Exploring the Synergy Between Science Literacy and Language Literacy with English Language Learners: Lessons Learned within a Sustained Professional Development Program

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Thirty-five elementary teachers participated in a yearlong professional development (PD) program whose goal was to foster science content learning while promoting language literacy for English Language Learners (ELL). The researchers utilized an explanatory design methodology to determine the degree to which science and language literacy co-developed. The research question guiding this study was: In what ways did the yearlong PD science program support teachers at 10 elementary schools to become more knowledgeable about fostering science literacy and its role in co-developing language literacy (e.g. reading, writing, listening, and speaking) for ELL? The measurable and significant gains on the quantitative state science and reading tests and the analysis of qualitative teaching episodes led to the conclusion that there is a synergy between science learning and language learning -- as one increases, so does the other.

Introduction

While several examples of science teacher professional development (PD) have been eloquently presented (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Sparks & Loucks-Horsley, 1990), many still fall short in bridging content-specific knowledge and language learning gap. Thompson (2004) notes that the language learning of grade-level content and English "… is a complex, non-linear process that is affected by many interrelated factors…" (p. 3). The focus of teacher learning during professional development should be the integration of science literacy and language literacy to narrow the achievement gap for English Language Learners (ELL).

The current study focuses on exploring the co-development of learning science and acquiring language literacy and is guided by the question: In what ways did the yearlong PD science program support teachers at 10 elementary schools to become more knowledgeable about fostering science literacy and its role in co-developing language literacy (e.g. reading, writing, listening, and speaking) for ELL? The PD program included monthly workshops at a central location in the fall and campus visits in the spring working with individual teachers and small groups.

The Study

Defining Literacy

For the purpose of this study, science literacy is defined as a person's "… ability to ask, find, or determine answers to questions derived from curiosity about everyday experiences … [and] to describe, explain, and predict natural phenomena" (National Research Council, 1996, p. 22). Hollbrook and Ronnikmae (2009) argue that enhancing scientific literacy is dependent on the need to "develop collective interaction skills, personal development and suitable communication approaches …" (p. 286). Based on this definition and the state standards for fifth grade science, developing scientific literacy requires students to: 1) collect information through observation and measurement, 2) construct graphs, tables, maps, and charts, 3) draw inferences, 4) represent the natural world using models, and 5) identify patterns and properties. Hands-on science learning provides a context for meaningful language usage (Castek, Leu, Coiro, Gort, & Lima, 2007).

In this study, language literacy is defined as developing the knowledge and skills outlined in the fifth grade state mandated reading objectives modified for ELL. Students acquire language literacy through: 1) reading and systematic word study, 2) drawing on their experiences to bring meaning to words in context, 3) analyzing cause and effect relationships, 4) representing information in different ways, 5) drawing inferences, and 6) analyzing characteristics of various objects. By co-developing science literacy and language literacy in tandem, learning accelerates for both the academic language of the discipline and everyday, informal language (Collier & Thomas, 2006; Cummins & Miramontes, 2006). Thompson (2004) states, "this process requires the integration of one's language skills, … and the ability to construct meaning from … printed materials …" (p. 1).

Participants

Thirty-five elementary public school teachers who taught science in English to ELL participated in the yearlong PD program. Of the total number of teacher participants from 10 schools in the district located in a Texas border region, more than 60% were Hispanic and bilingual with an average of 12 years of teaching experience. ELL students in these schools represented up to half of the total student population and over 80% were identified as economically disadvantaged.

The PD Curriculum and the 5E Pedagogy

The goal of the PD was to increase science achievement while co-developing language literacy. The curriculum focused on big science ideas and included a language literacy component embedded in the 5E pedagogy. Participants engaged in hands-on learning to explore topics more fully and had opportunities to generate new questions, offer fresh ideas, and use their reading, writing, speaking, and listening language skills.

The 5E hands-on pedagogy served as the delivery system for the PD curriculum. It includes five phases: engage, explore, explain, elaborate, and evaluate. The researchers' 5E pedagogy is a modified version of Bybee's 5Es (1997) in which the "elaborate" phase provides opportunities for students to identify relationships between ideas and/or variables in experimental investigations to promote learner discussion and reflection. In the "evaluate" phase, a "game" format, which included a science "vocabulary loop," measured science language and literacy learning. Each student received a card that bears one phrase, "I have [science term]" and another phrase "Who has [definition of a different science term]." The student who has the word or phrase on their card that matches the "who has" definition stands up next and reads their "I have [matching word]" followed by their "Who has" definition. The process is then repeated until all science vocabulary terms have been matched with

their respective definition. The loop ends when the last definition matches the first term that is read. Table 1 identifies the 5Es with descriptions of student behaviors.

from the fifth grade mandated state science and reading tests at 10 schools using a one-tailed test to compare two proportions. The data reported percentages of ELL who met state science and reading standards from 2009 to 2010. During the

Table 1
The 5E pedagogy delivery system with student behaviors for each phase used during PD

