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

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Introduction

The *No Child Left Behind Act* (NCLB) has mandated that all children be provided a learning environment in which students are taught by licensed professional teachers utilizing research-based best practices in schools that make annual yearly progress toward the success of every student in academic endeavors.

It is well documented that for some segments of our national student population, this lofty ideal is not being reached. This is the case for some Hispanic students (and students of other nationalities with native languages different from English) in general and for English Language Learners in particular. English Language Learners (ELL) are, from the time they enter a U.S. public school, challenged (1) to learn a new language, (2) to learn a new language in a relatively short time span, (3) to learn and master the content of at least the core disciplines, (4) to pass state-wide high stakes testing at periodic points along their educational career, and (5) to pass state-wide high stakes testing at the end of their educational career in order to receive a high school diploma. The challenge for teachers and administrators is to provide a positive learning environment that successfully maximizes the learning experiences of ELL students and provides them access to the opportunities for other educational experiences and meaningful participation in the democratic experience.

Purpose

The purpose of this paper is to review the scientifically based research literature regarding English Language Learners (ELL) and the teaching of mathematics for secondary (middle school) students.

Scope of this Study

The authors reviewed articles with any connection to “mathematics” and “ELL” and identified studies—those with at least an identified sample and some experimental procedure (quantitative studies) or description of a successful program (qualitative studies) connected to “mathematics” and “ELL students” at middle school grade levels (sixth through eighth). Sources for these studies included published journal articles, published research reports, and dissertations.

The studies reviewed fall into two categories: (1) studies related to programs and program effectiveness for ELL students in general (three studies), and (2) studies related to math instruction and ELL students (eight studies).

Studies Relating to Programs and Program Effectiveness for ELL Students

Genesee, Lindholm-Leary, Saunders, and Christian (2005) conducted a review of the research on the educational outcomes of ELL students. Their review synthesized the research on oral literacy, literacy, and academic development of ELLs from Pre-K to twelfth grade. Focusing on peer reviewed research, the authors synthesized approximately 200 articles and research reports.

Briefly, Genesee et al. (2005) reported the following:

1. Oral Language Development:
    a. The development of a second language (L2) oral language is vital to the school success of ELL students. It seems reasonable to assume that as oral language proficiency develops, one's capacity to further learn, acquire, and use that language also increases (p. 366).
    b. English L2 oral proficiency develops over time, typically three to five years, and progress from beginning to middle levels of proficiency is relatively rapid, but progress from middle to upper levels of proficiency is slower (p. 367).
    c. English language use both in the classroom and outside of school is positively associated with the development of English proficiency, though the effects of English use are probably limited.
        i. When using small group interaction to promote L2 usage, careful consideration must be given to the design of tasks that students engage in, the training of non-ELLs who interact with ELLs, and the language proficiency of the ELLs themselves.
        ii. A positive relation between English language use and English language oral proficiency exists for ELLs from families that report using English relatively more frequently as they tend to demonstrate higher levels of English proficiency than ELLs from families that report using English less frequently (p. 368).

2. Literacy:
    a. Aspects of English oral competence that are related to literacy and/or academic tasks are particularly influential in English L2 literacy development, more so than general L2 oral language abilities, specifically achievement in English reading.
    b. English L2 literacy development can proceed if students have limited L2 oral proficiency if they have well developed skills in certain L1 domains, particularly in the early stages of L2 literacy development.
    c. Studies of L2 and L1 oral proficiency indicate that there are two routes to initial literacy in English L2: one via skills that have been acquired in the target L2 and one via skills that are linked to the L1 in cases when ELLs lack well developed L2 skills.
    d. L1 features that are related to literacy and/or academic achievement or higher order cognitive uses of language are more influential in English L2 literacy development than more general aspects of L1 oral development.
    e. Successful ELL readers/writers employ a number of effective strategies (e.g., inferencing, the use of context and prior knowledge, and monitoring of comprehension) to comprehend text in English, and they use these strategies during both L1 and L2 literacy tasks.

f. ELLs with initial L1 literacy experiences, such as emergent or family literacy, as well as those with well developed L1 literacy skills progress more quickly and successfully in L2 literacy than ELLs without these experiences and skills.

g. Three major instructional approaches were identified (a) direct, which emphasizes the explicit and direct instruction of specific reading/writing skills and strategies; (2) interactive, which emphasizes learning that is mediated through interaction with other learners or more competent readers and writers; and (3) process-based, which emphasizes engagement in the authentic use of written language for communication or self-expression and de-emphasize teaching the component skills and strategies of reading and writing in favor of learning through induction. A combination of the three approaches is optimum (pp. 370-374).

