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Transforming Teacher Practice and Facilitating ESL Students' Learning of Mathematics: A Collaborative Project

■ **This paper describes a professional development model aimed at improving the language skills of English Language Learners (ELLs) while they acquire grade level appropriate mathematics skills specified by the state standards. A university professor, a Mathematics/ESL Lab teacher, and a middle grades Mathematics teacher worked as a team to specify teaching and learning outcomes and redesign their lesson plans to include language-building activities using mathematics core content. While students' test scores and journal entries provide insight into the their learning of both language and mathematics, teachers' journal entries provide insight into the transformation of their practice and their new perception of their roles as both language and mathematics teachers.**

Introduction

Studies indicate a relationship between language skills and mathematical capabilities (Kessler & Quinn 1987; Spanos et al., 1988; Cuevas, 1984; Mather & Chiodo 1994; Durkin & Shire 1991; Ediger, 1994), and the instructional practices of teachers, particularly those who teach English Language Learners (ELLs), must reflect this. With high stakes tied to state-mandated high school graduation requirements, teachers' accountability for the success of their ELLs puts their practice and learning objectives under scrutiny. Echevarria, Vogt, and Short (2001) write, "Many ELLs receive much of their instruction from content area teachers who have not had appropriate professional development to address their second language development needs" (p. 4). As they have emphasized, a major reason for ELLs' difficulty in school is the mismatch between student needs and teacher preparation. Many ELLs only spend between 45 and 92 minutes (in the state of Georgia) in classes that provide language support services. The importance of increasing the amount of time spent teaching content subjects using developmentally appropriate language cannot be overstated; academic content must be introduced early, and one way is to prepare all teachers to teach ELLs in appropriate ways. All content teachers should be trained in second language acquisition and English as a Second Language (ESL) methodology (Echevarria, Voght, & Short, 2001), particularly in integrating language and

content in sheltered instruction. However, unless training is sustained and not limited to short-term or one-shot workshops in content-based ESL instruction or sheltered instruction, it is ineffective (Gonzalez & Darling-Hammond, 1997).

The advantages of integration of language and content are reported in research studies (Short 2002; Crandall & Greenblatt, 1998). In this paper, I will describe a professional development model that involved the collaboration of a traditionally-trained middle grades mathematics teacher, a university professor, and an ESL-trained mathematics teacher; it aimed to provide language learning opportunities to ELLs while they learned mathematics. The teachers coached each other and planned lessons aligned with both the state's subject area standards and *ESL Standards for Pre-K-12 Students,* published by the professional association of Teachers of English to Speakers of Other Languages (TESOL).

I will also present lesson plans that include language objectives as well as mathematics content objectives, and report on students' performance and teachers' practice as shown in (a) students' gains in mathematics knowledge indicated by pre and posttest mathematics scores and results from the General Scoring Rubric for Mathematics (Pierce & O'Malley, 1992), (b) students' perception of their learning gains as reported in their journals, (c) students' oral language development as observed by teachers using the Student Oral Language Observation Matrix (SOLOM), and (d) teachers' reflections on their difficulties and gains in transforming their practice, which emphasize planning lessons that acknowledge their roles as both language and mathematics teachers.

In 2000, the National Council of Teachers of Mathematics (NCTM) published its *Principles and Standards for School Mathematics*, which underscores the importance of meeting the learning needs of a diverse society. It acknowledges the unique needs of students whose primary language is not English and the importance of developing language proficiency and mathematics content mastery through specially designed activities and instructional strategies. The popular assumption that mathematics is a universal language of symbols, and hence the least difficult subject for ELL students to learn, is misleading. Studies have shown that learning mathematics poses several difficulties: The language of mathematics is hard to understand, specifically vocabulary, semantics, and syntax; the cultural context of the word problem may be unfamiliar (Kang & Pham, 1995); students may be used to culture-specific notations and computational steps, and they may not have had formal schooling or may have skipped grade levels, resulting in a knowledge gap. Ediger (1994) claims that mathematics has its own unique vocabulary, which contains words that, although they correspond with words in other academic disciplines, have meanings specific to mathematics.

Several studies support the relationship between language skills and mathematical capabilities (Mather & Chiodo, 1994; Durkin & Shire, 1991; Ediger, 1994). In sum, "mathematics requires substantial linguistic processing in order for students to understand and apply mathematical concepts and operations to problem solving" (Peregoy & Boyle, 1997, p.119). In this regard, Suleiman (1995), suggesting that the learning and teaching of mathe-

matics must focus on promoting sensitivity to the cultural, linguistic, and cognitive characteristics of diverse learners, recommended writing and other language development activities. Similarly, Crandall and Greenblatt (1998) recommended incorporating language-building activities into mathematics literacy instruction.

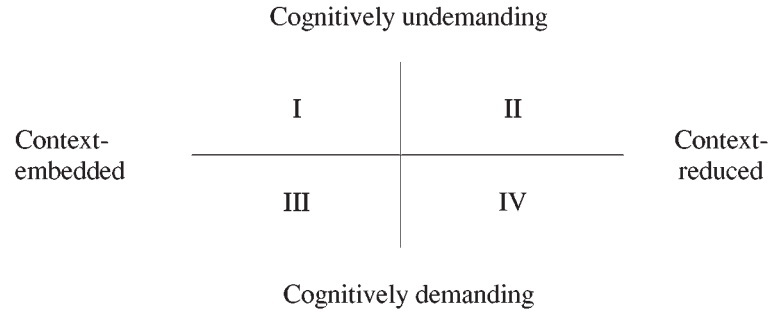
The Collaborative Project

Theoretical Framework

Experts distinguish between language used for basic social interaction and language used for academic purposes (Cummins, 2001). ELLs may need "substantial time and educational support to develop English skills such as those needed to understand academic lectures, to make and defend logical arguments orally or in writing, to read school texts efficiently, and to write effectively for academic purposes" (Peregoy & Boyle, 2001, p. 54). Chamot and O'Malley's (1997) list of language skills required in mathematics underscores the need for ELLs to be proficient in academic language to be successful. Specifically, ELLs need to understand explanations without concrete referents, understand specialized vocabulary, explain problem-solving procedures, and write verbal input numerically.

