We Are All Talking to Learn Science: Finding the Right Fit

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In this white paper, we explore the impact of a multiyear professional development (PD) program as it evolved to meet the needs of K – 2 teachers and, subsequently, their ELL students. By getting to know the needs of teacher-participants and through annual internal formative and summative assessments, the directors of the program made systematic changes to attempt to strengthen teacher content knowledge and implementation of oral language development strategies in science. As a result of this three-year journey of science and language development, implications for future work are: 1) in order to provide an effective program, professional development providers should be aware of their participants' context, skills, and district-mandated curricula; 2) professional development needs to be situated in classroom, school, district, and community contexts; 3) district support is essential for long-term change; 4) when teachers feel efficacious, they are more likely to continue to implement new ways of teaching (Guskey, 1988); 5) to be convinced of the benefits of science and language integration, teachers need to know the research and justification of the methods for their own professional growth; and 6) to effectively integrate science and language learning, a professional development team should include linguists, content specialists, and science educators.

Throughout the years and various models of our program, the directors of PD conducted several studies in order to determine which of the models was the most effective in preparing teachers to think about language and content integration. Throughout designing and

implementing an effective content and language PD model, we attempted to answer the following research questions:

1. What are the effects of teachers' participation in a professional development program that focuses on integrating language and content?

2. Which of the program models is the most effective in increasing (1) teachers' perceptions about the value of student-talk strategies, (2) teachers' implementation of student-talk strategies, and (3) student outcomes?

In this white paper, we briefly describe each model's design and goals, as well as the process under which we made decisions about the needs of our teachers in terms of thinking about language development through science content. Through the various data collection efforts and analyses, each of the models demonstrated important empirical findings and theoretical implications for professional development for teachers of science and language. Our panel discussion deepened this conversation with respect to both the results of this study and our recommendations for future work (also see Shea, Shanahan, Gomez-Zwiep, & Straits, 2012 and Shanahan & Shea, 2012).

Research Context: The Professional Development Program

In 2007, a Southern California university-based center obtained grant funding to work for three years with K-5 teachers in a low SES school district with a high English Language Learner (ELL) population. The goals of the PD program included: (1) enhancing the participants' science and math content knowledge; (2) increasing teachers' knowledge and use of strategies for ELL students; (3) supporting teachers in making their science and math lessons more comprehensible (Echevarria, Vogt, & Short, 2000); and (4) narrowing the achievement gap (Gándara, Rumberger, Maxwell-Jolly, & Callahan, 2003). With these goals in mind, the PD

directors provided standards-based, grade-level appropriate hands-on lessons using a 5E inquiry learning cycle: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 1997). In each workshop, highly qualified teacher-leaders chosen by the PD program's directors enacted science lessons half of the content time and math lessons for the other half. Teacher-participants engaged in the lessons as students to learn the content of the lesson. In other words, second grade teacher-participants collaboratively and actively participated as if they were second grade students in second grade content development lessons.

The directors based the design of the PD program on current theories of effective professional development (Garet, Porter, Desimone, Birman, & Yoon, 2001; Hawley & Valli, 1999). Research has shown that when teacher professional development is focused on content knowledge and provides opportunities for active learning of extended duration, positive change can occur in teacher learning (Garet et al., 2001). Creating and implementing PD that provides opportunities for teachers to engage in active learning experiences promotes awareness of the synergy between language and science learning, and provides a framework for the integration of science and language that has the potential to not only increase teacher outcomes but improve student outcomes as well (Shanahan & Shea, 2012).

PD Program Site

At the onset of these PD programs, the school district had 27,369 students enrolled, with 14,080 (51.4%) students designated as ELLs. Approximately 91% of the teachers were fully credentialed. The average class size for the district was 25.9 students. There were 21,672 students (80.9%) who qualified for free or reduced lunch.

At the time of these programs, Caswell Unified School District (pseudonym) was identified as a "High Need District" based on percentage of families in poverty (U.S. Census

Bureau, 2005). The district did not meet Adequate Yearly Progress (AYP) as determined by No Child Left Behind, which designated it as a Program Improvement (PI) District. English language learners were of particular concern as this sub-group fell below the AYP minimum across the districts at all grade levels. The four-year dropout rate for the district was 49.9% (California Department of Education, 2010).

At the onset of the PD program described in this paper, the district implemented its own ELD program in which students focused solely on language function and structure. The premise of the PD program, on the other hand, was that science was a more appropriate context for learning language because it provided authentic opportunities in inquiry lessons for student-to-student talk.

