Inquiry Science, Sheltered Instruction, and English Language Learners:
Conflicting Pedagogies in Highly Diverse Classrooms

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Over the past half century a great deal has changed in American education. Schools are no longer legally segregated, the number of students aged 25 years or younger has quadrupled, and currently one-fourth of all people in the United States are enrolled in school (US Census Bureau, 2001). Unfortunately, for all the money and expertise that has been invested in science education, especially during the National Science Foundation [NSF] heyday (Klopfer & Champagne, 1990), gaps persist in the science achievement between different cultural groups. The science education community seems unable to come to terms with the disparities in science learning of students from different cultural groups. The lingering divide between White student achievement and all other groups would imply we are only able to teach science to those students who are favorably predisposed toward the subject. For many, this suggestion is not only wrong-headed but ignores the moral imperative to teach science to all students (Siegel, 2002), an appeal frequenting the science education literature (e.g., AAAS, 1994; National Research Council, 1995). Unfortunately, the ambition to bridge the gap between the call of "science for all" and the realities with science classrooms remains unrealized. The will to resolve inequities in science achievement

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between Whites and non-whites is insufficiently buttressed by knowledge about how to accomplish this goal.

When planning to teach science to students who are English language learners (ELLs), science teachers and some science educators look to sheltered instruction (e. g., Echevarria, Vogt & Short, 2000) as a potential guide. The possibility of blending inquiry-based teaching (Olson & Loucks-Horsley, 2000) with a sheltered instruction framework seems a promising method for providing high-quality science learning experiences to students who are still working to attain English fluency. However, through our work with second graders, many of whom were ELLs, we perceived substantial discrepancies between our successes with teaching science by inquiry versus the manner in which sheltered instruction has been represented to us. We do not see this conflict as insurmountable; nevertheless, a fresh conceptualization of the interface between inquiry-based science teaching and sheltered instruction seems necessary.

Much of the research about teaching diverse learners focuses upon preservice settings. Alberto Rodriguez (1998) described efforts within his methods course to combat students' resistance to two interrelated belief systems about teaching diverse populations: ideological and pedagogical. Elaine Howes (2002) examined the predispositions teachers' hold about teaching science to all students. Christine Sleeter's (2001) quest for research examining the enduring effects of culturally responsive teacher preparation pushes us in a difficult but important direction: "Research in teacher education needs to follow graduates into the classroom, and our work needs to extend beyond preservice education, linking preservice education with community-based learning and with ongoing professional development and school reform" (pp. 102-103). The study reported here represents a modest effort at addressing this issue.

Context

San Juan School opened as a pre-K-6 building in August 2002. Students attending San Juan come from a mixed residential and commercial neighborhood (approximately one square mile in area), bounded by a major north-south thoroughfare to the east and an interstate to the west, just beyond which is an airport that is the hub for a major airline. To the north and south are the boundaries of two other relatively new elementary school buildings. The district in which San Juan School is located is undergoing substantial demographic changes because the federal government designated this city for refugee resettlement. The changing population resulting from the immigrant influx prompted the construction of San Juan. The consequence is a student population which

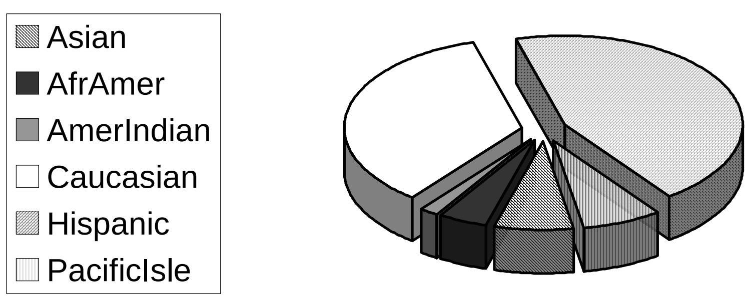
is very culturally diverse (Figure 1) with sixty percent of the students designated as English as second language or ESL (Note: our preference is for the ELL label yet the local district uses ESL to designate students as well as the training teachers are to take. Consequently we use both ELL and ESL throughout this article, always referring to students whose native language is other than English and who are being taught within a largely monolingual education system.)

