Inquiry Science in Bilingual Classrooms

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Abstract

This research was designed to determine the value of implementing a hands-on, inquiry science curriculum in classrooms where elementary children are developing second language skills along with their first language skills. The children were taught by interns from the University of Texas at El Paso in three elementary schools in the El Paso area. Half the instruction was in Spanish and half in English.The interns and in-service teachers provided evidence of the children's concept development. The elementary students provided data via an attitude survey and written assessments from 107 fifth graders. The consistency of the data indicates that there was a strong positive feeling about the value of this inquiry approach for increasing the children's language skills in both languages, that new science concepts were understood, and there was very little difference between children who chose Spanish or those who chose English to respond. The results of this research illustrate the value of a hands-on inquiry science program in a bilingual community.

Introduction and Background

The number of students entering our nation's schools with home languages other than English is increasing rapidly, and by 2050, it is projected nearly one-quarter of our population will be Hispanic (Riley, 1999). Often teachers have little or no preparation in working with these students (Samway & McKeon, 1999). The student who is in the process of learning English must focus on the academic content as well as learning a new language. It is important to provide tools to assist our teachers to provide quality learning experiences for their children even though the student and the teacher speak different languages.

Inequities

Latino/as represent about 10% of the U.S. population, and this percentage will increase in the next generations. The largest numbers of students in U.S. schools who are learning English as their second language are students from

Spanish-speaking homes. Latino/as and other minority groups must be fully able to participate in science to improve the quantity and quality of human resources of a country. In addition, a poor understanding of science and its implications is a disadvantage for any individual in the dynamic society of the future. Yet, Latino/as are not equally represented in science careers. Only 3.5% of the nation's graduates with science and engineering degrees in 1991 were Latino/as (Vetter, 1995), and only a small fraction of Latino/as enter chemistry and physics careers. Often, they receive a remedial science curriculum or none at all. "Disproportionate percentages of poor and minority students (principally African American and Hispanic) are using curricula designed for low-ability or non-college bound students. Furthermore, in general, low income and minority students have less contact with the best qualified science and mathematics teachers" (Oakes, Ormseth, Bell, & Camp, 1990). In multilingual communities, science education is often eliminated as schools focus on teaching the students English (Mason & Barba, 1992).

The dropout rate for Hispanics is 3.5 times than for White, non Hispanics (Secada, Chavez-Chavez, García, Muñoz, Oakes, Santiago-Santiago, & Slavin, R., 1998). Hispanics are often held back at least one grade, are mostly in urban school districts, and score significantly below national norms on academic achievement tests (García, 1991).

The inequities in Latino/a representation in science are even greater in some areas. In Texas, Latino/as represent 40% of the population, and this number is higher for the school-age population. On the 1996 National Assessment of Education Progress, 45% of Texas eighth graders were below the basic level in science achievement. Of the Hispanic eighth graders in Texas, 67% were below the basic level in science achievement (O'Sullivan, Reese, & Mazzeo, 1997).

Quality Science

Children, even from infancy, are natural scientists. They want to know more about the world. They explore their world by bringing information into their minds. They gather data through their senses, emotions, trials and errors, and conversations with others. They form concepts about their world, and they want to share that information with the people in their world. They observe with interest and they ask many questions.

When we organize explorations of our world into careful ways of forming questions, gathering information, designing investigations into natural or human made phenomena, and communicating the information publicly, we call it science. It is a process of finding answers and a system for organizing and reporting discoveries. The science education reform movement in the *National Science Education Standards* (National Research Council, 1996) describes science learning as active learning with many and varied opportunities to do science as scientists do science. They collect, sort and catalogue, observe, take notes, make sketches, interview, measure, and chart.

These skills combine with critical thinking to develop understanding. The document stresses the need for a quality science education program for all students, "regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science" (p. 2). The reasons for this emphasis are to provide personal fulfillment and to prepare U.S. citizens who are personally fulfilled and able to make wise decisions about our increasingly complex world.

