

Mathematics and English Language Learners in Elementary School:
A Review of the Literature

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Introduction

The process of educating the children of the United States has become more cumbersome due to the passage of the *No Child Left Behind Act* (NCLB). New standards for highly qualified teachers and research-based best practices that lead to annual yearly progress for all students have focused a spotlight on special needs populations. Educational reformers are looking for strategies that are both research-based and address the unique requirements of the special needs populations, in particular the English Language Learner (ELL).

Purpose

The purpose of this paper is to review the scientifically research-based literature regarding elementary English Language Learners and the concepts of mathematics. There is a plethora of material available addressing English Language Learners including a variety of journal articles, teacher research projects, qualitative teacher interviews and anecdotal records that, while informative, do not meet the criteria of research-based. NCLB defines scientifically research-based projects as having four distinct characteristics:

1. The use of rigorous, systematic, and empirical methods.
2. Adequacy of the data analyses to test the stated hypotheses and justify the general conclusions drawn.

3. Reliance on measurements or observational methods that provide valid data across evaluators and observers and across multiple measurements and observations.
4. Acceptance by a peer-reviewed journal or approved by a panel of independent experts through a comparably rigorous, objective, and scientific review (No Child Left Behind, 2001).

Scope of this Study

Although the initial search for documents produced several hundred potential sources for “ELL” and “mathematics”, a narrower search for “ELL”, “Elementary”, and “mathematics” reduced the number considerably. Literature reviewed for this paper included reports from Center for Research on Education, Diversity, and Equity, the National Clearinghouse on Bilingual Education, the Center for Applied Linguistics, peer-reviewed journal articles, masters’ theses, and doctoral dissertations. This search does not include Internet sources, e-documents, homepages of organizations and individuals, nor conferences proceedings. This is strictly a review of the literature that meets the NCLB criteria for research-based.

This study will present the findings of the literature review and offer recommendations for further research. It will identify the scientifically research-based literature regarding elementary English Language Learners and mathematics, include information on what was found in the literature, what was alluded to in the literature, and what was missing from the literature.

The studies reviewed for this paper are divided into two categories: (1) studies related to general ELL programs and students (five studies), and (2) studies related to ELL students and specifically mathematics instruction (four studies).

Studies Relating to General ELL Programs and Students

Mahoney, MacSwan, and Thompson (2005) investigated the effects the State of Arizona's Proposition 203 has had on English language learners since the passage of the bill. Proposition 203 mandated the use of structured English immersion only and disallowed districts from providing a variety of bilingual program models, unless the district could acquire a waiver. Under a confidentiality agreement with the Arizona Department of Education, the researchers were able to obtain student language test scores along with relevant demographic indicators such as home language and ethnicity. Over a two- year period, they tracked student oral language development using the Language Assessment Scales-Oral (LAS-O), the IDEA Proficiency Test (IPT), the Woodcock-Munoz Language Survey (WMLS), and the Woodcock Language Proficiency Battery (WLPB).

The findings of the study include the following:

- The number of ELLs who experienced a negative change in English proficiency (71%) exceeds the number of students who had any positive experience (29%).
- Eighty-nine percent of the students failed to achieve oral English language proficiency in one year's time as promoted by Proposition 203.

- The data indicated that the majority of students did not experience an increase in proficiency level and now are at risk of developing academic deficiencies in content areas.

Conde (1998) examined the effect participation in a dual language program has on performance on standardized tests in a second language and investigated whether students' general academic achievement in content areas is impacted by second language only instruction. The researcher used two groups of third grade students: (1) G1 who received content instruction in two languages – English and Spanish, and (2) G2 who received content instruction in English only. Using the standard Achievement Test (SAT) of reading comprehension, mathematics computation, and mathematics application as the tool with which to collect data, the research includes the following results:

- Over a four-year period, there was a significant difference in performance between the students who received instruction in two languages and those who received instruction in English only.
- Students who participated in Dual Language programs constantly scored as well or better than English only students on the mathematics application section of the SAT test.
- Students who participated in Dual Language programs consistently scored as well or better than English only students on the reading portion of the SAT.
- Students who participated in Dual Language programs scored as well as English only students on the mathematics computation section of the SAT test.

