

TEACHING MATHEMATICS AND SCIENCE TO
ENGLISH LANGUAGE LEARNERS:
THE EXPERIENCE OF FOUR
NEW JERSEY ELEMENTARY SCHOOLS

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¹ Names are listed in alphabetical order

Abstract

This paper explores the challenges of teaching math and science to English language learners (ELLs) and some approaches to addressing those challenges identified in four schools serving ELLs working with the New Jersey Math Science Partnership. We first describe some of the challenges of teaching ELLs and the variety of practices used by ELL teachers. We then explore three factors affecting those practices: the knowledge and beliefs of ELL teachers, district policies, and the impact of federal and state testing policies as interpreted locally. We suggest that the more successful teachers have a command of the academic as well as social language of the students they teach. Moreover, local responses to national policies may be increasing attention to mathematics but they may be encouraging the use of instructional strategies like vocabulary drill that may not have lasting learning benefits.

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Two factors have combined to raise bring attention to teaching mathematics and science to English language learners (ELLs). First, between 1979 and 2003 the number of children living in households where the native language was not English more than doubled from nine to 19 percent and the number of children in school who spoke English with difficulty increased from three to five percent (National Center for Educational Statistics, 2005). Second, No Child Left Behind (NCLB)—the most recent iteration of Title 1 of the Elementary and Secondary Education Act—provides sanctions for schools that do not make adequate yearly progress in reducing the achievement gap between ELLs and English speakers tested in mathematics and language arts. While not a new problem in American history, the number of children involved and the new demands placed by state and federal accountability policies created substantial stresses on the educational system and required a more intensive search for solutions.

The challenge of ELLs is especially acute with the teaching of mathematics and science. These subjects have their own complex symbol systems and vocabularies that are especially difficult to master when teacher and student speak different languages. The purpose of this paper is to explore the nature of these challenges and some of the approaches to addressing those challenges identified in four schools serving English Language Learners (almost all coming to English from Spanish) working with the New Jersey Math Science Partnership. In this paper, we first describe some of the challenges of teaching ELLs and the variety of practices used by ELL teachers. We then explore

three sets of factors affecting those practices: the knowledge and beliefs of ELL teachers, district policies, and the impact of federal and state testing policies as interpreted locally.

We suggest two hypotheses that, given the limitations of the data presented, require further exploration. The first is that when most ELLs come from the same language group and teachers use that language in instruction, it is important to have a command of the academic as well as the social language. The second is that local responses to national assessment policies are having mixed effects. While they are increasing attention to mathematics, but *not* science, and ensuring that ELLs spend more time learning that subject, they may also be encouraging the use of language learning strategies such as vocabulary drill that may not have lasting learning benefits.

Study Methods

This paper is part of a larger study of leadership for educational change conducted by the Center for Educational Policy Analysis (CEPA) in conjunction with the New Jersey Math Science Partnership (NJMSP). CEPA conducted case studies of five poor, urban elementary or K-8 schools that partnered with the NJMSP. The MSP consists of a relationship of two local universities and eleven urban school districts to improve the teaching of mathematics and science.

New Jersey is an interesting state to examine bilingual education because the phenomenon is relatively new. Twenty years ago, the dominant minority was African-Americans. In 2003, the K-12 population was 18 percent African-American, 17 percent Latino, 7 percent Asian and Pacific Islander. Four percent of its students were officially listed as ELLs.

The four schools that were the focus for this analysis were those with significant populations of ELLs and with at least some bilingual or ELL teachers. All of them were in districts that participated in the MSP. Moreover, all were in “Abbott districts”—i.e., districts designated by the State Supreme court to receive special state aid to equalize funding with the wealthiest districts in the state. They were also subject to special regulation as a result. The districts varied in size from about 5,000 to about 10,000 students. Table 1 provides demographic information about the schools.

Table 1
School Demographics

	District	Grades	Student Population	Percent Hispanic	Percent Learning English
Lopez	A	K-8	825	79	46
Kahlo	A	K-8	400	62	34
Marti	B	Pre K-5	541	47	29
Cardenas	C	K-6	400	88	41

The field team tracked nine teachers in each school. Teachers were selected to vary by grade level. No special effort was made to recruit teachers of bilingual students, but in fact we included five at Lopez and three at Kahlo in District A, two at Marti in District B, and four at Cardenas in District C. During the 2003-04 school year, each teacher was observed in three classes, typically two math and one science class. They were also interviewed; questions were asked about classroom observations and a variety of aspects of school and district organization including curriculum, professional development, and beliefs about teaching, students, testing, and, where appropriate, bilingual education. In addition, teacher leaders (teachers with release time to help their

peers improve their teaching) and the principal were interviewed about similar topics. This routine was repeated in 2004-05 to track changes over time.

Interviews were taped, transcribed, and entered into a qualitative data base. Classroom observations were recorded by hand and coded using the Reformed Teaching Observation Protocol (RTOP) (Piburn et al., 2000). Preliminary analyses were conducted after the 2003-04 year and after 2004-05. Inductive, thematic analyses of interview data focusing on issues of bilingual education are more recent.

Teaching Math and Science to ELLs

There is considerable debate about how to teach mathematics and science to ELLs. The academic debate can be framed along two dimensions, one concerning the teaching of content and the other related to the language of instruction. Teachers' practice does not always map neatly onto these debates however.

How to Teach Math and Science?

In a recent review of mathematics curricula, Schoenfield (2006) identifies two broad types that apply to science materials science as well. Traditional curricula are based on the core assumption that students should practice mathematical procedures or learn science facts until they have achieved mastery and that deeper conceptual understanding and transfer to new situations will come with fluency. To the extent that students need to know the concepts behind facts or procedures, those concepts are explained to students rather than discovered. The curricula are also based on the assumption of a hierarchy of skills where the basics must be mastered before more complex knowledge can be learned.

By contrast, reform curricula engage students in more complex problems initially. Students are expected to develop fluency with operations through solving more complex problem solving. They may also use more concrete teaching tools, “manipulatives,” to help students formulate and solve problems. Reform curricula also have broader aims. In addition to developing operational fluency, they intend to help students develop number sense, communicate mathematically, and apply their knowledge in the real world. Schoenfeld (2006) argues that there are inadequate data for concluding that either traditional or reform curricula are definitely better for teaching mathematics, and we would argue that the same applies for science.

In teaching, there is a similar distinction between direct or didactic and “constructivist” or inquiry-oriented instruction (Smerdon, Burkam, & Lee, 1999; Stigler & Hiebert, 1999). The former includes classrooms where teachers actively convey knowledge to students who passively receive it. Where students do work, they typically practice problems that have right answers that they get from the teachers who are viewed as the sources of correct information. Whole class instruction is the norm in didactic instruction, and the teacher is the authority. This has been the traditional form of instruction for most of American history (Cuban, 1993).

Inquiry-oriented instruction assumes that learning is an active process and socially constructed. Instructional activities are to build on students’ previous knowledge, but students are to be given opportunities to test their knowledge through in-class activities. They may work together in teams. As Smerdon and colleagues (1999) note, because inquiry-oriented instruction is more a theory of learning than a prescription for teaching, methods may not be as well spelled out as with didactic approaches, but the emphasis is

on allowing students to actively try out ideas, higher-order thinking, and collaborate. Teachers are less the final authority, although they scaffold the learning process by setting learning tasks and guiding the learning process.

The implications of these distinctions for bilingual education are unclear. On the one hand inquiry-oriented education using reformed curriculum may make more complex linguistic demands since students engage more quickly in higher order thinking, although some would argue that it should be more motivating because it can be more meaningful (Knapp, 1995). On the other, the use of manipulatives and group work may provide opportunities for language learning that are missing in a more didactic approach to instruction.

Language of Instruction

In simplest terms the language problem is coming to be “how quickly can the language of instruction become English?” The answer is not straightforward. Bilingual educators distinguish between oral or general English fluency and academic English fluency—the level of understanding required to cope with instruction in school subjects. They argue that because the latter may take several years longer to develop than the former, students who speak English quite competently with peers may have difficulty with instruction in English (Hakuta, Butler, & Witt, 2000).

There is little evidence on whether it is better to teach mathematics and science in English rather than using bilingual education. The best research available on English-only v. bilingual education is on teaching reading, and while the issue is hotly debated, the evidence favors extended use of bilingual programs (Slavin & Cheung, 2003). For practicing educators, however, this argument may be moot. NCLB provides for sanctions

for schools that do not reduce the achievement gap between ELLs and other students, and requires that students who have been in the country for more than one year to take their math tests in English (US Department of Education, 2004). Thus, policy forces ELLs to learn to at least cope with mathematics tests in English very quickly regardless of the quality of their academic English.

But what does teaching and learning English really mean? Moschkovitch (2002) suggests three ways to look at these process. The first focuses on simply learning vocabulary and views vocabulary as simply a list of words. The second, somewhat more complex view recognizes that words have multiple meanings by highlighting their registers. Thus a “quarter” is sometimes a coin and sometimes a fraction. In Spanish, “primo” is sometimes a cousin and sometimes a prime number. From both of these perspectives, the ELL’s problem is to learn the words to understand mathematics problems. In the first case, the challenge would seem to be relatively simple. If the student knows the vocabulary, he or she should be able to do the science or math. In the second, there is a somewhat more challenging problem of figuring out the context. Words have different meanings in an academic setting than in everyday life, but with some coaching students should be able to sort out a word’s relevant connotations.

