Using Science as a Context for Language Learning: Impact and Implications from Two Professional Development Programs

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Abstract

Effective forums to prepare teachers to meet the instructional needs of English Language Learners (ELLs) are necessary as these students will soon constitute a majority of America's K - 12 population. Current research suggests that the needs of ELLs are better met when English language and content areas are addressed simultaneously. This paper reports on how two professional development (PD) programs created, implemented, and researched training workshops to prepare teachers in promoting higher quality academic, student-to-student interactions and in increasing science literacy. Both PD programs modified the traditional 5E inquiry learning cycle format to incorporate explicit language development strategies for teachers to utilize with their ELLs. The two mixed-methods studies utilized teacher interviews and student scores on state-administered standardized tests. Results from these two PD programs suggest that science is a viable, and arguably a necessary, context to enhance students' skills in language and literacy while simultaneously developing conceptual understanding of science content.

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Introduction

In recent decades, the number of English Language Learners (ELLs) in U.S. schools has increased dramatically, with nearly 11 million ELLs now enrolled in diverse classrooms across the country (NCES, 2008). Teachers in most of these classrooms have had virtually no specialized training in how to adapt instruction for second language learners (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Too often these students' instructional needs go unmet. ELLs suffer poor educational and affective outcomes, and a high percentage fail to become literate in English or graduate from high school (California State Department of Education, 2009). Determining the most effective forums to develop in-service teachers capable of meeting the instructional needs of English Language Learners will benefit a population of students that will soon be America's majority.

Current research suggests that the needs of ELLs are better met when English language and content areas are addressed simultaneously (Lee & Luykx, 2005). Science is a discipline where language and content learning are intimately intertwined. In science, the "conceptual is the linguistic where language is the primary medium through which scientific concepts are understood, constructed, and expressed" (Bialystok, 2008, p.109). Specifically, research has shown that instruction with a science and English language combined focus can lead to increased student performance in writing, reading, and science (Stoddart, Pinal, Katzke, & Canaday, 2002; Lee & Luykx, 2005; Lee, Deaktor, Enders, & Lambert, 2008). The purposeful integration of science and language results in an understanding of both science and language beyond the scope of when either is used separately (Stoddart, Pinal, Latzke, and Canady, 2002).

Of course, integrating science and language instruction is not without its challenges. The majority of teachers instructing ELLs often lack the understanding and preparation to integrate English language development and literacy with content-area instruction (Gándara, Maxwell-Jolly, & Driscoll, 2004). Additional research has shown that teachers often assume that students must acquire English prior to formal science instruction, postponing access to science content until students master a certain level of English language proficiency (Bryan & Atwater, 2002). The challenges of this integrated approach are further compounded given that elementary teachers are often uncertain of their own science content knowledge and their ability to implement inquiry-based instruction (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Research in urban schools has shown that teachers need extensive support to effectively teach science to ELL students (Lee, Buxton, Lewis, & LeRoy, 2006). To address this, a number of professional development programs have recently been designed and implemented in the United States to give pre-service and in-service teachers opportunities to learn strategies for teaching ELLs in content areas (Lee et al., 2008). However, further study of these methodologies is required to investigate the potential impact of an integrated science and language approach. Specifically, the field requires further investigation to the trajectory of teacher learning to student outcomes.

The professional development programs described in this paper draw on the Vygotskian view of language as developed through social patterns and interactions with others (Williams & Veomett, 2007). Acceptable language use, including experience with discussion, turn-taking, intonation, pitch, and other pragmatic conversational skills, is internalized by the learner during interaction and production (Pica, 1987). The Vygotskian view has been further conceptualized by scholars such as Lave and Wenger (1991) in the situated perspective where humans learn through recognizing, using, and transforming patterns. However, in terms of language development, recognizing a linguistic and social pattern is not enough for a learner to fully

comprehend how to use the language and linguistically negotiate within it (Swain, 2005). These language abilities will only be gained when a learner has had ample opportunity to engage in meaningful and purposeful language *production*. Inquiry science lessons can serve as the perfect context for purposeful language production. As students gather data, communicate their findings, compare their findings to those of others, there is purposeful dialog that occurs throughout the process.

The aforementioned theoretical perspectives have been confirmed by interactionist studies that have found many benefits of production in language learning. Swain and Lapkin (1995) concluded that producing language allows learners to process both language and content more deeply than simply listening. Speaking and listening allow learners to negotiate meaning and adjust their output to make it comprehensible to their audience (Hill & Flynn, 2006). Using the target language in meaningful and relevant interactions allows for the gathering, transforming, organizing, and reorganizing of knowledge of the language to learn more about it (Fillmore, 1991). Interaction plays a critical role in acquisition whereby learners gain positive and negative evidence to continue on a learning trajectory. As students engage in inquiry science investigations, they use language to manipulate their content knowledge acquisition through gathering, transforming, organizing, and reorganizing data.

This paper reports on the impacts of two different professional development (PD) teams that created and implemented programs to prepare teachers in promoting higher quality academic student-to-student interactions and in increasing science literacy. Common across these PD efforts is the emphasis of blending of inquiry science and English language development using the 5E model. The findings reported here represent an important contribution in that it presents teacher learning and efficacy in relation to student outcomes.