The first of the 10 science content standards listed in the *National Science Education Standards* is the standard of inquiry. The description of inquiry in the document is more complex and encompassing than the steps to the scientific method. Students should:

> Develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (p. 105)

Teaching science to children should be enhanced by the use of inquiry and based on their natural tendency to explore their world. As teachers or family members, we guide them into more formal science skills. We help them learn to organize their questions and information gathering so they gain a deeper and more thorough understanding of a concept. For example: condensation on the outside of a cold glass appears to be water leaking out through the glass. More investigations with empty cold glasses, mirrors, and tea kettles provide data that will lead to better explanations. We give them tools such as hand lenses and magnets to gather more information. We help them organize their information into charts, tables, and graphs. As their development levels grow, we begin to lead them to understand how to design and interpret investigations. We help them analyze the information and communicate what they have learned about the exploration.

Inquiry Science as a Language Learning Tool

The U.S. Department of Education and the Evaluation Assistance Center East (George Washington University, 1996) created the "Guiding Principles Promoting Excellence" to ensure academic success for students who are learning English as a second language. These principles clearly define an optimal learning environment for students who are learning English, as well as other disciplines, which is the responsibility of educators, the family, and the community. They stress effective second language acquisition strategies and challenging academic programs built on the cultural and linguistic strengths of the students. According to the principles, these students should: (a) be held to the same high expectations of learning established for all students, (b) develop full proficiency in English, (c) be taught challenging content in all

areas, (d) receive instruction that builds on their previous education and cognitive abilities, and that reflects their language proficiency levels, and (e) be evaluated with appropriate and valid assessments.

García's (1991) analysis of recent descriptive research has documented instructional practices that have led to success for students who bring diverse languages and cultures to the classrooms. He consistently found integrated student-centered curriculum where literacy was pervasive in all aspects of the instruction. Teachers organized instruction so that students worked collaboratively, and student-to-student interaction was very common. Teachers in the primary grades used both Spanish and English, moving toward mostly English in the upper grades. However, students were allowed to use either language. García notes that students progressed to conventional writing in English in the upper grades and made the transition from Spanish to English themselves. The teachers did not pressure them to transition.

Several other researchers have found that student-centered inquiry classrooms provide excellent language and content learning for students learning English (De Avila & Duncan, 1984; Kessler & Quinn, 1987; Mohan, 1986; Thomas & Collier, 1995; Nieto, 2000). Students are allowed to use their natural curiosity to examine their world. They are actively engaged in the processes of science. They observe, introduce variables, record, measure, predict, infer, inquire, and explore. This allows greater involvement than a vocabulary-driven lecture or text book approach. In the active science classroom, students work in groups to talk out their thinking and planning. The oral language is imbedded in the context. The opportunities for the language learners to develop new language is social and based on commonly understood concepts. The opportunities are also strong for all students to develop new understandings and new vocabulary.

Language Development Programs

Often in the United States, bilingual programs have attempted to eradicate bilingualism as quickly as possible. Linguistic diversity has been viewed as a problem—a barrier to learning. Once the student speaks English, "real" education can take place. As a result of this thinking, some programs have been designed to help the students eliminate their home language. One serious social consequence of this approach is taking from the student and future generations the ability to communicate with their older family members and older members of their society.

The researchers were exploring inquiry science as a tool particularly helpful for teachers across the nation who are teaching children with a home language other than English and who are in the early stages of learning English. Therefore, we chose to implement the program in three schools in El Paso, Texas, where the children are mostly Spanish speaking and who are at various stages in their English language acquisition. In these schools, the teachers are implementing the transitional bilingual model and the maintenance bilingual model, or a blend of the two.

Research Design

The research was designed to determine the value of implementing an inquiry science curriculum in classrooms where elementary children are developing second language skills along with their first language skills. About half of the children were taught in English and about half in Spanish. This was determined by the classroom teachers' perceptions of their students' English- speaking ability. The data were gathered to provide information about the children's concept development and vocabulary development. There was no intention to do a controlled experiment to compare classrooms taught all in English or all in Spanish.

The children in the study are kindergartners through fifth graders in schools within two miles of the Mexican border. Their parents are often recent immigrants living in low-income communities. The majority of the students are Spanish-dominant English language learners. The schools group the children by their English-speaking ability. However, factors such as inadequate assessments, numbers of children per teacher, numbers of new students, etc., prevent these from being homogeneous groupings. Most of the classrooms are providing some or all of the instruction in English. To try to determine an understanding of the teachers' perceptions of their students' language abilities, the teachers in the 13 third-grade classrooms were asked to rate their classes on a scale of 1 (Spanish-speaking only) to 5 (fluent in English and Spanish). One classroom was rated as a 1, three were rated 2, five were rated 3, one was rated 4, and three were rated 5. Therefore, the teachers believe that most of the students are still developing English fluency.