Moschkovich’s third perspective focuses on “discourse” or ways of using language, other expressions, artifacts, and symbols as well as ways of thinking, feeling, and valuing as a member of socially meaningful group or network. This definition focuses on a wider range of resources for communications and may include more outcomes than solving mathematical problems or getting the right answer on a science recall test. She points out that that while this discourse-oriented perspective has some

overlap with inquiry-oriented approaches to instruction, it is more of an analytic perspective than an approach to instruction. Nevertheless, it suggests that for ELLs, learning math and science entails challenges beyond learning vocabulary and the multiple meanings of words, but also, as Moschovich illustrates, that two languages can provide added resources for learning those content areas.

Teaching Practice

While the debates about how to teach mathematics and science to ELLs continue, teachers combine approaches as best they can. Here we describe the work of four teachers of ELLs in two schools. Classroom observations and interviews with these four teachers yielded data concerning their knowledge base, teaching practice, professional development experiences, and beliefs. Two of these teachers, Marta Herrera and Rose Padilla, work at Lopez School in District A and two, Ashley King and Margaret Pareira, teach at Cardenas in District C. Table 2 provides a brief overview of some features of their instruction.

Lopez, Marta Herrera. Marta Herrera teaches ELLs at Lopez School in District A. She taught a fifth grade class composed of students of various English ability levels during the first year of the study and a fourth grade class of advanced (in English proficiency) bilingual students during year two. She is completely fluent in both English and Spanish. Her knowledge of Spanish encompasses regional vocabulary that enhances her communication with her class of students who come from Mexico, the Dominican Republic, Puerto Rico, and various Central American countries. She participates in the Rutgers MSP Lesson Study project and is pursuing a doctorate in bilingual studies at Seton Hall. Her teaching practice reflects her training in standards-based math and

science instruction and her knowledge of ESL strategies is evident in her teaching practice, as well.

Table 2
Some Features of Instruction of Four Teachers

FEATURES	HERRARA Lopez	CHICO Lopez	PAREIRA Cardenas	KING Cardenas
Approach to Instruction	Inquiry-oriented	Inquiry-oriented	Direct	Direct
Language of instruction	Spanish & English	Spanish	Spanish & English	English
Use of Groups	Yes	Yes	Yes	Yes
Knowledge of ESL strategies	Yes	Yes	Yes	Yes
Language Usage	Fluent in both languages	Code switching for technical vocabulary, English used to give directions	Errors in written Spanish	Teacher speaks English and aide speaks Spanish

Several examples illustrate how she uses her knowledge. During a lesson about aquatic environments, students worked in cooperative learning groups to test three different water samples for acidity. The lesson was taught in Spanish and at one point, the teacher asked the students about pond water that had been collected from a nearby park.

Herrera – *Qué otras clases de agua tenemos?*
What other kinds of water do we have?

Boy – *Represa*. (The boy uses the Spanish word for “dam” or “reservoir.”)

Herrera – *Usted siempre usa un vocabulario interesante de su país. De dónde es Usted?*

You always use interesting vocabulary from your country. Where do you come from?

Boy – Honduras.

Herrera – *Puede usar otra palabra que quiere decir lo mismo?*

Can you use another word that means the same thing?

Boy – *Estanco*.

T- That's right. A pond. It's water that sits. (in English)

The other students, mostly Mexican, did not understand the use of the word, *represa*, because it means something else in the Spanish of their home country. The teacher respected the student's regional vocabulary and gave the word the same value as a more easily understood Spanish word. It was necessary to establish mutual comprehension without denigrating the vocabulary that is unique to Honduras. The teacher exhibited both a depth of linguistic knowledge, as well as a sensitivity concerning her students' feelings about their own culture and its worth. In addition, Herrera demonstrated an awareness of ESL techniques, when she not only translated *estanco* into English, but also gave its definition in English.

While it might be assumed that in a classroom filled with Hispanic immigrants, the use of Spanish as the language of instruction would solve all language problems, this is not the case. Because the students come from different Latin American countries, their vocabulary which may use regionalisms, is not always universally understood. This situation demands that the teacher not only know about Spanish in general, but that he/she possess a deeper knowledge of regionalisms and pronunciation, as well.

Herrera's knowledge about both language acquisition and reform math instruction impacts on her classroom strategies.

"I think that first of all, in a bilingual classroom . . . it is very effective to use the primary language when you are teaching primary subjects like reading,

mathematics. That is one of the most effective I find in my opinion and it is research-based. . . .And if you teach them in their primary language, they are able to grow incredibly in their comprehension. They grow in reading, they grow in math, and that is very effective. Also using cooperative learning. Manipulating the material. The concepts are grasped so much better than if you are going to present it in a traditional way of lecturing. Children get turned off [if] they are not engaged. They do not acquire the concepts. They get confused.”

During the first year of the study, Lopez teachers followed the lead of their principal whose goal was to produce bilingual students, students who would be comfortable in both English and Spanish. Classes were heterogeneously organized and students’ abilities in English varied. The underlying philosophy was to take advantage of students’ discourse with those who knew more English helping their peers who knew less. In fact, one student, Larry, came into the class with little knowledge of Spanish, although his mother was a native born Hispanic. She wanted him to remain in a bilingual setting so that he would learn to communicate in Spanish. In a math class about graphing, conducted in Spanish, he was called to the blackboard. Herrera permitted students to respond in their language of choice and while most participated in Spanish, a few answered in English.

“Herrera – *Recuerden que empezamos al origen. Empiecen con cero. Y después, hay que decidir por dónde van. Es positivo o negativo?*”

Remember we start at the origin. Start on zero. And then you have to decide in which direction you want to go. Is it positive or negative?

Larry correctly indicates -1 on the x-axis.

Larry - You see. I know how to do it. I don’t think I can explain.

Herrera – (in English) Take your explanation from the coordinates. And then do it in your own words.

Larry– I don’t know if I can do it in Spanish.

Herrera – Then do it in English. We can always translate.”

Larry starts in English and switches to Spanish after the first sentence and completes his answer in Spanish correctly.

Herrera was very pleased by his progress in Spanish and explained to the observer, “We have a practically monolingual child who was probably placed here because of his last name and now he’s thrilled because he’s really learning Spanish.”

During Year Two, school policy was changed to accommodate the perceived demands of standardized testing in English. Students at Lopez were now placed in classes according to their English language ability. Herrera now worked with a class of advanced bilingual students, some of whom would be entering monolingual classes during the following year. She commented that the other class on the fourth grade consisted of students with a more limited knowledge of English and worked mostly in Spanish. The teacher of the other class expressed concern to Herrera that the lack of English knowledge among her students would cause them to perform poorly on the standardized testing in English in spite of her efforts to teach them English. While teachers at Lopez expressed concern about the appropriateness of testing ELLs in English and the impact of the scores both on the district and the school, observed teachers did not mention standardized tests in the classroom during instruction.

Teachers at Lopez who teach students with a greater knowledge of English try to use more English in the classroom and are conscious of the appropriate times when English can be introduced during a lesson taught in Spanish. During a math lesson about graphing, taught in Spanish, Herrera transitioned into English to help the students remember how to approach the graph. A student, using Spanish, explained his approach to the problem.

Boy – I moved to the left because that's the negative direction and then I counted down because the other coordinate is negative.

Herrera – (In English) If we put our hands up like this, what letter do you see?

She holds up her thumb and forefinger in the shape of an L.

Herrera - That can help you think of the direction. We did this in English. As we move to the left on the x-axis, the numbers get, what?

Students – Less.

Herrera – That's a good way to remember that.

Rose Padilla. Rose Padilla teaches science to port of entry and Spanish-dominant ELLs in the upper grades at Lopez. She uses an inquiry-oriented approach with discovery through cooperative learning as a focus of her practice and demonstrates a strong knowledge of science content. She speaks both English and Spanish, but does not possess a strong academic knowledge of Spanish. She is deeply committed to the participation of English Language Learners and volunteered to assist in a school program where Spanish-speaking adults were unavailable. When she discovered that ELLs were dropping out of the program because they did not understand what was being said, she offered her services. “, , , the reason I got involved with the Step-Up [program] was because last year was the first year of Step-Up. And I noticed that my students who are bilingual started out, they signed up for it, and then they, they stopped going because they didn't understand what was going on. There was no one to translate for them. And I felt that if I got involved, you know, maybe I could just keep them motivated and going. And the teachers who did it last year didn't want to do it this year. So I got that opportunity to do that.”

Her science classes are exciting, with students energetically sharing their ideas about the problem at hand as they sit at round tables, discussing their ideas in Spanish. Many of her students come from rural villages and this is the first opportunity they have had to handle batteries, convection chambers, and test tubes. She encourages them to ask questions and to hypothesize.

