

The Integration of English Language Development and Science Instruction in Elementary Classrooms

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Abstract This paper explores one district's attempt to implement a blended science and English Language Development (ELD) elementary program, designed to provide English language learners opportunities to develop proficiency in English through participation in inquiry-based science. This process resulted in blended program that utilized a combined science/ELD lesson plan format to structure and guide teachers' efforts to use science as the context for language development. Data, collected throughout the first 2 years of the program, include teacher-generated lesson plans, observation notes, and interviews with teachers and principals. The process by which the blended program was developed, the initial implementation of the program, the resulting science/ELD lesson plan format, and teachers' perceptions about the program and its impact on their students are described.

Keywords English language learner · Professional development ·
Elementary science · Integration

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The *No Child Left Behind* (NCLB) Act of 2001 (U.S. Congress 2001) created a national, high-stakes accountability system for education, however the law allowed each state to set its own policies regarding English Language Learners (ELLs). In California, statewide assessments for elementary schools exist in science, reading, and mathematics. However, while reading and mathematics are tested every year from second to fifth grade, science is only tested in fifth grade and contributes only a small percentage to the overall performance index for each school. This assessment policy has prompted some school districts to consider science instruction as secondary in curricular importance, particularly in the lower elementary grades. NCLB also mandates that students with limited English proficiency be assessed “in a valid and reliable manner.” In California, many districts have interpreted this to mean that all tests must be administered in English, even if students are not English proficient. Subsequently, the need for improved performance on these high-stakes tests have pressed schools to devote more instructional time to teaching English to ELLs, in an attempt to raise reading and mathematics test scores. Often this comes at the expense of science instruction. Shamefully, this has resulted in an inequitable situation: those meeting the performance goals have access to science instruction and those testing below this goal receive little to no science instruction. While this is true for low-performing students in general, the burden on ELLs is the greatest since they are more likely to perform below the required bar on tests written in a language in which they are not yet proficient (Garcia et al. 2006; Genesee et al. 2006; Solorzano 2008).

Nationally, scholars and education reformers alike have advocated for the teaching of science in the elementary grades. Specifically many have detailed an important link between science and literacy. As Norris and Philips (2003) contend, “Reading and writing are constitutive parts of science” (p. 226) and “Literacy in its fundamental sense is fundamental to scientific literacy” (p. 237). Students routinely use their literacy skills to gather information as well as communicate their understanding of scientific concepts to others. “Science can be constructed, reconstructed, transformed, and applied through the tools that we associate with literacy, defined as the capacity to use language in various forms to think, analyze, and communicate” (Miller 2009, p. 41). While students utilize generalized literacy skills while learning about science, there is also the issue of students being proficient in the literary style of the discipline such as evidence-based argumentation (Yore et al. 2006). For many, competence in learning is ultimately evident when learners can “appropriate” the language of a discipline (Bakhtin 1981). This intricate link between science and literacy skills is further demonstrated by the professional practices of scientists whom routinely use literacy to engage in dialogue about the discipline. Yore and colleagues suggest that literacy instruction can be embedded into scientific inquiry so that students may construct new science learning in the same way a novice scientist is guided by a supervisor into the scientific discourse of his/her discipline (Yore et al. 2006).

Given this close relationship between science and literacy, many have called for, and several are attempting, instruction that integrates these two content areas (Lee et al. 2005; Stoddart et al. 2002; Yore et al. 2006). While it is laudable that many districts are striving to implement more equitable practices, the burden of implementation cannot be on the classroom teacher alone (Lee et al. 2006; Loucks-Horsley et al. 1998). District support and teacher professional development are critical for success, as developing and implementing a blended program requires reconciling two very different perspectives about teaching and learning.