These demographic features influence not only this particular school but also the district and several adjoining school systems. In the 1990s, the Office of Civil Rights within the U.S. Department of Education investigated whether area districts were adequately providing programs and teachers for the substantial number of English language learning students. Responding to this challenge, the school districts invested considerable funds in updating teacher professional knowledge to the point of instituting a policy requiring all teachers to earn ESL credentials.

Linked to the immigration trends, the families of San Juan School are predominantly lower income, although there are several middle class professional families whose children attend this school. According to district criteria, over 80 percent of the students are from "economically disadvantaged" homes. While those unfamiliar with Utah, which is where the study took place, might imagine a relatively homogenous student enrollment, the demographic reality is far from that. The two classrooms used in this study enrolled twenty-five students each with an almost equal number of boys and girls. Of the fifty children, sixteen were considered limited or non-English speakers, twelve were fluent English speakers (whose first language was other than English), and twenty-two were native English speakers. Among the home languages were Tongan, Bosnian, Spanish, Vietnamese, and Navajo.

On a curricular level, the science program at San Juan is susceptible

Figure 1.
Student demographics at San Juan Elementary School



to the same pressures as most elementary schools in the country. With a formal school-wide literacy program and the pressure to elevate student scores on the spring math tests, science struggles to maintain its toehold in fourth place behind reading, writing and arithmetic (Saul, 2004). To her credit, the principal of San Juan is a science advocate and has set aside a classroom as the "science lab" and secured corporate funds to pay for a half-time lab assistant who offers supplemental science lessons and maintains a small menagerie. This same funding source was used to sponsor an intensive one-week science inservice course during the summer of 2003. The course focused upon inquiry as described by the National Science Education Standards (Olson & Loucks-Horsley, 2000) and was taught by John, first author of this paper.

Conceptualization of the Study

The impetus for this study was the body of research critically examining issues of teaching science to culturally diverse students, especially English language learners. Included within this corpus are questions regarding science as a culture whose borders students must navigate (Aikenhead, 2001), uncertainties about science's accessibility to non-native English speakers (Lee & Fradd, 1998), and the negotiation through discourse of scientific understandings within a culturally diverse classroom (Varelas, Becker, Luster, & Wenzel, 2002). Methodologically speaking, this study represents teacher research (Cochran-Smith & Lytle, 1990) as opposed to research on teaching. Instead of holding teaching at arm's length and attempting to describe and analyze it, the decision was made to look at teaching from up close. In this regard, we follow in the footsteps of Deborah Ball (2000), who describes her research efforts as studies of teaching and learning from the inside. The emphasis in teaching and learning from the inside is on the situation in which one is immersed and without necessarily having a goal of generalizability:

> What most clearly distinguishes first-person inquiry from other approaches in the study of teaching and learning is that it deliberately uses the position of the teacher to ground questions, structure analysis, and represent interpretation. … [The research] has as its primary goal to heighten deliberation in and about practice, to consider alternative interpretations, to seek information for next steps as a teacher of the class or child at hand. It is a form of inquiry most closely tied to the ongoing work of teaching. It pays least attention to the production of insights, ideas, or theories to be broadly shared with others. (pp. 365-367)

Using the same pool of funds that had supported other science efforts at San Juan Elementary, a complete FOSS *Air and Weather* kit was

purchased after an exploratory conversation with two second grade teachers who are the other two authors of this paper. Anne was in her second year as a classroom teacher; she was a former elementary science methods student of John. Kerri was another fairly new teacher, having taught for three years in other schools, who was in her first year at San Juan Elementary. This study was a joint venture: John visited the classrooms during several of the *Air and Weather* science lessons; these experiences became the focus of multiple joint conversations about the success of the individual lessons. We also co-planned an end-of-unit assessment, and the students' responses to these items were also the focus of considerable conversation. The result is our representation here of our collective interpretations of efforts to teach science to classrooms consisting of a variety of English language learners.