In the dissertation, *The impact of two-way dual language programs on fourth-grade students: Academic skills in reading and mathematics, language development, and self-concept development*, Gilbert (2001) examined fourth graders in a two-way dual language program in terms of academic skills in reading and math, language development, and self concept development. The study utilized the Texas Assessment of Academic Skills (TAAS), the Reading Proficiency Test in English (RPTE), and the Piers-Harris Children's Self Concept Scale.

The study looked at 221 participants, 124 labeled language minority students (Spanish language dominant) and 97 labeled language majority students (English language dominant). The study used three sites that all had a "regular monolingual English program", "a developmental English program", and a two-way dual language program. Student assessment for the study was in the participants' dominant language. Program identification was based on the majority of years the student was enrolled in a particular program.

The results of the study include the following:

- Students' oral language proficiency at first grade was a determining factor in achievement.
- Regardless of primary language dominance, all students benefited from full bilingual placement in first grade.
- Students with the lowest beginning dominant language proficiency did poorest throughout the study when compared with students who entered the program with higher beginning dominant language proficiency.

- Dual language programs and developmental bilingual programs produced no significant differences in academic skill, native language development, or self-concept development in Spanish dominant participants.

Thomas and Collier's (2002) *National Study of School Effectiveness for Language Minority Students' Long Term Academic Achievement* looked at the effectiveness of various programs serving language minority students in five school districts across the United States. Tracing the achievement of 210,054 students over a five-year period, the study evaluates the effectiveness of four theoretical program designs:

1. Two-Way Bilingual Immersion programs
2. One-Way Developmental Bilingual Education programs
3. Transitional Bilingual Education programs
4. English as a Second Language programs for ELLs

Standardized test scores (reading, language arts, and math) and variables such as socioeconomic status, number of years of primary language schooling, and gender differences were examined to draw the conclusions of the study. The results of the study include the following:

- Two-Way Bilingual Immersion and One-Way Developmental Bilingual Education programs proved to be effective.
- Transitional Bilingual Education and English as a Second Language programs failed to help ELLs achieve 50th percentile in both their native language and English in all subject areas.

- Students who were denied support due to parent refusal showed an increasing gap between themselves and native language speaking students by the fifth grade.
- Students who were instructed in bilingual programs showed a more sustained long-term growth than those instructed in English only programs.
- Emergent literacy skills and the amount of formal primary language instruction are the best indicators of successful second language acquisition.

The authors offer several recommendations to help close the achievement gap between ELLs and non-ELLs, including:

- language support programs must be integrated into the school curriculum,
- language support programs must be sustained for five to six years, and
- language support programs must show more than average yearly progress per student in order to close the gap between ELLs and non-ELLs.

Wright and Pu (2005) evaluated the impact of Proposition 203 on the achievement of English proficiency in Arizona. Using data collected from 2002 to 2004, the researchers looked at students in grades two through five in terms of how well the students were performing in a structured English immersion environment. To compare the progress of the state designated categories of All Language Learners (ALL) and ELLs, they looked at the two official assessment tools used by Arizona: the Arizona Instrument to Measure Standards (AIMS), and the Stanford Achievement Test *Ninth Edition* (Stanford 9).

The results of the study include the following:

- The state designated categories are misleading as the ALL category excludes the scores of ELLs who have attended less than four years of public schools.
- At the third grade level, the majority of the ELLs failed the AIMS test and scored below the 50th percentile on the Stanford 9.
- ELL students showed a slight increase in 2003 while ALL students ranking remained stable, but in 2004, ELL students showed a decline while ALL students remained stable.
- The improvement in 2003 occurred when districts had greater flexibility for offering ESL and bilingual education programs while the decline in 2004 follows the restriction to Sheltered English Immersion (SEI) mandated by Proposition 203.
- On the AIMS test, ALL category students ranked higher than ELL students in Math by 33%, 40% in Reading, and 30% in Writing.
- On the Stanford 9, ALL category students ranked higher than ELL students by an average of 20% in Language, 26% in Math, and 33% in Reading.
- The achievement gap on the Stanford 9 increased between 2003 and 2004 in all subtest.