Making mathematics instruction more accessible to ELLs while they develop their English skills necessary for academic success is an important consideration in this project. Mathematics teachers of ELLs must be aware of the linguistic demands of the mathematics activities they introduce in class, and these tasks must be appropriate to students' levels of proficiency. Using Cummins's two-dimensional model of language proficiency, Chamot and O'Malley (1997) classified activities into four quadrants based on varying levels of cognitive demand and contextual support (Figure 1). Quadrant I includes activities that are appropriate for language beginners, while Quadrant IV includes activities that are appropriate for advanced students.

Figure 1
Cummins's Two-Dimensional Model of Language Proficiency



The horizontal dimension of the model indicates the degree of contextual support that is provided in communication, while the vertical indicates the level of cognitive demand placed on the learner by language. At one end of

the horizontal axis is *context-embedded language*; i.e., language embedded within meaningful nonlinguistic cues such as gestures, facial expressions, and real-life materials. At the other end is *context-reduced language*, i.e. language in which linguistic cues to meaning predominate. The vertical axis has *cognitively undemanding language* on one end and *cognitively demanding language* on the other. This framework, which was found to be useful in planning topics and analyzing curriculum content (Cline & Frederickson, 1996), served as our guide in selecting instructional practices and activities which present the specialized language and content of mathematics as comprehensible input, thereby facilitating concept construction among students. Another framework that influenced the design of this project was *ESL Standards for Pre-K-12 Students,* a publication "developed to complement the discipline-specific standards created by other professional associations and groups" (TESOL, 1997, pp. 1-2). Meant to provide tools for curriculum planning and routes for language development, the ESL standards served as guides in developing language-oriented mathematics lessons and implementing them. Consequently, all the mathematics lesson plans that were carried out in this study included specific social and academic language skills. See Appendix A for sample lesson plans.

Settings and Participants

The project took place from February 28 to May 12, 2000, in the school districts of DeKalb County and Marietta City in Georgia. Both places have a steadily growing ESL population. Two mathematics teachers, one an ESL-endorsed mathematics teacher and the other a regular sixth-grade mathematics teacher without any prior ESL training, collaborated with me on this project. My selection of the two was based on their excellent teaching records as shown by both administrators' evaluations and peer recommendations. At the time of this study, both teachers had taught for more than 8 years and had received their Specialist in Education degrees.

The seventh/eighth-grade class was pre-algebra, although it was officially listed as Advanced Algebra. It was taught in a suburban Atlanta high school ESL Lab program, in which students study English through content area lessons for 2 years, then graduate and move on to a regular high school. This class, which met for 55 minutes, was comprised of students who came mostly from war-torn countries and usually had little or no formal schooling. Specifically, 8 did not have prior schooling, 3 had 5-7 years, and the rest had 1-3 years. They had extensive formal knowledge gaps, but they could not be put in lower grade levels because their ages ranged from 15-18. There were 26 students in this class at the start of the project, but 5 withdrew from school. In this class, which was designated high intermediate to advanced proficiency level (intermediate in actuality) in English, seven language groups were represented.

The sixth-grade class in Marietta City was a general mathematics class. It met for 52 minutes every day and had sixteen 11- and 12-year-old students. The class was designated high intermediate to advanced in English proficiency, and contained eight language groups. All students had had continuous

schooling since age six. The majority of the students had been in the US for 5 months. All 16 students moved as a cohort group from one class to another, spending 45 minutes with their ESL teacher every day.

Collaborative Professional Development Training for Project Teachers

The support and informal training given to the project teachers on different aspects of content and second language instruction were maintained during the project through reflective conferencing on teaching and student progress before and after observations. I also guided lesson planning to make sure all the mathematics and language objectives were in place; lessons provided direct vocabulary instruction. Detailed lesson planning was important because prior to the project, both teachers wrote no more than the content objectives for any unit. In fact, they reported that they often just copied the objectives of the unit or chapter. For the purpose of lesson planning, they used the lesson plan outline that appears in *How to Integrate Language and Content: A Training Manual* (Short, 1999). I further emphasized the importance of meeting their objectives by asking them to explain which aspect or segment of their teaching met their stated objectives during, before, and after lesson debriefings. Finally, although I worked with both teachers, I spent more time with the regular mathematics teacher who did not have prior ESL training to ensure he did not revert to his traditional predominant use of worksheets, lecturing and working problems on the overhead. Collaborative professional development took various forms, which are described below.