3. Academic Achievement:

   a. Regarding the academic achievement of ELLs, across studies there was strong convergent evidence that the educational success of ELLs is positively related to sustained instruction through the student L1 and that length of time in the program and time of assessment affect outcomes.

   b. Research also shows that ELLs who received any specialized program (bilingual or English as a second language) were able to catch up to, and in some studies surpass, the achievement levels of

their ELL and English-speaking comparison peers who were educated in English-only mainstream classrooms.

c. Studies also indicate that bilingual proficiency and biliteracy are positively related to academic achievement in both languages.

d. Programs that were relatively effective shared the following characteristics:

   i. A positive school environment

   ii. A curriculum that was meaningful and academically challenging, incorporated high order thinking, was thematically integrated, established a clear alignment with standards and assessment, and was consistent and sustained over time.

   iii. A program model that was grounded in sound theory and best practices associated with enriched, not remedial, instructional model.

   iv. Teachers in bilingual programs who understood theories about bilingualism and second language development as well as the goals and rationale for the model in which they were teaching.

   v. The use of cooperative learning and high quality exchanges between teacher and pupils (pp. 374-377).

Thomas and Collier (2002) conducted a national study built on fourteen years of related research on language minority students and their academic achievement. The study, *National Study of School Effectiveness for Language Minority Students' Long Term Academic Achievement*, collected data from five

school districts throughout the U.S. and attempted to understand how effective various programs were in serving language minority students. Four distinct theoretical program designs were included

1. Two-Way Bilingual Immersion programs: these promote academic achievement, bilingualism, and biliteracy for ELLs and native English speakers and typically last for five to six years,
2. One-Way Developmental Bilingual Education programs: offer instruction only to language minority students of one language background (including ELLs) and typically last for five to six years,
3. Transitional Bilingual Education programs: offer classes presented in the ELL's native language for two to three years and then receive all English instruction, and
4. English as a Second Language programs for ELLs: teach English to ELLs through academic content areas.

The sample for this study included 210,054 student records and followed student achievement for a period of five years by looking at and comparing the performance of ELLs and non-ELLs. (It is well documented that there is a gap between ELLs and non-ELLs in academic achievement.) The authors examined results from standardized tests (reading, language arts, and math) and variables such as socioeconomic status, number of years of primary language schooling, and gender differences for influence on academic achievement.

The results of the study include the following:

- 90/10 and 50/50 Two-Way Bilingual Immersion and One-Way Developmental Bilingual Education programs are the only programs found to date that assist students to fully reach the 50th percentile in both their native language and English in all subject areas and to maintain that high level of achievement, or reach even higher levels through the end of their schooling. The fewest dropouts came from these programs.
    - Two-Way Developmental Bilingual Education including Content ESL: 61 NCE (Normal Curve Equivalents); shows improvement until Grade 11.
    - One-Way Developmental Bilingual Education including Content ESL: 52 NCE; shows improvement until Grade 11.
    - Transitional Bilingual Education including Content ESL: 40 NCE; shows early improvements to about Grade 3 and then levels off to Grade 11.
    - Transitional Bilingual Education + ESL with both taught traditionally: 35 NCE; shows improvement to about Grade 3 and then declines slightly to Grade 11.
    - ESL taught through Academic Content (no Language 1): 34 NCE; shows improvement to about Grade 3 and then declines slightly to Grade 11.

  - ESL Pullout (no Language 1) taught traditionally: 24 NCE; shows improvement to approximately Grade 3 then a steady decline until Grade 11.

- ELLs who attended only English mainstream programs because their parents refused language support services showed large decreases in reading and math achievement by Grade 5 when compared to students who participated in language support programs. The largest number of dropouts came from this group.
- When ELLs initially exit a language support program into the English mainstream, those schooled in all-English medium programs (ESL) outperform those schooled in the bilingual programs when tested in English. The students schooled in bilingual programs, however, reach the same levels of achievement as those schooled all in English by the middle school years. Further, during the high school years, the students schooled in bilingual programs outperformed the students schooled in all English.
- The amount of formal primary language schooling that a student has received is the strongest predictor of second language achievement. That is, the greater the number of years of primary language, grade-level schooling a student has received, the higher his/her English achievement will be.