Findings presented here reflect the first two years of each PD program's implementation of blending science and language development instruction. Researchers in both programs conducted mixed-methods studies to determine the impact of the model in improving teacher quality and, subsequently, students' growth in science and language learning. The following research question guided both studies.

How does a professional development program that incorporates science and language development influence (1) teacher learning, (2) teacher self-efficacy, and (3) student outcomes?

Context

Hubbard and Levine Unified School Districts

Hubbard and Levine Unified School Districts (HUSD and LUSD, pseudonyms) are both large, urban school districts in California serving culturally and linguistically diverse populations. Fifty-seven percent of HUSD students and 54 percent of LUSD students are ELLs (California Department of Education, 2009). The majority of the students in both districts qualify for free or reduced-price meals and the districts have been identified as a "High Need District" based on percentage of families in poverty (US Census Bureau, 2005). Currently both districts are identified as Program Improvement Districts, the designation assigned by the state for districts with schools that fail to make Adequate Yearly Progress towards statewide proficiency goals. English Language Learners are of particular concern in HUSD and LUSD as this sub-group falls below the Annual Yearly Progress minimum across the districts at all grade levels.

Two separate universities in southern California created professional development programs for K-2 teachers of ELLs. While there are distinctions between these two programs,

both were guided by a common theory of action (Figure 1) and utilized the 5E inquiry model as a foundation for the integration of language development and science. In each program, professional development served Kindergarten through second grade teachers working within school communities characterized by low socio-economic status (SES) and a high percentage of minorities. Three schools from HUSD and seventeen from LUSD participated in these programs. Multiple teachers were included from each of these twenty school sites: in the years of this study, a total of 61 teachers participated in the HUSD program and 68 in the LUSD program.

The 5E lesson plan model is a popular version of the inquiry learning cycle (Bybee, 1997). In this format, each of the lesson stages of engage, explore, explain, elaborate, and evaluate components constitute an active role in student learning. The *Engage* component involves motivating the students to activate prior knowledge. *Explore* enables students to compare, test, and investigate. In *Explain,* the teacher probes students' understanding through questioning and invites clarifications. *Elaborate* allows students to apply their learning to the real world and reinforces student knowledge. Throughout the lesson, both students and teacher *Evaluate* understanding and monitor progress. In both the HUSD and LUSD studies, the PD programs' goal was to modify the traditional 5E format to incorporate explicit language development strategies for teachers to utilize with their ELLs.   As such, the 5E inquiry model served as the basis for lesson design as it (1) emphasizes hands-on activities and student discourse, (2) promotes student thinking and problem-solving, and (3) provides opportunities for students to apply their new knowledge.

Program Elements

- Provide PD for K-2 elementary teachers working in low SES, high minority districts

- Engage teachers in active learning experiences

- Promote teachers' awareness of the synergy between language and science learning

- Provide 5E inquiry learning cycle as a framework for the integration of science and language development

Teacher Outcomes

- Increase teachers' science content knowledge and pedagogical content knowledge

- Increase teachers' understanding of second language acquisition within a science context

- Teachers will come to purposefully embed second language acquisition strategies in inquiry science

Student Outcomes

- Increase students' achievement in science
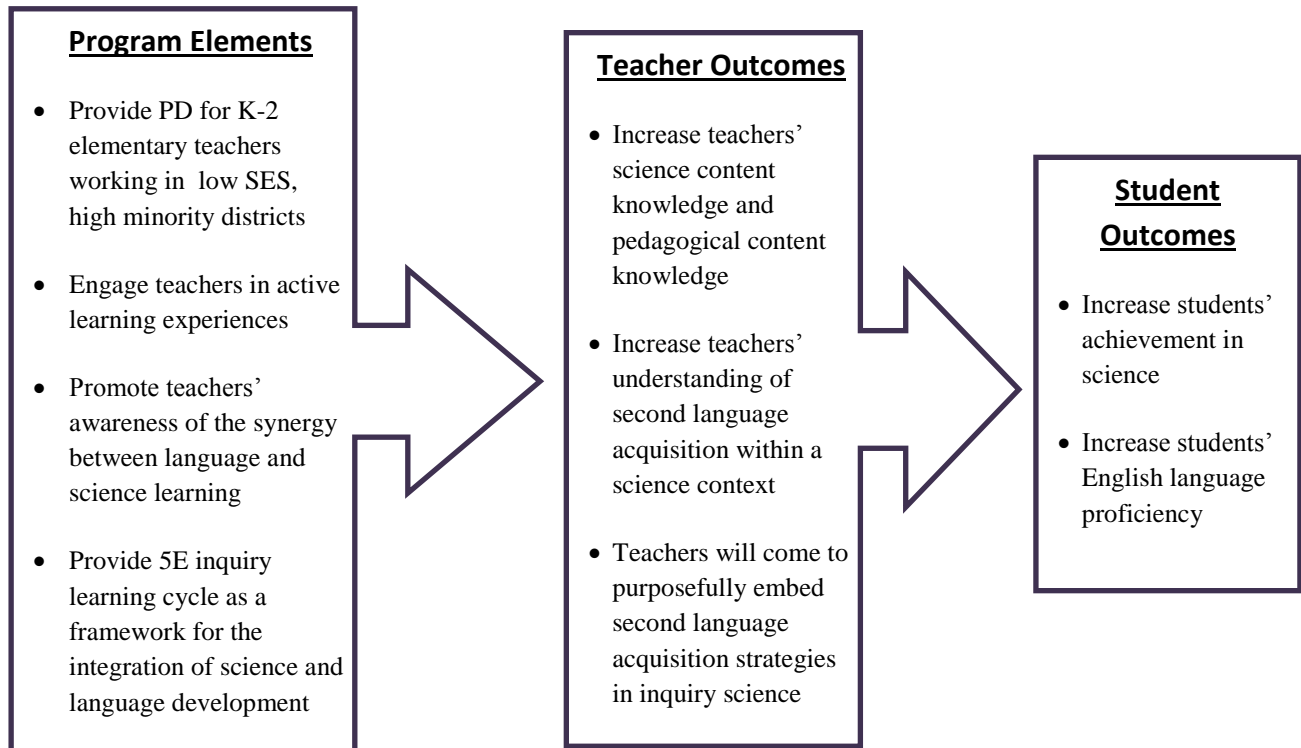
- Increase students' English language proficiency