And the way we do these units, we really don't give them a whole lot of information initially. We're trying to get them to kind of figure it out, you know? To see where they're at and to see what, because they all have ideas. They could be correct or they could be not correct. But that's also important. To know what is incorrect in their minds. So right now, they're writing down their impressions of why it worked. And then we'll discuss it and see how close they got to what actually was happening.

She has very clear ideas about using Spanish and English in the classroom although what she believes she does and what she actually does are not the same. She states,

Usually when I'm giving them instructions, I try to do it in English. Things that I think they should know by now. When I'm speaking about something kind of technical, I try to say it in Spanish because then it gets a little difficult to understand. I mean because then at that point, they're trying to understand the language and the concept. So that's rough. But when I'm asking them to do things like 'get me that and get me this,' I try to talk to them in English. And all the terms, the terms themselves I try to give it to them both in English and in Spanish.

In order to help students learn and understand vocabulary in Spanish, it is important for the teacher to be conversant with content-specific and technical vocabulary in Spanish when Spanish is the language of instruction. This expectation is not unlike expecting that every science teacher in the United States should know content-specific vocabulary in English. While a teacher may be a native-born Spanish speaker, he/she may not be familiar with vocabulary that is specific to math or science. His/her social language may be more developed than his/her academic language. When this occurs, the teacher may tend to code-switch, that is to use both English and Spanish in either the

same sentence or same group of sentences. This limits student acquisition of Spanish academic language and confuses the separateness of each language.

While Padilla believes that the students should be introduced to the scientific terms in both English and Spanish, in fact, she does not always know them. In a lesson about heat transfer, Padilla introduced the lesson by telling her students,

“Vamos a crear what we call a convection oven.”

We’re going to create a convection oven.

Her lessons, presented in Spanish, are peppered with both science-specific terminology in English, and incorrect vocabulary words in Spanish. In the same lesson, she asked a student to hand her incense but didn’t know the correct word in Spanish for incense. She said to the student, *“Lo que vamos a hacer es poner, cómo se dicen “incense” en español? Es para dar un olor. Vamos a decir incenso. (What we’re going to do is put, how do you say “incense” in Spanish? It serves to emit a smell. Let’s say incenso.)*

Unfortunately, the correct Spanish word for “incense” is *incienso*. In addition, *“cómo se dicen* should be *cómo se dice?”* The same teacher, presenting a lesson about electricity, continued to both make mistakes in Spanish language usage and to speak a combination of English and Spanish that resulted in that phenomenon known as “Spanglish.” Her lack of a Spanish register in science caused her to use English words in Spanish sentences. She used the following words in English within Spanish sentences during the same lesson about electricity: multimeter, fuses, component, voltage drop, switch, voltmeter, and resistors. When giving directions to her class, she said, *“Van a usar the board and poner the probes adentro. Entendido?”* (You are going to use the board and put the probes inside. Understood?) An overhead slide prepared by the

teacher provided incorrect spelling and written code switching. *“En electricidad, potencial es la habilidad de un sistema electrico mover electrons atra vez de un conductor.”* (In electricity, potential is the ability of an electrical system to move electrons through a conductor.) The sentence should have been written, *“En electricidad, potencial es la habilidad de un sistema eléctrico de mover electrones através de un conductor.”*

The problem of code switching and misuse of Spanish is not uncommon. When teachers speak Spanish at home as a home language, they often lack the content-specific knowledge of their subject area because they have not been trained in that area in Spanish. Neither have they necessarily been trained in Spanish at the university level.

Although science is presented to beginning bilingual students at Lopez using Spanish as a means of instruction, their workbook, the FOSS Weather and Water Lab Notebook, is in English. The students work collaboratively using an inquiry method to make scientific discoveries. They converse with each other in Spanish about science and the teacher instructs them in Spanish, but they are stymied by written material in English. In addition, because Ms. Padilla, a native Spanish speaker, has not developed a science register in Spanish, the students have no opportunity to develop a technical vocabulary in Spanish, the language in which they are working. Padilla spoke of how difficult she finds teaching in Spanish and using FOSS material in English.

“... I basically translate everything. And when we read these, it takes me of course as you can imagine, a whole lot longer to go through these things because we read them and then we have to paragraph by paragraph try to determine what it is saying. . . they [FOSS materials] also have exams that I have to translate because I cannot, I almost never will give them an exam in English . . . I want to make sure they understand the concept and it is not being hindered by the language . . .”

Ironically, FOSS material in Spanish would also assist the teacher in developing a Spanish register in science by providing her with the vocabulary that she does not know in Spanish.

While Padilla's approach to communication did not advance the students' vocabulary acquisition in either Spanish or English, language represents only one aspect of the lessons. Using a standards-based instructional model in science, this same teacher used strategies that challenged the students to use higher order thinking skills, that encouraged a hands-on approach to scientific discovery, that fostered student collaboration and student talk in Spanish, and that connected learning to real life situations. Students (some of whom came from small Mexican villages) sat at round tables, handled electrical components, and discussed and strategized with each other in Spanish about how to use the equipment to produce a desired effect. They were engaged and enthusiastic about their work. Padilla did not tell them what to do; instead she challenged them to discover for themselves. In a lesson about air pressure, she encouraged the students to create their own knowledge.

Lo que van a hacer. Primero, vamos a llenar el tubito del agua, agua con color para que se vea mejor. Quiero que Vds. traten de figurar cómo podemos subir la presión aquí adentro. No les voy a decir cómo. Quiero que piensen Vds.

What I want you to do. First, we're going to fill the small tube with water, colored water so that you can see it better. I want you to try to figure out how we can increase the pressure here inside. I'm not going to tell you how. I want you to think.

Herrera and Padilla share an inquiry-oriented approach to instruction. They differ in how they work with ELLs. While they both support those students, Herrera has a much stronger comprehension of the academic vocabulary in her discipline—mathematics—as well as an understanding of variation in terminology across the

countries of the students she teaches. Padilla lacks this understanding. Moreover, she is not supported by adequate bilingual materials for her largely Spanish-speaking classes. This would appear to create considerable confusion for her students who also lack an academic vocabulary in these areas and add to their guess work in learning the content; it creates, in effect, an additional barrier to learning content and to facility with their native language.

Cardenas School, Margaret Pareira. Margaret Pareira teaches the sixth grade at Cardenas School in District C. She teaches math using direct instruction. When asked about the students in her class, she explained that some spoke very little English. “. . . but [they] understand a lot because I speak mostly English to them. Necessity is the best teacher.” She believes that immersion in English is the best way to teach English Language Learners. “I start them off together in a little bilingual group and then put them in English-speaking groups, and then they just want to be part of the social aspect, they will want to learn English.” Like many teachers in District C, she is certified to teach English as a Second Language.

She teaches in English and a Spanish-speaking push-in teacher assists five students who are not yet able to work in English during two periods during the day. While Pareira is able to speak Spanish, her written Spanish is not as strong as her verbal use of the language. In the same way that students must develop facility with academic language in addition to social language, teachers must go through the same process. Because bilingual teachers may have learned social language at home and not acquired an academic knowledge of Spanish, they may use Spanish incorrectly, misspell words, code switch, and simply not be able to express themselves appropriately in Spanish.

Her teaching is very organized and focused on student comprehension of concepts taught in English. While oral discourse focuses on English, she supplements it with charts, visual aids, and Venn diagrams. She integrates the curriculum areas to reinforce student learning and to permit students to review vocabulary by referring to that vocabulary in different subject areas. To teach the students how to measure distance on a map, she integrated math, social studies, and literature. The students used a map legend in a novel they were reading to measure the distances on an island in the story. Working in pairs, the students used a ruler to measure the distances in the book and then, using the legend, converted inches into miles. The students worked in English and because they were paired, students who had difficulty with the language were able to receive assistance from their peers.

Most of the professional development available to Pareira through the district has dealt with second language acquisition. She has not had the opportunity to attend workshops on math and expressed an interest in learning how to use the sheltered English approach to teaching math. This is consistent with her focus on English language immersion and learning how to teach math content within that framework would support her teaching practice.

Cardenas School, Ashley King. Ashley King taught kindergarten. Her class was composed of both monolingual and English Language Learners. About half of her students were advanced bilingual students, able to work in English but still Spanish dominant. Two of these students would enter monolingual classes for the first grade. The other kindergarten class at Cardenas was taught only in Spanish.

While she was bilingual, King taught in English and depended on a Spanish-speaking aide to assist the ELLs in her classroom. She had very clear ideas about keeping the two languages separate to enable the students to see them as discrete entities. With the goal of promoting English language acquisition, she said, “. . . if you can’t say it in English, say it in Spanish. I don’t want them to say, oh, Spanish is banned here. We use Spanish if they need it. But I’m trying to stress them to use their English to build their vocabulary.” King held a certification in ESL and was very conversant with ESL strategies. Her lessons were rich in language experiences complete with puppets, and she used groups, hands-on activities, and pictures to motivate her students and support lessons across the curriculum areas.