Foundations of Science and English Language Development

Piaget's (1950) work and the constructivist learning theory that eventually developed provide one of the central theoretical frameworks behind science education. Fundamental to these ideas has been the experiences of the individual, shaping new knowledge through the connection of new experiences to past ones. Cognitive development is cumulative. New knowledge grows out of what has previously been learned. When students enter the classroom, they have had years of experiences in the natural world, creating well-established schemas prior to any formal science instruction. Therefore, a teacher must be aware of students' preexisting knowledge as it determines how new information will be interpreted. Instruction is not a one-way communication from the teacher to the students, and the teacher alone does not determine the meaning behind a lesson. Rather, science lessons become a dialogue between the teacher and students in an attempt to draw out from students their preexisting knowledge, allowing students to build their own construction of concepts. Students are encouraged to ask questions, plan and conduct investigations, use appropriate tools and techniques to gather data, think critically and logically about the relationships between evidence and explanations, construct and analyze alternative explanations, and communicate scientific arguments (National Research Council [NRC] 1996). While specific language and vocabulary are important, vocabulary instruction is secondary to conceptual development and is often delayed until the learner has had the experiences necessary for internal knowledge structures to develop.

Learning a language is described as a subconscious process where the learner acquires language through meaningful social interactions where the meaning of the language is more important than its proper form (Krashen 2003). Krashen's (1985) theory of second language acquisition emphasizes the importance of comprehensible input: the language a student encounters must include language structures the learner already knows (i) plus new structures ($i + 1$) in a combination that allows the learner to understand the message within the language. Learning a second language requires rich, comprehensible input by either the teacher or peer, where written or oral input is provided near the students' language proficiency-level as well as language just beyond. For readers more familiar with science education this description may sound consistent with constructivism, however how these ideas are enacted in the classroom differs greatly. Moving beyond informal language acquisition practices that support comprehensible input, formally "learning" academic language, as in school content, is a different process that relies on explicit intentional use of additional language development practices: a great deal of repetition, attention to language structures, structured interactive language practice and use, and grammar and error correction support (Genesee et al. 2006; Krashen 2003). Throughout lessons teachers specify the language and its use in order to ensure that the input is comprehensible and correct. Teachers must modify their language and further support students by repeating or restating their statements as well as rephrasing the learner's speech through corrective feedback (Carr et al. 2007). Through explicit English Language Development (ELD) curriculum specific vocabulary and language are "front-loaded" (i.e., pre-taught) with structured opportunities to practice the new language following that explicit instruction.

From a language viewpoint, explicit vocabulary instruction is necessary to develop English learners' English skills (Genesee et al. 2006).

While there are similarities between ELD and science instruction, they each view the role of the teacher, the student and the necessary structure of instructional experiences in fundamentally different ways. Although there are areas of clear overlap in the instructional strategies utilized by each field (e.g., prior knowledge probes, cooperative learning, graphic organizers), the purpose behind those strategies differs: scaffolding specific language use or developing conceptual understanding of science content. However, despite these differences, current research suggests that the needs of English Language Learners are better met when English language and content areas are addressed simultaneously (Lee and Luykx 2005). Specifically research on these efforts has shown that the combination of language and science instruction can lead to increased student performance in writing, reading, and science (Lee et al. 2005, 2008; Stoddart et al. 2002). Hence, within the professional development of teachers, teacher educators should consider addressing science through language and language through science.

The Blended Program

Setting

Hubbard Unified School District (pseudonym) is a large urban school district in California. The district serves a culturally and linguistically diverse population. Fifty-seven percent of students are English Language Learners (California Department of Education 2009). Eighty-one percent of the students qualify for free or reduced-price meals and the district has been identified as a "High Need District" based on the percentage of families living in poverty (U.S. Census Bureau 2005). Currently the district is identified as a Program Improvement (PI) District, the designation assigned by the state for schools that fail to make Adequate Yearly Progress towards statewide proficiency goals. Eight of Hubbard Unified's (HUSD) 18 elementary schools are in PI status. An analysis of state testing data from the 2007 school year indicates that a majority of all students are failing to achieve adequate academic progress in Language Arts, Mathematics, and English acquisition. However, English Language Learners are of particular concern in HUSD as this sub-group falls below the Annual Yearly Progress minimum across the district at all grade levels.

As the district struggled to move out of PI status, it has allocated an increasing amount of the school day to English Language Development and Language Arts instruction. As a consequence, elementary students and in particular ELLs received very little, if any, instruction in science. Like many others, HUSD was caught between a rock and a hard place: how to provide additional ELD instructional time without sacrificing science instructional time, so that ELLs can develop English language skills without falling behind in science content knowledge?