Figure 1. Theory of Action for both Hubbard and Levine Unified School Districts

These two professional development programs attempted to use science to enhance students' skills in language, literacy, science, and cognition. Both had science and language components that utilized existing district resources and aimed to provide in-service K-2 teachers with a stronger background in science content knowledge and pedagogical content knowledge (Shulman, 1986). Each was a three-year program supported by a state-funding agency with the intent of improving teacher quality. Both provided over 100 hours of professional development to their districts, including two-week long summer institutes that emphasized teachers' active participation in hands-on science using manipulatives and realia to build standards-based science content knowledge and provide opportunities for discussing language use during science lessons. Each conducted continuing PD throughout school year that provided feedback on teacher-developed lessons that integrated language development opportunities in each of the 5Es.

Both programs utilized teacher-leaders who had received additional training to develop their mastery in science teaching, language development, and group facilitation. For HUSD, teacher-leaders were invited from participating schools at the onset of the program. The HUSD teacher leaders eventually facilitated small group lesson study teams throughout the school year and workshop sessions during the summer institute. However, since their training began with the program's inception, the teacher-leaders shadowed and were coached by the program leaders for at least one year before facilitating on their own. For the LUSD program, the teacher-leaders were highly qualified classroom teachers currently teaching in the specified grade level who had participated in a previous 5-year National Science Foundation grant, which created a regional cohort of professional development providers. The directors of the PD program conducted several classroom observations to verify that the teacher-leaders were adept at teaching science lessons in their own classrooms. Although they were classroom teachers in other districts, they taught children from similar backgrounds as those in the district in this study.

HUSD-Specific PD Elements

At HUSD, the Teaching Learning Collaborative (TLC) strategy was used to expand the skills of K-2 teachers developed during the summer institute (DiRanna, Topps, Cerwin & Gomez-Zwiep, 2009). Within the TLC, teachers worked collaboratively to plan, teach and reflect on a lesson using a modified 5E lesson design (Gomez-Zwiep, Straits, Stone, Beltran, & Furtado, 2011) (An example of the HUSD modified 5E lesson is given in Appendix A.) In grade-level teams, teachers participated in three cycles of the TLC process each school year. During TLCs, guided by a facilitator and/or teacher-leaders, teachers worked collaboratively in grade-level teams to write a lesson plan. During this planning, teachers were guided to consider both science and language development objectives. The lesson was collaboratively taught by the team, followed by a debriefing of the effectiveness of the lesson evaluated by evidence collected during the delivery of the lesson. Teams analyzed student work and the facilitator's transcription notes of the lesson for indicators of the relationship between teacher decisions in the lesson plan and student understanding. The lesson was then redesigned, based on evidence from the classroom, and taught to another group of students collaboratively by the same team of teachers. The process of looking at student work was repeated and the lesson is further refined.

Hubbard Unified School District assembled a professional development team, consisting of district personnel, faculty from local universities, English Language Development (ELD) and science educators, and professional development experts from a national, nonprofit education research and service agency. This team's endeavors to provide science and language professional development were guided by the understanding that (1) science content could

provide a highly-contextualized setting for language development; (2) although students might not yet be proficient in English, they could still process science content at a high level, through complex thinking processes (in other words, the science should not be simplified in an attempt to simplify language); (3) vocabulary, along with specific language functions and forms, would need to be carefully considered for what, when and how they would be used (decisions need to be made about which new words would be embedded in the lesson and which new words would be front-loaded (pre-taught) based on the instructional goals of the lesson); and (4) the 5E inquiry model should serve as the basis for lesson design as it emphasizes hands-on activities and student interaction, promotes student thinking and problem-solving, and provides opportunities for students to apply their new knowledge and language. The 5E lesson design was modified to include language development strategies that centered on language structures (grammatical features or word usage such as *adjectives)* and language functions (the purpose for using language, such as *compare and contrast*). This view led the professional development team to create a lesson planning tool to be utilized by participating teachers as the template for the integrated science/ELD lessons (Gomez-Zwiep, Straits, Stone, Beltran, & Furtado, 2011) that teachers created during professional development and grade-level planning. This template was refined throughout the HUSD program.