In the bilingual models in these three schools, most of the instruction is provided in Spanish in the primary grades. As they enter the higher grades, more and more of the instruction is provided in English. The goal is for the children to be bilingual after their elementary school experience without sacrificing content learning. However, new students enter the schools with varying levels of English language acquisition. Classes are often created in the higher grades to provide most content instruction in Spanish to children who are new learners.

The science programs at the three schools were weak. A few teachers used science fair as an ongoing science program, but most used it as a short-term project in the spring or did not participate. No regular science curricula was in place in the schools. In one of the schools, a fifth-grade teacher taught science to all the fifth graders each day.

During the research period (spring 2000) over 100 university interns from the University of Texas at El Paso (UTEP) Teacher Education program taught from 6 to 12 science lessons in one of the three schools. Sixty-two teachers from the three schools opened their classrooms to our intern teams one afternoon each week. Most of the university interns are bilingual. The university interns provided instruction in the language that the classroom

teacher recommended. In about half of the classes the curriculum was delivered mostly in English and about half was delivered mostly in Spanish. In three classes the interns were asked to teach only in Spanish, and in 10 classes they were asked to teach only in English.

The university interns taught the Full Option Science Series (FOSS) curriculum on a weekly basis. FOSS is a hands-on curriculum for science instruction and assessment for students in kindergarten through Grade 6. The inquiry-based collaborative learning program was developed via extensive research and design by the Lawrence Hall of Science, University of California, Berkeley. It aligns with the instructional program described in the National Science Education Standards (NRC, 1996). FOSS is one of several inquiry-based elementary science programs. It was selected because the curriculum materials were provided to the schools in the study by a grant through UTEP Engineering Programs, funded by Agilant Diversity in Education Grants. FOSS has curriculum and student activity sheets available in Spanish.

Data Analysis

Data were gathered from the university interns, the children in the 62 classrooms receiving the new science curricula, and the teachers who participated.

University interns provided data through written responses (from 100 interns) and three focus group sessions (20 interns total). The interns were asked to write an open-ended paper about their experience after implementing two lessons. After four weeks, they were asked to provide written evidence of the elementary students' development of a specific concept, and evidence of students' development of language (English or Spanish). After the sixth week of teaching, 20 of the students participated in one of three focus groups to address the question, "What was the effect of implementing the inquiry curriculum in this school community?"

The qualitative data from the university interns (written comments and focus group comments) were analyzed using the constant comparative method (Lincoln & Guba, 1985; Maykut & Morehouse, 1994) by coding and categorizing the comments and selecting the most common themes and strands. Using more than 300 pages of qualitative information from the university interns, the most typical or relevant comments are reported. Only 12 comments were negative and they dealt with not having enough time to get to know the children by name and problems with the live materials. (The snails were dead when the interns started their lesson, and some of the seeds did not germinate.)

Elementary student data sources were an attitude survey from 80 third graders and a written assessment from 107 fifth graders. The attitude survey results were the total responses for each subject the children selected. The data from the fifth-grade written assessments were analyzed in two categories: "acceptable answer" or "not acceptable answer."

The classroom teachers responded about their perceptions using a Likert scale and through open comments. The totals for the scale responses are reported.

Results

Evidence of Increased Content Knowledge

The inquiry curriculum used in this program was designed to engage students in science thinking processes. The goal of the program is for students to learn important scientific concepts and develop the ability to think well by actively constructing ideas through their own inquiries, investigations, and analyses. Because the future is so dependent on changes brought about by science and technology, it is important for all citizens to be scientifically literate. Project 2061 of the American Association for the Advancement of Science (1990) describes scientific literacy as:

1. Familiarity with the natural world;
2. Understanding the big ideas of science;
3. Knowing that science, technology, and mathematics are interdependent human enterprises;
4. Ability to think scientifically;
5. Using scientific knowledge and thinking patterns for personal and social purposes.