This undertaking began as a struggle with issues about science instruction and diverse learners raised by Okhee Lee (2003). Dewey (1933) stated that the drive to resolve a source of confusion is a regulating force for reflective thinking. Lee (2003) provided the perplexity that provoked this investigation:

> In seeking to integrate academic disciplines with students' languages and cultures, research may identify ways in which the two domains are continuous or discontinuous. Research may also examine how diverse students make sense of Western science based on their linguistic and cultural experiences and how they learn to articulate cultural norms (e. g., respect for authority or collaboration with peers) with the practices of Western science (e. g., questioning and argument). In addition, research may examine how students of diverse backgrounds achieve positive academic outcomes while maintaining their cultural identities. (p. 481)

As a collaborative project, we each brought our unique perspectives and experiences. John is a science teacher educator concerned with teaching science in multicultural settings. Anne and Kerri bring considerable skill as elementary school teachers along with formal training in teaching English language learners. In a sense, we personified the tension between theory and practice even as we shared the goal of improving our understanding and skill about teaching science to all students.

Curriculum

The activities Anne and Kerri implemented were drawn from the FOSS *Air and Weather* module developed at the Lawrence Hall of Science (2002) with NSF support. According to the front matter of the teaching guide, FOSS advocates for inquiry, hands-on activity learning, multi-sensory methods, student-to-student interaction, discourse and reflec-

tive thinking, and reading and research. The only obvious accommodation of cultural diversity within the materials were the Spanish language blackline masters. Otherwise there was nothing about the curricular materials representing a culturally relevant pedagogy (Ladson-Billings, 1995).

The weather components of *Air and Weather* were rather standard (maintaining a weather journal, graphing weather conditions, learning to use a thermometer, identifying cloud types) while the air investigations were more innovative. During December and January, the second graders in these two classrooms participated in activities in which they considered the properties of air and its relationship to the weather. Science lessons were conducted during the final hour of the day on Monday, Tuesday and Wednesday afternoons. The structure of the lessons was inductive in that students were given firsthand experience with the materials followed by a whole class discussion to process the activity. The directions provided to the students were usually quite brief: introduction of the materials, explanation of the task (often couched as "exploring"), and a description of the process by which equipment was to be distributed. From there the students began investigating.

Classroom furniture was arranged into hexagonal tables with three to five students in each group. Each student had their own equipment and any cooperative learning that occurred were spontaneous collaborations as students shared their ideas with whomever they chose. During the exploration phase, the teachers encouraged students, sometimes proposing other factors they might test. There was no direct instruction during this phase. The teachers made a deliberate effort not to indicate whether the children were right or wrong in their explanations; instead, a very common response to a child's discovery were comments such as "That's interesting," "Why do you think that happens," or "See what else you can explore." Not surprisingly, the second graders responded to the equipment with great enthusiasm and excitement. Remarkably, the need to redirect students to the task at hand was rarely necessary.

Following the exploratory portion of the lesson, which lasted from thirty to forty-five minutes, the students gathered on the carpet in a designated section of the classroom to discuss what they had done and the sense they made of those experiences. The implicit philosophy of this technique was to begin establishing a common set of shared experiences which would in turn contribute to individual understandings of the science concepts (Vygotsky, 1986). These experiences were drawn upon in subsequent discussions of scientific ideas and real world events throughout the duration of the unit.

Findings

During our discussions about the students' performance on the end-of-unit assessment we came to a greater realization about the promises and challenges of teaching science to English language learners. We have captured our impressions by grouping them into three categories: inquiry-based science teaching, science learning by English language learners, and the contradictions between inquiry-based teaching and a sheltered instruction framework.

Inquiry-Based Science Teaching

The inductive approach characterizing the science lessons represented a pedagogical shift for the classrooms teachers. Both teachers withheld introducing concepts and/or terminology at the start of their science lessons. Rather, they would describe for the students the question, challenge or task they would be exploring, show the equipment, and then allow the children to begin investigating. The subsequent whole class discussion was when students' understandings would begin to solidify. Anne, even though she had been introduced to inductive science teaching as an undergraduate and had learned more about inquiry during the summer course following her first teaching year, had reservations about this approach. Kerri was unfamiliar with the inquiry approach but felt it held promise as a method for making science learning more authentic and meaningful to her students. During the *Air and Weather* unit, they found the student-centeredness inspired responsibility in the students for their own learning.