Studies Relating to ELL Students and Mathematics Instruction

Bernardo's (2002) study examines the effects of bilinguals' first and second language on mathematics word problem solving. A total of 92 second graders

participated in the study. All participants were fluent in both English and Filipino, with 48 students having Filipino as their native language and 44 being native English speakers.

The students were given a random selection of nine Filipino and nine English word problems (four labeled easy and 14 labeled as difficult). They were also given the identical computation problems in the standard mathematical vertical format to eliminate the possibility of computation skills being confused with language skills. The researchers qualified comprehension as being able to either recall the problem verbatim or paraphrase the problem with great accuracy.

The results of the study include the following:

- When working in their native language, students comprehended the easy problems 75% of the time and the difficult problems 47.7% of the time.
- When working in their native language, the native Filipino-speaking students comprehended 61.2% of the problems while native English-speaking students comprehended 54.3%.
- When working in their second language, the native Filipino-speaking students comprehended 52.3% of the problems while native English-speaking students comprehended 45.8% of the problems.
- Students were more successful answering the same problem in numeric form.
- When working in their native language, the native Filipino-speaking students correctly answered the questions 95.3% of the time, and the native English-speaking students correctly answered the questions 96% of the time.
- Bilingual students performed better in their native language.

- When bilingual students were asked to demonstrate mathematics skills in a second language using word problems, their answers did not demonstrate lack of mathematics skills but rather lack of language skills.

Mathematics reform and English Language Learners (Himmele, 2001) examines the degree to which language proficiency impacts student performance and understanding of a mathematics program that emphasizes the development and articulation of mathematical reasoning and the values endorsed by the mathematics reform. The study was conducted in three classrooms, two multilingual and one native English-speakers. A total of 41 students participated. The study was based on five initial ideas that included:

1. the use of manipulatives will help reinforce mathematical problem solving concepts through hands on practice;
2. students' English proficiency levels will affect their ability to communicate mathematical concepts;
3. students' English proficiency levels will affect their ability to understand procedural directions given by teachers;
4. teachers will need to modify instruction in order to facilitate mathematical understanding for second language learners; and
5. math concepts will be enhanced when the culture of teaching and the learning process is given explicit attention.

The results of the study include the following:

- Though the manipulatives seemed to be one of the components that teachers most appreciated in terms of supporting concept development for students, manipulatives did not always help to reinforce problem solving concepts.
- English proficiency is an indicator of how successful an ELL student will be in communicating mathematical concepts.
- English proficiency does affect how well the student understands and is able to follow the procedural directions of the teacher.
- In order for English language learners to benefit from a mathematical program that relies heavily on the articulation of mathematical reasoning, the instruction must be modified to prevent English proficiency from interfering with obtaining the skills required to articulate mathematical reasoning.
- Students' attitudes toward mathematics improves when mathematics instruction includes hands-on activities.

Kiplinger, Haug, & Abedi (2000) addressed the issue of evaluating mathematical ability on a mathematics test rather than reading ability by investigating how changing the format of a test impacts the achievement rate of ELLs. The study developed and administered three separate mathematics tests to 1,198 fourth graders. The three test forms were in original English, simplified English, and original English with a glossary provided.

The results of the study included the following:

- Academic achievement for ELL students on a mathematics test is directly related to proficiency in reading English.
- Students performed better on the simplified English test than on the original English test.
- Students performed better on the original English with a glossary provided than on the original English test.
- Students performed at the lowest achievement level on the original English test.

Secada (1991) studied how Hispanic students solve mathematics problems and to what extent their success is related to the semantic structures of word problems in a similar manner across the Hispanic students' two languages. Forty-five participants from four first grade classrooms were involved in the study. All participants were enrolled in bilingual classes and received at least 90 minutes of instruction in their native language.

Students were given language proficiency, early number, and arithmetic problem solving tasks in February and March of the study year. Four sessions were conducted for the study, and tasks were administered in English and Spanish. Two sessions were conducted in English and two in Spanish. Two sessions assessed word problem solving skills and two assessed language proficiency.