In the language-rich environment of the kindergarten classroom, King focused on the acquisition of communication skills in English: listening, speaking, reading, and writing. During a lesson, she introduced a variety of activities that would support students’ greater understanding of English. Because she taught kindergarten, she focused on age appropriate activities and was conscious of the curriculum demands for early childhood education. District C provided professional development and collaborative opportunities for early childhood teachers that enabled King to become more knowledgeable about the needs of younger children. The same opportunities were not available to support the acquisition of knowledge about language issues. At Cardenas, she collaborated both at grade level and in science. Janeen James, the science teacher for King’ class did not speak Spanish, and the two teachers worked together to provide a rich science experience for the kindergarten class. They offered lessons about similar topics, and King provided vocabulary support in English to enable her students to participate in

James's classes. James planned a follow-up activity to the lesson on butterflies in which the students would have the opportunity to breed butterflies.

In a science lesson about the life cycle of the butterfly, King tried to focus on several areas appropriate to both the educational needs and age of her students: science content that included the life cycle of the butterfly and the ways in which living things change, vocabulary associated with the lesson, sequence, graphic representation, and student explanations of the life cycle.

She introduced the following activities: the students sang a song about cleaning up the room, they recited a poem about hearing a story read, the teacher held up pictures of different kinds of food that would be mentioned in the story, King read The Very Hungry Caterpillar aloud while a student holding a caterpillar puppet demonstrated what she read, the teacher drew a circle on the whiteboard to demonstrate the cycle (egg, caterpillar, cocoon, and butterfly), the teacher covered her drawing and the students drew their own version of the cycle, individual students explained the cycle to the class, students labeled their drawings, and for the final activity, drew a butterfly on a piece of paper that looked like a cocoon. The teacher encouraged the students to imagine how the butterfly looked and said to the class, "I like Michael's idea. He drew the cocoon on one side and colored it in and now he's drawing what he will be on the other side. I like his idea. In fact, his idea is better than mine. I really like his idea."

Prior to reading the story, the teacher distributed pictures of food that she was going to mention when she read the story. Each picture had a hole in its center. As she read the story, individual students approached the boy with the caterpillar puppet and put the pictures on his arm to simulate the caterpillar eating. This helped students recognize

words. While perhaps not all of the students could produce the vocabulary, they were able to listen and understand, an important step in the acquisition of language. After all the food was mentioned, the teacher spoke of the caterpillar's cocoon. The student exchanged the caterpillar puppet for a cocoon puppet which he placed on his hand. At the close of the story, a caterpillar left the cocoon, was replaced by a butterfly, and the student now removed the cocoon puppet from his hand and put a butterfly puppet in its place.

The lesson served many purposes. The science content was part of the curriculum and King believed that it served a more global goal. She commented,

So they realize that things can grow and change and not everything is going to be the same all the time. I always tell them that they are always growing and changing as well, it's not something that's fixed on just say insects but it also can relate to animals, people, plants, and animals.

In addition, she focused on sequence and writing. By asking the students to label their drawings, she reinforced the science content, the directionality of writing, the formation of letters, and free expression, all appropriate for their stage of development.

Many teachers who work with ELLs at Cardenas have certification in either teaching ESL or in teaching bilingual studies. Opportunities to collaborate with other ELL teachers are minimal and perhaps because they believe that they possess knowledge about these areas, the teachers work independently of each other, and have very differing beliefs about what should do to help their students acquire greater communication in English. Every observed lesson in ELL classrooms were models of traditional instruction. Teachers used elements of ESL strategies at varying levels and degrees and there seemed to be little agreement among them about how to address the needs of non-English speaking students. King would have liked the opportunity to learn more about

language strategies and while Pareira had the opportunity, she was not able to learn about strategies, such as sheltered English, that interested her.

These four teachers used a variety of teaching strategies. Two favored a more inquiry-oriented approach and two used more direct instruction. They used a variety of strategies to communicate with ELLs to extend discourse possibilities, but these did not line up with their basic instructional approaches. The teaching strategies they used reflected district policies. Their discourse strategies reflected their knowledge and beliefs about teaching ELLs. These seemed to be largely idiosyncratic. Teachers brought with them to school levels of knowledge of Spanish that they often learned at home or before they chose to become teachers and beliefs about language of instruction that were quite deep seated. In the next sections, we explore the knowledge and beliefs of the four teachers whose classrooms we described above. We then explore district professional development policy related to both math and science teaching ELLs.

Teachers' Knowledge and Beliefs Related to ELLs

This section reviews the knowledge and beliefs of the four teachers described earlier to clarify why they use Spanish in instruction the way they do. These are summarized in Table 3.

Lopez, Marta Herrera. The teaching practice of three of the four profiled teachers reflects their beliefs about the use of language for instruction. Herrera structures her beliefs about the teaching of English Language Learners based on her extensive knowledge of the literature gained in part as a doctoral student in bilingual studies. In an aside to the observer, she spoke of the research of Cummins, Krashen, Hakuta, and Garcia, believing that content area instruction in the first language supports cognition and

the acquisition of content knowledge but that it is equally important to provide instruction in English, as well. she remarked, “. . . sometimes I see that bilingual programs don’t work, but when you really look at what was being researched at the time, their ESL component was weak. So you can’t have a good an effective bilingual program if your ESL component is not strong.”

Table 3
Teachers Language Use and Beliefs

	PADILLA	HERRARA	KING	PAREIRA
ORAL SOCIAL USE OF SPANISH	Fluent	Fluent	Fluent	Fluent
ORAL ACADEMIC USE OF SPANISH	Does not use correct scientific terminology in Spanish	Total fluency	Not used in the classroom	Not used in the classroom
KINDS OF ERRORS IN SPANISH	Sentences consist of a mix of both languages Misuses Spanish vocabulary	None	Not observed using Spanish	Grammatical and spelling errors in written Spanish
BELIEFS ABOUT USING SPANISH AS LANGUAGE OF INSTRUCTION	Spanish should be used to strengthen conceptual knowledge and to assess student knowledge	Spanish should be used as language of instruction for port of entry and beginning students	Spanish should be used as language of instruction for port of entry and beginning students	Believes in total English immersion

She has a clear sense of the educational program that should be offered to ELLs, providing Spanish instruction in all subject areas until the student has acquired a social knowledge of English and at the same time, and offering a strong ESL component on a

daily basis. The student should then be gradually exposed to more academic uses of English in preparation for the student's transition into the school's monolingual program.

The best way depending on their proficiency level if you have a child which comes in with no English, basically the primary subjects, the primary subjects, math, science, social studies, language arts, reading, when that child comes in should be taught in their native language, so as not to discontinue the growth cognitively. And they should receive instruction in these primary subjects throughout the school day and have very strong ESL component part of their day should be at least two periods per day 80-90 minutes a day in addition to their special area classes, music, art, gym. Those classes are usually in English. But the important thing is to develop their native language so that these children can then more easily transfer their skills, in a more effective way into English. And as they progress throughout the years, with this kind of a model they can make the transition more easily.

She chose to teach and remain at Lopez because her beliefs about using Spanish in the classroom were in agreement with those of the school's principal who supported bilingual education. She was uncomfortable with the district's move toward English immersion in order to prepare students for standardized testing. Grounded in the literature, she considers the district's move towards increased English immersion to be unwise:

...they think that how are they going to learn the English if we continue to, provide them Spanish instruction. So let's just throw the English at them and have them, and throughout the years for over 20 years, 20-30 years in bilingual research, they have found that that doesn't work. Because you need to be able to reach a cognitive level in your native language before you can transfer that cognition to a second language.

Based on her understanding of research in the area of bilingual education, Herrera has tailored her instructional practice to accommodate the needs of her students. She believes that the language of instruction must reflect the students' language abilities. During the second year of the project, Herrera worked with advanced bilingual students, teaching in English and using Spanish to clarify a concept, when necessary. Because the students had acquired a high level of proficiency in English and

were anticipating transition into monolingual classes in the next grade, Herrera tried to use the maximum amount of English in her instruction without sacrificing comprehension. However, if students needed to ask a question in Spanish, they felt comfortable doing so.

Because she was so versatile in both English and Spanish, Herrera was able to move easily between the two languages when necessary. She was quick to use Spanish if she believed her students were lost. “. . . if I spoke only in English, I’d have at least 10 little faces that would look at me weirdly. They wouldn’t understand what I was saying. They pick up bits and pieces but they wouldn’t get the gist of it. And then, subsequently, you wouldn’t be able to get their participation.” Herrera consciously avoided code-switching and was clear in her discourse about moving from one language to another.

We have them [textbooks] in both languages and if they prefer to have an English textbook that is what I give them, whatever they feel comfortable [with]. When we write in our journals, anytime there is a free writing activity, they get a choice. I don’t [insist on English] unless it is an ESL session, which we do have during the day. We have at least a whole period and I do an extra 34 minutes of English and then at that point it has to be done in English.

Herrera acknowledged the need for the teacher of ELLs to possess a variety of knowledge bases; she combines her knowledge of language acquisition, her profound abilities in both languages, and her knowledge of content area in both science and in math both in the instruction of newly arrived students, as well as the teaching of students preparing to exit the program.