Conferences. The project teachers and I met on several occasions. A month before the project commenced, I met with the two teachers for 3 hours to discuss the project and establish project goals and expectations, baseline information on the students, frequency of writing entries in the teacher and student journals, assessment, the schedule of my school visits, and administration dates for pre and posttests. The following week, we had a 6-hour crash course in content-based second language learning, cooperative grouping, comprehensible input, and Cummins's quadrant model of language activities. We sampled writing lesson plans with mathematics objectives and ESL standards and assessment using models from *ESL Standards for Pre-K-12 Students*. I impressed upon the project teachers that their lessons must include direct instruction on the vocabulary, syntax, semantics, and discourse of mathematics. Drawing from best practice literature (Lappan et al., 1996; Jarrett, 1999), we all agreed that the teachers would incorporate language learning instructional practices and activities:

- Discussing the vocabulary and situational context of the math problem; attaching personal meaning to the problem; providing visual cues such as gestures, graphic representation, and role play to help students derive meaning; asking students to rephrase the problem in their own words; encouraging pair work so students can explain to each other how problems can be solved.
- Having students keep journals to clarify concepts and communicate knowledge.

- Teaching familiar words that may have different meanings in math (e.g., *column*, *table*, *rational*, *irrational*).
- Teaching synonyms for *add*, *subtract*, etc.
- Teaching complex strings of words such as *square root, multiplication table,* and *least common denominator* through kinesthetic activities using student-made props.
- Engaging students with models and poster projects.

In addition, teachers were also encouraged to use a rebus technique in which they assessed what key words may not be understood by the students, wrote the words on the board, and then drew a *rebus*—a series of pictures or symbols that represent the words. Several examples of rebus work appear in *Getting to Know Connected Mathematics* (Lapin et al, 1996). One example is as follows:

> The teacher says:
>
> "Suppose a lock has five numbers. How many three-number combinations are possible if repeated numbers are not allowed?"
>
> The teacher writes on the board:
>
> Lock has five numbers (6, 10, 4, 3, 8).
> Three-number combinations (2-4-5).
> Repeated numbers not allowed ~~(5-3-3)~~

Another example of rebus work contributed by a mathematics teacher is as follows:

> The teacher says:
>
> "A polygon is a closed figure made up of line segments. A polygon is named by the number of line segments it has. A polygon with three sides is a triangle. A polygon with four sides is a quadrilateral. A polygon with five sides is a pentagon. A polygon with six sides is a hexagon. A circle is not a polygon."
>
> The teacher writes on the board:
>
> A polygon is a □ made up of ___ segments.
> A polygon is named by the number of ___ it has.
> A polygon with three ___ is a △.
> A polygon with four ___ is a ▯.
> A polygon with five ___ is a ⬟.
> A polygon with six ___ is a ⬣.
> A ○ is not a polygon.

We met again to exchange and discuss lesson plans the teachers had already completed. We invited a mathematics teacher educator to make sure the grade level mathematics component was optimally met and taught. Two months into the project, the project teachers and I met for 2 hours to validate our experiences, offer suggestions, and share resources.

Critique of Videotaped Teaching and Learning. As soon as the project got underway, videotaping of the project teachers' classes began. These videotapes of best practices were used as learning tools for both teachers, and particularly for the regular mathematics teacher as part of his ESL training. By viewing video clips, all participants were able to analyze strategies they had used.

Exchange of Lesson Plans. Teachers submitted their lesson plans ahead of time. Consequently, we were able to exchange plans and revise if necessary. All three of us offered suggestions on teaching concepts and selecting activities to ensure comprehensible input. In addition, through e-mail, we encouraged communication among ourselves. Here is an example of an email message I sent to both teachers: "Mr. R., Did you get the lesson plan I faxed you? Consider using the geoboard to introduce the concept. Do you have questions regarding Ms. Y. using it for this lesson?"

Teacher Educator's Classroom Visits. I visited each teacher every other week for 3 months. During classroom visits, I wrote observation notes, which I shared with the teachers during debriefings. The following is an example of what I wrote asking the teacher for more student feedback: "Please ask your students to reflect on lessons you had taught, so we could assess their understanding or appreciation of your lesson."

Assessment Measures of Student Mathematics and Linguistic Performance

Data on students' oral language proficiency and mathematics content acquisition were collected using various measures.

Mathematics Test

On January 31, the seventh/eighth-grade class took the Orleanes-Hanna Test, comprised of 50 problems, to derive the baseline against which each student could be measured after the practices were implemented. The posttest was administered in May.

The sixth-grade class was administered a pretest developed by the Marietta City Schools sixth-grade Mathematics Department in February. The pretest covered all areas taught in fifth grade and extended into topics covered in the sixth-grade curriculum. The posttest was administered in May, as the school recommended.

The Student Oral Language Observation Matrix (SOLOM)

Standardized tests or objective tests are difficult to apply to a phenomenon as complex as the development of language skills. Objective tests do not test students' facility with language in real settings, and so, as Peregoy and Boyle (1997) assert, we thought that teachers' observation of students' oral language use during day-to-day classroom activities would provide a more accurate, precise, and descriptive picture of student progress. The SOLOM provides a means of assessing students on a number of general oral language traits: comprehension, fluency, vocabulary, grammar, and pronunciation. For accuracy of results, teachers were asked to be consistent in the selection of

the social context of their observation. They assigned a rating to each of the traits on a scale of 1 to 5. Both the seventh/eighth-grade and sixth-grade classes' oral language proficiency was observed and rated three times.

General Scoring Rubric for Mathematics

Because teachers from two different schools in two different districts were scoring students of different ages, the Pierce & O'Malley rubric (1992) was used to ensure as much as possible that scores in mathematics performance were calculated in a similar fashion, regardless of the student, school, or the person in charge of the assessment. In this way, the rubric reflects gains in student performance more accurately and precisely, and it allows for comparison between groups. The rubric assesses students based upon understanding of the problem, use of strategies, and accuracy of answers. When scoring, teachers assigned a rating on a scale of 1 to 4 to each criterion. To plot cumulative gains in mathematics performance, all the students were rated 3 times.