The results of the study included the following:

- The participants did as well solving problems in English as their monolingual English-speaking classmates.

- The participants did better solving English word problems than Spanish word problems.
- Arithmetic instruction based on development of initial and intuitive problem solving skills for first graders is not effective.
- Language Assessment Scales (LAS) tests are not accurate predictors of how well ELL students will perform with word problems.
- As students become truly bilingual, their competence in mathematics develops.

Findings Based on a Search of the Literature:

- There is a scarcity of research on elementary English Language Learners and mathematics that meets the No Child Left Behind (NCLB) criteria of scientifically-based.
- Researchers tend to investigate mathematics achievement in terms of literacy rather than looking at mathematical ability.
- English Language Learners learn best when instructed in their native language first and then in their second language (Bernardo, 2002).
- Mathematical concepts are enhanced when instruction includes explicit attention to cultures (Himmele, 2001).
- Teachers must recognize the differences in ELL students' ability to speak academic language as opposed to personal language (Cummins, 1984; Montano-Harmon, 2002).
- English Language Learners are more successful with number problems rather than word problems (Bernardo, 2002).

- Early oral language proficiency is an indicator of academic success in later years. (Gilbert, 2001; Himmele, 2001).
- The use of manipulatives in mathematics instruction does not appear to make a significant impact on English Language Learners' comprehension of mathematical concepts. (Himmele, 2001).
- English Language Learners perform lower than native speakers on mathematics assessment due to lack of reading ability rather than mathematical ability. (Kiplinger, Haug, & Abedi, 2000).
- Proficiency in the language of the assessment affects the ability to communicate mathematical concepts (Kiplinger, Haug, & Abedi, 2000; Himmele, 2001).
- Students who are truly bilingual perform as well as native English speakers on grade level mathematics assessments (Secada, 1991).
- Successful mathematics programs allow for modification in instruction that requires fluent articulation of mathematic reasoning (Himmele, 2001).
- Structured English immersion (SEI) programs are less successful than other bilingual alternatives (Mahoney, MacSwan, & Thompson, 2005).
- There is no evidence to support the theory that English-only instruction will increase ELL's rate of English language proficiency (Wright & Pu 2005).
- There is no evidence to support the theory that including ELLs in English-only high stakes testing programs will increase English language proficiency (Wright & Pu, 2005).

- Arizona's accountability formulas exclude some lower performing ELLs, thereby affecting the test results which demonstrate improvement in ELL performance. (Wright & Pu, 2005).
- The most successful programs for English Language Learners are two-way dual language programs (Thomas & Collier, 2002).

What is Not Discussed in the Literature:

- There is no comparative study of the achievement gap between diverse groups of English Language Learners (i.e. Hispanic, Asian, Eastern European).
- There is no evidence of funding issues that prolong bilingual placement.
- There is a lack of professional development opportunities for teachers to learn mathematics strategies designed specifically for English Language Learners.
- Teacher preparation programs are not preparing preservice teachers with quality mathematics pedagogy.
- There is a lack of elementary teachers who meet NCLB criteria for highly-qualified in both bilingual education and mathematics education.
- It is not only English Language Learners who perform below state standards; a systemic problem exists with math instruction in the public schools.
- Two-way dual language programs should be for all students so that native English speaking students can develop a second language as well.
- The impact of teacher attitude on the success rate of English Language Learners has not been examined.

Recommendations:

- Restructure teacher preparation programs so that preservice teachers receive mathematics instruction that includes both content and pedagogy.
- Reevaluate the traditional funding system for bilingual education to tie funding to exiting students from the program rather than maintaining students in the program.
- Develop a standardized TAKS test that assesses mathematical ability, not reading ability.
- Support and fund professional development that addresses mathematics instruction for English Language Learners specifically.
- Support and fund two-way dual language programs for all students, not just those who are not native English speakers.
- Support and fund research to develop programs that target mathematics instruction for English Language Learners.
- Recognize the differences between the diverse cultures that make up our English Language Learners, and investigate the achievement gaps between those groups.
- Support and fund research that examines how teacher attitudes toward English Language Learners affects the success rate.

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