The inquiry-based approach was not without its challenges, but we all recognized its power for supporting and advancing the students' understandings. Kerri confessed that she once believed all she had to do as a teacher was to teach and the students would learn; as she recognized the fallacy of this view, the inquiry-based approach was a welcome change. But inquiry-based teaching does not mean easy preparation. Rather, this way of teaching requires more thoughtful and deliberate preparation, especially when it comes to identifying outcomes students are to gain from their experiences. Anne initially found it hard to step back and not tell the students the information, yet discovered the rewards when all students who might otherwise be seen as "low" were developing scientific explanations on par with the "high" students.

Bringing together the cultures of students and the culture of science in ways recognizing and honoring the respective value of the cultures has prompted the image of border crossings (e.g., Brand & Glasson, 2004). Instead of regarding student backgrounds as a challenge to overcome,

teachers use children's "funds of knowledge" as a resource to ground and extend science instruction, thereby reducing the discontinuities between school science and everyday life. In classrooms with as much cultural diversity as is the case in San Juan Elementary, an inductive approach to science instruction served to bridge cultural divides between science and the students' lives, as well as among the varied cultural backgrounds of classmates. By starting the science lessons with shared experiences, students were not entering science discussions with inequitable amounts of background information; instead of defining air pressure or syringes in advance of the experience, by putting the phenomena quite literally into the hands of the students, potential misunderstandings due to different life experiences were reduced.

Connection-making by the students seemed to be a natural feature within inquiry-based teaching. This occurred because the ideas the students raised drove the lesson even as the teacher held a clear objective in her mind. Kerri felt that with each science lesson she taught, she became increasingly aware of the mismatch between her assumptions about what the students knew and had experienced compared to the realities of what they knew and had experienced. Even students who, on the surface, might appear to have similar backgrounds, had significant variability in their knowledge and background experiences. An inquiry-based lesson provides a shared experience, in the form of a hands-on activity, allowing every child to think, write, and talk about science. These experiences also provided a means for students to make connections to their personal life-worlds and begin to critically think about what is happening around them.

The Science Learning of ELL Students

In addition to the problems that can occur when a teacher inappropriately assumes his or her personal childhood experiences are common with those of the children in the classroom, when teaching science to ELLs there are language issues about which teachers may be incompletely aware. Such challenges may not be as evident during conversation but become quite evident in written communication. Many elementary teachers are accommodating of children's inventive spellings and recognize that misspellings may not signify incomplete understandings. However, the written language of ELL students may signify more than the strategy of "sounding out" a word and spelling it phonetically. Some examples from the end-of-unit assessment illustrate the challenge of sorting out misunderstandings from misspellings.

The assessment we created for the end of the unit was used not for the purpose of assigning grades to the students but as a means for

uncovering what they had learned. Because the assessment was used for diagnostic purposes (of student learning as well as of the curriculum and instruction), our comments about the students do not signify a failure. Instead, their work provided us with insights into the thought processes of the children, their efforts to communicate their ideas, the influence of the various hands-on experiences, and information about the assessment instrument's validity. This perception of the assessment's purpose was shared among the two teachers and the professor; the problems we note here represent a self-critique.

When examining ELL's written responses it can be difficult to differentiate between linguistic and conceptual issues. This creates a challenge for the classroom teacher, the researcher, and those whose task is to score student responses on standardized tests using open-ended items. The Council of Chief State School Officers commissioned a document entitled *Guide to Scoring LEP Student Responses to Open-ended Science Items* (Kopriva & Sexton, 1999) that was designed to inform and sensitize test writers and raters to the unique features of writing by students with limited English proficiency (LEP). More specifically those crafting the document indicated they wanted a guide that

> gives readers information about the linguistic issues that can be confounding factors in assessing an ELL's responses. ELL students are asked to demonstrate not only scientific skills, but also reading and writing skills in a language that they have not yet fully acquired. This poses a challenge to both the student and the individual who scores the items, since they must differentiate between evaluating the student's knowledge of science with accuracy despite the hurdle of functioning in a second language. (p. 4)

For classroom teachers of science and science teacher educators, it is important to become aware of the variety of issues influencing the writing efforts of English language learners. Those categories of factors appear in Figure 2. This information is presented for two purposes: to inform the reader about a framework for interpreting students' written responses and to highlight the idea that the errors by students may have cultural bases. The point is that ELL students are products of their culture and appropriately sensitive teachers need to be aware of this fact; that is, the sorts of flaws (e. g., inventive spellings) we might attribute to the children's intellectual development may have a cultural component. In this regard, we hope teachers of ELL students will begin to look at the "whole child" as being a product of his or her background, familial as well as cultural.