Based on these findings, the authors propose that in order to close the average achievement gap between ELLs and native English speakers (non-

ELLs), language support programs must be well implemented, not segregated, sustained for five to six years, and demonstrate achievement gains of more than the average yearly progress of the non-ELL group each year until the gap is closed. The problem here is that the achievement gap is at best a moving target since non-ELLs progress academically each year for their grade level, while ELLs typically fall further behind with each grade level. Thus, even the most effective language support programs can only close half of the achievement gap in two to three years.

Cruz (2000) constructed a qualitative study that examined the learning experiences of English language learners in a two way bilingual education program. More specifically, this study examined the typical language, literacy, and content area learning experiences that ELL and English proficient students encountered in a two-way bilingual education program at a middle school implemented in a second language enrichment design format.

The participants in this study included the entire educational community of a two-way bilingual education program, including seven teachers, three administrators and twenty-four students (sixth, seventh, eighth grades). Only sixth through eighth grade students who were at or above grade level in their native language could participate in this program. The data collection strategies included open-ended interviews, direct observation, and written documents.

The results of the study included the following:

1. The goals of the two-way program studied were similar to those goals identified nationally: Two-way programs promote bilingual proficiency, academic achievement, and cross-cultural understanding.
2. Learning experiences encountered by students fell into two main categories: (1) grade level curriculum, which includes parallel curriculum (same or similar learning experiences carried out by mainstream and bilingual teachers in English or Spanish), reciprocal exchanges, which refer to purposeful exchanges done among two teacher that taught the same content area, and interdisciplinary units, which included content from multiple domains; and (2) curriculum enrichment learning experiences, which included experiences supported by the grade-level curriculum by means of expansion or culminating activities for units of study, and experiences focused on social interaction.
3. The curriculum, instruction, and assessment features identified the two-way program under study reflect those identified in the national directory of two-way programs.
4. The study found that bilingual teachers used the native language for multiple purposes, including serving as a bridge to learning in the second language.
5. The program had only a three-year life span.

6. The program transitioned students through the three years from 85/15 and/or 90/10 to the recommended 50/50 ratio of second language to native language instruction.
7. One feature of a successful program identified was a strong collegiality among the bilingual mainstream, second language and monolingual mainstream teachers that was supported by the school structure and the program.
8. Finally, the study identified three major problems in the two-way program: (1) there was a lack of the same materials in both languages of instruction for all student participants; (2) there was a lack of bilingual certified subject area teachers for the program model at the middle school; and (3) not being able to reach the 50/50 ratio of language use for all students in the program created a different treatment for both language groups (pp. 196-204).

Hunt (1996) constructed a study to compare Spanish-speaking, limited English proficient (LEP) students in sheltered mathematics classes (immersion) with Spanish-speaking, limited English proficient (LEP) students in regular mathematics classes (submersion) to determine if the immersion students (a) demonstrate significantly higher mathematics achievement, (b) have a more positive attitude toward mathematics, (c) drop out at a lower rate, and (d) demonstrate a significantly greater tendency to complete mathematics courses in high school.

The sample for this study included advanced eighth grade Spanish-speaking LEP students enrolled in the Dallas Independent School District ESL program. Data for achievement, dropout information, and mathematics coursework completed were drawn from student records in the school district. The attitude survey was given to eighth grade level three Spanish-speaking LEP students.

The results of the study included the following:

1. There was no significant difference in achievement between the immersion and submersion eighth grade populations.
2. Regarding the attitude measures, they were not more positive for the immersion population than the submersion populations of the study.
3. The dropout rate was significantly lower for regular math students.
4. The earned mathematics credits were not significantly different between sheltered and regular students.

Hewlett-Gomez and Solis (1995) reported on the Literacy Program for Recent Immigrant Students, which is an English/Spanish program of instruction for recently immigrated secondary students located in a south Texas school district. This program was utilized in two middle school campuses serving grades six, seven, and eight. The program used a team teaching approach: a certified and endorsed bilingual/ESL teacher who taught in English, and a Spanish-speaking *professora,* a teacher from Mexico hired as an assistant, who taught in Spanish.

