores, which is slightly greater than the slope of the first line for CELLA scale scores. In the first equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 72 at a CELLA scale score of 800. In the second equation, a mean geometry EOC scale score of 40.140, corresponding to a projected mean geometry EOC scale score of 87 at a CELLA scale score of 800. In the third equation, a mean geometry EOC scale score of 40.140 corresponds to a projected mean geometry EOC score of 99 at a CELLA scale score of 800. A CELLA scale score of 800 was used because that was the target passing CELLA scale score to demonstrate language and vocabulary proficiency.
Summary of the data

The mean CELLA scale score for higher SES students was 2261.740 (85.550) and for lower SES students was 2210.24 (106.136). The mean CELLA listening / speaking subtest score for higher SES students was 749.190 (36.430) and for lower SES students was 733.120 (44.121). The mean CELLA reading / vocabulary subtest score for higher SES students was 783.860 (11.231) and for lower SES students was 751.510 (40.513). The mean CELLA writing subtest score for higher SES students was 745.700 (29.100) and for lower SES students was 726.340 (34.348). The mean geometry EOC scale scores for higher SES students was 46.980 (10.655) and for lower SES students was 39.070 (11.870). The reading / vocabulary subtest score showed the largest difference between higher SES and lower SES students (4.127%). The listening / speaking subtest showed the lowest difference between higher SES and lower SES students (2.145%).

Results suggest that CELLA subtest scores are correlated with geometry EOC scale scores. Correlation coefficients ranged from $r = .207 \ (p < .01)$ to $r = .374 \ (p < .01)$ for all ELL students. Note that the strongest correlation between CELLA subtest scores and geometry EOC performance for all ELL students was observed between the Reading / Vocabulary subtests and geometry EOC scale scores, $r = .374 \ (p < .01)$. The weakest correlation between CELLA subtest scores and geometry EOC scale scores for all ELL students was observed between the Listening subtest and geometry EOC scale scores, $r = .207 \ (p < .01)$.

In defining the stepwise multiple regression relationship, three equations were used in the form $y = a + bx$. Equations represented all ELL students, higher SES
students, and lower SES students. The first equation shows where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean geometry EOC scale scores), ‘\( b \)’ was the regression coefficient relating CELLA scale scores and geometry EOC scale scores (unstandardized \( b \)), and \( x \) was the independent variable (CELLA scale scores). The second equation shows where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean geometry EOC scale scores), ‘\( b \)’ was the regression coefficient relating CELLA scale scores and Geometry EOC scale scores (unstandardized \( b \)), and \( x \) was the independent variable (CELLA reading subtest scores). The third equation shows where \( y \) was the dependent variable (geometry EOC scale scores), ‘\( a \)’ was the constant (mean geometry EOC scale scores), ‘\( b \)’ was the regression coefficient relating CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores (unstandardized \( b \)), and \( x \) was the independent variable (CELLA scale scores and CELLA reading subtest scores).

The difference among means was statistically significant at the .01 significance level for all ELL students for the CELLA scale scores \( (F = 80.029, t = 8.946) \), and for CELLA reading subtest scores \( (F = 48.746, t = 9.359) \). CELLA scale scores regressed on geometry EOC scale scores, \( b = .086, SE \, b = .017, \beta = .291, R^2 = .140 \). CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, \( b = .110, SE \, b = .012, \beta = .374, b = .114, SE \, b = .012, \beta = .387, R^2 = .166 \).

When comparing all ELL students, \( y(CSS1) = a + b(CSS)x, \ y(CSS2) = a + b(CSS)x, \) and \( y(CSS, CRSS) = a + b(CSS, CRSS)x, \) where \( b(CRSS, CSS) \) is higher than \( b(CSS2) \) and higher than \( b(CSS1) \ (b = .086, b = .110 \text{ and } b = .114) \). The slope of the \( y(CSS, CRSS) \) line is greater than the slope of the \( y(CSS2) \) and \( y(CSS1) \) line. The first
The equation is \( y = 40.140 + .086x \). The second equation is \( y = 40.140 + .110x \). The third equation is \( y = 40.140 + .114x \).

The difference among means was statistically significant at the .01 significance level for higher SES students for the CELLA scale scores \((F = 29.569, t = 5.438)\), and for CELLA reading subtest scores \((F = 17.253, t = 4.283)\). CELLA scale scores regressed on geometry EOC scale scores, \( b = .046, SE \ b = .008, \beta = .412, R^2 = .169 \). CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, \( b = .081, SE \ b = .019, \beta = .726, b = .098, SE \ b = .021, \beta = .825, R^2 = .193 \).