Teacher Participants

In each year of the program, teachers from 17 elementary schools in Caswell Unified School District self-selected to participate in the professional development program. The district offered stipends for teachers' participation at the workshops. The teachers' ethnicities, ages, preparation, and teaching experience varied widely. Participants had diverse experiences in language acquisition training, for example some teachers had never taken courses or professional development with a language focus, while others had Masters Degrees with a language emphasis. Five elementary schools in Caswell Unified did not have the option to participate and served as non-treatment or comparison schools.

Figure 1, below, shows the progression of the models throughout the three years. In the following sections, we further explain each of the models, a brief overview of their empirical results, and our thinking about changes to the models.

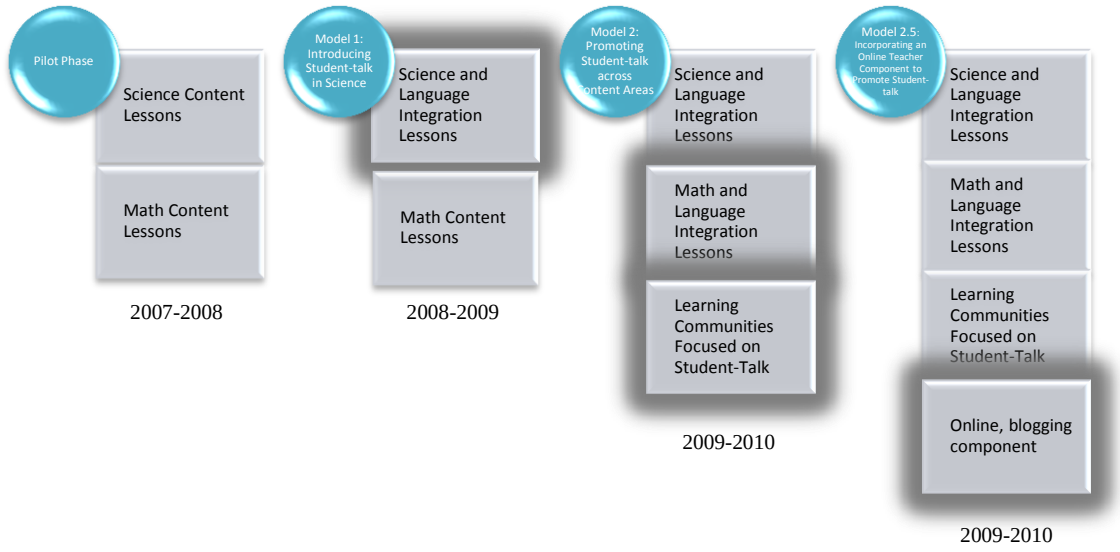


Figure 1. Professional Development Workshop Components in Each Model. Changes from the previous models are highlighted. Model 2.5 is not discussed in this paper, however can be found in Shea, 2012.

Professional Development

Pilot phase. During a brief pilot phase in 2007-2008, in an attempt to provide rich opportunities for student-talk in science lessons (Chamot & O'Malley, 1994), the professional development providers embedded student-talk strategies in science lessons, however these strategies were not overtly presented to the participants. The strategies were present and experienced by the teacher-participants within the lessons, but no further mention or discussion was made about the strategies. Following Bandura's (1997) efficacy model through these grade-level sample lessons, teachers actively participated as students in a lesson enacted by a teacher-leader who was currently teaching in the specified grade level. The participants identified with the presenters since they shared similar grade-level teaching experiences. After engaging in grade-level-appropriate math and science lessons, the teacher-participants had a 15-minute conversation about teacher practice and brainstormed how they could incorporate the

lesson with their own students. They discussed the challenges they or their students might have in the lesson. When returning to their school sites, participants shared with colleagues about their own experiences in participation, which furthered social persuasion and positive reinforcement. They then taught the lesson to their own students, which provided them with mastery experiences. Lastly, the project aimed to help teachers to gain an identity of an effective science and math teacher and professional development participant, positively influencing their emotional state. A goal of the pilot phase of the program was to determine whether the implementation of a professional development model based on both Bandura's and Hawley and Valli's theoretical frameworks could develop teachers who learn and implement the lessons taught, while creating a stronger sense of teacher efficacy in teaching the content.