Five features of the program are noteworthy, the authors state, because most secondary programs lack them:

1. a sensitivity to students with the most limited English skills and mainstream experiences,
2. instruction in two languages,
3. comprehensive instruction which extends horizontally to the four literacy skills—listening, speaking, reading and writing, and vertically to address all language proficiency levels,
4. both language and content instruction, and
5. the incorporation of student's cultural experiences into the curriculum

The program featured five components, including (a) identification, assessment, and placement; (b) curriculum, instruction, and materials; (c) staffing; (d) staff development; and (e) parental involvement.

The program begins with a comprehensive assessment of students, including formal assessment, a collective, informal observation procedure, and analysis of student characteristics for language ability. Based on this assessment procedure, students were divided into Dimension I and Dimension II groupings. Dimension I students had little or no Spanish academic skills, while Dimension II students possessed varying levels of Spanish academic skills which were deemed sufficient to benefit from a more accelerated instruction in Spanish. Dual language is provided for Dimension I and II students with a three-year instructional plan to help each group develop skills at its proficiency level. This instructional plan includes (a) an integrated, disciplinary curriculum with a whole

language philosophy, (b) instructional strategies and materials with specialized instruction in both Spanish and English in reading, language arts, and writing, with a content-based model for mathematics, science, and social studies, and (c) a culture component integrated across the curriculum. Two teachers, one teaching in English and one teaching in Spanish, taught the students. The Spanish duties were provided by *professoras,* Mexican licensed teachers with credentials and degrees from Mexican teacher preparation schools. Staff development was extensive for both members of the teaching team. Specifically, the training included knowledge on (a) the natural approach and second language acquisition, (b) whole language philosophy, (c) Cognitive Academic Language Learning Approach (CALLA), (d) the Counseling Language Learning Method, (e) transitional reading techniques, (f) process writing, (g) adaptations of key approaches for Spanish instruction, (h) cooperative learning and grouping patterns, (i) classroom management for lesson planning and positive behavior modifications, (j) instructional lesson planning, (k) strategies to integrate culture into the classroom, and (l) informal assessment techniques. Parental involvement linked parent concerns and their needs for helping their children in school. Parental training opportunities and the use of a parental liaison were utilized to link the school to the home.

The program was evaluated following the first year of implementation. It was found to provide support for the program design's success. In brief, test assessment results showed some quantitative gains in Spanish and English achievement. Comments by teachers, students, and parents about the program

indicated that the program was well received by students, teachers, and administrators. In particular, students felt like they were learning in school, wanted to attend classes, and were liked by their peers.

Studies Relating to Math Instruction and ELL Students

Hindley (2003) conducted an investigation to design and field test lesson plans that incorporated a variety of methodologies intended to enhance the mathematics achievement of LEP students of Hispanic decent. The author created twenty curricular lessons using four methodologies (peer tutoring, cooperative learning, manipulatives, and curriculum supplements) for ninth grade mathematics. The units covered included polynomials (manipulatives), equations (peer tutoring), angles and parallel lines (cooperative learning), and graphing of lines (curriculum supplements, such as *Spanish Math Terms and Mathematical Operations*). The trial lasted ten weeks with twenty-two students in New York State.

At the beginning of each unit the students (1) were given a pre-assessment, (2) were taught a unit of mathematics using one of the four methodologies, (3) were given a post-assessment, and (4) were asked to complete a questionnaire regarding the teaching methodology. Following the completion of the units, four evaluators reviewed the lesson plans and evaluated them to assess the realistic implementation of the lessons.

The results of the study included the following:

1. All four methodologies helped students acquire a good understanding of the topics.

2. Preferences for methodologies were (in order of preference): manipulatives, peer tutoring, cooperative learning, and curriculum supplements.
3. Using the different methodologies fostered communication between students in class and made students more comfortable.
4. A disadvantage of the process was that the length of the class period required careful lesson planning.

Hofstetter (2003) conducted a study that looked primarily at what classroom and school factors are most related to ELL performance in National Assessment of Educational Progress (NAEP) mathematics assessment and the interactions between contextual factors and type of test accommodation. The sample was composed of eighth grade LEP and non-LEP students predominately of Hispanic descent. Students were administered the same NAEP mathematics test items in one of two different accommodation formats (modified English or original Spanish) or with no accommodation at all (original English). Students came from mathematics classrooms that varied in language of instruction (English instruction and Spanish instruction) and by level of mathematics class (eighth grade mathematics, pre-algebra, algebra).