LUSD-Specific PD Elements

In the LUSD PD model, the teacher-leaders created standards-based, grade-appropriate lessons that included the overt focus on oral language development; namely student-talk. Members from the university PD team reviewed the lessons, made suggestions, and edited them to ensure that the lessons included accurate content and appropriate student interaction strategies. Then, in each PD workshop, the teacher-leaders modeled and facilitated the 5E, student-talk science lessons while the teacher-participants 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 (An example of the LUSD modified 5E lesson is provided in Appendix B.) The teacher-leaders explained the cognitive, linguistic, and social benefits of student oral-language production while explicitly noting the rationale for the strategy within the content lessons. After engaging in the grade-level appropriate lesson, teacher-participants had a 15 minute conversation about teacher practice and brainstormed how they could incorporate the lesson and its student-talk strategies with their own students and what challenges they or their students could have in the lesson. Additionally, the program included multiple opportunities for facilitators and teacher-participants to engage in extended collegial conversations about the importance of oral language in content lessons.

The PD program had goals of increasing oral language development through self-expression, interaction skills, proper use of language structures, and vocabulary development. 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), these student-talk strategies provide language learners with a critical base for language acquisition. Challenging the common trend in education in which K-12 teachers typically dominate classroom discussions and spend the majority of instructional time talking (Cazden, 2001; Wyse, 2002), the student-talk strategies give students the voice to interact and use language at a greater rate.

The academic student-talk strategies utilized by the LUSD program came from their district's English Language Development curriculum at the time of the PD (the district has since changed to a different curriculum). These student-talk strategies supported concept development while providing students with opportunities for relevant, meaningful academic talk. Instead of a teacher posing a question or conversation topic to the whole class and having one or two students use language to respond, these strategies gave each student the opportunity to practice language. In the PD program, these student-talk strategies were embedded within each science lesson. An example of a student-talk strategy is a three-way interview (Hampton-Brown, 2007) where pairs of students question each other about a topic. Then, the student reports his partner's information to the class. In this example, every student, not just those called on, practices and listens to specific language tasks. There are several additional benefits to using a strategy such as a three-way interview, including (1) allowing students to talk to different students in the class, (2) giving each student an opportunity to share and listen to various answers and language structures, (3) talking one-on-one with a variety of partners which allows for a risk free fluency practice, and (4) practicing question formation and academic vocabulary development.

Data Sources and Analyses

Hubbard and Levine Unified School Districts

Both PD programs utilized a Randomized Control Trial design where some district schools were assigned to "treatment" or "participation" and others were assigned to "control" or "comparison". Researchers from both programs used the same instruments to measure student outcomes: the California Standards Test (CST) and the California English Language Development Test (CELDT). The CELDT assesses language development in the four subscales of listening, speaking, reading, and writing, with the purposes of identifying students who have limited proficiency in English, determining the level of English language proficiency, and assessing the progress of ELLs in language acquisition (California Department of Education, 2009). Employees of the school district, who have received formal training, administer the test. The estimated time for administering the test for student in grades K-1 is 10 to 30 minutes per subscale. Second graders can take up to two hours. Under state mandate, ELLs in HUSD and LUSD have annual scores.

In the years of this study, second graders statewide were tested using the CSTs. These tests were developed and reviewed by independent groups of content experts to assess students' knowledge of the California content standards. The State Board of Education adopted these standards, which specified what all children in California were expected to know and were able to do in each grade or course. CST scores are used for calculating each school's Academic Performance Index and adequate yearly progress (California Department of Education, 2010). The students in these districts, as part of this study and as state mandated, completed this battery of testing in English Language Arts and Mathematics.

Furthermore, selected teachers from both PD programs participated in semi-structured interviews to gain insight into teacher perceptions related to each PD program. The remaining teacher related outcomes were measured with instruments unique to each program.

Hubbard Unified Study

Throughout the program, teachers were supported in their teaching of blended science/ELD through a variety of professional development activities. The PD program included summer institutes that provided science content directed at the adult learner. Therefore, although the content was developed around the California state science standards, the activities and discussions were not necessarily appropriate for direct use in a K-2 classroom. Each year had a specific content focus (Earth, Life, Physical) while the science and language pedagogy sessions had similar themes that flowed through the entire three-year program (questioning strategies, the 5E learning cycle, language form and functions). Teachers participated in TLC cycles three times each year of the program (3 years total) and teams were grade-level and site specific. TLC sessions were initially facilitated by one of the PD team members and later by teacher leaders. The findings presented here represent the first two years of the three-year program.

Participants in HUSD

The HUSD professional development program involved 61 K-2 classroom teachers from low-performing schools in the district. Schools were invited to participate in the PD program. However, once the school agreed to join the program, all K-2 teachers were required to participate although they were compensated for their time outside the regular school day. Their ethnicities, ages, preparation, and teaching experience varied widely. The majority of the K-2 teachers held general teaching credentials and had liberal studies backgrounds. All of the participants had previous second language acquisition training and experiences in teaching ELLs.