In an attempt to mediate this situation, the district has merged ELD and science instruction. While many projects have attempted to make science accessible to

similar populations, this project is unique in the fact that it focuses on the *blend* of both science and ELD, developing students' English skills with science as the context for that learning. This endeavor holds science equal with ELD. Thus, although one of the goals is improved English skills, the work also focuses on providing inquiry-based science that offers complex content and demands high-level thinking. To help successfully develop and implement this program Hubbard Unified School District assembled a professional development team consisting of district personnel, faculty from local universities, ELD and science educators, and professional development experts from a national, nonprofit education research and service agency. Together this team endeavored to provide ELD and science professional development to teachers and administrators of three elementary schools within the district.

The three sites selected to participate in the program were all classified as Program Improvement sites, based on past years' performance on state assessments. All three K-4 elementary schools have significant numbers of ELLs and participating educators all have experience with ELD instruction. A total of 60 elementary teachers, three school principals, and six ELD coaches from HUSD participated in this project. The overall structure of this professional development effort included intensive 2-week long, summer institutes, focused on a functional linguistic approach to ELD theory and practice (uniquely adapted to integrate language acquisition strategies and interactive-talk structures with an academic language emphasis) and on science content and pedagogy (where inquiry through the 5E lesson design is central), along with site-based lesson study teams, called Teacher Learning Collaboratives (DiRanna et al. 2009) held throughout the year.

The Two Perspectives

As the professional development team approached the development of a blended lesson design, we entered the process with different foci for lesson designing. Science educators were using a modified version of Bybee's (1997) 5E lesson design (i.e., engage, explore, explain, elaborate, and evaluate) as the lesson-planning template. The 5E design was modified to focus the elaboration stage on extending the understanding of the science concept. In addition a concept column was added for each stage to illustrate the development of a science concept from students' prior knowledge to the learning goal of the lesson sequence (DiRanna et al. 2009). The science lesson template emphasized conceptual understanding, hands-on activities, and student interaction. Lessons began with the elicitation of students' prior knowledge of a concept and then provided a series of experiences that would allow students to build on that initial understanding. Although there were specific points in each lesson where students discussed their thinking with peers and their teacher, vocabulary and specific language functions and forms were not a focus of the lesson planning.

On the other hand, ELD educators traditionally focused lessons on making the language of instruction (oral and written) accessible to the learner through the use of specific forms (e.g., grammatical features or word usage such as *adjectives*) and functions (i.e., the task or purpose, such as *compare*) of language. This often

required the use of explicit instruction, modeling, and scaffolding by the teacher (Duffy 2002). Language forms and functions were often scaffolded with predetermined sentence frames that students used to build language. Sentence frames were used to provide the necessary support for students to generate sentences and express their thinking as students often possess vocabulary specific to the content but lack the words or phrases necessary to construct sentences. For example, “I think _____ because _____.” In addition, ELD lessons often front-load language. This involved the pre-teaching of specific grammatical structures and vocabulary prior to their use in a cognitive task. Although language instruction was often embedded in content-based lessons, conceptual understanding was not emphasized, the goal is the development of English language skills (Echevarria et al. 2008).

Our Initial Agreement

Overall, the science education philosophy was grounded in inquiry instruction where concepts and language unfold out of student-centered learning experiences, while the ELD philosophy relied more on highly-facilitated instruction where the teacher frames, directs and monitors student language use, accommodating for varied English language proficiency levels. However, despite this clear distinction, common ground emerged. In the end these points were agreed upon:

1. Science process and thinking skills mirrored functional purposes for using language (i.e., describing, comparing, citing information);
2. Science content could provide a highly-contextualized setting for language development;
3. Although students may not be proficient in English, they could still process science content at a high level, through complex thinking processes. As such, the science should not be simplified in an attempt to simplify language; and
4. Vocabulary, along with specific language functions and forms, would need to be carefully considered for what, when and how they would be used. Which new words would be embedded in the lesson and which new words would be front-loaded (pre-taught) would be based on the instructional goals of the lesson.