Results and Analysis: Quantitative Data

Mathematics Test

The following table (Table 1) shows pretest and posttest scores for students from both districts. There is a marked increase in both the sixth-grade (Marietta City) and the seventh/eighth-grade (DeKalb) students' posttest scores; the minimum scores in particular improved dramatically. The mean score also improved substantially for both groups.

Table 1
Descriptive Statistics on Pretest and Posttest Scores: Orleanes-Hanna (DeKalb) and Marietta City District Test

	DeKalb County Orleanes-Hanna Test		*Marietta City Marietta District Test*	
	Pretest	***Posttest***	***Pretest***	***Posttest***
N	21	21	16	15
Valid	21	21	16	15
Mean	25.6190	68.6667	23.5625	66.4000
Median	22.0000	76.0000	20.0000	68.0000
SD	16.49993	16.65333	13.89469	13.56887
Minimum	6.00	28.00	7.00	32.00
Maximum	64.00	86.00	63.00	86.00

Appendix B shows the differences between the pretest and posttest scores for both the seventh/eighth-grade DeKalb students and the sixth-grade Marietta City students. All but two students (Student 1 and Student 9) in the seventh/eighth-grade class showed much improvement. Students 1 and 9 had been erratic in attendance because of late-night work schedules. The sixth-grade class was similarly successful, with the exception of Student 8. The

teacher had identified her before the beginning of the study as an undiagnosed special education ESL student. Notwithstanding, her posttest score was higher than her pretest.

SOLOM: Traits of Comprehension, Fluency, Vocabulary, Pronunciation, and Grammar

The SOLOM score is a more precise way of measuring students' proficiency because it takes into account several aspects of language use, and it is applied by teachers who see the students on a daily basis; hence, it is also a better measure of students' improvement. Students who received scores between 5 and 11 were classified *Non-English proficient*; students whose scores ranged from 12 to 18 were deemed *Limited English proficient*; to be *English proficient,* students needed scores between 19 and 24. Students who were *Fully English proficient* received scores of 25.

Out of the 21 seventh/eighth-grade students, only 4 did not show increase by 2 or more points on all traits at the last testing. It was on comprehension and fluency that all students showed more development. See Appendix C for seventh/eighth-grade students' SOLOM total scores on all traits. A similar trend occurs in the results of the sixth-grade students. Like the seventh/eighth-grade class, the sixth-grade students scored higher on comprehension and fluency over time. Except for three students who already scored high on the initial test, all students showed language growth on all traits. See Appendix D for sixth-grade students' SOLOM total scores on all traits.

The following table shows summary frequencies statistics for the seventh/eighth-grade and the sixth-grade groups. Both groups showed improvement approaching fluency.

Table 2
Descriptive Statistics of total SOLOM Scores of the Seventh/Eighth-Grade Class

Seventh/Eighth-grade class	***Total score from 2/15***	***Total score from 3/30***	***Total score from 6/05***
N Valid 21			
Mean	10.8095	13.7619	16.5714
Median	11.0000	15.0000	16.0000
Mode	11.00	15.00	15.00
SD	2.821	2.406	2.9928
Minimum	5.00	9.00	10.00
Maximum	15.00	18.00	21.00

The sixth-grade statistics were as follows:

Table 3
Descriptive Statistics of Total SOLOM Scores of Sixth-Grade Class

Sixth grade		*Total score from 2/14*	*Total score from 3/27*	*Total score from 5/15*
N Valid	16			
Mean		14.9375	17.1875	19.73339
Median		15.0000	17.5000	19.0000
Mode		12.00	15.00	19.00
SD		4.10640	3.41016	2.05171
Minimum		9.00	10.00	16.00
Maximum		22.00	22.00	23.00

General Scoring Rubric for Mathematics

All the traits: understanding of the question, use of the appropriate strategies, and accuracy of answers were considered, and a composite score was assigned to each student. The numbers correspond to levels of performance: 1=*Minimal Achievement*, 2=*Basic Achievement*, 3=*Advanced Achievement*, 4= *Outstanding Achievement*.

All students in the sixth-grade class showed gains in mathematics achievement. In the seventh/eighth-grade class, 2 students did not show any improvement, 4 students improved between the first and second tests but not on the third, and the rest showed increased scores. See Appendix E for individual student scores of seventh/eighth-grade and sixth-grade classes on the General Scoring Rubric for Mathematics. The upward trend in the students' performance in mathematics from minimal achievement to outstanding achievement is clearly presented in the following table.

Table 4
Descriptive Statistics of Total Scores on the Scoring Rubric of Seventh/Eighth-Grade Class

Seventh/Eighth-grade class		*3/10*	*4/21*	*5/31*
N valid	21			
Mean		1.3333	2.0952	2.8571
Median		1.0000	2.0000	3.0000
Mode		1.00	2.00	3.00
SD		.65828	.62488	.96362
Minimum		1.00	1.00	1.00
Maximum		3.00	3.00	4.00

Table 5
Descriptive Statistics of Total Scores on the Scoring Rubric of the Sixth-Grade Class

Sixth-grade class	*2/14*	*3/27*	*5/15*
N valid 16			
Mean	1.3750	2.5000	3.4667
Median	1.0000	3.0000	4.0000
Mode	1.00	3.00	4.00
SD	.61914	.81650	.63994
Minimum	1.00	1.00	2.00
Maximum	3.00	4.00	4.00

Results and Analysis: Qualitative Data

Teachers' Journal Entries

The narrative data contained in teachers' journal entries describes in detail how although teachers initially had reservations about the new ways of integrating language into math courses, their skepticism turned into enthusiasm when they saw how language instruction improved their students' interest and skill in both language and math. Moreover, it led to positive changes in the teachers' engagement and a greater willingness to make their activities more student-centered.