In earlier experiences with inquiry science curricula, the authors had noticed the potential for this program to develop science concepts and critical thinking. However, existing programs were not large scale, not consistent, and were not implemented in these schools where children were learning English as their second language. Because the curricula and support materials were available to all the university interns, and the science teaching experience was the basis of their science methods course, we could assure that the curriculum was taught as it was designed in an inquiry manner. This provided the opportunity to gather relevant data.

The data from this research provide evidence that the elementary children involved in the program did develop concepts and thinking abilities that are components of scientific literacy. The sources of this evidence are (a) university interns via written comments and focus group interviews, (b) in-service teachers in the three schools via a Likert scale and written comments, (c) elementary students (80 third graders) via an attitude survey, and (d) elementary students (107 fifth graders) via written assessment.

Perceptions of the university interns

The university interns gathered specific information that they felt gave evidence that the children were learning science concepts. During the short time, we did not expect the interns to have a thorough understanding of every

student's learning record, nor how to adequately assess their learning. However, when we asked them to give specific examples, the following evidences emerged.

Kindergarten children developed observation skills through examining and comparing animals such as worms, snails, and fish:

> Intern Ana: It was impossible to focus on one child's response because all were making successful connections and discoveries. When asked to recall information from the prior week's lab, the majority of students had a response. One little girl recalled that they observed worms, which she had put on her nose and it has wiggled. When asked about the snails, they were able to respond successfully to each of the questions posed.
>
> Intern Barbara: The kindergartners are able to compare themselves to the animals. The children look for a nose, a mouth, eyes, and ears on each of their animals. The room is full of noise and giggles as they explore their animal of the week. I can't wait to do the snail race this week!
>
> Intern Carla: One little girl was observing the fish. She was really studying it. I asked, 'How do you think the fish moves?' She replied, 'Look Miss, see the fins move him.' I asked a little boy why does the fish have a tail?' He said, 'So it can turn itself, see?'

First-grade children grew plants using four methods of propagation:

> Intern Delia: We asked them, "What do you think will happen if we put the stem in water?" Many students have been precise on answering that they hope to see roots. Most children drew the stem as the first picture and the second with roots and leaves.
>
> Intern Eddie: The children are also grasping and acquiring the information given and observed. Every week they jot down their observations which leads them to compare and comprehend their observations.

Second and third graders explored air and weather:

> Intern Fran: They have learned that a parachute will move depending on what direction the wind is blowing. Also, they learned that adding weight to the parachute will have an effect on the movement of the parachute.
>
> Intern Gloria: The students were able to explain why a balloon rocket travels. When we asked, "What happened when the balloon inside the bag was released?" Jorge said, "El globo viajó porque el aire se salía, así se empujaba." (The balloon traveled because the air went out, and that pushed it.) Edith stated that she blew on the pinwheel from different directions and the best direction to blow should be from the side.

Fifth-grade students tested foods for fats, acids, and sugars:

> Intern Aidi: Children were asked what they had learned in the previous lesson. They replied that the had learned about nutrients. They named all six: fat, proteins, carbohydrates, vitamins, minerals, and water.
>
> Intern Jorge: I observed many exciting conclusions coming from the students. I heard and watched the students grasp the understanding of how yeast absorbs sugar. The students were understanding how yeast "wakes up" with heat and sugar. I am learning along with the students and enjoy the activities.

The interns provided many examples (from their perceptions) indicating that the children were using their thinking abilities:

> Intern Karin: I have noticed that no longer with prompting they are immediately looking at how the animal moves, or if it has eyes, or if it has a tail. They are connecting the new information with the old information. The comparisons they are making involve excellent thinking skills. Lastly, I have enjoyed our lessons because their vocabulary has grown and reflects their new knowledge.
>
> Intern Lynn: The students are coming up with wonderful and creative ideas. We use these ideas as extensions and spring boards to new science concepts and vocabulary. The weather journals have been a plus in assessing how the students are relating to the science concepts being taught—especially because they are free to put their ideas as they see it. I am really having a good time with this project.
>
> Intern Mary: We noticed that they were full of questions and answers. When we let them study and play with the materials, they came up with several different things to do with the supplies. Things we didn't even imagine.
>
> Intern Nate: The thing that is working really well for me is letting the students discover the new roots growing on their cutting without giving them the answer. I find that the students are much more engaged in part of the learning process when they discover on their own. And I am better able to gage what they are and are not understanding.
>
> Intern Olga: I think that the kids were happy with the lesson as well. I think that they like the freedom they are given to explore and create on their own. This guided self-learning stuff really does work! You can see and hear learning take place in the room. Sometimes the kids will bring up good questions that maybe we did not think to mention about the lesson.
>
> Intern Patti: The teacher in the classroom really likes what we are doing and is surprised at how many questions the children are actually asking at the end of the class. As the children share and discuss

throughout the activity, they are learning new vocabulary words. Using the charts and recordings are a great tool as the students graph, record keep, and make observations.