Participants in this study were 849 eighth grade students enrolled in forty-five mathematics classrooms with nineteen teachers in nine low income, urban predominately Latino middle schools in southern California. Students in intact mathematics classes were randomly administered one of the three test booklets—a standard NAEP mathematics assessment in English or one of two

test accommodations—using random assignment. Each booklet contained the same contents except in a different form. Each booklet also contained a Student Language Background Questionnaire, and NAEP Reading Test.

The results of the study reveal the following:

1. Student's English reading proficiency continues to influence LEP and non-LEP students' mathematics test performance.
2. LEP students who received mathematics instruction in Spanish performed lower on the NAEP mathematics test than students instructed in English.
3. LEP students instructed in Spanish and who received original Spanish accommodation performed higher than students with no accommodation at all.
4. Students in higher-level mathematics classes performed better than students in lower classes regardless of LEP status.
5. Students who received modified English accommodation scored slightly higher than students who received no accommodation but not significantly.
6. Students with the original Spanish accommodation performed lower than students with no accommodation, unless their language of instruction was Spanish, which suggested that giving LEP students an original Spanish accommodation does not necessarily enhance student performance.

Sayavong (2003) constructed a study to examine the effect of a technology based mathematics approach (Interactive Mathematics software called *Mediated Learning*) on the academic achievement and attitudes of high school mathematics students that included Mexican-Americans and Mexican immigrants. According to the software description, Mediated Learning is teacher guided and learner centered. The software was designed to explain and demonstrate mathematical concepts using multiple representations to address individual learning styles. Depending on a student's preference, he or she can choose to see (1) a method to that guides the learner to the solution, (2) view pictures or graphic representations to help conceptualize the problem, (3) find another way to do the problem, or (4) learn why a procedure works. One high school in Monterey County was the location of the three-year study. The study had a total of 910 pre-algebra and algebra students participating with 644 Mexican American or Mexican immigrant students being included in the sample. Most students were in the ninth grade. The study compared traditional instructional classrooms to Mediated Learning classrooms. Students were give the Algebra Readiness Test as a pre-test, and the Student Questionnaire was given to assess student attitudes regarding mathematics. The Course Achievement Test was administered the last week of the semester.

The results of the study found the following:

1. Mexican American and immigrant students who received traditional instruction made larger pre to post-test gains compared to Mediated Learning instruction using the Algebra Readiness Test. Results from

the Course Achievement Test showed the opposite effect with the Mediated Learning classes outperforming the traditional classes.

2. Pre-algebra students who received Mediated Learning expressed more positive attitudes toward computers than traditional group.
3. Girls outperformed boys in the Course Achievement Test.
4. In the Mexican immigrant group, students in traditional classes scored higher on the Algebra Readiness Test but lower on the Course Achievement Test in the Mediated Learning classes.
5. In the algebra course, no significant differences were found in mathematics achievement between students in the two treatment groups when considering gender or U.S. residence status.

Schuck (2003) constructed a study that looked at the impact of Internet use in mathematics by examining student achievement, critical thinking skills, and time on task. The study involved five algebra classes composed of eighth grade Latino students (n=127) who displayed three distinct skill levels (low, medium, high). (The author did not identify any of the sample as being LEP or ELL students.) The study involved three modules that used three instructional modes (frontal, which utilized instruction using an LCD projector; individual, and small groups, which involved random grouping of students), and were structured around three standards: simplifying expressions, problem solving, and linear equations.

Students in this study accessed the Internet, which was considered to be an instructional tool. Students accessed “pure math sites,” which provided

mathematics problems according to topic and difficulty and “virtual critical thinking sites,” which provided data and information to solve real world algebraic tasks.

Based on the results of the study, the author offered these conclusions:

1. Among medium and high skill level students, there is a direct correlation between the use of the Internet as an instructional tool and student achievement when a problem-solving task is involved.
2. Use of the Internet as an instructional tool with a problem-solving task increases student-to-student verbalized higher order thinking skills.
3. Use of the Internet as an instructional tool with a problem-solving task increases student higher order thinking skills in their written products.
4. When students of all skill levels are given a problem-solving task, the use of the Internet as an instructional tool correlates directly to the time on task for frontal, individual, and small group instruction.
5. Student skill level is variable which affects the results of using the Internet as an instructional tool as it correlates to student achievement, critical thinking, and time on task (pp.161-164).