Data Sources and Analyses for HUSD

The 61 teacher participants had approximately 1800 students each year. Data from the statewide standardized English Language Arts and English language proficiency exams were analyzed for all participating teachers in this study. Each of these data sources is described below.

Teacher outcomes. All participating teachers completed pre- and post- content tests designed around the specific content emphasis of each summer institute (Earth Science and Physical Science). These content exams included justified multiple choice, short answer and constructed response items. Teacher self-efficacy was measured using the Science Teaching Efficacy and Beliefs Instrument (STEBI-B, Riggs & Enochs, 1990). The content tests were developed by the researchers using TIMSS and NAEP released test items that aligned with the content focus on each summer. Teachers completed the content pretests on the first day of each summer institute and the post-test on the last day of the summer institute each year. The STEBI was completed at the beginning of the program and again at the end of the second year. Descriptive statistics were utilized to identify any coding errors and identify the distribution of responses. T-tests were utilized for both teacher measures to see if there was a significant change in the mean score. Confidence intervals were also employed to give plausible ranges of improvement.

A purposeful sample of participating principals, teacher leaders and teachers were selected for interviews. Twenty participants were selected based on school site, role in program, and grade level. Individuals selected participated in a 30-60 minute semi-structured interview at their school site at various times throughout the school year following the first summer institute. Interview questions focused on the perceived challenges and benefits to a blended ELD and Science program. 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 insights were re-visited as new data provided alternative vantage points for re-interpretation. Ultimately, these insights provide perspective on the impact the blended program had on teachers, students, and the school culture overall.

Student outcomes. Student achievement data included scores from the California English Language Development Test (CELDT) and the California Standards Test (CST) in English Language Arts (ELA). Participating teachers' students were measured against a non-participating comparison group from similar schools within the district. In the analysis of student achievement data, the response variable was mean improvement from baseline year and t-tests were utilized to see if the mean improvement was greater in the treatment versus comparison schools. Confidence intervals were also employed to give plausible ranges of improvement.

HUSD Findings

Teacher Outcomes in HUSD

The HUSD program impacted teachers and their practice in various ways. In this section we will report on findings related to teacher content knowledge, science teaching self-efficacy and teacher perceptions related to implementing the pedagogical approach.

Increased science teacher content knowledge. At the time of this study, participating teachers had received two years of pedagogy and content training, focused on Earth Science in the first year and Physical Science in the second year. Although the content was delivered for the adult learner, it was presented in a manner that modeled best practices in elementary education discussed in the pedagogy sessions (e.g., a sound conceptual framework, good questioning strategies, ELD integration). Participating teachers' science content knowledge was measured by content tests completed at the beginning of and following the summer institutes. Test items were selected from TIMSS and NAEP items based on their match to the concepts addressed each summer. However, test questions were never specifically addressed in content nor were the discussions or activities ever directly related to any test question. The lessons the teachers received were conceptual in nature and supported the contention of Shepard (2000) that students can acquire higher achievement through conceptual teaching and learning. T-test results suggest a significant positive growth between pre- and post-test scores in both the first and second year of the program (Tables 1 and 2).

Table 1

Teacher Content Growth Year 1

Earth Science	Pre-Test (%)	Post Test (%)	Delta
Mean	45.00	68.39	23.39**
S.D.	12.21	12.62	
N	61	61	

**p <0.0001, 95% confidence interval 27.77-19.00

Table 2
Teacher Content Growth Year 2

Physical Science	Pre-Test (%)	Post Test (%)	Delta
Mean	45.15	65.24	20.01**
S.D.	14.06	12.76	
N	56	56	

**p <0.0001, 95% confidence interval 23.88 -16.29

Improved teacher science self-efficacy. Content sessions during summer institutes were designed in a way to help teachers feel more confident in their science teaching ability. Topics were broken down and presented as a storyline, concepts were investigated through inquiry activities allowing participants to develop their ideas about content in a way that was personally meaningful and relevant, and small group collaboration was used extensively in the institute to allow peer-to-peer discussions and learning. Findings suggest positive growth in participating teachers science self-efficacy (Table 3) as measured by the STEBI (Riggs & Enochs, 1990).

Table 3
Teacher Self Efficacy

Self Efficacy	Pre-Test (%)	Post Test (%)
Mean	44.61	51.00
S.D.	8.61	6.60
N	56	56

**p <0.0001, 95% confidence interval 8.28 - 4.51

Increased pedagogy in science and language integration. Participants were elementary teachers working in a school district that has, over the past decade, prioritized the teaching of language arts and mathematics at the expense of science. In addition to the lack of recent experience teaching science, many of the teachers did not have a strong science background. The lack of content knowledge and discomfort with the idea of teaching science may limit a teacher's willingness and ability to teach science (Loucks-Horsley, Hewson, Love, & Stiles, 1998). HUSD teachers were going to use science as a context for teaching English; to be successful they needed to be comfortable and competent in their science content knowledge. This PD program's focus on science with ELD was timely as it addressed both a great teacher need (science content) and a main teacher priority (language development). Given the timeliness of this program, it is not surprising that teachers made great gains in their understanding of and attitudes toward science as demonstrated by the quantitative data presented above. What is surprising is how this teacher growth spread well beyond science to impact teacher practice broadly.