When comparing higher SES students, \( y(CSS_1) = a + b(CSS)x \), \( y(CSS_2) = a + b(CSS)x \), and \( y(CSS, CRSS) = a + b(CSS, CRSS)x \), where \( b(CRSS, CSS) \) is higher than \( b(CSS_2) \) and higher than \( b(CSS_1) \) \( (b = .046, b = .081 \ and \ b = .098) \). The slope of the \( y(CSS, CRSS) \) line is greater than the slope of the \( y(CSS_2) \) and \( y(CSS_1) \) line. The first equation is \( y = 40.140 + .046x \). The second equation is \( y = 40.140 + .081x \). The third equation is \( y = 40.140 + .098x \).

The difference among means was statistically significant at the .01 significance level for lower SES students for the CELLA scale scores \((F = 51.035, t = 7.144)\), and for CELLA reading subtest scores \((F = 33.519, t = 7.475)\). CELLA scale scores regressed on geometry EOC scale scores, \( b = .106, SE \ b = .015, \beta = .359, R^2 = .129 \). CELLA scale scores and CELLA reading subtest scores, regressed on geometry EOC scale scores, \( b = .109, SE \ b = .015, \beta = .370, b = .111, SE \ b = .016, \beta = .377, R^2 = .163 \).

When comparing lower SES students, \( y(CSS_1) = a + b(CSS)x \), \( y(CSS_2) = a + b(CSS)x \), and \( y(CSS, CRSS) = a + b(CSS, CRSS)x \), where \( b(CRSS, CSS) \) is higher than \( b(CSS_2) \) and higher than \( b(CSS_1) \) \( (b = .106, b = .109 \ and \ b = .111) \). The slope of the
y(CSS, CRSS) line is greater than the slope of the y(CSS2) and y(CSS1) line. The first equation is \( y = 40.140 + .106x \). The second equation is \( y = 40.140 + .109x \). The third equation is \( y = 40.140 + .111x \).
Chapter Five

Discussion

Summary

The purpose of this study was to ascertain the relationships among English language proficiency, vocabulary proficiency, socioeconomic status (SES), and math performance on the geometry end of course (EOC) exam for English language learner (ELL) students. Specifically, the extent to which vocabulary proficiency and SES can contribute to performance on the geometry EOC exam was investigated. It was also examined whether vocabulary proficiency and SES had a different predictive value for math performance, particularly in geometry, for higher SES ELL students than for lower SES ELL students.

Questions investigated through the course of the research are: 1) What is the strength of the relationship between English language proficiency and math performance on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores and subtests? 2) What is the strength of the relationship between vocabulary proficiency and math performance on the geometry EOC for ELL students as measured by CELLA and geometry EOC scale scores and subtests? 3) For all ELL students, how much of the variance in math performance is explained by English language proficiency and vocabulary proficiency?

The hypotheses tested in this study were: 1) For all ELL students, there is significant predictability between English language proficiency, as measured by CELLA scale scores and subtests, and math performance as measured by geometry EOC scale
scores. 2) For all ELL students, there is significant predictability between vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance as measured by geometry EOC scale scores. 3) The multiple regression coefficients of English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, regressed on math performance as measured by geometry EOC scale scores is greater for higher SES ELL students than for lower SES ELL students.

The first hypothesis stated that for all ELL students, there was significant predictability between English language proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The descriptive statistics for English language proficiency, CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores for ELL students and multiple regression results supported hypothesis one.

The second hypothesis stated that for all ELL students, there was significant predictability between vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores. The descriptive statistics for vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and multiple regression results supported hypothesis two.

The third hypothesis stated that the multiple regression coefficients of English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, regressed on math performance as measured by geometry EOC scale scores was greater for higher SES ELL students than for lower SES ELL students. The
descriptive statistics for English language proficiency and vocabulary proficiency, as measured by CELLA scale scores and subtests, and math performance, as measured by geometry EOC scale scores and multiple regression results supported hypothesis three.

The descriptive statistics findings suggested that English language proficiency, vocabulary proficiency, and socioeconomic status might affect how all ELL students perform on the CELLA and geometry EOC exams. The reading and vocabulary subtest may rely more heavily on language than do other parts of the exam, where the differences were lower. Relying heavily on language may put all ELL students at a disadvantage.