The 5E Pedagogy	
Phases	*Student Behavior*
Engage	Students encounter or identify the phenomenon to spark their interest. They make connections between past and present learning experiences providing opportunities for contextualizing science learning. They ask higher order questions to identify a situation or offer a solution to a problem.
Explore	Students interact with materials and resources and rely on these experience(s) to guide their exploration to satisfy their curiosity. They observe situations, collect data, dialogue with peers to confirm hypotheses, and begin to analyze results.
Explain	Based on student experiences during the 'explore,' the teacher introduces the appropriate science content language associated with the experience(s). The teacher guides the students through the discourse to build science understanding over time, encourage them to use their language skills to make connections between inscriptions, representations, and hands-on experiences, and provide a learning environment for understanding the difference between facts and the big ideas (concepts).
Elaborate	Students build relationships between variables identified during an experiment that relate to the topic being studied. Students use models (scientific and mathematical) to make connections between ideas and theories. Students also become aware of connections between their ideas and other ideas or concepts (sometimes involving correlation and/or causality).
Evaluate	Students are assessed in a variety of ways to identify level of learning of fundamental skills, academic language, science big ideas, and interpretations of visual representations and graphics through writing, oral and written exercises such as a vocabulary loop, and interactions with peers/their teacher.

Methodology

An explanatory mixed methods design was used to collect both quantitative and qualitative data. The quantitative phase of the study included collecting and analyzing disaggregated scores

qualitative phase, observation data were collected and analyzed. The results from analyzing both forms of data shed light on how the PD program built science teachers' instructional capacity to support students in learning both science and language.

Results

Quantitative Phase

Quantitative results indicate that fifth grade ELL performance in science at all campuses showed significant gains from 2009 to 2010. To measure language literacy gains, we collected and analyzed scores from the state mandated reading test. This test was selected because it aligns well with district and state science objectives. To be successful on the state mandated science test, students need to know reading comprehension, vocabulary development, and multiple representations of information. In addition to collecting quantitative data, we collected and analyzed qualitative data.

Qualitative Phase

Qualitative data were collected in participant classrooms during the spring term through a series of in-person and videotaped observations. A constructivist grounded theory methodology (Charmaz, 2008) was used to gather and analyze classroom and videotape observation data. Teaching episodes were used to examine the interactions between students and students as well as students and their teachers. Through coding and constant-comparison methods, two theoretical categories were constructed (see Table 2).

Theoretical categories of "engaging as verbalizing and experimenting as communicating" evolved into specific meanings over the course of the analysis. They were based on our interactions with the participants that made possible a plausible theory to address the research question: In what ways did the yearlong PD science program support teachers at ten elementary schools to become more knowledgeable about fostering science literacy and its role in co-developing language literacy for ELL?

Discussion

Teachers are key to the successful education of ELL. This success is predicated on learning and acquiring content-specific knowledge and navigating the grammatical patterns and the nuances of language. The yearlong PD program embedded ways for teachers to strengthen their science knowledge and pedagogical skills while developing a mind-set for instructional change. This change meant viewing science and language synergistically to build and use the language of science in ways that make sense and have meaning for their students.

Table 2
Theoretical categories and their attributes

Theoretical category	*Attributes*
Engaging as verbalizing	For teachers, the "engage" phase of the 5E was the time to have students speak to each other (and to the teacher) about their initial ideas, observations, and their prior ideas. Discussion became a critical part of the "engage" phase, the beginning of the lesson.
Experimenting as communicating	Teachers believed that building vocabulary during science investigations necessarily involved writing along with speaking. Discussion, based on science observations and journal writing, became an integral part of the "explore" phase.

Learning science or any other discipline in the curriculum is made possible through reading, analyzing the text, interpreting, discussing, and writing, which are fundamental elements of language literacy. Huntley (1998) and Baker and Saul (1994) emphasize and support the synergistic nature of science and language learning. The results of this study led to the conclusion that there is a synergy between science learning and language learning -- as one increases, so does the other.

Instructional change is always a challenge, and contextualizing science literacy along with language literacy can be overwhelming for teachers. It is not surprising that science scores for ELL continue to fall far below other groups of students. There are several possible reasons why science instruction is not an integral part of the curriculum for ELL. For one, there is a perceived urgency to first increase language proficiency and then consider teaching ELL the other disciplines. This long held assumption is no longer tenable. Our research provides additional evidence that there is a continuum of learning between science and language, and teachers do not have to make a choice between teaching science and teaching language. They can teach both using science as the instructional engine.

Our plan for the yearlong PD program was multifaceted. First, participants experienced a content-rich and language-rich science classroom using hands-on experiences. Second, we observed participants' teaching to determine how they applied their knowledge. Lastly, we wanted teachers to recognize that they could integrate language with science without having to sacrifice valuable instructional time for either one. Participants also recognized that learning gains were possible to achieve based on changes they made in their teaching repertoire. Their long-standing approach of isolating language instruction from academic disciplines, such as science, seemed to dissipate. What began to emerge was a belief that science and language can co-develop and have a reciprocal quality.

Conclusion

At the conclusion of the PD program, the participants became more at ease with promoting language learning in the context of science using the 5Es. Teachers began to discern that hands-on experiences were catalysts for promoting communication. We are not advocating one best way to support English Language Learners in the science classroom, but we hope we have opened a new window to teaching science and language. Our PD program offers an array of hands-on approaches embedded in the 5Es that will inform both instructional practice and research focused on teaching ELL. It shares the lessons learned on our journey to explore the synergy between learning science and contextualizing language. Without this perspective, we believe that the science and language literacy achievement gap for ELL will continue to widen.

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