Ambrose, R. y Molina, M. (2010). English-language learners' problem solving in Spanish versus English. 2010 Annual Meeting of the American Educational Research Association. Understanding complex ecologies in a changing world. Denver, Estados Unidos.

English Language Learners´ Problem Solving in Spanish versus English

ABSTRACT

To explore the role of language in English Language Learners (ELLs)´ problem solving, we compare the performance of a group of Latino first graders when working in Spanish and in English on two equivalent sets of story problems. We contrast our results with others from previous studies with bilingual and monolinguals children by focusing on students´ performance in problems with the same semantic structure. This comparison leads us to discuss some factors influencing students´ problem solving. The findings support the use of problem solving in teaching ELLs. Students' performance was slightly higher in English, even in problems of higher language complexity, but lower than monolingual students from other studies.

Objective and Theoretical Frameworks

This research grew out of work with teachers of five-to-seven-year old English Language Learners (ELLs) who questioned whether an instructional approach with a heavy emphasis on story problems was appropriate for their students. When we turned to theoretical and empirical work in mathematics education to address their query, we came up with two different responses. Some (e.g. Cummings, 2000) would say that academic language is acquired slowly, long after children have developed proficiency in everyday language. So, since story problems include academic language, ELLs will have trouble learning mathematics when story problems are the focus of instruction. Others (e.g. Carpenter, Ansell, Franke, Fennema, & Weisbeck, 1993; Cummins, 1991) would say that all children have informal experiences combining, separating and partitioning quantities, and children can solve problems based on these experience by acting out the stories. The language in story problems is here considered very close to the everyday language which ELLs learn readily. Therefore, a story problem focus should work as well with ELLs as it does with monolingual students. Secada's (1991) study of bilingual (Spanish/English) first graders, showed that the children readily solved the simplest problems in both languages but were not as successful as monolingual English speakers on the more complex problem types. This ambiguous finding led us to replicate Secada's study. Our study differs from his because his students were in bilingual classrooms where ours were in English Only classrooms; we also included more problem types.

Since our teachers were unable to communicate with their students in their first language, they could not tease apart mathematical issues from language issues. The teachers were aware that learning language while learning mathematics placed a high cognitive demand on students (Adetula, 1990; Adler & Setati, 2000), and they were eager to find out whether to emphasize mathematical ideas versus language comprehension issues.

To address these concerns we conducted a research study with the teachers' students by giving a set of problems in English and Spanish to see if children were more successful solving the problems in their first language suggesting a language issue, or if they performed similarly in both languages suggesting mathematical issues. We were mindful that language and mathematics issues might be so intertwined that "teasing them apart" might be impossible, but we were eager to gather empirical evidence so we could more deeply examine the language/mathematics interplay and inform the teachers´ teaching practice.

METHODOLOGY

Sixteen six-to-seven years old Latino English Language Learners with a level 2 or 3 in the California English Language Development Test (CELDT), from two schools within the same school district were interviewed. The district serves students from a low-income community in which 79.8% of the students receive free or reduced lunch, 43% of are designated as ELLs and 35% of the students are Hispanic. All mathematics instruction is in English.

We constructed two batteries of problems one in English and one in Spanish, both with seven problems of the same type according to their semantic structure, including the structures studied by Carpenter, Hiebert, & Moser (1981), Secada (1991) and Carpenter et al. (1993). The problems, presented in Table 1, were also similar in number size and alike in language complexity. The first five problems were intentionally built to be linguistically simple: with short sentences, simple and frequent vocabulary, present or past tenses, and avoiding the use of conditionals, subordinate clauses and connectors. The last two problems were selected to replicate the wordy problems that students sometimes encounter at school.