Cardenas, Ashley King. Certified in English as a Second Language, King was conversant with current research in the field and knowledgeable about pedagogy. She

was raised speaking Spanish to her Cuban mother, grandmother, and aunts and felt at ease in the language. “I’ve always heard it growing up but I’m more comfortable speaking English. . . . I understand it [Spanish] very well but when I go to speak it, I get a little, tongue-tied at times. But I feel comfortable talking to kids in Spanish. And it helps when trying to talk to parents.”

She chose to teach in English and had her aide communicate in Spanish, based on her pedagogical beliefs. She had clear ideas about the use of English and Spanish in the classroom. Because she taught kindergarten, she believed that if she were to use both English and Spanish she would confuse the children and as a consequence, she follows current thinking that suggests that young children should hear only one language from a particular individual. Her aide speaks Spanish to the students and King believes that the separation of language speakers prevents confusion. She believes that the two languages should be maintained as discrete entities. When the aide was absent, the teacher used Spanish to assist students who encounter difficulty with comprehension in English. “I try to separate it like there’s someone from Spanish and English just so that they don’t get confused. And I don’t go back and forth with it. But because my aide’s out, I have to go into Spanish and English for him so he [a student] understands.” This was not a serious problem because half of the class was monolingual and the students who were considered ELLs were level three and four advanced bilingual students.

Cardenas, Margaret Pareira. This teacher was also certified in English as a Second Language. Her ideas concerning the language of instruction for English Language Learners were diametrically opposed to those of King. While both teachers had been exposed to current thinking and literature about the education of ELLs and taught at the

same school, they reached different conclusions. Pareira believed that the focus of education for these students was total immersion in English. Those students who were not able to participate in English-only lessons were assisted by a push-in teacher who works with them in Spanish. Unlike King, Pareira worked in English only because she believed that “. . .necessity is the best teacher.” She believed that students will be forced to function in English if they have no other choice. She explained that the easy availability of communication in Spanish at Cardenas impeded the learning of English. “. . . it is easier to rely on your own language if you are allowed. And in some districts you are not. When you have everyone speaking Spanish in the building then it doesn’t really encourage the student to learn English.”

While King chose not to use Spanish in the classroom to avoid confusion, Pareira’s approach borders on hostility. “Yeah, I have three that don’t speak English really well. But I try not to translate everything so they get the gist of it. They have Spanish books but I find that when they focus too much, then they don’t want to learn English because it is just easier to have the crutch of the Spanish book and one girl has been here almost three years. It is time to speak English and she doesn’t want to.”

When it is necessary, Pareira does use Spanish. While she can communicate orally, her written Spanish contains grammatical and spelling errors.

The practice of the three teachers whose beliefs have been discussed, Herrera at Lopez, and King and Pareira at Cardenas, demonstrates coherence with their beliefs. Herrera advocates content instruction in the home language for students with little knowledge of English and increases her use of English in the subject areas as the students begin to develop academic ease in English. King is in agreement with Herrera and

provides instruction in English to those students with greater English language proficiency while an aide provides the Spanish component for lower level students in the same class. Pareira works only in English because her philosophy concerning the instruction of English Language Learner is the opposite of Herrera' and King' beliefs. *Lopez, Rose Padilla.* Padilla presents a contrast to the other three teachers because while she holds deep beliefs about teaching practice, her language in the classroom differs from her thoughts about language. She is not doing what she believes she should be doing. She believes that it is necessary to work in Spanish to enable the students to develop clear concepts about science.

When I am speaking about something kind of technical, I try to say it in Spanish because then it gets a little difficult to understand. I mean because then at that point, they are trying to understand the language and the concept. So that is rough. But when I am asking them to do things like, 'get me that and get me this,' I try to talk to them in English. And all the terms, the terms themselves I try to give it to them both in English and in Spanish.

However, while she understood students who spoke to her in Spanish, her academic knowledge of Spanish was minimal. Padilla spoke of the importance of providing the scientific terms in both languages but she did not do that. She made errors in her oral and written language and often spoke "Spanglish," a combination of English and Spanish wording and syntax in the same sentence. She was so completely focused on enabling students to build knowledge and to be challenged to develop concepts on their own, that she did not focus on the language that she used. Her beliefs were clear and pedagogically consistent with current thinking about science instruction for English language learners. However, these beliefs did not translate into her classroom discourse. She seemed unaware that she did not present two separate discrete languages. While she spoke of the

need to use Spanish to help the student develop the scientific concepts, she appeared unaware that she was not using Spanish vocabulary for the technical words that the students had to master.

At the same time, she was aware of the role that language played in assessment and she measured what students knew in science by testing them in Spanish.

I almost never will give them an exam in English because I am trying to see what science they have learned rather than you know? I will give them vocab, quizzes in English. But I do not want them to, I want to make sure they understand the concept and it's not being hindered by the language, you know?

Padilla remained apart from the other profiled teachers because unlike them, her beliefs were not reflected in her practice. Her inabilities in Spanish prevented her from achieving what she believed that she should be doing.

Organizational Factors

This section first explores organizational factors affecting the teaching of math and science and then bilingual policies and the way the principal mediates the latter policies. Here we examine general policies. Responses to state tests and NCLB are discussed in the next section.

Math and Science

Table 4 indicates the pattern of teaching across nine classrooms, including classes with and without ELLs, in each school. It suggests that inquiry-oriented instruction was not the dominant pattern in any school. Lopez School, where Ms. Herrera and Padilla taught had the most inquiry-oriented instruction, and Marti the least. Cardenas, where Ms. King and Pareira taught, was also relatively low on inquiry-oriented instruction.

Table 4
Characteristic of Lessons By School

Teaching	Cardenas	Marti	Kahlo	Lopez
Traditional pedagogy	20%	30%	13%	8%
Inquiry-oriented design and Traditional pedagogy	69%	54%	73%	65%
Towards Inquiry-Oriented Instruction	11%	15%	15%	28%

To some extent, this pattern of instruction reflected district policies with regard to teaching math and science. Each district made somewhat different contributions to the teaching of math and science to ELLs. In District A, where Kahlo and Lopez Schools are located, the district's major contribution role has been to increase general math and science teaching capacity by providing substantive professional development and changing the curriculum to teach those subjects in an inquiry-oriented manner. Strong input from this reform came from the district's math and science supervisors who worked closely with the MSP. As part of the district reform, the school has adopted an inquiry-oriented math textbook in 2002. One principal described the textbook saying,

The program gave the students more hands-on kinds of things to do. And more engaging, more real-life activities and the kids just fell into it. It wasn't the rote memorize the multiplication... questions. Or division things. But they really were able to apply these skills. And if they didn't get it, you know, it kind of revamped itself, it spiraled back and the kids were able to pick up on the second round about of the concept.

The district had also adopted science kits and mandated their use in the elementary grades.

At these schools, teachers' intentions responded to the mathematics and science reforms the district supervisors were trying to implement. Teachers mentioned that the purpose of the lesson was to allow students' exploration and figuring out. The district also had a history of providing professional development related to inquiry-oriented

mathematics and had been doing so since before the new materials had been adopted. Moreover, the supervisor was supported by math and science teacher leaders, teachers with release time who were assigned to work with other teachers to help them improve their math and science teaching and also ensure that materials were used in an inquiry-oriented manner.

At District B, the district where Marti School was located, the district had a similar approach to District A. The district had been providing with professional development related to the implementation of new math curricula, first TERC's Math Investigations and in the second year, Everyday Math. Teachers would meet during three full days in hands-on workshops to perform tasks that their students would be required to do. Teachers mentioned that this kind of professional development increased both their knowledge of content and teaching strategies to implement the program.

In addition, math teacher leaders provided in-service on a monthly basis at each of the schools. The math teacher leader provided support to teachers on an individual basis in their classrooms. Teacher leaders made suggestions or modeled some lessons. During some grade level meetings, teachers would discuss lessons plans for math. However, the assistant principal who led these grade level meetings had emphasized learning about literacy. A teacher mentioned that the principal was supportive of the math changes and offered staff development days to discuss the math changes.

Teachers received five-day training during the summer on the implementation of new textbooks or kits. According to teachers, content knowledge was treated in-depth; the workshops were oriented to give the reason beyond using materials and provided them with clear expectations and practical ideas on how to utilize the new textbooks. The

district also set monthly math teachers' meetings in which teachers across district schools talked about the implementation of the curriculum and their experiences. The district also offered workshops on how to prepare 8th grade students for the State Test. A teacher said that during these workshops teachers would bring samples of students' work to assess using the State rubric. Teachers commented that it was useful to learn what skills and strategies the test required. It supported the improvement of teaching math and science by providing professional development and changing the math textbooks and science materials.

The district sought to control teachers through observations, testing, and a mandate to follow the book. While both District A and District B monitored teaching through observations, in District A, monitoring was followed by substantive feedback on what to change and support from the district supervisors and teacher leaders. This was less frequent at District B where district supervisors provided more evaluative feedback. While strategies were similar in these two districts, the outcomes were different, as Table 3 indicates, perhaps because of differences in initial teacher knowledge and beliefs.

In District C, the district where Cardenas School was located, the district focused its improvement efforts on the high school. Because high-school test scores were the lowest in the district, district leaders and MSP staff worked on eliminating all low-level math courses, introducing more challenging materials, and providing continuous in-service to teachers. In addition, the district focused on solving its overcrowding problem by building a new middle school in the district.