At the end of the pilot phase, internal evaluations revealed promising content-related results, with participants showing a significant increase in their content knowledge as measured by a pre-/post-test. However, classroom level results suggested that the teacher-participants needed more overt focus on language learning strategies. This meant that the model needed to change. A language and literacy doctoral student, with a background in applied linguistics, joined the science directors and aided in making systematic changes to the PD. Together, the science PD team decided to increase the oral language opportunities in each area of the science 5E lesson plans. The strategies would become more numerous, overt, and complementary to the learning stage of the participants.

Incorporating Content and Language: Models 1-2

Model 1. After the pilot phase, the second and third years of the program marked an attempt to more intentionally integrate content and language PD for the teachers in Caswell Unified. With the same base-line characteristics as the pilot study, the next model of the

professional development program (Model 1) continued to consist of science and math workshops for K-2 teachers.

Model 1 had goals of increasing oral language development through self-expression, interaction skills, proper use of language structures, and vocabulary development. These goals were related to the language proficiency standards written by the Teachers of English to Speakers of Other Languages (2006) that: 1) English language learners communicate for social, intercultural, and instructional purposes within the school setting; and 2) English language learners communicate information, ideas, and concepts necessary for academic success in all content areas, including science.

Since oral language development has been shown to be a precursor for more advanced literacy skills (August & Shanahan 2006; Pearson & Hiebert, 2010; Shanahan & Lonigan, 2010; Snow, 1999), repeated student-talk strategies were included in the lessons for language learners to have authentic, content related linguistic opportunities. The team tapped into the current research that suggested that the needs of English Language Learners are better met when English language and content areas are addressed simultaneously (Lee & Luykx, 2005) and that science is a discipline where language and content learning are intimately intertwined (Quinn, Lee, & Valdes, 2012). With the focus that science provides a place where the "conceptual is the linguistic where language is the primary medium through which scientific concepts are understood, constructed, and expressed" (Bialystok, 2008, p.109), the team had new goals to challenge the common trend in education where K-12 teachers typically dominate classroom discussions and spend the majority of instructional time talking (Cazden, 2001; Wyse, 2002). The overt focus on oral language development (namely student-talk strategies) would give students the voice to interact and use language more often within the science content lessons.

In Model 1, knowing the needs of the teachers allowed the PD team to determine how to scaffold the teachers' learning through strategies and purposeful steps. In other words, the team knew that the program could not introduce too much too fast or it risked introducing misconceptions or overwhelming participants. The program aimed to provide support within the participants' Zone of Proximal Development (Vygotsky, 1978). That said, the development team decided to incorporate academic student-talk strategies from the district's English Language Development curriculum at the time, with which the teachers were already slightly familiar.

The PD program did not use published science curricula or hands-on inquiry programs. The teacher-leaders created their own standards-based, grade-appropriate science lessons that included the overt focus on oral language development. Members from the PD team reviewed each lesson, made suggestions, and edited them to ensure that the lessons included accurate content and appropriate student-talk strategies. Then, in each PD workshop, the teacher-leaders modeled and facilitated the 5E, student-talk science lessons while the teacher-participants again actively experienced the lessons as learners with the intent that they would take these "educative materials" (Davis & Krajcik, 2005) and strategies back to their classrooms. Each stage of the 5E lessons featured multiple opportunities for students to relevantly talk in groups or pairs. As a teacher-leader was about to implement a specific student-talk strategy, he/she paused to explain the cognitive, linguistic, and social benefits of student oral language production. For example, in a three-way interview student-talk strategy in science (see Appendix A for examples of student-talk strategies), teacher-leaders stressed that every student in the lesson had opportunities to use scientific language, ask scientific questions, and listen to peer responses. The teacher-leader would contrast the quality and quantity of oral language to more traditional whole-class reporting

where the teacher asks a question and one student is chosen to respond so participants could interpret the value of using the student-talk strategy. Once again, teacher-participants engaged in the lessons as students, being given many opportunities to use oral language in science.

In this model, there was an intensive one-week summer institute followed by academic year Saturday workshops that continued the content and language integration model. The teacher-participants were in grade level groups, receiving content and language 5E standards-based lessons in science taught by teacher-leaders who had similar students in their own classrooms in other districts.

At the end of Model 1, we collected many forms of data, conducted several qualitative and quantitative analyses, and concluded important findings which were reported to the science education community and guided our thinking about PD for our teachers. In brief, at the teacher level, our interviews with teacher-participants and classroom observations revealed that teachers were emerging thinkers in terms of language and science integration. Teachers were trying the strategies in their classrooms and were beginning to understand why oral language development supported student learning and language acquisition. Pre- and post- classroom level results showed that students were relevantly talking at an increased rate. Students were observed to be using content language, academic structures, and discussing content with peers. (For more in depth detail of the specific research questions, data collection, analyses, and findings, see Shanahan & Shea, 2012; Shea, 2012; Shea, Shanahan, Gomez-Zwiep & Straits, 2012). A brief overview of each is presented in Table 2 in Appendix B.