Table 1. English and Spanish story problems used at the interviews

Problem type	**English problems**	**Spanish problems**
Join Change Unknown	The teacher had 6 books. She got some new books. Now she has 12 books. How many new books did she get?	Marta tenía 7 lápices. Su mamá le dio algunos lápices más. Ahora Marta tiene 14 lápices. ¿Cuántos lápices le dio su mamá?
Separate Result Unknown	Saul had 14 balls. He lost 9 balls. How many balls does he have now?	José tenía 13 galletas pequeñas. Se comió 9 galletas. ¿Cuántas galletas le quedaron?
Compare Difference Unknown	Your friend has 10 flowers. You have 16 flowers. How many more flowers do you have than your friend?	Tu amigo tiene 10 tarjetas de béisbol. Tú tienes 15 tarjetas. ¿Cuántas tarjetas tienes tú más que tu amigo?
Multiplication	There are 3 nests. Every nest has 5 eggs. How many eggs are there altogether?	Hay 6 bicicletas. Cada bicicleta tiene 2 llantas. ¿Cuántas llantas hay en total?
Partitive Division	There were 12 children at the party. They sat at 4 tables. Every table had the same number of children. How many children sat at each table?	La Señora Gómez tenía12 pasteles. Los puso en 3 cajas. Puso el mismo número de pasteles en cada caja. ¿Cuántos pasteles puso en cada caja?
WORDY Separate Result Unknown	16 people are waiting to see the giant panda. 7 people leave. How many people are still waiting to see the giant panda?	14 leones marinos estaban descansando en una roca. 6 se metieron al agua. ¿Cuántos leones marinos quedaron en la roca?
WORDY Part-part-whole, Whole Unknown	In the morning a zoo keeper gave 8 pears to the monkeys. At night he gave them 5 apples. How many pears and apples did the monkey get that day?	Ayer por la mañana María agarró 9 rosas en el parque. Por la tarde agarró 5 margaritas en el jardín de su casa. ¿Cuántas rosas y margaritas agarró ayer María?

Both authors interviewed the students, one in English and one in Spanish, following Ginsburg’s (1997) dynamic assessment model. Blocks, paper and pencil were available to the children. We elicited explanations and coded their strategies. Once we determined what the child could do without any assistance, if the child could not solve a problem or generated an incorrect answer, we supported him/her by rephrasing the problem, or suggesting the use of a different or particular tool/resource. We recorded children's success rate on the story problems with and without help.

We used the Peabody Picture vocabulary test (Dunn & Dunn, 1997), a standardized test to measure students´ receptive vocabulary achievement proficiency in English and in Spanish. We also had the children do some counting tasks in both languages to roughly measure their mathematics language proficiency.

FINDINGS

Results of the Peabody Picture vocabulary test indicated that the students´ receptive vocabulary ranged from an age equivalent of 3 years-6 months to 7 years-3 months in English, and 2 years-11 months to 6 years-6 months in Spanish. The average of the results of the test of all the students was slightly higher in English than in Spanish: an age equivalent of 4 years-11 months versus 4 years-9 months. Seven students performed higher or slightly higher in Spanish; one performed similarly in both languages. The rest (8) did better in English. In addition, only 5 of the 16 students were able to count from 10 to 25 in Spanish. In the Spanish interview, in most problems students needed to count in English in order not to miscount and to hear the numbers of the problems in English to be able to correctly identify them..

Table 2 shows children's success rates, without interviewer support, on each of the problem types. Most of the children in our study were successful solving versions of the Separate Result Unknown problems and the Wordy Part-part-whole/Whole Unknown problems in both languages. Results for these problems were similar to results from other studies (see Table 2). Children performed similarly to the children in Secada (1991)'s study on the Join Change Unknown and Compare Difference Unknown problems, but considerably lower than the children in Carpenter et al.'s studies (1981, 1993). Likewise, children in our study did not perform as well as children in the Carpenter et al. (1993) study on the multiplication and partitive division problems. Like the children in Secada (1991)'s study, the children in our study performed similarly in English and in Spanish with a slightly higher success rate in English. The wordiness of the last two problems of the set did not negatively affect the students´ performance. Students´ use of strategies in both languages was similar with a predominance of direct modeling strategies (see Table 3).