Abedi, Hofstetter, Baker, and Lord (2001) conducted a study to examine the validity and comparability of selected test accommodations on math performance for students with limited English proficiency (LEP), as compared to students who were more fluent in English. The study consisted of 946 eighth grade students with varying degrees of English proficiency selected from 33 math classrooms in six middle schools from a larger non-probability sample. The

students came from Los Angeles and Long Beach school districts. Schools with large English language learner populations and varying socioeconomic and ethnic makeup were selected to be included. The math classes varied in content and level (from basic math, pre-algebra and algebra) as well as language of instruction, with several classes taught by the same teachers.

In this study, five test accommodations were utilized:

- Original English: English language math items taken directly from the NAEP test booklet,
- Modified English: linguistically modified (linguistic structures and non-technical vocabulary) version of the English math items,
- Glossary only: original English-language math items with glossary definitions for non-math terms identified as potentially difficult for LEP students to understand,
- Extra Time Only: original English-language math items plus students were given an extra 25 minutes to work on the math test, and
- Glossary plus Extra Time: original English-language math items with glossary definitions and extra 25 minutes to work on math test (p. 17).

One of five test booklets was administered randomly to intact math classrooms. Each test booklet contained the same NAEP math test items, in the same order, with 24 multiple-choice items and 11 performance-based items.

The study found

1. Students designated LEP by their schools scored, on average, more than five points lower than non-LEP students.

2. The greatest score improvements, by both LEP and non-LEP students, were on the accommodation version that included a glossary and extra time.
3. LEP students' scores were higher on all types of accommodations except Glossary Only; Modified English, Extra Time and Glossary plus Extra Time helped LEP students.
4. Most types of accommodations helped both LEP and non-LEP students; the only type of accommodation that narrowed the score between LEP and non-LEP students was Modified English.
5. Students who were better readers, as measured by reading test scores, achieved higher math scores (p. 57).

Abedi and Lord (2001) conducted a study that investigated the importance of language in student test performance on mathematics word problems. Students were given a test consisting of released items from the NAEP mathematics assessment, along with parallel items that were modified to reduce their linguistic complexity. These items did not change the math task, but did modify non-math vocabulary and linguistic structures. Linguistic structures that were changed included the following:

1. Familiarity or frequency of non-math vocabulary—unfamiliar or infrequent words were changed (a certain reference file > Mack's company).
2. Voice of verb phrase—passive verbs were changed to active (if a marble is taken from a bag > if you take a marble from the bag).

3. Length of nomials—long nomials were shortened (the pattern of the puppy's weight gain > the pattern above).
4. Conditional clauses—conditionals were replaced with separate sentences, or the order of conditional and main clause were changed (if two batteries in the sample were found to be dead > he found three broken skateboards in the sample).
5. Relative clauses—removed or recast (the total number of newspapers that Lee delivers in 5 days > how many newspapers does he deliver in 5 days).
6. Question phrases—complex question phrases were changed to simple question words (which is the best approximation of the number > approximately how many).
7. Abstract or impersonal presentations—made more concrete (. . . 2,675 radios sold > . . . 2,675 radios that Mrs. Jones sold) (p. 3).

This study was composed of 1174 eighth grade students from 39 classes in 11 schools in the Los Angeles area with a range of language, socioeconomic, and ethnic backgrounds. Students came from math classes that included honors algebra, algebra, high mathematics, average mathematics, low mathematics, and ESL mathematics. The student group consisted of 31% English Language Learners (ELL).

The study was composed of two parts. In part one, the Student Perception Study was conducted to determine (1) if students respond differently to different linguistic structures, and (2) do they prefer simpler items? A total of

36 students were interviewed with a ten-fifteen minute response to paired sets of items. In general, students preferred the modified version of the item in each pair. This supports the notion that the math items could be linguistically simplified in meaningful ways. In part two, the Accuracy Test was administered to entire group of students by retired teachers and principals experienced in test administration. Students were given one of two booklets. Booklet A contained ten original items, and Booklet B contained the revised versions of those items. Similarly, Booklet B contained a second set of ten original items, and Booklet A contained the revised versions of those items. Booklet A was given to 51% of the students, and Booklet B to 49%. Booklets were randomly assigned within each class. A Language Background Questionnaire (LBQ) accompanied each booklet.

The findings of this study include the following:

1. ELL students scored significantly lower than proficient speakers of English.
2. Modifying the linguistic structures in math word problems can affect performance.
3. On paper-and-pencil tests, over 1,000 of the students scored significantly higher on the linguistically modified items.