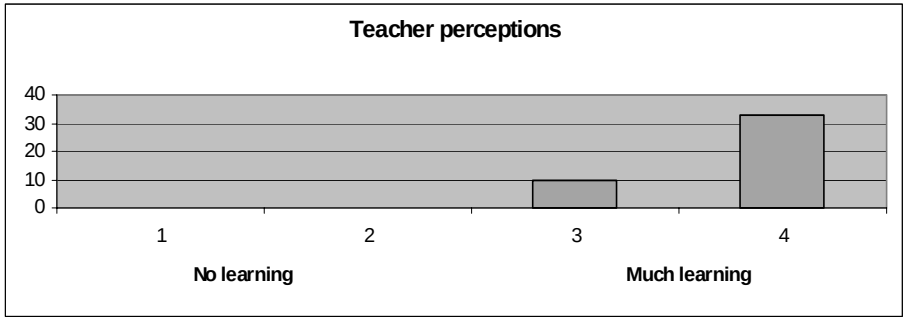
In two examples, the students demonstrated the AAAS Project 2061 skill of using scientific knowledge and thinking patterns for personal and social purposes:

> Intern Reina: The students' input is excellent. Actually our students have begun to be interested in weather. Some statements they have expressed are, 'I watch the weather channel' and questions like, 'What is the wind chill factor?'
>
> Intern Sara: One important thing is they had fun and that will push them to like science. I don't think science is fun except now. I don't even remember my science. My students even made connections to water pressure: "That's how the water comes up in a fountain!"

Perceptions of the teachers in the three schools

Most of the 62 classroom teachers stayed with the interns to observe the lessons. They were asked to rate their student learning during the science classes on a scale from 1 (no science learning was evident) to 4 (much science learning was evident). Of 43 responses, 33 rated the learning as a 4, and 10 rated their learning as a 3. The chart below presents the numbers of teachers who responded to each of the four levels.

Figure 1. Teachers perceptions about their students' science learning



In addition to the data (above) about their students' learning, 35 of the 43 teachers volunteered comments and all were positive. Typical responses included:

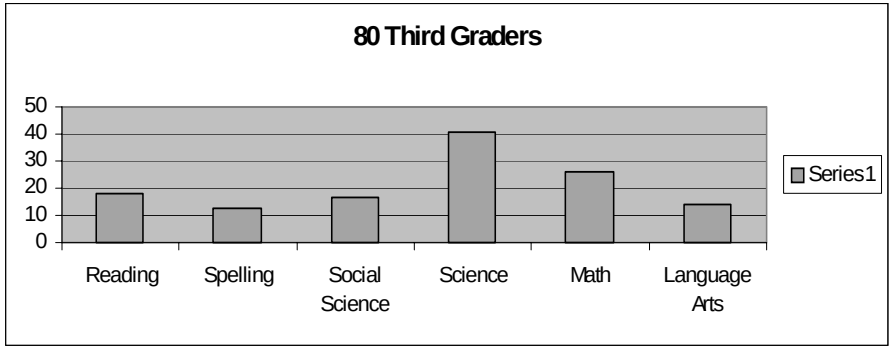
1. "The investigations really motivated all the students to participate and enter the scientific process."
2. "Please do it again! My students' science learning was very much evident, and we want more! I highly recommend these wonderful science student teachers to anybody interested in science learning."

3. "The children were very responsive to every lesson introduced. They looked forward to Mrs. Hernandez and Mrs. Avila's visit. Thank you for allowing us to participate with UTEP."
4. "Great lessons, very effective discipline management."

Elementary students' attitudes about science

The third graders in the program were asked to circle their two favorite courses from the list provided below (Figure 2). Science clearly is one of their favorites. Science had not been taught in the third-grade classrooms during the school year prior to our program.