Table 2. Children’s Performance on Story Problems Compared to Other Studies

	Study			
Language	**Our study**	**Secada (1991)**	**Carpenter et al. (1981)**	**Carpenter et al. (1993)**
	Join Change Unknown			
Spanish	25%	24%		
English	38%	29%	51%	74%
	Separate Result Unknown			
Spanish	69%	56%		
English	75%	69%	79%	73%
	Compare Difference Unknown			
Spanish	38%	24%		
English	25%	24%	67%	67%
	Multiplication			
Spanish	12%			
English	25%			71%
	Partitive Division			
Spanish	0%			
English	12%			70%
	WORDY Separate Result Unknown			
Spanish	69%			
English	100%			
	WORDY Part-part-whole, Whole Unknown			
Spanish	81%			
English	88%		86%	

Table 3. Strategies Used

Strategies Used	Spanish	English
Direct Modeling	25 (53%)	33 (60%)
Counting	8 (17%)	5 (9%)
Derived Fact	3 (6%)	3 (5%)
Fact	11 (25%)	14 (25%)
Total	47	55

To further examine the difficulties our children had with the Join Change Unknown and Multiplication problems in comparison to the children in Carpenter et al. (1981, 1993) studies we examined children's performance on these problem types without and with interviewers' help. Table 4 illustrates that adding the two numbers in the problem was a frequent initial response for both problems. When given some additional support, several more children were successful on each of the problems solving the multiplication problem by drawing it and solving the Join Change Unknown problem by reconsidering their initial answers.

Table 4. – Children's performance on Multiplication and Join Change Unknown Problem

	Correct		**Correct Strategy with Miscount**		**Added both Numbers**		**Other (e.g. saying one number of the problem)**	
	Sp.	**Eng.**	**Sp.**	**Eng.**	**Sp.**	**Eng.**	**Sp.**	**Eng**
Multiplication problem								
No help from interviewer	2 (12%)	4 (25%)	1 (6%)	1 (6%)	7 (44%)	6 (38%)	6 (38%)	5 (32%)
After incorrect answer: Interviewer Suggests Drawing and reminds child of quantities	8 (50%)	10 (62%)	1 (6%)	2 (12%)	1 (6%)		4 (25%)	
Total	10 (62%)	14 (87%)						
Join Change Unknown problem								
No help from interviewer	4 (25%)	6 (38%)		1 (6%)	4 (25%)	5 (32%)	8 (50%)	4 (25%)
After incorrect	3	3			3		6	

	Correct		Correct Strategy with Miscount		Added both Numbers		Other (e.g. saying one number of the problem)	
	Sp.	**Eng.**	**Sp.**	**Eng.**	**Sp.**	**Eng.**	**Sp.**	**Eng**
answer: Interviewer rephrases problem	(19%)	(19%)			(19%)		(38%)	
Total	7 (44%)	9 (57%)						

Children had the most difficulty with the Partitive Division problem in both languages. We asked children to retell this problem before solving it, and many had difficulty keeping track of the quantities and units. For example, in the English interview, one child retold the problem as: “There were 12 children. They all sat at each … at a table”. She then paused for a long time and said she could not remember the rest. Another child retold the story as: “There is 12 chairs. Each people sit on a chair. They’re numbered. I forgot the last part”. Only 5 children successfully recalled that there were 12 children and 4 tables, but none of them could describe the whole story. The students´ retelling of the equivalent partitive division problem in Spanish demonstrated similar difficulties and even when the problem was repeated several times children had trouble solving it.

DISCUSSION

Even though English was their second language, these children were able to perform as well in their second language as their first. Even when the language complexity of the problems was increased in the two “wordy” problems, the children were still able to solve these problems. This suggests that teachers do not need to avoid story problems with their ELLs. Like their monolingual peers, ELLs will be most successful on problems where the result is unknown. The children’s success in comprehending these problems is not surprising when one takes into consideration that the children were at similar levels in their English and Spanish development. While their mastery of vocabulary in each language lagged a bit behind their monolingual peers, we found their competence in the two languages to be impressive.

The ELL students´ difficulties with two of the problems may have been due to the semantic structures of each of these problems. Join Change Unknown problems require children to plan ahead which children at the direct modeling stage do not always do. With support, the children in our study had a similar success rate as the children in the Carpenter et al. (1981) study on the Join Change Unknown problem. The Compare Difference Unknown problem remained difficult for the children even with interviewer support. The lack of action in this problem makes this problem type particularly difficult for children, and we suspect that determining the difference of two quantities was an unfamiliar task to the ELLs. Changing the language in the question to, “how many extras do you have?” did not help the children solve the problem.