Both the regular mathematics and the ESL-trained mathematics teachers noticed positive changes in their teaching. The regular mathematics teacher wrote about how difficult it was to change from the teacher-fronted and very teacher-controlled structure of his daily lessons and activities to those that allowed for group work and peer teaching. Adding language-building activities to his computation lessons also caused him much anxiety. He was worried about not being able to cover all the materials the state required. In addition, he was skeptical about the relationship between language skills and mathematic skills. Changing routines and practice was equally challenging to the ESL-trained mathematics teacher. She found lesson preparation and lesson plan writing time consuming. As the project progressed, she noticed the changes in her practice and attitude. She described herself as more thorough and excited about her teaching as students began to respond more positively to her activities.

Sixth-grade Project Teacher

Discomfort at not being in control of time

The students began drawing their own practice graphs today. Most were successful. Jessica and Maira had a difficult time, but it is because of their skills level. Even with almost total assistance, neither really grasped what we were trying to do. As usual, Chen, Alex and Rener were ready to show the class what to do. The class goes so quickly when we do activities. I never get accomplished what I set out to do. (Journal entry, February 14, 2000)

The students seem to understand the samples I did today. They have to graphically/pictorially represent the multiplication of fractions. It was quite time consuming!" (Journal entry, April 12, 2000)

Satisfaction with progress

Having ESL students write is essential to their success. It has taken me awhile to really know this. The act only strengthens their writing abilities. (Journal entry, March 15, 2000)

The students responded very well today. The manipulatives have really given the students a great "visual." Even though I have drawn on the overhead many times, the manipulatives offer variety and certainly help with time management. Additionally, the girls seem to more apt to participate when using manipulatives. (Journal entry, March 22, 2000)

The students took a test today. They had to discuss the vocabulary with the parapro and me while they were taking the test. They did a great job. The grades were unusually high. Maybe this vocabulary thing is really working! (Journal entry, May 1, 2000)

Metacognitive awareness and self-efficacy

At this point in the project, I am amazed at how emphasizing vocabulary can be so effective in the true learning of mathematics. The students have been more responsive to learning new concepts and more importantly, they seem to be able to apply the skills more readily to real-life situations. The students' writing and spelling have improved as well. I have used some of what I do in the ESL class in my other regular math classes and the students do better as well! (Journal entry, April 12, 2000)

I attribute my students' learning to my change in approaching the subject matter. Previously, I had taught the ESL students in virtually the same way as I had my other students. This project made me conscious that I had to make some definite changes in my approach. I emphasized math vocabulary and application of the vocabulary for a better understanding of the topics. I also emphasized more interaction among the students, utilizing the cooperative learning approach. Additionally, the students were asked to do more work at the chalkboard or overhead projector and be able to explain what they had done and why. This technique allowed me the opportunity to make immediate corrections or give additional information where it was most needed. (Journal entry, April 7, 2000)

Seventh/Eighth-grade Teacher

Self-discovery and self-perceived efficacy

Although I teach math at the ESL Lab, I found myself noticing more things in the lesson that in any way relates to language. As I plan the first week's lessons, I begin with math concepts but I am also aware of the language needs of the students and so I focus on the language then the math? The students like it. They are flowing easily in and out of language and math. Although I am aware of the language connection to

math, often I focus mainly on math because I am so concerned with covering so many chapters. (Journal entry, February 2, 2000)

This week there was a lot of verbalization. This is occurring more now that the focus is on language and math. Participation is up. There are many new words in this chapter and I am trying to use the students' experiences to introduce them. This is allowing them to talk more. They talked endlessly about the rules for the game of soccer and they were excited when I called on them to translate a sentence on the board into their native language to demonstrate that algebra is a language and expressions can be translated into the language of algebra. This is another good week. (Journal entry, May 2, 2000)

This week we worked in groups using cups and counter to demonstrate variables. We began by talking about the word *vary* and variations of the word. Then I demonstrated an activity so that students can infer the function of a variable. Then they worked in groups to create and demonstrate algebraic expressions. They liked the cup and counter activity. One student suggested, "When you put your bag to hold a seat for someone, the bag is a variable because people don't know who the bag stand for. So a variable is a place holder." They came up with other examples. I'm so proud of them. (Journal entry, March 28, 2000)

These journal entries illustrate that teachers were able to integrate the teaching of language skills into their math class work. They found that rather than detracting from the math lessons, language skills encouraged participation, enhanced understanding of math vocabulary and concepts, and seemed to help students apply math concepts to real-life situations. The teachers were excited about the positive changes in their teaching practices and the promising performance of their students, and they were motivated to continue reforming their practice.

Students' Journal Entries

The students also saw the virtues of combining language lessons with math classwork. They described the activities as "fun" and enjoyable, and they seemed to attribute some of the pleasurable nature of learning to the integration of math and language skills. The increasing number of words they used and the clarity of expression suggest some development in writing skills over time.