One student's response to an assessment item illustrates the value of being aware of linguistic issues (Figure 3). In this prompt Rico was to

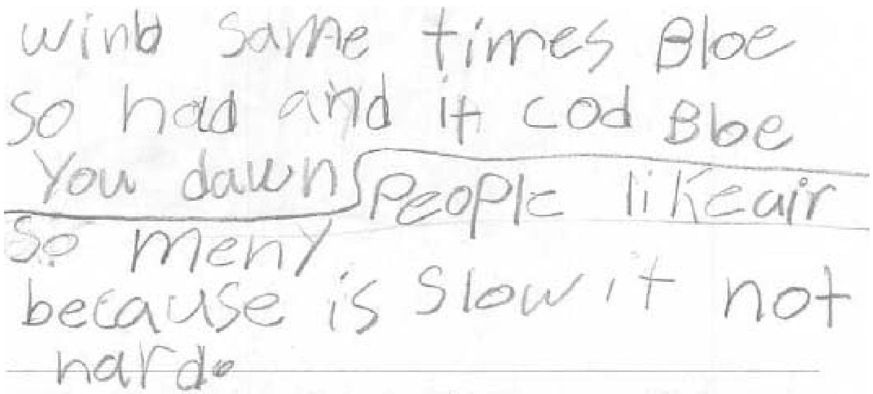
Figure 2.
Effects of English Language Development on ELL Student Responses

Linguistic Issues	Cultural Influences	Issues Related to Language Acquisition Development
Native Language Influences - Interpretation of Sounds	Symbols, Characters, Markings and Accents	Confusion in Meaning
Omissions - Consonants, Vowels, and Pronouns	Auditory Transfer	Emerging Syntax - Novice Sentence and Paragraph Structures
Code Switching	Neologism	Limited Use of Language – Alternative Response Formats
Transposition, Substitution, and Reduction of Words	Long Sentences	
Phonetics and Spelling	Stylistic Preferences·	
Native Language Patterns	Circular Responding	
English Phonetic Influences	Inductive/Deductive Reasoning Approaches	
Merging of Words	Abbreviated Reasoning Approach	
Omissions and Misuse		

(Kopriva & Sexton, 1999)

describe the difference between air and wind, a topic of considerable discussion among the students since the first lesson within the unit. His writing is full of mistakes but we need to recognize how errors may have roots in his efforts to learn the English language. This includes his reduction of consonant clusters (e.g., "cod" for "could" and "had" for "hard"), phonetics ("meny" for "many" and maybe "had" for "hard" again), word reduction (e.g., "because is slow it not hard" instead of "because IT is slow AND IT is not hard"), and native language influences ("bloe" instead of "blow" since "w" is rarely used in Spanish). What is feasible is that rather than an inattentiveness to conventional spelling, Rico exhibits the telltale signs of an English language learner. If we are willing to accept those "mistakes" for what they are then we can consider his conceptual understanding. As was true for many of his classmates, at the conclusion of this unit Rico did not recognize air and wind as being the same substance. Instead, they ascribed intensity as a defining characteristic and, time and again, treated air and wind as different substances. This was a recurring perception during the discussions from the "Wind Speed" activity. Somehow the information about the simplified Beaufort

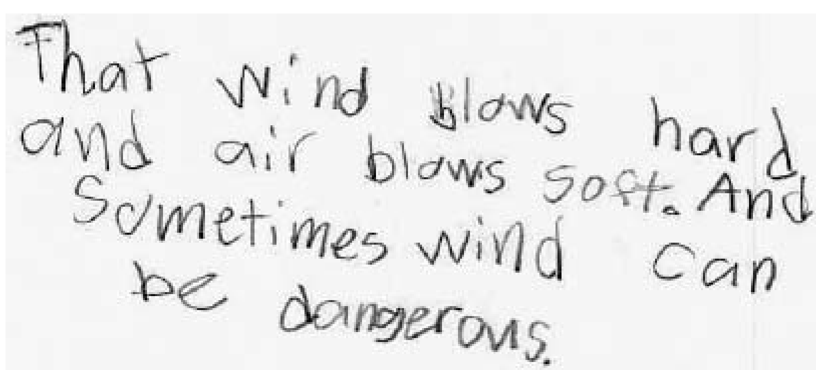
Figure 3.
Rico's Explanation for the Difference between AIR and WIND


wind same times Bloe
so had and it cod Bbe
You dawn People likeair
So meny
because is Slow it not
hard.