In the Join Change Unknown and Multiplication problems several children’s first response was to add the quantities. The children may have already developed the habit identified by Sowder (1989) to pick out the numbers and ignore most of the words and guess at an operation. When we encouraged them to draw the multiplication problem, most were able to successfully solve it. Even if the children had developed a “when-in-doubt-add” habit, they readily modeled the problem when a suggestion was made to do so. ELLs may be more prone to this habit than monolinguals due to the added cognitive demand of processing problems in a second language and ELLs may require additional encouragement to make sense of the problem situation.

For the most part, children’s successes and failures on the problems could be attributed to mathematical rather than language issues. The division problem proved to be the exception, and children’s work on both versions of that problem demonstrated the interplay between language and mathematics. Most of the children struggled when trying to retell the division story. When we watched them trying to solve this problem in English, we noticed that most drew one table and placed all of the children around it in keeping with their own experiences at parties. The words and syntax of the problems did not interfere with their ability to solve this problem but the fact that the scenario was not aligned with their experience tripped them up. Word problems can be unrealistic and children who literally interpret the context described in a problem sometimes fail to provide the expected answer. Verschaffel, Greer, & DeCorte (2000) pointed out that solving school word problems can become a kind of game in which children learn to ignore some of the unrealistic features of a problem while giving precedence to the mathematical structures. Lubienski (2000) pointed out that low SES children tend to have more difficulty figuring out how to deal with problems in contexts.

Our data suggest that ELLs can make sense of story problems presented in English as long as the problems resonate with students' experiences. As the mathematical structure of the problems becomes more complex, ELLs may be less successful than their monolingual peers but presenting the problems in their first language does not appear to ameliorate the difficulty. Encouraging students to devote greater attention to the context in the problem can be helpful as long as this context resonates with their experience. We conclude that story problems presented in a child's second language can be a fruitful instructional approach but teachers may need to provide additional encouragement to make sense of the problem situation and be particularly careful that the problems involve personally meaningful experiences.

REFERENCES

Adetula, L. O. (1990). Language factor: does it affect children's performance on word problems. *Educational Studies in Mathematics, 21,* 351-365

Adler, J. & Setati, M. (2000). Between languages and discourses: Language practices in primary multilingual mathematics classrooms in South Africa. *Educational Studies in Mathematics,* 43 (3), 243-269.

Carpenter, T.P., Ansell, E., Franke, M.L., Fennema, E., & Weisbeck, L. (1993). Models of problem solving: A study of kindergarten children's problem-solving processes. *Journal for Research in Mathematics Education, 24*(5), 428-441.

Carpenter, T.P., Hiebert, J. & Moser, J. (1981). Problem structure and first-grade children's initial solution processes for simple addition and subtraction problems. *Journal for Research in Mathematics Education, 12*(1), 27–39.

Celedón-Pattichis, S. (2003). Constructing meaning: Think-aloud protocols of ELLs on English and Spanish word problems. *Educators for Urban Minorities, 2*(2), 74-90.

Cummins, D. D. (1991). Children's Interpretations of Arithmetic Word Problems *Cognition and Instruction, 8*(3), 261-289.

Cummings, J. (2000). *Language, Power and Pegagogy*. Clevedon: Multilingual Matters.

Dunn, L. M., & Dunn, L. M. (1997). Peabody Picture Vocabulary Test (3rd ed.). Circle Pines, MN: American Guidance Service.

Ginsburg, H. P. (1997). *Entering the child's mind: The Clinical Interview In Psychological Research and Practice.* Cambridge: Cambridge University Press.

Lubienski, S. T. (2000). Problem solving as a means toward "mathematics for all": An exploratory look through a class lens. *Journal for Research in Mathematics Education, 31*(4), 454-482.

Secada, W.G. (1991). Degree of Bilinguism and arithmetic problem solving in Hispanic first graders. *The Elementary School Journal, 92*(2), 213-231

Sowder, Larry. (1989). Choosing operations in solving routine story problems. In Randall I. Charles & Edward A. Silver (Eds.). The teaching and assessing of mathematical problem solving (pp. 148-158). Reston, VA: The National Council of Teachers of Mathematics.

Verschaffel, L., Greer, B., & DeCorte, E. (2000). *Making sense of word problems.* Lisse: Swets & Zeitlinger.