Seventh/Eighth-grade Journal Entries

Student A

Last week we did a great job. We looked for the new words in the dictionary. When we find the mining, when we try to find a picture represent the word because we will memorize the words. I really liked to do this work. (Journal entry, March 3, 2000)

I enjoyed doing this ch 2. The easiest was divide and times in this ch 2. The difficult part is add and subtract. I did a lot of practice to learn in this ch 2. My math teacher help me to understand. The teacher could help you more. You can ask her what you don't understand. You can help yourself by making or doing a lot of practice in this ch 2. (Journal entry, April 12, 2000)

Student B

I learned about pre-algebra. So far I learn the order of operation, variables, expressions, and properties addition and multiplication. At the first I didn't understand the parentheses and brackets and also division. But I keep practice and my father held me. He also gave some problem for practice. These is how I learn.(Journal entry, February 14, 2000)

Our project was fun. We had 11 new words. We found the picture and we wrote the story. I really like to find the picture and write the story. It was fun because I understand much better. I enjoy our group. It is much better to understand all the new words when we write the story. When we get the picture we talk together what is the picture represent. This is how we do our project everytime. (Journal entry, March 6, 2000)

Sixth-grade Journal Entries

Like those of the seventh/eighth-grade class, the journal entries of the sixth-grade students varied in length and clarity over time. Interesting was the students' use of the journal to clarify and illustrate what they had just learned. These entries informed the teacher's instruction the next day. One example is included here.

About what was learned in class that day

I understand adding and subtracting decimals because is not so hard and not so easy. An example of a adding decimal is: you first line up decimals

$$\begin{array}{r} 1.35 \\ +10.85 \\ \hline 12.20 \end{array}$$

and start adding, just follow Mr. R's rule. Subtracting decimal is not easy because some times I get wrong. An example of a hard subtraction is: 50.000, 20.121. You line up decimal

$$\begin{array}{r} 50.000 \\ -29.879 \\ \hline 20.121 \end{array}$$

and start subtracting, and if a number is less than the other you have to take one from the one who [illegible] by you. (Journal entry, March 1, 2000)

The improvement in the writing skills of the two students in the seventh/eighth-grade class is clearly shown. Their earlier journal entries lack the coherence and fluency of the later entries. While the earlier ones have misspelled words and syntax errors, the later ones, which are syntactically well formed and include transitional expressions, indicate a higher level of competence.

Journals recorded students' responses to class activities and to instruction. Interesting to note were the students' comments that they were "learning" and "having fun" in their classes. Students thoroughly enjoyed interactive activities such as the poster project, which got them out of their chairs and onto the floor. Huddled in groups of four, they joked and laughed while negotiating the best way to present their problems and solutions pictorially. Another activity that students described as "fun" in their journals was the oral presentation of their project.

Finally, by writing about what they understood from the lesson or explaining the solution to a problem in their journals, students remembered concepts better. Through these journals, students had an opportunity to display their oral skills and their understanding of math concepts, thereby providing teachers with a means for quick assessment of lesson mastery.

Conclusions and Implications

Throughout the project, I asked myself two questions: (1) Will language-building activities promote language development and enhance the performance in mathematics of ESL students? and (2) Will the changes in instructional practices result in teacher satisfaction?

On all measures, the students' performance is quite encouraging. Clearly, the scores on the mathematics tests, SOLOM, and the general mathematics rubric, as well as the quality of students' journal entries, suggest that language development and mathematics learning are not mutually exclusive. That mathematics contexts may be fertile venues for successful language learning for ESL students and that language development activities promote mathematics concepts acquisition are indicated. The two teachers strongly recommended that mathematics teachers plan lessons with clear language objectives in order not to lose sight of teaching language skills while teaching mathematics. This applies to all content subjects.

The findings indicate benefits for all. The students, encouraged by their language gains, will further develop their language skills, which will serve them well socially and academically. The teachers benefited from the instructional changes they implemented, and their journals point out their professional development. They acknowledged the relationship between language development and mathematics achievement. They also wrote that although they worked hard to change their way of developing lessons and presenting materials to their classes, they got the satisfaction of seeing their students participate more in class and of reading about what their students did and did not understand in the student journals.

By making writing a part of their activities, they allowed students to have a clear voice in their classrooms. Providing a window into their stu-

dents' minds, student journals gave teachers insight as to how their students made sense of the classroom and the world around them as they tried to make connections between their mathematics lessons and their lives. In their own words, students provided ways for their teachers to gauge the success of their instruction. Finally, like the teachers and the students, I, too, grew and learned. I reflected on the theories as I saw them actualized by teachers and students who made language learning in mathematics—or perhaps, learning language and mathematics—meaningful, creative and fun.

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References

Chamot, A., & O'Malley, J. (1997). *The CALLA handbook*. Reading, MA: Addison-Wesley.

Cline, T., & Frederickson, N. (1996). *Curriculum related assessment, Cummins and bilingual children*. Philadelphia: Multilingual Matters.

Crandall, J., & Greenblatt, L. (1998). Teaching beyond the middle: Meeting the needs of underschooled and high achieving immigrant students. In M.R. Basterra (Ed.), *Excellence and equity in education for language minority students: Critical issues and promising practices* (pp. 43-80). Washington, DC: The American University Mid-Atlantic Equity Center.

Cuevas, G. (1984). Mathematics learning in English as a second language. *Journal for Research in Mathematics Education, 15*, 134-144.

Cummins, J. (2001). *Negotiating identities: Education for empowerment in a diverse society*. Ontario, CA: California Association of Bilingual Education.

Durkin, K., & Shire, B. (Eds.). (1991). *Language in mathematical education*. Philadelphia: Open University Press.

Echevarria, J., Vogt, M., & Short, D. (2001). *Making content comprehensible for English language learners: The SIOP model*. Boston: Allyn and Bacon.

Ediger, M. (1994). Problems in reading mathematics. *Viewpoints, 120*, 3-14.

Gonzalez, J.M., & Darling-Hammond, L. (1997). *New concepts for new challenges: Professional development for teachers of immigrant youth.* McHenry, IL: Delta Systems.