During interviews with researchers, participating teachers reported shifts in their expectations for students and the effect these new expectations had on their pedagogy. The teachers described a change in their thinking about what a child with limited English proficiency was 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."*

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 proficiency. 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. Teachers were more focused on how they structured learning in the classroom and less focused on the label of the student.

> *"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."*

Perhaps the greatest outcome of the work thus far has been the initial development of teachers as critical practitioners. This may have been a direct result of the TLC process that requires teachers to (1) develop both a series of questions as well anticipate the expected student responses for those questions, (2) consider the impact and effectiveness of each part of the lesson after the initial teaching in order to make revisions for the second teaching of the lesson, (3) analyze student work collected each time the lesson is taught and (4) discuss what the evidence does and does not indicate what students know and understand as a result of the lesson. Based on their participation in the blended language and science program, teachers reported a new appreciation for the need to consider the range of student understanding, both in content and in language. Evidence suggests that teachers in the program became more purposeful in their implementation and critical in their reflection of their teaching practice. Teachers in the program became more reflective about their teaching, 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?' and 'What about the student who is low or high in both content understanding and English language skills?' For example, the teachers believed sentence frames to be essential scaffolds for students with limited language skills; as students gained new scientific knowledge, they needed support in order to express that knowledge in sentences. However, teachers grew to understand that the sentence frames they provided often led to limited student responses - since students were using the same frames, all the responses were similar, if not identical. Subsequently, student work failed to display the range of content understanding that exists across all students. 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.

Student Outcomes in HUSD

  Student growth in English Language Arts (CST, Grade 2). At the outset of thisprogram, there was some concern that eliminating the existing ELD program and replacing it with one that included an additional content area would take away from students' language learning. With regard to English Language Arts, perhaps the greatest finding was one of "no significant difference." There was no significant difference between treatment and comparison groups on the state exam (California Standards Test) for second grade language arts

achievement[1]. That is to say, teaching ELD *and* science is no less effective in student language development than teaching ELD while omitting science (Table 4).

Table 4

Second Grade Achievement on Language Arts CST

Grd	TEST	(Treatment) 95% CI for mean improvement	Treatment (Average Improvement)	(Control) 95% CI for mean improvement	Control (Average Improvement)	p-value on a 2 sample T-test	CI on improvement
2	ELA	(15.2,24.7)	19.9	(20.1,30.9)	25.5	Not Significant	(-12.7, 1.6)

Although not reflected on the state language arts exam, during interviews, teachers and principals routinely reported growth in student language. Teachers reported this increase in both oral and written English, but seemed most impressed by students' increased use of oral language. Teachers were noticeably elated as they described this change in their students.

> *"It [science] is much more exciting so kids are willing to talk more, in English."*
> *"You should see the vocabulary they [students] use now, 'we predicted today, we did some observations.'"*

This increase in English use extended beyond science and beyond the classroom. Principals and teachers 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 at lunch and they were using English even though the office staff are fluent in Spanish. That was a first around here."*

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 ESL instruction during the first two years of this program.

Consistent with interview data, all three schools showed steady improvement in the percentage of students performing at the proficient or advanced levels on the ELA portion of the CST (Table 5). The scores from the comparison schools were highly variable with one comparison school performing similarly to the treatment schools and the other performing much below those levels.

Table 5

CST- ELA: Percentage of Students Performing At Proficient And Advanced Levels

School	Baseline	Year 1	Year 2	% Change
Treatment School A	30%	34%	37%	+ 7%
Treatment School B	25%	35%	40%	+15%

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[1] This test is not administered to students in Kindergarten and first grade.

Treatment School C	30%	38%	40%	+10%
Comparison School a	39%	41%	35%	-4%
Comparison School b	35%	30%	47%	+12%

CST: ELA increases for ELLs. As opposed to the whole school lens reported above, when this data is analyzed specifically in terms of ELLs, the differences between the treatment and comparison schools is more evident. At all treatment schools, the ELL population shows marked improvement in their performance at higher or similar levels than the ELL populations at the comparison schools (Table 6). These gains for our ELLs are also evident on state assessments of English Language Development. Comparison schools were selected at the beginning of the study based on similar teacher and student demographics. After their initial selection, comparison schools were monitored for extreme changes only (significant changes in teaching staff, new curriculum or PD program, etc.) which did not occur during the period of this study. Any specific inference regarding comparison school performance is outside the scope of this study. Rather, the data presented here is intended to indicate the effect of students in the "treatment" program compared to the rest of the district.