In general, the language modifications had a greater impact for low-performing students:

1. ELL benefited more than proficient speakers of English.
2. Low SES students benefited more than others.

3. Students in low-level and average math classes benefited more than those in high-level math and algebra classes.

Wang and Goldschmidt (1999) conducted a study in which they examined data from a larger urban school district in California to investigate the roles of opportunity to learn (OTL), language proficiency, and immigrant status on 2,443 middle school students' mathematics achievement over three years. This study concentrated on the specific issue of curriculum equity in terms of coursework measures and investigated the relationship between students' mathematics achievement and their opportunity to learn in terms of course taking. The study had two objectives. The first objective was to examine whether students' language proficiency and immigrant status affect students' course taking and to what extent, and whether course taking directly and indirectly affects students' mathematics achievement and growth. The second objective was to investigate how students' course taking affects their mathematics achievement and growth rates after controlling for their previous achievement, language proficiency, immigrant status, and other background values. The authors examined whether there were significant differences in students' course taking by ethnicity, language, and immigrant status.

According to the authors, five important results emerged that partially account for differences in eighth grade mathematics achievement.

- First, when the type of mathematics course taken was equalized, girls' mathematics performance was statistically lower than the boys' performance. The results indicate that the gender gap is not simply a

result of girls not pursuing more mathematics courses in high school. Unequal treatment and differences in OTL in middle schools may negatively affect girls' attitudes towards mathematics. Girls also may avoid pursuing advanced mathematics courses in high school, at which point the gender gap may become a function of both inequitable treatment and differences in course taking.

- Second, differences in SES explain some achievement differences, but are much less important than other student level characteristics. Students who received free lunch scored eight points lower than did students ineligible for free lunch.
- Third, students' course taking patterns vary across their language proficiency, immigrant status, and ethnicity. The middle school students' course-taking distribution by language proficiency is markedly different for non-immigrants and immigrants, especially for re-designated students. Other research has shown that African-American and Hispanic students are usually underrepresented in algebra and honors courses.
- Fourth, students' course taking explains their mathematics achievement differences even after considering students' descriptive characteristics, language proficiency, immigrant status, and SES. Students who study algebra, honors mathematics, or an elective mathematics course had significantly higher test scores compared with students enrolled in standard mathematics classes. Students who took

a minimum standard course performed significantly lower than did students in a standard mathematics class. Also, students in ESL mathematics course had lower test scores, even though the difference was not statistically significant. Students who took different courses also had different growth rates. Students who took elective mathematics had the highest growth rates, and students in minimum standard classes had the slowest growth rates.

- Fifth, the results indicate that there is an important interplay between students' OTL and language proficiency. The authors' results reveal that although re-designated students had a sufficient grasp of English to be classified as being fully English proficient, their level of English proficiency was not enough for them to succeed in advanced courses. Those students required some language support after re-designation. On the other hand, ESL mathematics is as beneficial for LEP students as standard mathematics is for English only students. This finding should disprove the belief that non-native English speakers are inferior in learning content areas because they do not speak English.

Abedi, Lord, and Plummer (1997), in an executive summary, describe the findings of three studies. The three studies were preceded by a review of the literature to identify language variables that could be applied to NAEP data as an extension of their research efforts. Items from the eighth grade NAEP math tests were analyzed using a linguistic categorization scheme. The results of this research aspect revealed lower math proficiency scores, lower performance

when considering linguistic complexity, and higher omitted/not reached items for subjects who predominately spoke a language other than English in the home. Following the preliminary findings from the literature review, the authors conducted three studies to determine whether linguistic complexity had any impact on student's math performance.

The first study was a Student Perception study that consisted of interviews with a group of eighth grade students (n=38). The purpose of the interviews was to investigate whether linguistically simplified items were perceived as easier to understand by students. The findings indicate that student preference for the simplified items support the idea that math items could indeed be linguistically simplified in meaningful ways (p. xi). The second study was the Accuracy study in which 1,031 LEP students were tested regarding math items in two forms—linguistically complex and linguistically non-complex. The results indicated that (1) student background in math (as indicated by the level of math class) had a significant impact on student math scores; (2) students in ESL programs had lower scores in math than non-ESL students; (3) males and females performed at about the same level; and (4) there were some differences in students' math performance with respect to ethnicity (p. xi). The third study was the Speed study, in which 143 students were tested with items similar to the Accuracy study but were subjected to a timed situation. The results indicated that native speakers performed higher but not significantly, and there was a significant difference between students in low versus high math class category. Finally, no

significant difference was determined between students with different lunch codes (pp. xii-xiii).