Jarrett, D. (1999). *The inclusive classroom: Teaching mathematics and science to English-language learners.* Portland, OR: Northwest Regional Educational Library.

Kang, H., & Pham, K. (1995, March). *From 1 to 2: Integrating math and language learning.* Paper presented at the annual meeting of the Teachers of English to Speakers of Other Languages, Long Beach, CA.

Kessler, C., & Quinn, M.E. (1987). ESL and science learning. In J. Crandall (Ed.), *ESL through content-area instruction: Mathematics, science, social studies* (pp. 55-87). Englewood Cliffs, NJ: Prentice Hall Regents.

Lappan, G., Fey, J., Fitzgerald, W., Friel, S., & Phillips, E. (1996). *Getting to know connected mathematics: A guide to the connected mathematics curriculum.* New York: Dale Seymour Publications.

Mather, J., & Chiodo, J. (1994). Mathematical problem: How do we teach mathematics to LEP elementary students? *The Journal of Educational Issues of Language Minority Students, 13*, 1-12.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Peregoy, S., & Boyle, O. (1997). *Reading, writing, and learning in ESL.* New York: Longman.

Pierce, L.V., & O'Malley, J.M. (1992). *Performance and portfolio assessment for language minority students.* Washington, DC: National Clearinghouse for Bilingual Education.

Short, D. J. (2002). Language learning in sheltered social studies classes. *TESOL Journal, 11*(1), 18-24.

Short, D. J. (1991). *How to integrate language and content instruction : A training manual.* Washington, DC: Center for Applied Linguistics.

Spanos, G., Rhodes, N., Dale, T., and Crandall, J. (1988). Linguistic features of mathematical problem solving. In R. Cocking & J. Mestre (Eds.), *Linguistic and cultural influences on learning mathematics* (pp. 221-240). Mahwah, NJ: Lawrence Erlbaum Associates.

Suleiman, M.F. (1995). *Teaching math and science to language minority children: Implications for teachers.* East Lansing, MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. ED391390)

Teachers of English to Speakers of Other Languages, Inc. (1997). *ESL standards for pre-K-12 students.* Alexandria, VA: TESOL.

Appendix A
Sample Lesson Plans
With TESOL Pre-K-12 Standards, Language, and Content Objectives

Fifth Period ESOL General Mathematics
Textbook: *Prentice Hall Middle Grades Mathematics: An Interactive Approach*
Supplemental Textbook: *Grade 6 Mathematics Unlimited*
Date: Thursday, April 20, 2000

ESL Standards

Goal 1:	To use English to communicate in social settings.
Standard 2:	Students will interact in, through, and with spoken and written English for personal expression and enjoyment.
Goal 2:	To use English to achieve academically in all content areas.
Standard 1:	Students will use English to interact in the classroom.
Standard 2:	Students will use English to obtain, process, construct, and provide subject matter information in spoken and written form.
Goal 3:	To use English in socially and culturally appropriate ways.
Standard 1:	Students will use the appropriate language variety, register, and genre according to audience, purpose, and setting.

Student Characteristics

Level:	High intermediate to advanced
Age:	11-12
Countries represented:	Mexico, Colombia, China, El Salvador, Puerto Rico, Panama, Brazil, Ecuador.

Lesson

Theme and Content:	The language of decimals in the study of place value, addition and subtraction of decimal numbers, and comparing and ordering decimal numbers, and rounding decimal numbers.
Topic:	Rounding and adding decimal numbers.
Objectives:	The learner will round decimal numbers to the nearest tenth, hundredth, and thousandth. The learner will add decimal numbers.
Language Skills:	The learner will use appropriate mathematical terminology in rounding, comparing and ordering decimal numbers. The learner will use appropriate mathematical terminology in adding decimal numbers.
Listening and Speaking:	The learner will verbally answer questions related to place values in decimal numbers and in the process of rounding decimal numbers. Additionally, the learner will verbally answer questions related to addition of decimal numbers.
Reading and Writing:	The learner will communicate mathematically in written form.

Content Skills:	The learner will round decimal numbers. The learner will add decimal numbers. Emphasis will be on aligning decimals with addition and subtraction.
Thinking Skills:	The learner will be able to explain why he or she decided to round to the chosen number. The learner will be able to explain why and how to align decimals in addition and subtraction of decimal numbers.
Vocabulary:	*Round*, *compare*, *order*, *estimate*, *align*, *aligning decimals*
Materials:	Notebook paper, pencils
Motivation:	The instructor will refer to last week's lessons including the use of manipulatives. The instructor will use a number of examples to demonstrate addition or subtraction of decimals.
Presentation:	The instructor will review last week's lessons using a practice worksheet. The instructor will guide the students through the practice worksheet using a transparency copy. The instructor will present examples of addition and subtraction of decimal numbers on the overhead projector.
Practice:	The students will be asked to demonstrate their knowledge of how to round decimal numbers using the practice worksheet. The students will be asked to demonstrate their understanding of aligning decimal numbers. The instructor will write problems horizontally and ask the students to write the problems vertically, demonstrating their knowledge of aligning decimals.
Application:	The students will demonstrate their knowledge of rounding decimal numbers using the practice worksheet. The students will apply their understanding of aligning decimal numbers for the use of addition and subtraction.
Assessment:	The instructor will observe the students as today's assessment.
Review:	The instructor will review the lesson.
Homework:	No homework

Fifth Period ESOL General Mathematics
Textbook: *Prentice Hall Middle Grades Mathematics: An Interactive Approach*
Supplemental Textbook: *Grade 6 Mathematics Unlimited*
Date: Friday, April 21, 2000

ESL Standards

Goal 1:	To use English to communicate in social settings.
Standard 1:	Students will use English to participate in social settings.
Standard 3:	Students will use learning strategies to extend their communicative competence.
Goal 2:	To use English to achieve academically in all content areas.
Standard 1:	Students will use English to interact in the classroom.