Blended Lesson Design

Initially, the science/ELD lesson template was not a blend, but rather a compilation of everything included in both science and ELD lessons. The result was a document that teachers found overwhelming to teach from and an impossible model for their own lessons. Although the language component focused on the vocabulary found in the science lesson and the science lessons were designed around context-rich experiences, the science did not truly support language development and the focused ELD instruction impeded the development of scientific understanding. Included in the design were prompts for language input (teacher) and output (student), modified according to English proficiency levels. However, these prompts

were external to the 5E lesson, not integrated in a way that strengthened either the science or the language. Within the 5E science lesson were science activities and prompts, but, in practice, these activities often included “watered-down” content in an attempt to address the beginning English skills of the students. In addition, we lacked a clear protocol for when to focus on content and when to focus on language and failed in our attempt to serve two masters simultaneously. Due to this lack of clarity, as well as the overwhelming nature of the document, teachers tended to either focus on language and ignore the science or focus on the science and ignore the language development in their planning regardless of what the template included. Thus, although we could see the overlap between scientific processes and language functions, we found that an additive approach to creating the blend was unable to produce the level of student learning we had hoped. Clearly teaching ELD with science needed to be conceptualized differently than simply teaching ELD *and* science.

The initial lesson design was field tested by teachers during the first quarter of the school year. Subsequent modifications, based on extensive feedback from teachers, ELD coaches, and district personnel and much discussion among the professional development team, resulted in a revised, streamlined lesson plan format (Fig. 1). The changes were designed to be true to two very important priorities, putting student thinking first and making language development authentic. Subsequently,

Learning Sequence Concept:					
Science Standard:					
Language Objective:					
ELD Standards:					
5E stage	Teacher Does	Student Does with Language Proficiency Levels			Concept/Language Function
		Low	Med	High	
Engage					
Explore					
Explain					
Elaborate					
Evaluate					

Fig. 1 Blended 5E Lesson Template. This template serves as the lesson-planning tool that teachers use to create blended science and ELD lessons. An example of a partially completed lesson plan can be found in Fig. 2 (below)

the new format required that science be planned first before any considerations for which language forms and functions would also be taught within the lesson. This change was aligned with our primary goals and was also important for several pragmatic reasons: (a) the science content must be accurate and appropriate for the grade-level in order for the necessary language to emerge from students' thinking; (b) language can get in the way of the thinking, if it is artificially imposed on the content; and (c) as teachers discuss and collaboratively plan their science lessons, natural conversations about the content emerge as they design teacher questioning and predict student responses; the language during these conversations can be used to guide decisions about which language forms and functions become the ELD focus of the lesson.

Although the lesson design blends both science and ELD, the planning now focused on the science portion first. This shift in focus necessitated additional lesson plan features that would blend the ELD components seamlessly into the science. As a 5E lesson unfolds, students engage in different levels of scientific thinking in each stage, providing students with context-rich opportunities to practice different language functions. Thus, a language function column was added to the lesson template. In addition, the input/output frames were more specific to the language or activity at each stage in the lesson. For example, if students were asked to recall information about rocks in the engage stage, but to compare and contrast properties of rocks in the explore stage, appropriate teacher prompts and student frames were designed in each section. This allowed for more specific language support, making it easier for teachers to engage students with limited English skills in more scientifically-rich conversations and activities. The input/output portions of an ELD lesson were embedded into the 5E design in the "teacher does" column and student sentence frames were moved to the "student does" column. Within these columns, headings were provided to focus teachers on accommodating students' language development according to the varied English proficiency levels in their classrooms (see Fig. 1).

With science as the first consideration and structural center of the lessons, when and how to introduce vocabulary became another area of debate. Should vocabulary be introduced once an understanding of the concept had been developed or should it be described and clarified prior to any related investigation? After field-testing, it was decided that vocabulary would need to be carefully analyzed to determine which terms should be taught prior to the lesson (front-loaded) and which would fold out of the lesson itself (embedded). This allowed the narrowing of vocabulary within one lesson and more precision around the purpose and use of that vocabulary. This flexibility was especially important to accommodate the needs of students at varied language proficiency levels. Words that might be front-loaded are words that students need to discuss and describe materials that are manipulated and described during exploration. These are words that one might expect students who are proficient in English to know and be able to use (e.g., above, round, blue). Front-loaded words would be taught in a more traditional ELD lesson prior to the science lesson. However, within the science lesson, students can practice the authentic use of these words during the science/ELD blended lesson and teachers are able to assess and monitor their use. Embedded words are those that can be developed

through scientific exploration (e.g., sedimentary rock, liquid, precipitation). These words would be introduced during the lesson (teacher input) once students have experiences related to the scientific concept being explored, providing students rich opportunities for practicing and using the new language (student output) in a meaningful context.