Table 6
CST- ELA: Percentage of ELL Students Performing at Proficient and Advanced Levels

School	Baseline	Year 1	Year 2	% Change
Treatment School A	22%	28%	38%	+ 16%
Treatment School B	23%	36%	33%	+10%
Treatment School C	20%	22%	29%	+9%
Comparison School a	22%	40%	4%	-18%
Comparison School b	24%	24%	33%	+9%

Student growth in English language proficiency. The California English Language Development Test (CELDT) assesses speaking and listening for Kindergarten and first grade students and assesses speaking, listening, reading, and writing for second grade students. As indicated in Table 7, Kindergarten students that received the blended ELD instruction with science outscored their comparison group counterparts on both CELDT subscales ($p = 0.027$ speaking and $p = 0.010$ listening) and teacher participants' first and second-grade students achieved at significantly greater levels than comparison group students in the subscale of listening ($p = 0.024$ and $p = 0.001$). There were no significant differences for speaking in first and second grade or the reading and writing measures in second grade.
Table 7
Average Improvement CELDT, 2009 Score – Baseline:2007 Score

Grd	TEST	(Treatment) 95% Confidence Interval (CI) for Mean Improvement	Treatment (Average Improvement)		Control (Average Improvement)	p-value on a 2 sample T-test	CI on Improvement
K	**CELDT-Listening**	**(127.5,150.9)**	**139.2**	**(104.1,128.8)**	**116.5**	**.010 Treatment**	**(5.6, 39.8)**
K	**CELDT-Speaking**	**(163.0,195.9)**	**179.5**	**(131.0,170.6)**	**150.8**	**.027 Treatment**	**(3.2, 54.1)**
1	**CELDT-Listening**	**(86.1,110.9)**	**98.5**	**(60.1,91.5)**	**75.8**	**.024 Treatment**	**(3.0, 42.4)**
1	CELDT-Speaking	(96.1,130.6)	113.4	(82.2,117.1)	99.7	Not Significant	(-11.0, 38.5)
2	**CELDT-Listening**	**(70.7,101.2)**	**85.9**	**(33.9,65.3)**	**49.6**	**.001 Treatment**	**(14.5, 58.1)**
2	CELDT-Speaking	(61.9,93.9)	77.9	(65.2,100)	82.6	Not Significant	(-28.1, 18.8)
2	CELDT-Reading	(72.7,95)	83.9	(74.3,99.2)	86.8	Not Significant	(-19.5, 13.6)
2	CELDT-Writing	(83.7,113.5)	98.6	(97.7,128.4)	113.1	Not Significant	(-35.7, 6.8)

Levine Unified Study

Through its integrated science and language development components, the professional development program at LUSD aimed to prepare in-service teachers with a stronger background in science subject matter and pedagogical content knowledge (Shulman, 1986). In the specific year discussed in this paper, the science component had an additional objective to overtly emphasize the importance and implementation of academic student-talk and student interaction in science lessons.

By using academic student-talk strategies from the district's English Language Development curriculum, the science director, a graduate student researcher (a former bilingual teacher and current doctoral student in language and literacy), and master teacher-leaders worked together to create lessons which integrated student-talk opportunities in each of the 5Es.

The PD was continuous throughout the academic year with workshops at evening dinner meetings, Saturday mini-conferences, and summer content institutes. It supported teachers by providing them with classroom materials to teach the lessons modeled in each session. Teachers from seventeen schools in the district were invited to participate.

Participants in LUSD

For the focus of this study, the PD program at LUSD included 68 K-2 classroom teachers from the low performing school district. In contrast to HUSD, all teachers from the participating schools self-selected to attend. Their ethnicities, ages, preparation, and teaching experience varied widely. About half of the K-2 teachers had prior participation in previous university-sponsored professional development programs. Participants had diverse experiences in language acquisition training.

Data Sources and Analyses for LUSD

     Teacher outcomes. To thoroughly investigate the issues of central importance to this research (Patton, 1990), researchers purposefully selected observed teacher-participants to partake in interviews. Utilizing an explanatory, mixed-methods design (Creswell, 2003) to examine how participation affected teacher perceptions. Six interviewed teachers were chosen to comply with the grade-level, gender, and participation-rate proportion of the full K-2 teacher-participant population. The teachers' classroom experience ranged from seven years to 15 years. These six teachers included four English Language Learners and two native English speakers.

     The teachers participated in one semi-structured interview lasting approximately 30 minutes and taking place at the end of the academic year. Questions probed for perceived shifts in teacher knowledge, self-efficacy, implementation strategies, and student learning. Researchers used data from the interviews to triangulate findings from other analyses. Teachers were asked to comment on various aspects of the professional development in relation to their learning or practice changes. The goal was to look deeper into teacher perceptions of how and why their learning and self-efficacy might have shifted in relation to the professional development.

     The researchers utilized a grounded theory approach with the interview data. The data were checked for instances and descriptions of student-talk. Similar dimensions of teacher learning, practice, self-efficacy, and perceptions of student growth were grouped together. As patterns emerged, they were examined in relation to the research questions. By constantly comparing the teachers' comments to relevant literature, this programmatic study attempted to uncover the underlying themes of teacher learning, self-efficacy, and practice change (Dick, 2005; Glaser & Strauss, 1967). For research questions, in which quantitative and qualitative data were necessary, a data integration technique was used whereby the observation, interview, and student test score data were merged into a coherent whole (Johnson & Onwuegbuzie, 2004). To ensure valid results, leaders of the center's PD team and researchers worked together to check the coding schemes and their relation to the research questions.