Figure 2. Students' favorite subjects



Written assessments from the elementary children

There was little hope to find evidence of students' increased content knowledge after six one-hour lessons spread over six weeks taught by interns; but we made a focused effort to gather authentic data. Gathering evidence from students under these conditions is difficult; however, with the assessments embedded in the curriculum, we were able to administer one written assessment to 107 fifth graders in the three schools. All had participated in parts of the Foods and Nutrition Unit. This four-page written assessment was available to the students in Spanish or English and they could respond in the language of their choice. Fifty-five percent of the children chose to respond in Spanish, and 45% responded in English.

The first item asked that the student read a drawing of the results of a fat test and place the foods in order from most to least fat. They were to observe the ring of oil that formed around the food. All students had participated in this activity for testing fats. Most students (54% Spanish and 46% English) were able to respond correctly.

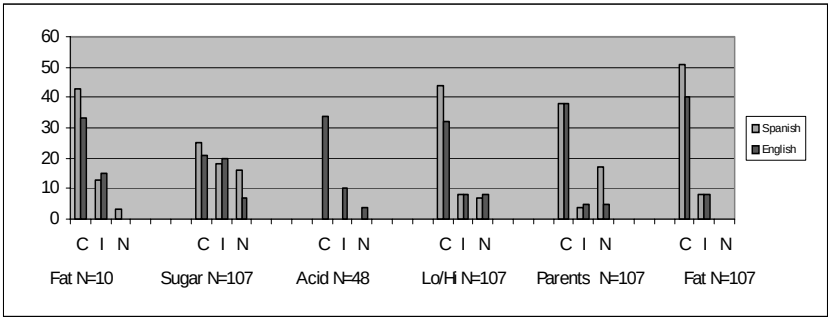
In the acid test question, the students had to identify which food contained the most acid by the amount of carbon dioxide that formed when baking soda was added to the food. The gas was measured in a syringe placed in the bag containing fruit juice and carbon dioxide. Only two classes (both English speaking) performed this lesson during the six weeks. Of the 48 students who responded to this, 71% were able to correctly list the juices from most acid to least.

All of the classes had done the sugar testing activity, but the question to determine their ability to do a sugar test required that the students describe the correct procedure, a rather complex series of steps involving crushing equal quantities of different cereals into baggies, adding a quantity of dry yeast and warm water, placing them in a water bath, and, after a certain time, measuring the gas that is formed. Only 38% of the 84 children who responded to this question were able to identify some aspect of this test (14 Spanish and 18 English). Only two children (English) wrote all the steps to the procedure. Others responded to this question ("Tell what you would do if you wanted to find out if a contained sugar") by writing that they could read the label on the package (8 Spanish and 7 English). Reading package labels was a part of the lessons, and this is a technically correct answer, so these are included in the correct response column. Reasons for these less than satisfactory results may be the short time for taking the test, the complexity of the response, or students' lack of knowledge about the test.

The responses to three open-ended questions were analyzed. The first was to list foods that were high in fat and ones that were low in fat. Most students were able to do this correctly. The second was to tell why parents want their children to eat their vegetables. Almost everyone who responded was able to identify that vegetables are healthy or they will not make you fat. The third question analyzed was to define a fat. In this question, also, the children responded satisfactorily that fat is a nutrient or food high in oils.

Time to administer this assessment was cut short in most classes because of external programs. Some students did not respond to every question. Not enough information is available to tell if it was because of a time factor, because they did not cover this concept in the lessons, or because they did not understand the question or answer. Students were able to read and answer the assessment in either Spanish or English. Figure 3 (below) summarizes the results of the assessment. The first bar shows the number of correct responses, the second the number of incorrect responses, and the third the number who did not respond. Of particular interest is the similarity of results from Spanish responses and English responses.