For CELLA scale scores of all ELL students, CELLA performance explained 13.8% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 16.3% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores. For CELLA scale scores of higher SES students, CELLA performance explained 16.4% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 18.2% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores. For CELLA scale scores of lower SES students, CELLA performance explained 12.7% of the variance between CELLA scale scores and geometry EOC scale scores, whereas CELLA performance explained 15.9% of the variance between CELLA scale scores, CELLA reading subtest scores, and geometry EOC scale scores. Although significant, the model only accounted for smaller percentages of the overall variance among CELLA scale scores and geometry EOC scale scores when comparing all ELL students, higher SES students, and lower SES students.
As the graph indicates, the slope of the regression line relating CELLA reading and vocabulary subtest scores and geometry EOC scale scores together was slightly greater than the slope of the regression line relating CELLA scale scores and geometry EOC scale scores for all ELL students and also for higher SES ELL students when compared to lower SES ELL students. English language proficiency correlates to how students score in CELLA and geometry EOC exams. This could have created a larger disparity between the CELLA scale scores and subtests and geometry EOC scale scores for all ELL students, higher SES students, and lower SES students. One possible reason that the differences were not as large could be that the ELL population of students has English language proficient individuals that are ready to exit the ELL program, and therefore cannot truly be classified as ELL students. As with any sample of students, there were both high-achieving and low-achieving students in each group. Just because a student is language proficient does not mean that the student necessarily will score higher on standardized exams. On the converse, just because a student is not proficient in language does not mean that the student necessarily will score lower on standardized exams.

English language proficiency and vocabulary proficiency, as measured by the CELLA scales scores and subtests, and socioeconomic status, as determined by the Free and Reduced Lunch Program, is related to math performance, as measured by the geometry EOC scale scores. Several correlation and regression analyses were conducted to evaluate the relationship of English language proficiency and vocabulary proficiency, and socioeconomic status to math performance. Students, who have higher English language proficiency and vocabulary proficiency, as measured by CELLA scale scores
and subtests, and higher SES, as determined by the Free and Reduced Lunch Program, perform better on math exams, as measured by the geometry EOC scale scores, than do students who have lower English language proficiency and vocabulary proficiency, and lower socioeconomic status.

Despite many educational efforts to increase English language proficiency and vocabulary proficiency in the U.S, results from international large-scale assessments suggest that, although the U.S students outperform most countries in mathematics, American students still lag behind their Asian counterparts. At the national level, evidence shows that a large percentage of fourth and eighth graders perform at the lowest levels of proficiency in math and that math and vocabulary skills have decreased within the last three years (Bracey, 2009b). Since language and vocabulary skills are the foundations for understanding concepts in other subject areas, students who struggle with language and vocabulary experience difficulties in other subjects. Struggles with vocabulary strategies can affect comprehension of concepts and materials, decreasing academic achievement. Bracey (2009b) stated that when students struggle with basic skills, then they cannot master more difficult subject content material. This suggests that some ELL students have lower language proficiency, vocabulary ability, and socioeconomic status, and therefore, they are less successful in math performance.

**Limitations**

The ex post facto stepwise multiple regression research design was used, which was useful in identifying the relationship between the CELLA scale scores and subtests and geometry EOC scale scores. The testing results were not compromised due to improper handling of the data from the state or from the school district. A possible
limitation of the ex-post-facto stepwise multiple regression research design was the difficulty in finding statistically similar groups within the samples. In this study, it was difficult to statistically compare higher SES ELL and lower SES ELL students. English language proficiency, vocabulary proficiency, and math performance of these two groups was compared, but there may be factors other than English language proficiency or vocabulary proficiency that could possibly cause differences in the math performance of the two groups. Performance differences may violate assumptions of group homogeneity that are required to statistically compare groups.

Multiple regression research is a process to attempt to show the linear relationships among outcome and predictor variables, in this case, SES, CELLA scale scores and subtests, and geometry EOC scale scores. Stepwise multiple regression analyses helped to compare CELLA scale scores and subtests and geometry EOC scale scores of ELL students. One reason that some ELL students may struggle with CELLA scale scores and geometry EOC scale scores could be their command of vocabulary. Similarly, some ELL students could struggle less with CELLA and geometry EOC scale scores and subtests. Multiple regression research is used to help make meaningful and intelligent predictions, but should not imply that association necessarily means causation.

**Threats to internal and external validity**

There were some threats to internal validity. The possible correlation among ELL status, SES, CELLA scale scores and subtests and geometry EOC scale scores could be the result of other characteristics from which cannot be accounted. This includes some examples of extraneous variables in the study such as limited data, the inability to
explore other relationships, and prior subjects of the students, including the quality of education prior to the year of study and individual subject characteristics. These extraneous variables could provide alternative explanations as to why there would be differences between ELL students, other than language proficiency. External threats to validity could include the fact that the results of the study may not be able to be generalized to other populations of students. The comparisons among students in this study and other students might be limited to districts in states with similar demographics.