Even though the research results were encouraging, the teacher-participants seemed to need more theoretical underpinnings for the student-talk strategies that they were implementing to a slightly positive effect. In some cases, participants' administrators did not support teachers

using their instructional minutes to teach science. Since only math and English Language Arts were being tested in California, elementary principals in the district were insistent that their teachers focus only on these two areas of instruction. Thus, the teacher-participants needed the theoretical background to have professional conversations with their principals about the benefits to their ELLs of being given rich oral language opportunities provided in science lessons. Knowing the needs of the teacher participants and their school context allowed these critical modifications to be made.

At the same time, the university math professional development providers acknowledged that their math lessons needed more embedded student-talk strategies as well. So, at that point, the doctoral student began working with them to provide this support in their content lessons.

Model 2. Model 2 became an extension of Model 1. In 2009-2010, improvements on Model 1's design consisted of enhancing several characteristics from the research on effective professional development. First, the model included more *continuity* and *support* for teachers' learning. In this academic year, the language integration was more continuous, whereby each section of a workshop-day incorporated student-talk. Each Saturday session began with a school-based professional learning community conversation around oral language. During this morning workshop led by the teacher leaders, they modeled the student-talk strategies that would be highlighted later in the content lessons. From this, the teachers were able to see the generalizability of the strategies, mainly how they could be used in other contexts.

Overall, this PD model included (1) student-talk-infused lessons in science *and math* presented in the same format as described in Model 1 and (2) additional pedagogical *support* with readings and discussions of student-talk research. Second, the professional development sessions were more *information rich* in that they not only incorporated real-world connections to

the science or math being taught, but also made language development connections across the disciplines. Third, each PD session more thoroughly *focused on theoretical understanding* by utilizing academic readings on the benefits of student-talk in the content areas of math and science. Each of the components is further described below.

Math and science content lessons. The cohort of K-2 teachers participated in both science *and math* lessons integrated with student-talk strategies. Following the pilot phase model, teacher-leaders implemented grade-appropriate lessons while teacher-participants engaged as students. Teacher-leaders utilized the student-talk strategies as they pertained to the science *and math* lessons.

Student-talk learning communities. In addition to engagement in student-talk-infused math and science lessons, teacher-participants in this PD model attended a complementary component involving student-talk, namely supportive and collegial learning workshops. In these 90-minute workshops, a teacher-leader and teacher-participants from the same school participated in reading academic research related to the importance of student-talk in the content areas. The teacher-participants discussed student-talk research and theory, while a teacher-leader facilitated the group by utilizing the student-talk strategies. After reading and discussing the research, the teacher-participants collaborated to decide how they could best use the student-talk strategies within their schools given their populations.

After teacher-participants experienced the grade-appropriate content and student-talk lessons and collaboratively discussed the cognitive and social benefits of student-talk, the PD leaders expected the teachers to try the specific lessons and student-talk strategies with their own students. The next professional development workshop included time for teacher-participants to debrief and reflect about their own classroom implementation of the language-infused content

lessons. Making the teacher-participants more accountable for using the student-talk strategies from workshop session to workshop session was more powerful in that the teacher-participants felt compelled to try a strategy with their students because they were expected to report to their school-level peers at the next session.

At the end of Model 2, researchers once again collected many forms of data including teacher interviews and classroom observations. We conducted several qualitative and quantitative analyses and concluded that the teachers were more confident and efficacious in their use of the oral language strategies across multiple content areas. In the classroom observations, the teachers were not necessarily using the program's science lessons but they were teaching science using the strategies. The teachers now recognized how the student-talk strategies benefited their students and consequently, the teachers incorporated these strategies with more frequency. We anticipated that having more oral language opportunities would result in improved English Language Arts achievement for the ELLs, and subsequently the school level and classroom level results demonstrated those expectations as well as increases in ELA for the general population. A more detailed description of these analyses and findings was presented in our panel discussion.