Standard 2:	Students will use English to obtain, process, construct, and provide subject matter information in spoken and written form.
Standard 3:	Students will use appropriate learning strategies to construct and apply academic knowledge.

Student Characteristics

Level:	High intermediate to advanced
Age:	11-12
Countries represented:	Mexico, Colombia, China, El Salvador, Puerto Rico, Panama, Brazil, Ecuador

Lesson

Theme/ Content:	The language of decimals in the study of place value, addition and subtraction of decimal numbers, and comparing and ordering decimal numbers, and rounding decimal numbers.
Lesson Topic:	Adding Decimal Numbers.
Objectives:	The learner will add decimal numbers.
Language Skills:	The learner will use appropriate mathematical terminology in Rounding, Comparing and Ordering decimal numbers. The learner will use appropriate mathematical terminology in adding decimal numbers.
Listening and Speaking:	The learner will orally answer questions related to place values in decimal numbers and in the process adding decimal numbers. The learner will orally answer questions related to addition of decimal numbers.
Reading and Writing:	The learner will communicate mathematically in written form in his or her journals.
Content Skills:	The learner will add decimal numbers. Emphasis will be on aligning decimals with addition and subtraction.
Thinking Skills:	The learner will be able to explain why and how to align decimals in addition and subtraction of decimal numbers.
Vocabulary:	*Align*, *aligning decimals*, *horizontally*, *vertically*
Materials:	Notebook paper, pencils
Motivation:	The instructor will use a number of real-life examples to demonstrate real-life application of addition or subtraction of decimals.
Presentation:	The instructor will present examples of addition and subtraction of decimal numbers on the overhead projector.
Practice:	The students will be asked to demonstrate their knowledge of how to round decimal numbers using the practice worksheet. The students will be asked to demonstrate their understanding of aligning decimal numbers.
Application:	The students will apply their understanding of aligning decimal numbers for the use of addition and subtraction.

Assess-ment:	The instructor will observe the students as today's assess-ment.
Summary/ Review:	The instructor will review the lesson.
Homework:	No homework
Looking Ahead:	Subtraction of decimals.

Appendix B
Individual Students' Scores on Orleanes-Hanna and Marietta City District Tests

DeKalb County *Seventh/Eighth- grade students* *Orleanes-Hanna Test*		
Student	***Pretest***	***Posttest***
1	16%	32%
2	34%	64%
3	22%	76%
4	12%	68%
5	8%	80%
6	26%	60%
7	6%	80%
8	8%	40%
9	6%	28%
10	28%	84%
11	64%	86%
12	20%	64%
13	48%	78%
14	38%	82%
15	40%	78%
16	14%	68%
17	30%	76%
18	56%	84%
19	18%	64%
20	12%	76%
21	22%	72%

Marietta City *Sixth-grade students* *Marietta District Test*		
Student	***Pretest***	***Posttest***
1	23%	68%
2	20%	52%
3	23%	66%
4	30%	78%
5	47%	58%
6	23%	68%
7	17%	80%
8	17%	32%
9	13%	No test
10	17%	66%
11	20%	76%
12	27%	68%
13	10%	56%
14	20%	80%
15	7%	62%
16	63%	86%

Appendix C
Seventh/Eighth-Grade Students' Total Scores on All Traits

Students	*2/15*	*3/30*	*6/05*
1	5	10	14
2	13	15	20
3	14	18	20
4	10	13	15
5	13	16	21
6	10	13	16
7	13	15	20
8	9	12	15
9	12	15	16
10	15	15	19
11	10	9	15
12	15	16	20
13	11	12	17
14	11	15	20
15	12	15	17
16	5	10	10
17	10	15	15
18	11	15	16
19	11	15	16
20	11	15	15
21	6	10	11

Appendix D
Sixth-Grade Students' SOLOM Total Scores on All Traits

Students	*2/14*	*3/27*	*5/15*
1	21	21	22
2	14	17	18
3	22	22	22
4	21	22	23
5	16	16	18
6	10	14	17
7	12	20	20
8	10	13	16
9	9	10	**
10	16	19	19
11	15	19	21
12	19	19	21
13	15	18	22
14	15	15	19
15	12	15	19
16	12	15	19

Appendix E
Individual Student Scores of the Two Classes on the Scoring Rubric

Seventh/ Eighth-Grade Students	*3/10*	*4/21*	*5/21*	*Sixth-Grade Students*	*2/14*	*3/27*	*5/15*
1	1	2	3	1	2	3	3
2	2	2	3	2	1	2	3
3	2	3	4	3	1	2	3
4	1	2	3	4	2	3	4
5	1	2	4	5	2	3	3
6	1	3	4	6	2	2	4
7	1	1	1	7	1	3	4
8	1	1	1	8	1	1	2
9	2	3	4	9	1	1	**
10	3	3	4	10	1	3	4
11	1	1	2	11	1	3	4
12	1	2	3	12	2	3	4
13	1	3	4	13	1	2	3
14	3	2	3	14	1	3	4
15	1	2	2	15	1	2	3
16	1	2	2	16	3	4	4
17	1	2	3				
18	1	2	2				
19	1	2	3				
20	1	2	2				
21	1	2	3				

** Moved back to Mexico