**Assumptions and Delimitations**

Killion (2002) observed that schools and districts are complex social systems, student learning results from many different areas, and there may be many different unanticipated contextual or organizational factors that may influence results. The research study included many assumptions and delimitations. The student population included in this study originated from a similar geographical area from high schools in four surrounding school districts during the 2011–2012 school years. The original data set included records for all district students. However, some cases were not included in the study analysis due to missing or incomplete data. Students may not be representative of the general population. The motivation of students in English language arts, vocabulary, and math may vary according to many different factors. Information on teacher instructional experience was not available, and some of the teachers may have had additional teaching experience that their colleagues did not. These variables were not included in the analyses.

Limiting the study to the populations mentioned could decrease the possibility of generalization. Therefore, results may not be able to be generalized to other grades,
contexts, or content areas. Social factors that influence learning and achievement of high school students, such as motivation, classroom and school climate, peer relations, and student mobility, were outside the scope of this research, as was the content areas of subjects other than English language arts, vocabulary, and geometry, as well as grade levels other than those commonly regarded as part of the curriculum. The study did not incorporate some mediating and moderating student level variables that may be associated with student achievement in mathematics, such as gender, ethnicity, identification in special learning situations, including gifted and talented, specific learning disabled, student participation in extra help session in mathematics, which might have had an effect on the student achievement results.

Relevant teacher-level variables were not included in the study. Teacher mobility information was not available which might have contributed to the study results. Therefore, some teacher characteristics that might relate to student results were not available for analysis. Since this study collected and analyzed historical data, it was not be possible to collect data on instruction. Clearly, many other factors may affect student learning. Likewise, information regarding other educational experiences in which students and teachers might have engaged was not available. Therefore, this might influence the study results.

Implications

Correlations and regressions among CELLA and geometry EOC scale and subtest scores showed that language proficiency, vocabulary proficiency, and socioeconomic status was connected to how students performed on the CELLA and geometry EOC exams. Some of the CELLA and geometry EOC scale scores and subtests were
connected in ways that no one imagined. Research showed that many of the language, reading and vocabulary strategies, skills, and concepts were important to learning and understanding math. Students who could gather information, generate a main idea, and fill in the blanks, generally performed better in both vocabulary and math assessments.

The study helped to examine language and vocabulary proficiency, socioeconomic status, and math scale scores of students to determine if language proficiency, vocabulary proficiency, and socioeconomic status impacted performance on the geometry EOC exam. An ex post facto stepwise regression study was conducted using a random stratified sample. Regression analyses were used to investigate if language proficiency, vocabulary proficiency, and socioeconomic status had a different predictive value for all ELL students, higher SES students, and lower SES students.

In a culture of accountability, legislators want to know why our students are not performing better on standardized vocabulary and math exams. They want to know why students are not learning and gaining knowledge effectively. While there are many reasons why students struggle, this study outlined some possible causes, particularly for students who are not proficient in the English language. The findings have meaning in terms of educational policy and practice as well. From the results of the study, stakeholders, including teachers, administrators, and community members could see the need to design more effective strategies, interventions, and lesson plans that support the integration of language, vocabulary, and math strategies and help reinforce strategies to increase vocabulary and math assessment scores.
**Recommendations for future research**

Given the findings, future research should be conducted to add to the body of literature and support for the connections among language proficiency, vocabulary proficiency, socioeconomic status, and math performance. Several authors have discussed the link between how students learn vocabulary and math concepts. More research is required to show why students struggle with learning the language, absorbing main ideas, gathering information, and applying these concepts to learning other subjects, such as mathematics.

It may be helpful to have more accurate classifications of ELL students and to investigate differences by language proficiency level rather than grouping all the ELL students together. One of the reasons only small differences were found was because of how ELL students were grouped together. The results might have changed with a comparison between different levels of ELL and NES students. Results could look differently with a comparison among the different classifications of ELL students. Only certain, basic statistical techniques were used for the study. Results could be different with an examination of the variances at different hierarchical levels of analysis using HLM.

Another study might use formative and summative assessments to determine the areas of need of a group of students and then examine specific strategies, interventions, and lesson plans to help raise vocabulary and math test scores. A model could be used starting with a formative assessment, then progress monitoring, next some re-teaching of
needed concepts, summative assessments, and then finally some additional supportive interventions for students who still need more help.

Some possible future studies might utilize the best practices of teachers who have been successful with teaching students to be proficient in given languages. One might examine how they teach students vocabulary and math concepts together to help reinforce the similarities between the subjects, rather than focusing on the differences among subject materials. Interviews, accounts, and procedures can be taken from the teachers who are at the top of their field in teaching vocabulary and math concepts to their students. Through this additional research, it can be found what classroom procedures and practices are most practical and yield the best results in the test scores of the students.
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