scale reinforced this conception. Although Darla's writing (Figure 4) does not present the same challenges to the reader that Rico's work does, we can see the similarities in their misconceptions about wind and air. Whether this idea can be "undone" by more effective teaching is not clear; nevertheless, we recognize that Rico and Darla have comparable misconceptions.

Science is characterized to a large extent by the specialized vocabulary created and used by its practitioners. For students who are attempting to obtain English fluency, the additional burden of specialized vocabulary (e.g., pressure, speed, anemometer) might be sufficiently frustrating for students that teachers might opt out of teaching science,

Figure 4.
Darla's explanation for the difference between AIR and WIND


That wind blows hard
and air blows soft. And
Sometimes wind can
be dangerous.

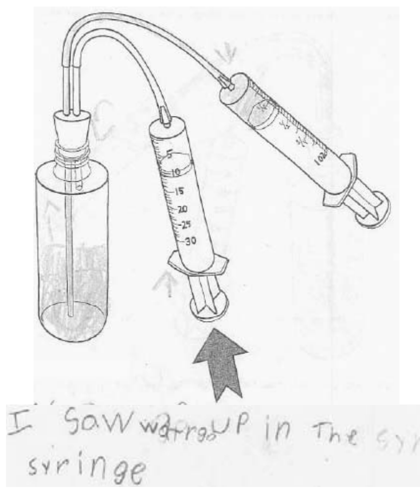
or perhaps hold lower content expectations of ELL students. We discovered that the learning of scientific terms was enhanced by the inquiry-based approach. Anne regards inquiry as less intimidating than more traditional teaching approaches. Inquiry is inviting to the students because it doesn't initially require sophisticated language skills, which automatically encourages all students of all abilities. Anne's sense was that by teaching science in an inquiry fashion all of her students could participate and become genuinely successful in science.

Like Anne, Kerri noted that the inquiry-based lessons were effective for her ELL students. Beginning with direct experiences encouraged them to explore new options and to think more critically about what they observed. Even when the words were not accessible in English to express their thinking, she saw her students working harder, experimenting in different ways, and asking more questions as they strived to make sense of their experiences. Several of the ELL students stretched themselves to absorb and use new vocabulary in order to express their ideas. When their speaking vocabulary was not sufficient to express their thoughts, it made them visibly frustrated. When the words were supplied to them, they were quick to incorporate them into their verbal interactions in small groups as well as during whole class discussions.

When faced with the dilemmas associated with assessing scientific understandings of ELL students, one will sometimes hear the suggestion that having children draw what they know can be a reasonable substitute. Two examples are provided here to demonstrate the utility of this approach. Below we present Pedro's drawing showing the presence of air (Figure 5). His response is scientifically accurate. In this example we can appreciate the power to communicate ideas afforded by drawings that may not be possible for ELL students when they are required to write. The prompt for this item was to predict what would happen when the syringe indicated by the arrow was compressed. Because the tube to which the syringe was connected did not reach the bottom of the bottle while the longer tube connected to the alternate syringe was below the dyed water's surface, the water was forced along as Pedro not only showed in his diagram but was also just as he had predicted. To illustrate the movement of air and the resulting movement of water, Pedro added arrows, almost too dim to be seen, at four places on this picture.

Two significant features are apparent about Pedro's ideas. First, he understands at a conceptual level that air pressure will have a sufficient force to displace water out of a container and up a tube into the other syringe. Second, his written explanation ("I saw watr go up in the syringe") seems to underestimate his understanding; the opportunity to

Figure 5.
Performance-based Item Where the Illustration of the Equipment Was Then Shaded by Pedro To Show the Movements of Colored Water



illustrate his ideas shows that his conceptions were much more complex and scientifically accurate than one would infer from his writing.