Implications for Future Work

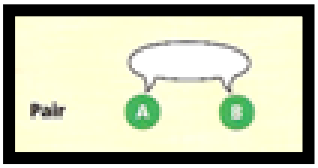
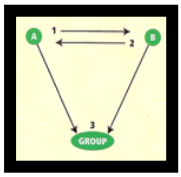
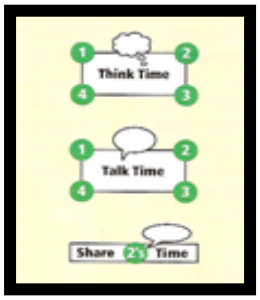
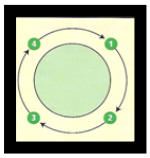
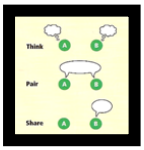
The journey to create a PD program focused on science and language development was laborious and intensive. However beneficial, it took time to know the participants, their context, their learning, and their potential. Once a relationship was established, the team best concluded that they had to start with strategies that were in place at the district level in order to scaffold the connection between science and language development. Starting with less complicated strategies and providing research to their merit allowed the PD providers to show the participants that the

synergies between language and science exist and should be unified for the sake of language learners.

As previously stated, the PD team and authors of this paper make the following points for discussion when determining how to best create and implement PD focused on science and language development: 1) professional developers should know their participants' context, skills, and district-mandated curricula; 2) professional development is situated in classroom, school, district, and community contexts (Parrish, Linquanti, Merickel, Quick, Laird, & Esra, 2002); 3) district support is essential for long-term change; 4) when teachers feel efficacious, they are more likely to continue to implement new ways of teaching (Guskey, 1988); 5) to be convinced of the benefits of science and language integration, teachers need research for their own professional growth as well as for justification to their principals for this integration; and 6) to effectively integrate science and language learning, a professional development team should include linguists, content specialists, and science educators.

Appendix A

A Sample of Student-talk Strategies (Adapted from Avenues, Hampton-Brown, 2007)

Design	Description	Benefits and Purposes
Report to a partner 	• Each student reports his/her own answer to a peer. • The students listen to their partner's response. ("Turn to a partner on your left." "Now turn to a partner on your right" etc.)	• This allows students to talk to different students in the class and gives each student an opportunity to share and listen to various answers and language structures. • Talking one-on-one with a variety of partners gives risk free fluency practice. • Students practice speaking and listening.
Three-way Interview 	• Students form pairs. • Student A interviews student B about a topic. • Partners reverse roles. • Student A shares with the class information from student B; then student B shares information from student A.	• Interviewing supports language development in question formation. • Students participate in speaking and active listening. • This ensures participation by all students.
Numbered Heads 	• Students number off within each group. • Teacher prompts or gives a directive. • Students think individually about the topic. • Groups discuss the topic so that any member of the group can report for the group. • Teacher calls a number and the student from each group with that number reports for the group.	• Group discussion of topics provides each student with language and concept understanding. • Random recitation provides an opportunity for evaluation of both individual and group progress.
Roundtable 	• Teacher seats students in small groups around tables. • Teacher asks a question with many possible answers. • Each student around the table answers the question a different way.	• Encouraging elaboration creates appreciation for diversity of opinion and thought. • Eliciting multiple answers enhances language fluency.
Think, Pair, Share 	• Students think about a topic suggested by the teacher. • Pairs discuss the topic. • Teacher strategically chooses certain students to individually share information from their discussion with the class.	• The opportunity for self-talk during the individual think time allows for the student to formulate thoughts before speaking. • Think time allows students to think about the concepts and the language before producing. • Discussion with a partner reduces performance anxiety and enhances understanding.

Appendix B

Table 2

Data and Analyses to Answer the Research Questions

Research Question	Data Sources	Analyses
1. What are the effects of teachers' participation in a professional development program that focuses on integrating language and content?	Classroom observations, student test score data, and teacher interviews	Linear modeling, analyses of means, survival analysis, and structural coding
2. Which of the program models (comparing Model 1 and Model 2) is the most effective in increasing (1) teachers' perceptions about the value of student-talk strategies, (2) teachers' implementation of student-talk strategies, and (3) student outcomes?	(1) Interviews (2) Classroom observations and teacher interviews (3) Student test score data and teacher interviews	(1) Structural coding (2) Linear modeling, analyses of means, and structural coding (3)Linear modeling, survival analysis, and structural coding

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For additional information and materials related to the conference "Exploring Science and English Language Development: Implications for Teacher Professional Learning", visit the Institute for Inquiry at exploratorium.edu/education/ifi/inquiry-and-eld.