For example, in a fourth grade lesson involving the rock cycle, there is a great deal of vocabulary involved in both describing and classifying rocks. They will need certain vocabulary words in which to discuss and debate with their peers about the different qualities they find. This vocabulary could include words such as smaller, bigger, dark, light, rough, smooth, bumpy, shiny, and dull. Words like these are necessary for students to engage in discourse within the inquiry experience. However, to front-load terms such as luster, hardness, coarse and fine grain, igneous and sedimentary would lessen the students’ opportunity to form their own conceptions about the rocks they are given as well as their own ideas about how to categorize those rocks. Rather, these terms can be laid on top of the students’ own descriptions once they have had the opportunity to develop their own ways of describing these qualities or categories. Which terms students need in order to participate in the inquiry depends on the activity itself, the students’ English proficiency levels, and previous instruction (see Fig. 2).

Additionally, teachers must be cognizant of how they model the new vocabulary contextualized for particular academic language functions. In our lessons, sources of language (e.g., teacher talk, peer talk, text) were explicitly embedded within tasks and supported by strategies that ensure comprehensibility. For example, in a classroom with beginning English language proficiency kindergarten students observing ants, there would be a great deal of teacher-talk, modeling the language of observation (*I see ants using their legs to move.*) and teacher-questioning (*Are the legs long or short?*) eliciting descriptive language from students. Here, observing/describing is the function and the language forms, including questions the teacher uses, reflect the function of body parts and relevant adjectives. Explicit language input (vocabulary) could follow this experience with a co-created pictorial chart that

5E	Teacher Says/Does	Student Says/Does			Science Concept/Language Function
		Low	Med	High	
Engage 10 - 15 min.	Introduction: <i>Think about yesterday’s lesson on Matter. How many different states were there? What were they?</i> (Record student responses on board.) Gallery Walk- Post objects & pictures related to matter (e.g., water, a ball, pieces of fabric, craft sticks, lemonade, syrup) around room. (1 min rotations): <i>There are objects and pictures of matter posted around the room. Observe each picture and tell your partner what you observe.</i>	<i>Three Solid, Liquid and Gas (with gestures and/or native language support)</i>	<i>There are 3 states Solid, Liquid, and Gas</i>	<i>There are 3 different states of matter The three states of matter are Solid, Liquid, and Gas.</i>	Science Observe solids and liquids. Solids and liquids have observable properties. Language Describing and Comparing
		Students walk in groups to each picture and describe what they see			
		<i>One word answers or Yo veo ____.</i>	<i>There is ____ I see ____ It is ____.</i>	<i>This feels ____ and looks ____.</i>	

Fig. 2 The Blended 5E Lesson Template in Use. The figure represents the Engagement phase of a teacher-designed 5E science/ELD lesson

would continue the focus on the vocabulary and language forms students can use to describe their vivid, language-rich observational experience.

Our teachers recognized that while students gain new scientific knowledge and vocabulary, ELLs need support in order to express that knowledge in complete thoughts, or sentences. With this in mind, teachers found sentence frames to be useful in their science/ELD lessons particularly for students with limited language skills. The teacher use of sentence frames varied based on the proficiency level of the students, as well as the design of the task. Explicit emphasis on sentence frames ranged in degree from highly-facilitated prior to the lesson to completely embedded within the task, depending on the English proficiency level of the students and the demands of the academic science language. Teachers were encouraged to address these language development considerations during planning. However, a particular issue emerged for teachers and their reliance on sentence frames; sentence frames can lead to limited student responses (i.e., since students are using the same frames, they all say/write similar sentences). For science this is problematic because this practice did not lead to student work that displayed the range of conceptual understanding across students. For students with beginning language skills, teachers needed to temper their reliance on sentence frames and use additional measures of student understanding that are appropriate for language development, yet are not language dependent, such as providing realia or pictures, and asking students to make concrete observations, to physically manipulate materials, or to draw one or a sequence of diagrams to express their thinking.