Changing elementary math and science instruction was not a priority in the district. Instead, leaders encouraged teachers to do "more of the same" to increase test

scores. The lack of district support to improve the teaching of mathematics and science can explain in part the teaching of mathematics in this school.

At Cardenas, professional development focused on behavior that affects learning, which may have reinforced teachers' beliefs that learning depends largely on behavior (such as following procedures) rather than on cognition. The workshops provided during the two years that data were collected in the areas of math, English as a second language, and classroom management were sporadic and not linked among each other. For example, one workshop was about measurement and another on using counters.

Attendance at professional development activities was voluntary in all districts, At Cardenas, however, district administrators would not free teachers from teaching to attend professional development events. Rather, teachers had to apply to attend professional development events, and the administration permitted teachers to attend if there was money and space in the workshops offered by the district. Opportunities were much more restricted than in the other two districts.

Bilingual Policies

District A did not explicitly provide professional development related to ELLs. However, it did reorganize school boundaries to allow more students to attend neighborhood schools in a way that all schools in the district would receive a diverse population and to reduce the class sizes. Before this re-organization, children who did not speak English were bussed to specific schools in the district, such as Lopez, that specialized in teaching ELLs. Kahlo did not receive ELL children. As a result of the district re-organization, Kahlo added a bilingual program to meet the needs of its 88% Latino population. Push-in, or inclusion programs, were also added to meet the needs of

students who might have otherwise been bussed to another school. Thus, the challenge of addressing the growing Hispanic population was redistributed.

During our second year of data collection, the district started regulating the ELL programs that before were apparently left in the hands of school principals. The district mandated a transitional program, more ESL periods, and re-defined the after school programs to include teaching the vocabulary that would be on the test.

While there was no explicit professional development related to ELLs, one math program did provide opportunities to share knowledge related to those students. This was a “Lesson Study” program operated in part by the MSP. In this group, about ten teachers from different schools in the district prepared, observed, and discussed a lesson taught by one of the group members. After one class in District A that had been observed by several teachers, the group leader raised a question about English Language Learners:

There’s an open debate about the difficulty for kids with special needs and language needs. Are these issues that we need to deal with? These reformed curriculum resources tend to have a higher level of comprehension needed by kids. It throws it back to us.

The teacher who had been observed responded by referring to course work she was taking at another university and suggesting some material the group could read. Thus, this on-going working group exposed the participants not only to thinking about inquiry-oriented math but to research available concerning ELLs. This professional development setting enabled District A teachers to discuss both constructivist math instruction and the acquisition of language at an academic level.

The teachers went on to analyze the lesson, the strategies used by the students, the role of manipulatives, and the aspects of the lesson that were problematic for the students.

A teacher commented, “Years ago, I wanted to give the answer. And then you develop the kind of question and answer technique. When I saw them counting one by one, my hair was going to fall out and I looked at [the group leader who was also observing] and she was so calm.” The teachers gained insight into student-centered teaching practice. Another teacher added, “I was looking at a group that had manipulatives and they couldn’t make it work for what they needed and they were getting concerned. And one boy got frustrated and he decided to do it a completely different way. The group was saying it correctly but they weren’t writing it correctly. Once they changed, they were able to move on.”

One final comment addressed the ELLs, in particular. The teacher who had been observed said, “I was very proud that they did this in English. This is a bilingual class, folks. It’s wonderful that they’re moving on to monolingual with the exception of two. Most of them have been here since kindergarten or first grade. This is a great accomplishment for our school.” The teachers have collaborated throughout the year and believe that they have learned from the experience. Most of the group planned to continue in the Lesson Study program during the next school year. The observed teacher, as a leader in the group, was able to educate the other participants about ELLs and learned about inquiry-oriented math from her colleagues.

More generally, teachers said they learned new teaching strategies, acquired in-depth understanding of mathematical concepts, and gained knowledge of how children think from Lesson Study groups. They said that Lesson Study Group was useful because “it brings up the professional level for teachers,” encouraged them to share with colleagues, and contributed to build consistency of teaching strategies within the school.

Teachers reported feeling more confident in mathematics resulting from Lesson Study Groups.

The presence of both monolingual and bilingual teachers in this MSP-sponsored program provided greater articulation, supporting the smooth transition of ELLs into a monolingual setting. Because monolingual and bilingual teachers were exposed to the same reform math philosophy and strategies, the students were familiar with that kind of instruction when they entered monolingual classes. In addition, monolingual teachers were exposed to the educational needs of ELLs because they observed lessons in bilingual classrooms. It was difficult for teachers of ELLs to remain focused on math content because so much of their teaching was directed toward language comprehension. This kind of professional development provided the balance that they need.

District B, a school district whose student population until recently predominantly African-American, had a growing number of Latino students, 55% of the district at the time of field work. Marti had one of the largest bilingual programs. As a result of this demographic change, the school provided a bilingual class and a transition class on each grade for grades K-3. On a trial basis, one classroom on each grade offered English-only immersion for upper level bilingual students. Thus, the district still seemed to be trying to figure out how best to serve ELL students. The district also provided professional development for bilingual teachers and Spanish courses, which teachers perceived as very useful. Beyond the district-wide professional development, District B also offered a Lesson Study Group. However, few Marti teachers participated.

District C did not seem to have a centrally regulated program for ELL students. However, the district required all teachers to be certified as bilingual education or ESL

teachers. If teachers were not certified, the district supported teachers' education in the local university towards their certification. With this policy, the district assumed that all teachers would be equipped to address the needs of ELL students and did not provide further professional development. The district regularly tested ELLs on their English ability twice a year and classified them in three groups from Spanish dominant to English dominant. Based on the test, children were grouped homogenously based on their language proficiency.

Principal and Bilingual Education

Most principals mediated district policies for bilingual students based on what they believed was best for their students and on the actual resources available at their school buildings. Principals would often extend the Spanish support to ELL students for longer than the district mandated. We have described how Lopez's principal believed that children needed to be fluent in both Spanish and English and that content should be taught in Spanish. A teacher at Lopez who shares the principal's philosophy, appreciated the principal's support. She said:

. . . I wasn't new to bilingual education, but you know throughout the past six years here, um, you know I think I've been fortunate to be under the direction of an administrator who realizes the importance of the native language and the role it should play in bilingual education. . . . there is more of an idea [within the district] of getting away from the native language and immersing children into English. So, I've been fortunate to be working for an administrator that tries to do the right thing, research based instruction.

At the school, the principal allowed teachers to disobey the district mandate of teaching math in both English and Spanish and allowed teachers to teach in English in the morning and Spanish in the afternoon, a model more consistent with his beliefs about bilingual education. He also provided professional development on bilingual education

during staff meetings and in informal conversations with teachers. Teachers reported that he was constantly reinforcing the vision that teachers needed to teach the content in the native language first and that students should be truly bilingual.

At Kahlo, the principal who was a former bilingual teacher and held a doctorate in ESL, provided students with additional support after they transitioned to the monolingual program arguing that students “were not ready”. He also made it a point to address the needs of bilingual teachers because, as a former bilingual teacher, he mentioned that ESL teachers were perceived as less important than the regular teachers and always lack of materials and other support including being invited to meetings and professional development events.

At Marti, the principal made sure that the “book of the month” that he selected, was available in Spanish. In addition, he provided concurrent translation for parents during school meetings. Bilingual teachers were also included in meetings.

At Cardenas, the principal was in a difficult position. On the one hand the district tested students twice a year to be placed in homogenously grouped classes based on language. On the other hand, most often, he did not have the number of bilingual teachers, or classrooms to place students in the rooms they needed. On top of that, the school was overcrowded. Some classes were held in trailers leaving little options for organizing strategies. Thus, he often would move some more advanced ELLs into monolingual classes before they might be ready. Nevertheless, most staff in the school was bilingual which helped assist students’, teachers’, and parents’ needs. In addition, the principal provided workshops for parents in Spanish, leading the workshops himself, to help parents help their children in math and science.

All principals seemed to support the education of ELL students in different ways based on their own beliefs and on the school capacity to respond to the students' needs. In some cases, this support did not necessarily align with the district policies.

In summary, two districts had coherent programs for teaching math and science, but policies for teaching ELLs were less elaborate and less developed. The math and science policies integrated materials and professional development. The ELL policies addressed issues of student placement in schools and grouping within schools and certification (in one district). There were also some efforts to provide professional development, but these were minimal and to mandate instructional approaches, but these will be better understood when we turn to the issue of testing policies.

How Testing Influenced Teaching

Almost all teaching and learning in the US is affected by federal and state testing policies. These policies have been growing since the 1970s, spurred by doubts about the efficacy of the American educational system and new interest in holding schools accountable for student performance (Hamilton, 2003). The spread of state testing policies provided the basis for the passage of federal No Child Left Behind legislation which called attention to and created sanctions for gaps between the achievement of English Language Learners and other students.