Inquiry Versus Sheltered Instruction

As yet there is not a specific instructional model for teaching science to English language learners. However, Sheltered Instruction seems to hold some promise. John first heard of this at a science education conference, while it was a central component of Anne's ESL training (Echevarria & Graves, 1998). Even though Sheltered Instruction has little to say specifically about science teaching, we considered the Sheltered Instruction Observation Protocol [SIOP] (Echevarria, Vogt & Short, 2000) as a tool for refining our efforts during the *Air and Weather* unit. What we discovered were considerable discrepancies between the inquiry approach that had been successful with our second graders and the SIOP model.

The SIOP model was the driving force for the lessons the inservice teachers were developing for their ELL course. Anne struggled with the misalignment between the thirty-item SIOP checklist, for which she was to write a science lesson plan, and the inductive approach to science she had found that worked with her ELL students. While her students came to construct experience-based understandings of air and its ability to take

up space without being specifically told this concept at the start of the lesson, the approach ran counter to the SIOP approach which emphasizes an initial linking of concepts, previous experiences, and new vocabulary as a way to begin lessons.

Consistent with her training in ESL instruction, Anne believe that she was to tell the students exactly what to expect to learn before they began an activity. Within the SIOP model, teachers were to insure that their lessons clearly defined language and content objectives for students. Further, communicating these objectives to the students was to occur at the outset of the lesson. This inclination to begin with definitions and follow this with experiences to contextualize the knowledge is in direct conflict with inductive instruction. The inductive, inquiry-based approach she had successfully employed reserved the formal vocabulary instruction until after the students had participated in a hands-on activity. Anne found that when she did not tell the students in advance what they were going to learn, they felt they discovered why something occurred without being told so by their teacher. That the science lessons worked so well for her English language learners when she deliberately did not provide definitions at the outset was frustrating for her.

We might allow that Anne's ESL instructor was misinterpreting the SIOP approach; perhaps this strict adherence to initiating lessons with vocabulary was not what the authors (Echevarria & Graves, 1998; Echevarria, Vogt & Short, 2000) had intended. However, the examples in the training always gave high ratings to teachers who begin with the explicit teaching of vocabulary. It seems that to adhere to the SIOP model, when teaching science, the vocabulary comes first. However, from our experience teaching a highly varied group of ELLs, it seems the suggestion by Dyasi and Dyasi (2004) that children should be "reading the worlds before reading the word" was the better tactic.

Our claim is not based upon our unwillingness to accept alternative instructional approaches. However, by teaching science in an inductive fashion, characterized by a high-level of student engagement as well as delaying the formal instruction of vocabulary until after direct experiences, convincingly supported the development of the children's scientific understandings. Except for the difference in word choices in their written responses, ELL students had equivalent achievement on the end-of-unit assessment compared to their more fluent classmates. Similarly, the engagement in direct experiences and their participation in whole class debriefing sessions revealed little difference between ELL and non-ELL students. In light of these events, our inclination is to recommend that those using SIOP within science instruction make adjustments to the concept and language objective components of the model. We endorse the

value of these two components but we question the rationale for presenting the information prior to students' experiencing the science equipment.

Discussion

The ethnic distributions of students in pre-college classrooms is changing even as the teaching force, as well as those in the teaching pipeline, is considerably less representative of immigration patterns. Consequently, the cultural gaps between teachers and their students are likely to increase over the next several years. Related to this is the need for teachers to become more sensitive to the challenges of teaching science, as well as other subjects, to children who are designated as English as a second language (ESL) or English language learners (ELLs). Teachers must continue in their efforts to create environments in which the cultural aspects of science become instructionally congruent with the cultural aspects and language abilities of the students (Lee & Fradd, 1998). As we learned during the *Air and Weather* unit, the congruities include firsthand experiences with natural phenomena for the students as a prelude to discussions about their understandings. Similarly, teachers need to be aware of language factors shaping the written responses students create. In total, this necessitates an increased appreciation of the uniqueness of each child including his or her cultural and linguistic heritage. To ignore or deny the relevance of these factors sustains ambivalence toward and misunderstandings about the role of culture in learning.