As ELLs acquire more proficiency, explicit language models work in concert with the emerging student language base being developed, and are derived primarily from student thinking and language inherent in the task. The sentence frames need to reflect more complex usage of thinking and language, while at the same time teachers must be cautious of an over-reliance on their use. With this new format teachers are able to encourage student thinking and conceptual understanding, to develop language in ways and at times that were authentic and effective, and to readily adapt their lessons to include the range of language proficiencies represented among their students.

Testing the Blended Program

In an effort to better understand how this program impacted teachers' practice, we analyzed teacher-generated lesson plans, observed classrooms as teachers implemented these lessons, and conducted semi-structured interviews with participating teachers and principals throughout the first year and a half of the program. Teachers were initially interviewed during professional development sessions devoted to team planning time of ELD/Science lessons and were conducted at their school sites. The interviews, conducted at participants' school sites, spanned all grade levels K-4 included teachers and principals, and represented participants from two of the three schools. A total of 28 teachers, including three principals, were interviewed during the first phase of this study, representing 46% of the total number of teachers who have participated in the project as a whole. Initial

Table 1 Data sources included in investigation

Data source	Data type	Number
Teachers	Semi-structured interviews	28 teachers from two of three school sites were included in these interviews
	Informal interviews	29 teachers from all three participating school sites were interviewed
	Lesson plans/classroom observations	Lessons from ten teams of grade level teachers were analyzed and observed. Teams typically involved 3–5 teachers. All school sites were included in sampling
Principals	Semi-structured interviews	Principals from two of the three school sites were interviewed

interviews were semi-structured and guided by a series of predetermined questions. Later in the project, interviews were less formal, consisting of recorded conversations between researchers and participants about the project. Twenty-nine teachers from all three participating schools were included in the second phase of interviews conducted at the second summer institute. During these interviews, questions focused on the perceived science instruction before and after implementing the blended program, the challenges and benefits of participating in the project and what next steps are needed to take to address current challenges (Table 1).

Recorded interviews were transcribed and data were analyzed through multiple readings by the researchers. Selective or focused coding (Charmaz 2002) was used to sort, synthesize, and conceptualize the emergent qualitative data by adopting frequently appearing initial codes relevant to the guiding questions of the study. Coded data, which posed coherent sets of ideas, were organized into categories. These categories were re-visited as new data provided alternative vantage points for re-interpretation. Ultimately, those categories that sustained coherent and plausible interpretations were organized as “key insights.” These insights provide perspective on the impact the blended program had on teachers, students, and the school culture overall.

Insight #1: Enhanced Status for Science

It is an understatement to say that prior to the implementation of this program, science was not a priority at the participating elementary schools. In fact, teachers reported that, when new science textbooks were adopted in 2008, at the end of the 7-year curriculum cycle, they turned in brand new science textbooks, never opened. “We all joked when we were turning them in that some of us let the kids take them home for a week before we turned them in so that they would look more used” (Teacher 16, Interview 2). However, the status of science changed with the implementation of the new program.

English language development has always been a key focal point. It is so engrained in us that we need 45 min a day, no matter what. Putting both of them [science and ELD] together makes science one of the top priorities.

Before it was we had half an hour a week to teach science, social studies, and P.E. Now science is taught everyday. (Teacher 2, Interview 2)

There was and continues to be a great deal of pressure to improve student scores on the state's high-stakes assessments and this translated into a significant portion of instructional minutes devoted to English language development. It was not surprising that connecting science to ELD heightened the importance of science in the eyes of teachers. What was surprising to participants was students' responses to science.

Principals and teachers report that students are excited about science and look forward to their science lessons. While, we as science educators believe that the hands-on, process of discovery is intrinsically motivating for students, there seems to be something more behind the additional appeal of science for students. As one teacher reported, "One of my students told me, 'I don't go to ELD anymore, now I get to go to *science* instead'" (Teacher 23, Interview 1). From the student perspective, the new program may be seen as a change in the class they attend to include science rather than a different approach to ELD, lifting away negative stereotypes related to the label "English Learner." Teachers have been surprised by how easy science is in terms of classroom management, after previously expressing this fear as a major factor discouraging teachers from hands-on science. Since science is now seen as a privilege, students have fewer behavioral problems during science lessons compared to other instructional times during the day. "Now I don't have any real behavior issues. Now I just say, 'Is that how scientists act?' and they get back into it. They're really intense" (Teacher 4, Interview 1). Researchers observed similar student excitement about science during classroom observations and teachers and principals from all three sites consistently commented on about this trend.