Figure 3. Fifth-graders responses to nutrition content questions



(C–Correct response, I-Incorrect response, N-No response)

Elementary students' language development

There are several reasons why inquiry science is especially well-suited for students learning a second language. First, the activities are hands-on and interactive, and the concepts are built through manipulating the materials, prior knowledge, and verbal interaction with peers. Second, the foundation for many science terms is Latin, and its vocabulary is often similar to Spanish. Third, the inquiry approach is inclusive rather than exclusive. We observed, for example, a classroom where the students were speaking about the science lesson to each other mostly in Spanish as the university interns conducted the class in English. This bilingual phenomenon occurred throughout the lesson, enabling every child to be fully involved. In this activity, the children were given a large syringe and a plastic tube and told to use these tools to explore air. Each child attached the tube to the syringe and began pushing and pulling air through the tube. Soon, each child found a partner and asked if they could use the friend's syringe to attach to the open end of the tube. Then they both began pushing the syringes. They could force the air into the tube, but when one student released her or his pressure on the plunger, the air pressure forced the plunger backward. The syringes were marked so the children began to measure the amount of the pressure. Soon one of the children addressed the intern in English: "Look, Miss. You can feel the air push." She asked the children if they knew the science word for "air push." When no one responded, she said the word was "compression" in English and *compresión* in Spanish.

The interns' comments support the value of using science to build concepts in classrooms where children are learning English.

> Intern Tina: The children are learning a tremendous amount in both the bilingual and monolingual classrooms. I really believe that we have eliminated the language barrier. The barrier is not present because our lessons are heavily based in observation. Therefore, there is no wrong answer. They are eager to describe what they see.
>
> Intern Umberto: Even the students who have problems understanding English try to find out what to do because they want to be involved.
>
> Intern Vickie: We were monolingual English. I noticed all were willing to participate even if their answer was wrong. They didn't care, they wanted to share their thinking.
>
> Intern Will: Maria was able to verbalize the name for air pressure in her native language. However, when in English, she seemed confused.
>
> Intern Arleen: We have learned that in science there are no language barriers with hands-on activities. The students can relate the ideas presented in the activity with the world around them.

Thomas and Collier (1995) found that classes that are highly interactive provide the kind of social setting for natural language acquisition to take place simultaneously with academic and cognitive development. This was

evident as the children were trying the target language and building new vocabulary.

> Intern Beth: Students use the terminology learned about air and weather in a social manner. The students were able to use the vocabulary we presented them with (in English) and used those words to answer questions we asked them. Classroom participation has been very successful.
>
> Intern Carl: We definitely see evidence of students developing language. They are using the vocabulary they have learned to describe their plants. During the "roots" lesson, they kept saying that they loved eating "roots" referring to the carrots and radishes. Several of my students are referring to "nodes" in English. They are also referring to stems and roots when we talk about our cuttings.
>
> Intern Dina: Students will respond in English and were using the vocabulary of the lesson.
>
> Intern Elena: Three or four of the students try to speak in English but the majority of them feel more comfortable speaking in Spanish.

One intern team had a bilingual intern and a monolingual English intern. Their interaction showed respect for the children, for each other, and for both languages.

> Rosalie: I have even found that the children are trying to speak to me in English at times. I feel that this is hard—the language barrier—on the students and myself. I wish I know how to express myself in Spanish. I try to say something and I receive "blank" stares. I try to help them help me by asking them the Spanish word and then repeating it. This is when I get a "glow" of excitement.
>
> Rosana: The children seem to be having a great time and most importantly it seems like they are understanding what we are teaching them. I know because when we ask questions, they recall on what they have done or experienced. I only have one concern. That concern is that my partner at times does not feel comfortable speaking to the children because they are not fluent in English and she does not know much Spanish. I tell her that the children do seem to understand, they just can't express themselves in English. The great thing is that they try to communicate with us in English to help her!

In the monolingual Spanish classrooms, Spanish speakers were developing concepts and vocabulary in their native language. First language development can be accomplished through a language maintenance program similar to that provided at these schools or through two-way dual language programs. Many studies cite the value that cognitive and academic development in the first language has on the development of the second language (Thomas & Collier, 1995; García, 1994; Cummins, 1979).

Intern Gilberto: They develop Spanish. I said that because when they have to write what they learn, they ask how should I write this? Or how should I say this? I notice that they have the idea and they are asking how do you call this?

Intern JoAnna: They have mostly developed speaking and writing in Spanish. Their main language is Spanish. I found these second graders were able to express their ideas in Spanish very well. I was impressed by how well they can also write in Spanish.

Intern Kati: We taught monolingual Spanish and they were able to communicate with us. We didn't have any difficulties, because they were able to communicate with me all the time. They developed a lot of language skills. Sometimes they wanted a translation. They were translating for each other.