An interesting aspect of this study was found in the discussion of analysis of the language background questions that occurred across the two phases of the study. The analysis revealed the following:

1. Non-native English speakers tend to use their native language more with their parents and grandparents than with their siblings and friends.
2. Beginning ESL students showed more signs of concern in the area of understanding, speaking, reading, and writing English.
3. All students reported that they have more problems understanding teachers' explanations, textbooks, and texts of tests in the area of math than in the areas of science or social studies.
4. Native English speakers self-reported a higher level of proficiency in English than non-native speakers.
5. Males and females reported about the same level of proficiency in English and the "other language."
6. The most apparent differences between groups of students were across the categories of ESL class placement codes; differences were found on their self-reported level of English proficiency (understanding, speaking, reading, and writing) and on their understanding their teacher's explanation, textbook, and text of their exams.

Henderson and Landesman (1992) reported the effects of thematically integrated mathematics instruction on achievement, attitudes, and motivation in

mathematics among middle school students of Mexican descent. Thematic instruction, as posited in this study, may provide an effective way to contextualize instruction. It incorporates a concrete learning-by-doing orientation and has the potential to facilitate cooperative and interactive learning opportunities in the classroom. Similarly, cooperative learning can provide opportunities for hands-on activities that result in products on which students perform mental operations, and in situations that engage students in the use of concepts and materials. These features have been identified as characteristics of classrooms that have proved effective for Hispanic students with limited English proficiency.

Since it has been held that there is a substantial relationship between what schools actually teach and what students learn, it holds that fragmented and de-contextualized mathematics instruction poses barriers for understanding and achievement, while a thematic, contextualized mathematics instruction provides students with opportunities to make sense of mathematics concepts and problem-solving strategies.

This study utilized a middle school serving a population of students of predominately Mexican descent, with 90% of the students being Hispanic and 66% being identified as limited English speakers. Seventh grade students were divided into classes that were thematically taught and traditionally taught. Theme students were grouped into two heterogeneous classes, one of which was taught in English only, while the other was taught bilingually. The second year students were not randomly assigned to treatment groups.

The results of the study found that in both the theme and comparison conditions students demonstrated significant gains in computation, but neither group exceeded the other. However, rather than a negative aspect, the results show that thematically taught students achieve as well as traditionally taught students. The difference, in essence, is the quality of the learning displayed by students: the authors reasoned that computation would receive a great deal of attention in comparison classes, and theme students would be exercising computational skills in meaningful problem-solving contexts rather than practicing skills and algorithms as isolated ends in themselves. As well as making gains in achievement levels, students also expressed a high degree of liking for mathematics, students considered themselves to be good at mathematics, and the majority indicated they wanted to take more mathematics.

Findings and Recommendations

Findings in the Literature

- There is a paucity of research specific to mathematics and ELL students in middle school.
- Two-way language programs hold the most promise for delivery of all content to ELL students; however, two-way programs tend to be non-existent in middle schools.
- Using a variety of instructional methodologies (i.e., manipulatives, peer tutoring, cooperative learning, curriculum supplements) assist ELL students to interact with mathematic concepts and ideas and to assist in their understanding.

- English reading proficiency influences all students' (both LEP and non-LEP) mathematics test performance.
- The use of technology and the Internet to assist students in learning mathematics provides the greatest gains when used to supplement or extend learning experiences rather than provide instruction.
- The use of accommodations (i.e., providing modified English texts or a glossary and extra time) assists ELL students in performance on mathematics tests; further, most accommodations help both LEP and non-LEP students with mathematics tests.
- Modifying the linguistic structures of math word problems can affect performance.
- All students (not just ELL) have problems understanding teacher's explanations, textbooks, and texts of tests in the area of math more so than in the areas of science or social studies

Recommendations

- Support and fund research specific to mathematics and ELL students.
- Support and fund the development of two-way dual language programs at all school levels, not just elementary schools where these programs are typically found.
- Support the professional development of teachers of mathematics by providing training in instructional methodologies that assist ELL students.

- Support and fund reading programs for all students. Successful readers are more able to be successful in mathematics.
- Support the development of curriculum supplements and materials that modify the linguistic complexity of traditional mathematics texts and materials.
- Support changes in mathematics instruction from process to conceptual foundations for all kindergarten through twelfth grade students.

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