Insight #2: Increased Use of Oral Language

An additional impact of students' general excitement for science is that students are *talking* about science. Across the board, teachers and school administrators are overwhelmed with the students' increased use of English. During interviews teachers report this increase in both oral and written English, but seem most impressed by students increased use of oral language. Teachers are noticeably elated as they describe this change in their students. "It is much more exciting. So kids are willing to talk more, in English" (Teacher 2, Interview 1). "You should see the vocabulary they [students] use now, 'we predicted today, we did some observations'" (Principal 2, Interview 1). This increase in English use extends beyond science and beyond the classroom. Principals and teachers from multiple school sites described an increase in English use in other content areas and in non-classroom settings such as recess or in the office when speaking to support staff.

We had a group of students in the office trying to settle a dispute that occurred on the playground and they were using English even though the office staff are fluent in Spanish. That was a first around here. (Principal 1, Interview 1)

School principals reported that students often want to tell them about the science activity, book, or lesson they are learning about in class, “When I am walking around the cafeteria or see the children walking out of the library they can’t wait to tell me about the different planets, rocks and minerals, or erosion” (Principal 2, Interview 2). Principals also noted an increased English language use beyond academics. This increased use of oral language, both within and outside the classroom, has perhaps been the most apparent and wide-ranging impact of blending science and ELD instruction. However, students aren’t the only ones changing.

Insight #3: Changes in Teacher Perceptions

All participating teachers commented on the changes they have seen within their own teaching practices, most prominently in terms of student expectations and the affect these new expectations have on their pedagogy. Teachers are now more focused on how they structure learning in the classroom and less focused on the label of the student. The teachers interviewed described a shift in thinking about what a child with limited English is capable of learning, both in terms of content and language. “Even my low EL learners can verbalize these [science] things. You have to expect them to because sometimes it is just the language and not that they aren’t thinking these things in their minds” (Teacher 9, Interview 1). Teachers often commented on the belief that their students can have a good understanding of the science, but be limited in their ability to express that thinking by their language ability. In other words, a limited student response might represent limited English skills rather than limited conceptual understanding. In addition to expectations, teachers also commented on changes in their perceptions about teaching, specifically the structure of their lessons.

It is how I teach it that is going to give me the desired outcome. If I expect the child to know this then I need to guide them to that place and not expect it to come out of the blue somewhere in my lesson. It makes sense, but I never thought about it that way before. (Teacher 2, Interview 1)

Our close work with teachers has provided important insights to teachers’ creation and implementation of science/ELD blended lesson plans. Many of these are not earth-shattering for teacher educators, but were enormously enlightening for individual teachers as they grew in their understanding of effective teaching and their ability to critique their own practice. Many teachers grew in their understanding of ELLs, and came to see that language ability was at times impeding students from fully demonstrating the rich science understandings they had attained. For example, although our teachers believed sentence frames to be essential scaffolds for students with limited language skills; they grew to understand that the sentence frames they provided limited student responses and student work failed to display the range of content understanding. This critical insight led teachers to explore additional measures of student understanding (especially for students with beginning language skills) that were not as language dependent—developing assessments that included graphic organizers, pictures, and asking students to physically manipulate materials.

This initial development of teachers as critical practitioners has been one of the greatest outcomes of our work thus far. The strength of this lesson template, as evidenced by the 2 years of successful classroom implementation in over 60 classrooms, is that it is both an effective and manageable tool for teachers to use. However, to be successful teachers need to be sophisticated in their use of this lesson template, making decisions about when to shift the focus from language to science and from science to language based on the needs of their students any given point during a lesson. Teachers in our project are now considering the range of student understanding, both in content and in language. Teachers are becoming more discerning of their lessons, asking themselves critical questions such as, What about the student who understands the science really well but lacks the skills in English to express it? What about the student who is low or high in both content understanding and English language skills?