Limits to full inquiry learning when science is delivered solely in the second language

Although the children were fully engaged and learning, there is evidence that a lack of English skills is a barrier to the full inquiry experience when it is solely delivered in English. At the end of the interactive activity, the university interns held group discussions with the children. During this time, the children were encouraged to share what they had discovered in their explorations. This is a very language-rich experience as children are using new concepts and new vocabulary and publicly presenting their thinking to the class. On several occasions, the students demonstrated inquiry thinking by asking what would happen if they modified the materials or the procedure. The inquiry teacher used this as a starting point to lead children to designing scientific investigations.

In a setting where the teacher does not know the home language of the student, this group dialogue may be difficult for the student with very little English skills. With an inquiry curriculum, however, the teacher knows that the child was included and was participating in the majority of the lesson. The child was fully engaged in the science processes up until the point when the large group began to dialogue about their new experiences. This dialogue is a valuable point for the teachers to assess the students' understanding and thinking. When the teacher does not know the home language of a student in the early stages of learning English, this student will be at a disadvantage during the large group dialogue, and the teacher will not be able to assess the student as well as English speaking students. Further investigations into teaching English-language learners may reveal options to increase the student's involvement in the group dialogues and the teacher's ability to assess the student.

Intern Pat: I did instruction in English. The only problem was the vocabulary. The teacher wanted them to speak in English. When they wanted to respond they had difficulty with the language. For some

they had to respond in Spanish. Rather than having them not write anything, I let them write in Spanish. I wrote vocabulary in Spanish and English as they brought it up.

Intern Laura: I'm not really comfortable with using English with the children who struggle with the language. I believe that this prevents them from having all the fun the others have with the activity.

Intern Mayra: We tried the first week to conduct the class all in English. All the children were involved in the activity, but we found that the children are staying too quiet. They cannot discuss or question very well in English yet. Would it be OK if we tell them that they can talk to us in Spanish?

Intern Nora: The only problem was with translation. You could see in their faces they wanted to tell you something but couldn't bring it out in words.

Intern Rita: I think it should be taught in English and Spanish. It can be taught as a tool to teach English. It is easy for them to grab the concept. Mostly they speak Spanish to each other. Yet they tried their hardest to speak English to us. We set up the instruction in English. If we saw a struggle, we did Spanish one on one. No one was left out because we had two teachers and two monitors to assist the students. We worked as a team.

Summary and Recommendations

This investigation was designed to improve understandings about the value of teaching inquiry science in elementary schools where the children's home language is one other than English. We had the unique opportunity to observe closely the interactions between teachers, university interns, and elementary students in 62 classrooms, where almost all the children are learning English as a second language and science through an inquiry approach. We also had the unique opportunity to team with university interns who are bilingual and have a personal understanding of the benefits and detriments of various bilingual programs.

The consistency of the data gathered indicates that there was a strong positive feeling about the value of this inquiry approach for increasing the children's language skills in both languages and that their science content and skills increased. The student assessments show that new science concepts were understood, and there was very little difference between children who chose Spanish or those who chose English to respond. The children rated science as a favorite subject. The classroom teachers were strong in their assertions that these few weeks of inquiry instruction were effective in increasing their children's science content. The university interns were able to provide many specific examples of students' content and vocabulary development.

The results of this research illustrate the value of a science program in a bilingual community that is aligned with the high standards for quality as described in the *National Science Education Standards* and the *Guiding Principles Promoting Excellence* to ensure academic success for students who are learning English as a second language. Even with limited time to observe the curriculum implementation, the variety of sources of information and the consistently positive data indicate that this was a valuable method to achieve these standards in many models of bilingual education. The research was implemented to explore the value of an inquiry science tool for teachers who do not speak the home language of their children who are learning English. However, the data indicate that this type of science learning may be valuable in any bilingual setting.

Traditional programs in bilingual communities often eliminate science in order to focus on more rigid vocabulary development or implement a text book approach where the children are exposed to words but denied the opportunity to interact with materials from which to build related concepts. The standards for excellence in science education and in bilingual education are consistent in recommending rich content, high standards, interactive learning, and many opportunities for hands-on, minds-on explorations into real world phenomena. This can be achieved through a language-sensitive inquiry science curriculum.

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