In spite of the spread of testing and accountability policies, their effects on teaching and learning have been disputed. Advocates argue that high stakes have encouraged educators to focus more on the curriculum and taking teaching and learning more seriously in ways that benefit students (Cawelti & Protheroe, 2001). Opponents speak of the negative consequences of teaching to the test (McNeil, 2000). Hamilton's

(2003) review found a mix of positive and negative results stemming from state testing. Research in New Jersey suggests that, in response to state tests, teachers tend to emphasize topics included in state assessments and that those in lower income districts stress direct instruction but do not change the amount of inquiry-oriented instruction (Firestone, Schorr, & Monfils, 2004). More generally how teachers respond to tests depends on their knowledge and beliefs. Better educated teachers who are oriented towards constructivist teaching strategies will find ways to use them to prepare students for tests while those who are less well informed about math and science and are more didactically inclined will maintain those inclinations while preparing students for tests (Firestone et al., 2004).

The effects of testing on bilingual education have been less well studied. Some documentation after the passage of No Child Left Behind suggests that bilingual teachers appreciate the attention that they and their students have received because of provisions of that law. However, there is disagreement about the effects of that attention somewhat similar to the disagreement about the effects of testing more generally. Some think that resulting professional development is helpful, and others think that new policies create demands for results that are unrealistic given the time that new immigrants need to learn English (Zehr, 2006).

State testing drove a great deal of teaching of ELLs in these four schools. Speaking of how the district administered tests in a grade where there was no state test, Pareira said,

Well now we're forced to kind of push reviewing skills for the Terranova test instead of you know, a lot more because there are children who would have been excluded normally or you know now have to take the grade-level test. And it's not fair because there are some children who never went to school and now she,

the girl that I have in my room now never went to school in her country [El Salvador] . . . She first arrived, couldn't even hold a pencil. How can you expect that child to be, not be left behind?

In all four schools, teachers felt pressure to increase tests scores. Pressure came from the principal, district leadership, community, and the State. One of the principals observed, "if I can quote my superintendent. He tells us all the time. It's the test, stupid. It's the test. You know so we are really driven by the results of the state test scores."

Teachers mentioned feeling the pressure to increase test scores to avoid school and teacher sanctions. One teacher said, "it's very important to us as a school not to become Category 1, not to have sanctions placed on the teachers." Teachers mentioned being afraid of losing their jobs or being labeled as unqualified teachers. When asked what were the main issues in the school, almost all teachers said that test scores were the main issue. One teacher mentioned "the test is first and foremost always. The test meaning the eighth-grade test or the fourth-grade test is such a big political issue. Such a big sword hanging over everyone's head." In two schools, the district would show the test scores to teachers the first day of class creating competition and public scrutiny among the schools. One teacher said:

Realistically, we have to continue to increase our test scores... it's a constant competition, which school is gonna be 1, 2, 3...you don't want to be toward the, be one of the failing schools. I mean that's a really big deal, especially in a district [with low socio-economics], so, it can be kind of stressful.

It is in this context that schools and teachers were trying to teach math and science to bilingual students. These pressures applied especially to mathematics. As one teacher leader explained, "Math is valued more and that's because the state has made it that way. If we don't pass our GEPA or ESPA in science, nobody cares. We're being judged on math, and reading, and writing. And that's an artificial construct. It doesn't mean science

should be valued less, but it is.” The strong pressure to increase test scores influenced the schools’ approach to bilingual education, student grouping, staff allocation, the type of after-school programs offered, and the focus during the math and science lessons.

From Bilingual Programs to Transitional or Immersion Programs

In all schools the main goal is now to “transition” children from bilingual classrooms to monolingual classrooms. Sometimes, however, this transition is done too quickly for students given their knowledge of English. Transition had not been the focus at Lopez School. On the contrary, the principal had supported the concept of student growth and development in both languages. He had encouraged greater skills in both languages with the goal of true bilingualism. However, several incidents pressured the school to move towards a transitional program. First, some district leaders and Lopez teachers mentioned that ELL students were in part responsible for the school’s low test scores. These individuals argued that many students failed the test simply because they did not know enough English to complete an English test. Second, there was a mandate from a newly appointed Superintendent to eliminate bilingual programs where Spanish was the main instructional language because these programs were not preparing children to take the mandatory test in English. Third, the new regulations required students to take the State math test in English. Fourth, the law demanded teachers to place students in a monolingual class after three years of schooling in the district. A teacher mentioned:

[The principal’s] vision is that the children will be bilingual and bicultural by the time they graduate from here. In fact, what he wants...is [the children to be] reading at the same level in English and in Spanish by the time they graduate. The problem is that we’re in a transitional program. And by law, we need to get the kids out by the third year. They tested out. So it’s very hard ...bilingual education is viewed here as a passage way to monolingual education. So there’s a hierarchy and beliefs within the [district] educational system that...lower is bilingual and higher is monolingual. Instead of realizing that monolingual, we’re just about the

same if not more because we do teach in both languages if it's done correctly. But it seems like you see bilingual as a crutch.

Because of these incidents, the school was forced to replace its bilingual program with one that taught English quickly to students. Students received instruction in Spanish for mathematics, social studies, and science and studied English as a second language for one period daily and an additional period of reading/language arts in English every day.

Transitional programs characterized the rest the schools. At Kahlo, the focus was on English acquisition while providing additional support to ensure that the ELLs master English. Kahlo's ESL teachers spent 4-5 periods each day in bilingual classrooms. The expectation in the school was that Spanish-speaking students would enter monolingual classes after three years in a bilingual program.

Marti provided a bilingual class and a transitional class on each grade for grades K-3. On a trial basis, one classroom on each grade offered English-only immersion for upper level bilingual students. In addition, ESL was provided for students in monolingual classes and classroom assistants were bilingual. As in Kahlo, the ESL teachers helped teach the content areas rather than English as a Second Language in isolation. The amount of daily time that ESL teachers spent with individual classes during the reading block increased from 30 minutes to one hour during in the second year. In contrast to Lopez and Kahlo Schools, ELL children seemed to transition much more quickly from bilingual classrooms in Marti, in some cases within a year.

At Cardenas, the district followed the traditional transitional bilingual model. Teachers taught content knowledge in Spanish, and taught English as a Second Language. The school regularly tested students (twice a year) and classified them in three groups from Spanish dominant to English dominant.

While transitional programs were the norm in these schools, teachers' practice with the use of English varied. In one school, a teacher reported, "Some children want to try to write in English, we encourage them to do that. I don't like to force it. If I see that they're ready, excellent. I don't want to hold them back." Another from the same school only spoke English in the class, in spite of being bilingual, because she thought that students would learn English faster if only English was spoken and written. This approach is closer to full English immersion rather than transitional programs or "sheltered English" where teachers teach the content in English providing some translation or help to English language learners. For example, a teacher who enforced immersion reported writing phrases on the board to help the ELL students besides mixing ELL with monolingual students so that they would learn English faster.

This approach indirectly focuses on the learning of the language over the math. In one observation where the teacher only spoke English, some students did not understand the math because they did not understand the language. These students were doing nothing during the math class. The teacher was forced to translate when she realized, but at that point, the students were already behind in the explanation. Some students however, went to their peers for help and the more advanced ELL students assisted their classmate spontaneously.

In Kahlo, not all staff members share the transitional program vision. The acting principal there was concerned that some children were not ready for total instruction in English. He said,

It is hard for some kids. So some kids might have the knowledge but they are so shy that you would kill them if you put them in a regular classroom. So better to give them another year to improve their English skills a little bit more. Their speaking skills. And then do it. So with those kids, we have them in the bilingual class, yet we

know that they really could have exited so our goal is to still support them in Spanish but really have them transition to English. So the teacher knows coming up, these three kids are supposed to be instructed entirely in English. But they still use Spanish in the classroom.

In Marti School, some teachers also questioned the transitional program and taught the content in Spanish because they argued that otherwise their students would not understand the concepts. In particular, one teacher who taught in Spanish had recently arrived student in her classroom.

These examples showed that there was variation within the schools depending on teachers' beliefs about what was best for their students. This happened in spite of the school mandate to have a transitional English program.

Grouping

The four schools grouped students by language as well as math or science ability. In most cases, language ability was the more important criterion. In some schools, classroom observations suggested that this grouping strategy was problematic because changes in class composition during the school year made it hard to keep stable classes and the numbers of students at different language levels did not always work out evenly. In addition, homogenous grouping reduced opportunities for students at different levels to help each other in class.

At Lopez, teachers said they had no input on grouping students. Besides using language ability as one of the criteria, the principal asked teachers to provide a list of students and their performance. The principal used students' performance as other criteria to group students. Some teachers opposed homogenous grouping. One teacher mentioned that students who have the math ability but not language ability were not included in the algebra class. Another teacher said,

It's usually, the thought was at one point to group the children in the bilingual program by language proficiency. Of having the port of entry students all together... We're asked to give a list of performance, you know, by students, rank them by performance. And then they sort of group classes like that. I don't find that... fair. It's not fair towards me. I don't think that that is healthy for the children, either... Because then you can work with the children that are not having those kinds of behavior problems or emotional problems or learning problems, to help those children. If you have a classroom completely set up where all the kids have learning problems...