Considerations

Blending science and language instruction is not without its challenges and research in urban schools has shown that teachers need extensive support to effectively teach science to ELL students (Lee et al. 2006). One challenge with this approach is that teachers of ELLs often lack the understanding and preparation required to promote academic success and English language competence for this particular population (Gándara et al. 2004). However, here at HUSD this was less of a hurdle. The district has, over the past decade, placed priority on English language development and language arts and had launched a comprehensive ELD professional development initiative 3 years prior to the beginning of this project. Our teachers have had years of training and experience in working with ELLs and many of the teachers are language learners themselves. Subsequently, the teachers were very open to, comfortable with, and capable of the changes that we asked them to make in their instructional practice with regard to language development.

For HUSD teachers, like many elementary teachers, the greatest challenge of this blended approach was teachers' uncertainty with regard to their own science content knowledge and their ability to implement inquiry-based instruction (Loucks-Horsley et al. 1998). Early in this professional development effort, teachers would often discuss language considerations and strategies during their planning sessions, however they lacked the content knowledge necessary to engage in meaningful instructionally-related discussions of science content. This lack of content knowledge and discomfort with the idea of teaching science can limit a teacher's willingness and ability to teach science. Whereas, teachers who have pedagogical content knowledge (PCK) are effective because, "they understand how to teach materials to diverse student populations... [and] know appropriate analogies, illustrations, examples, demonstrations and are able to recognize misconceptions that may arise during the course of learning" (Shea and Greenwood 2007, p. 81). Content support was a necessary component of this program and was provided for general topics (weather, matter) during the summer institute as well as for grade level specific topics (matter can be observed, the moon's appearance changes in a

predictable pattern) during the Teacher Learning Collaborative when teachers planned and tested 5E lessons. Without this knowledge teachers may not be equipped to improve their science instruction; this is particularly true in our program as the blending of science and English language development is a complex process. Teachers' decisions as to which terms and language functions should be front-loaded or scaffolded greatly depends on the content of the lesson and the sequence of that content within the overall flow of ideas throughout the unit or year. Without an understanding of science specific PCK, teachers can inadvertently remove the inquiry out of the science in an attempt to scaffold the language. Which language forms or functions are necessary for students to fully engage in the science learning and which would stifle their explorations are decisions best made by the teacher who not only possesses great knowledge of second language development and a varied repertoire of strategies, but also commands a deep understanding of science content.

This project has had the good fortune of being a "whole school" project with all K-4 classroom teachers participating, as well as being the primary professional development effort at each school. In addition to increasing our confidence that the positive outcomes reported here are related to our efforts, this situation has allowed teacher to focus on their science/ELD instruction. This focused effort of teachers and professional development providers has allowed us to adapt to various student and teacher needs as they arise, leading to the creation and refinement of the science/ELD lesson protocol presented here. As we go forward, our efforts will now focus on further developing teachers' grade-level specific science content knowledge with hopes of further improving their science/ELD instruction and, ultimately, increasing students' science learning and English language acquisition.

Conclusion

While there has long been a call for a scientifically literate populace (American Association for the Advancement of Science 1992), without universal access to science instruction it is unlikely that this goal will ever be reached. While socioeconomic status can significantly impact student achievement, a students' proficiency in English can be another significant barrier, not only to science achievement, but to science access as well. As more instructional minutes are assigned to English Language Development and other related content areas (e.g., writing, reading), there is little time left for science. Subsequently, students who enter school with limited English proficiency too often must wait until they develop fluency before they are provided access to science content, leaving them years behind their English speaking counterparts, struggling to catch up.

Although the traditional curricula for English Language Development and inquiry-based science typically place different emphasis within a lesson, it is possible to successfully fuse the two into one method. When the blend is successful, science can be an effective platform for English language development providing a familiar and tangible context for students to develop new language. In addition, due to the inherent high-interest nature of science, students may be more willing to

practice newly acquired language skills about science related observations, questions and ideas. Finally, since science has become a content luxury available to students who perform at specified achievement levels, this blend provides a means to equalizing this disparity, helping to assure “science for *all* Americans” regardless of their primary language.

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