The curriculum, as written and as implemented by the teachers, made use of an inductive approach to instruction. Direct experiences by the children preceded formal teaching. Although novices to this approach, both teachers felt the "naturalness" of it promoted the learning of all students, including the English language learners. However, the dictates from the local ESL course promoted an instructional model in stark contrast to the inquiry-based approach used in science. The problems this creates extend beyond a mere mismatch between teaching strategies. The Sheltered Instruction approach, when it does reference science instruction, portrays the learning of the subject as developing vocabulary and following procedures (Echevarria, Vogt & Short, 2000). A further problem with the attendant observation protocol is that it precludes the use of other than deductive instruction. Worse yet is the possibility for a skills orientation toward teaching and learning that not only overlooks the cultures of the subject areas, but also the cultural backgrounds of students beyond their lack of English language fluency.

The implication for classroom teachers and science educators is the

need to remain vigilant and involved in improving the science instruction being provided to English language learners. For those whose area of strength is science education it becomes necessary to learn more about bilingual education. For example, initial content instruction in students' native language followed by sheltered content instruction is a combination regarded as the best approach to bilingual education (Gort, in press), yet is not widely known within science education. Meanwhile, those with shallow backgrounds in science education who advocate for a skills-based focus should recognize this as a formula sure to discourage many children and perpetuate the inequitable representation of non-Whites in science courses, degree programs and professional positions. As are others (Hampton & Rodriguez, 2001), we are troubled by the potential for inequities when a substantial segment of the school population is not provided with the best in science instruction. Inductive instruction is a viable technique and should not be reserved for a subset of the larger school population. Furthermore, curriculum that is designed with an inductive approach holds promise for advancing teachers' understanding, confidence, and willingness to teach in a manner that builds upon children's direct experiences with concepts. In addition, to replace the notion that English language learners are somehow poor candidates for science suggests we must do more than profess our opposition to the "deficit model" many oppose. More substantively, we must "envision pedagogical possibilities that build on diversity as an intellectual resource rather than a problem or tension in science learning" (Warren, et al., 2001, p. 548). This requires sensitivity to the likelihood that our students' experiences will be different from those we had as children. It also emphasizes the need to create and sustain effective links between classroom science and family life, a task we still are only beginning to grasp.

Several questions remain about teaching science to English language learners. One is whether the successes reported here will translate into measurable science achievement. Our optimism that the learning we noted among these second graders will reveal itself on standardized science tests is based largely on faith; whether there is empirical support for this confidence remains untested. Another question is whether these efforts at the classroom level can extend to the homes and families of these students. The need to reconsider science within the broader community (Barton, 2000) is a challenge we should force ourselves to address. While teachers at San Juan Elementary School are beginning to see the value in connecting families with school science, the steps for enacting such an ambition remain unclear.

Goodwin (2002) has cautioned against the tendency to subsume "immigrant" students within the broader category of "English language

learning" students. Her contention is that lumping together children from displaced families with children who are U.S. born but whose families speak a language other than English is inappropriate. Whether this custom, by teachers and researchers alike, is effectively rendering invisible the immigrant aspect of these children's lives (dislocation, illiteracy, cultural disorientation, and language barriers) remains a possibility. Perhaps as the field matures, those involved with multicultural science education will begin endorsing the significance of such distinctions. Clearly the generational aspects of immigrant life are substantive with first generation students holding different perspectives from those who are second generation immigrants; these are factors warranting further examination (Valenzuela, 1999; Milan-Niler, 2004; Grant, Stinson, Hasin, Dawson, Chou, & Anderson, 2004).

These concerns notwithstanding, providing science instruction to English language learners so inequities in science achievement are diminished looms as a substantial challenge. Whether, as our knowledge grows and our sensitivity improves, the differentiation of immigrant from non-immigrant ELL students will take on more significance is uncertain. In the meantime, the research agenda advanced by Lee (2003) prompts more questions than we have answers for. At the very least, the experiences described in this study are cause for hope. It seems possible that appropriately acknowledged and accommodated cultural and language backgrounds can lead to a discernible improvement in English language learners' success in science.

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