At Cardenas, students took a test and were grouped homogenously based on their language proficiency. Because the number of ELLs was not distributed equally among the grades, staff found it necessary to combine students with different levels of English ability in the same class on certain grades. For some grades, they placed advanced bilingual students in monolingual classes. In general, the principal tried to have one bilingual class per grade level, but because of the high mobility and students coming in during the year, they could not keep this organization. The principal tried to provide an additional teacher for both situations at different times of the day in recognition of the difficulties encountered by Cardenas's more advanced bilingual students.

In some classrooms, bilingual teachers pulled students, who need to be taught in their native language, out of the classroom for math and literacy, or bilingual teachers would work with bilingual students and regular teachers would work with students who know English together in the same room. Some individual teachers tried to remediate the problem by pairing students who knew English with students who did not, in addition to holding bilingual classrooms.

Staff Allocation

All schools prioritized tested grades over non-tested grades in allocating staff. This implied that more staff were allocated to those grades. At Kahlo and Marti Schools,

teacher leaders—i.e., teachers with release time to provide support to their peers—spent most of their time working with teachers in tested grades. At Marti School, the principal mandated that classes in tested grades would be divided in two groups, one for the regular classroom teacher and one for the teacher leader so that teachers could better reach individual students. A similar approach was taken at Kahlo where the teacher leaders taught some of the tested grades.

In addition, ESL teachers were placed in after-school programs that focused on the teaching of English to understand the math test. At Lopez, ESL teachers were required to team-teach with regular classroom teachers in tested grades. The expectation was that both teachers would teach the content, one in each language. Teachers decided not to implement this approach after trying for a few weeks because they argued that it was too confusing for the students having two people talking at the same time in two languages, and it was too confusing for the teachers, as well.

Assigning teacher leaders to teach tested grades meant that teacher leaders had less time to provide assistance and in-class professional development to teachers. Moreover, because the emphasis was placed on math and literacy, no ESL teachers were provided to assist in other subject areas such as science. For example, one of the interviewed teachers in Cardenas, who did not know Spanish, was a science teacher. Science is not tested in the elementary grades and not viewed as important by administrators in all three districts as mathematics and language arts. She commented that she would learn the basic words of the topic she would be teaching in Spanish to be able to talk to her ELL students. Most of the time the teacher did not have a Spanish speaking

aide in the classroom so she relied on the students who were more advanced to explain science to the other students. Still, she said:

To me you know, not having a bilingual speaker in the room is very difficult at times. Mostly I rely on the other students. And I pick the stronger bilinguals but they're always, they're in the bilingual room because they're just learning the English language so their vocabulary is not as developed as mine. So when I'm explaining directions and things, sometimes stuff gets lost in the translation.

The lack of staff to assist the science teacher in Cardenas had a tremendous impact on the quality of science instruction and learning. It is questionable how much students can learn when the teacher speaks only in English while saying random words in Spanish that students may not know in their own native language because they may be learning those science concepts for the first time.

From Enrichment to Remedial After-School Programs

One strategy that all four schools adopted was redefining their after-school programs. After-school programs had included enrichment activities, such as sports or arts. They also were used as the "homework club" and, more recently, as test-preparation classes. Most recently, these schools targeted their after-school programs to ELL students.

At Lopez and Kahlo, the after-school programs focused on teaching math in English as part of the test preparation efforts. Bilingual students received more after school lessons than monolingual students did. A teacher said,

Well like right now, for the GEPA [the 8th grade state test], the ESL, the bilingual students are going to classes after school five days a week and the monolinguals only go I think twice a week so...They are stressing English.

To emphasized the learning of English, the school provided ESL teachers for the after school programs. A teacher commented,

We have a very large ESL staff. We have ESL teachers, we also in the after-school program this past year started using ESL teachers to help us um, ah, with second language acquisition as well. We never really had ESL instruction throughout the after-school program, as well.

At Cardenas, the school also offered “Port of Entry classes”. This was an after school program aimed at teaching English. The programs ran every day for an hour-and-a-half. The goal was “to make our students more fluent in English.” Students who needed the most help in learning English also received tutoring during the school day in reading. In addition, the school offered an ESL program for parents.

Teaching the Vocabulary on the Test

One teaching strategy adopted across the schools was teaching English vocabulary relevant to the test through the after-school program and during regular instruction. For example, Kahlo School compiled a list of the 100 most frequently occurring words on the math section of NJ-ASK [the new 3rd and 4th grade test] to be used as a resource for ELLs.

At Cardenas School, teachers taught students to use “key words” that could suggest which mathematical operation were needed to solve a word problem. Teachers reminded students of the key words they needed to memorize. Teachers posted key words on the wall as observations documented:

There are posters of math words on the wall that read: Place value, digit, equals, value, inner, outer, thousands, hundreds, tens, ones, sum, addend, add, subtract, minus, standard form, expanded form, estimates, round, about how many, regroup, carry.

Two other posters read: Key addition words, use + if you read: Add, sum, total, plus, in all, altogether. Key subtraction words, Use – if you read: minus, subtract, how many more, how much more, how much farther, difference, less, left.

A Marti teacher took a different approach. Instead of teaching key words, she taught her students to translate their answers into English. She asked students to solve the problem in Spanish, arguing that naturally ELL students think in their mother tongue, and translate just the answer into English. She required students to translate about five sentences everyday for homework to get them ready for the test. This would allow students to solve the open-ended problems if they have the tools to understand the problem through the use of key English words.

In summary, the strong pressure to increase test-scores has affected not only the way schools teach ELL students, but also some aspects of how they teach math and science.

Conclusion

This paper provides an exploration of math and science teaching for English Language Learners in four schools in New Jersey. Results must be treated as tentative both because they come from case studies of a limited number of schools and because the case studies were not originally designed to pursue questions about the education of ELLs. Nevertheless, they provide a picture of how these students are being educated in math and science in a part of the country where that population is growing rapidly and where little attention has been paid to this issue.

Teachers used a variety of strategies to support ELLs. How they used those strategies depended substantially, since these ELLs were largely Latino, on their knowledge of and beliefs about using Spanish. One case study teacher had a strong academic knowledge of Spanish and English and considerable skill in inquiry-oriented approaches to teaching math. She could move between languages effectively to build a

discourse that helped children develop a deep understanding of the content she taught. Another had a good understanding of inquiry-approaches to instruction but her understanding of academic Spanish was limited so she was likely to confuse students or at a minimum not support the development of their knowledge of Spanish. A third teacher understood Spanish but used English primarily. She worked with a Spanish-speaking aide so students would have a clear sense of each language being spoken. The fourth teacher spoke almost entirely in English because she believed in immersing students in the language of this country and forcing them to cope.

All teachers wanted their children to wind up speaking and writing English, but they differed in their beliefs about how quickly they should shift to English. They also differed in their knowledge of academic Spanish and the models they provided of correct Spanish. In keeping with a discourse perspective, all teachers used a variety of tools to supplement whatever language they spoke. They rarely received extensive ongoing support from their districts. In District C, there was support for initial certification as ESL or bilingual teachers, and District B provided assistance for learning Spanish.

Beyond that, most bilingual policy across the three districts was geared to rapid conversion of students to English, not so much on pedagogical grounds but because of pressures to raise test scores. All three districts had schools that were at risk of not meeting AYP criteria, sometimes because of achievement gaps involving ELLs. Because these students were tested in English, district leaders apparently believed that instruction should be as much in English as soon as possible. Thus, districts supported a number of moves in that direction including the use of transitional and immersion policies and devoting time to teaching vocabulary that would be on tests. Districts also put resources

into tested grades by allocating teacher leader time and making resources available after school, but these moves were usually at the expense of some other grade or use of funds so whether they contributed to long-term growth is hard to say.

Two arguments were made against these policies in the schools, however. First, there was a sense that forcing students into English too soon created a barrier to content instruction. Children were believed to not learn math or science in part because they did not understand what was going on in the classroom. Second, children were shy, and those who were not fluent in English were hesitant to participate in a language they had not fully mastered. Those who made these arguments did not question the need to help students develop fluency in English. The question was about timing and effectiveness.

Beyond the preference for English-based instruction, we found more similarity within schools in patterns of content instruction than in supporting ELLs. This reflects clearer school and district approaches to teaching content than to supporting ELLs. Districts had more of a history of working with content areas. Periodically, they had to make decisions about curriculum and the professional development to go with it. Moreover, curriculum affected all students. ELLs were a new problem in two districts—District A and District B—although their numbers were growing dramatically.

What created the interest in ELLs was state testing and especially the regulations and sanctions linked to No Child Left Behind. The pressure these regulations and sanctions produced generated new interest in ELLs and a need within each district to do something quickly to raise achievement within this population. In fact, each district developed a variety of responses. However, with growing populations, high turnover, resource constraints and the fact the ELLs were but one of several priorities each district

faces, those responses appear to have taken the form of short-term, expedient coping strategies.

This report is an early exploration of how schools and districts respond to the needs of ELLs learning math and science. We need to know more about a variety of issues. These include teachers' understandings of the issues these students have, strategies for working with students and how those interact with strategies for teaching the content, effective modes for helping teachers to improve their practice, and policy instruments for supporting ELLs.

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