     Findings from the author's previous work (see Shanahan & Shea, 2012) suggest that teachers implemented the student-talk strategies learned in the science PD both in their science lessons. Therefore, since researchers knew that students were exposed to student-talk strategies, they subsequently investigated change in student outcomes at a school level.

     Student outcomes. Twenty-one elementary schools from Levine Unified School District were involved in the PD program and study. Of those, 17 schools had teachers that were invited to participate in the PD program. The remaining four served as comparison schools. One of the control schools had contamination concerns as several teachers from the PD program switched schools between academic years. This left three comparison or non-participating schools. Researchers purposefully selected schools from the 17 treatment schools that participated in the PD program to investigate school level student outcome changes for this study. Matching criteria was based on resemblance to the size of the school, the percent of ELLs, and number of students qualifying for free/reduced lunch. Eleven schools fit the matching criteria. Research shows that, when at least 30% of a school's teaching staff participates in reform efforts, change in student performance can occur (Westat, 2008). Thus, researchers narrowed the selection by choosing the participating schools attendance rates higher than 50%. Based on the level of teacher participation and population similarities, three treatment schools were selected to contrast against the comparison schools. Lastly, researchers confirmed that the three treatment and three

comparison schools had non-significant differences in their baseline English Language Arts student test scores.

To investigate school level change over time, researchers collected student test scores on the California Standards Tests for grade two in English Language Arts from the three treatment and the three comparison schools. Because science is not tested in the grade levels of these PD programs and the aim of the PD was to increase language development through science, the English Language Arts standardized tests served to evaluate student growth in relation to this PD program. Researchers collected these data for the three participating schools and three non-participating schools from a baseline year (2007-2008), the year of this study (2008-2009, Year 1), and a follow-up year when teachers continued to participate in the program (2009-2010). Aggregate data of student levels of *proficient* or *advanced* on both sections were collected. Additionally, disaggregated data for English Language Learners were collected for these tests as well.

Researchers also collected three years of student data from the CELDT exams for the three participating schools and three non-participating schools (a baseline year, plus data from two program years). As this test is administered at the beginning of the academic year, this specific analysis examined first, second, and third grade scores to measure effects of the K-2 program. Since the student-talk strategies in the PD provided opportunities for all students to speak within various parts of the lessons, the speaking component of the CELDT exams most readily aligns to the program. For example, one of the strategies requested students to report ideas to a partner; another required students to report what a partner said. When using these strategies, students needed to use academic vocabulary to show what they learned in a lesson. The many and varied instances of speaking within the science and mathematics lessons were designed to promote academic and English language development. The researchers hoped that the CELDT tests would provide evidence of the expected growth in speaking as a result of increased opportunities to produce language within the content setting. Consequently, for this study, researchers specifically focused on the speaking component of the CELDT.

Similar to the Hubbard study, the mean score of participating schools' students were measured against the mean score non-participating schools' students. Researchers examined change from a baseline year. T-tests were utilized to determine the significance of difference between the change scores.

Findings for Levine Unified Study

As in HUSD, this study demonstrated several important results of how a science professional development program can increase teacher learning, practice, and self-efficacy in relation to language learning in content lessons. Additionally, the study suggests that increased student outcomes can be attained.

Teacher Outcomes in LUSD

Through the interviews with the six 2nd grade teachers, several patterns emerged as to increased learning from the PD program. Teachers stated that they increased their knowledge of science, improved their pedagogy by incorporating student-talk strategies, and felt more efficacious about their science teaching.

Increased science content knowledge. Internal program evaluation revealed that teachers in the PD program increased their knowledge of physical science content by five percent in a pre/post test evaluation (Shanahan & Swiggert, 2009). One goal of the semi-structured interviews was to uncover teachers' perceptions of their science content learning increases. Teachers' comments corroborated their science content knowledge growth. Before the program teachers reported feeling weak in science content knowledge before the program, but gained knowledge throughout their participation. Teachers talked about the ease with which they implemented science lessons due to their increased science knowledge from their PD participation. Examples that demonstrate this perceived learning include:

"It kind of amazes me how foggy I was on everything [in science]"

"Before I was in [the PD program], science was so difficult for me to teach to the students. I know I had to teach it, but it was just very difficult."

"Science, now, is a lot easier than before in this program."

Improved teacher self-efficacy. Teachers in our study claimed to feel more efficacious in regard to teaching science and incorporating language teaching through science. By actively engaging in lessons through vicarious experiences, then sharing their learnings socially, and teaching the lessons in their own classrooms while continually being encouraged to be a science and language teacher, the interviewees reported a raised feeling of confidence. One second grade, interviewed teacher reported a stronger sense of efficacy when questioned about her integration of science and language development.

"I still need to learn more about the science, but I feel confident. I am confident."

Another teacher demonstrated her increase in efficacy when she discussed her understanding that students learn better when they actively engage in student-to-student talk. She reported that she lectured less, her students improved academically, and she gained confidence in her new way of teaching.

"I think [the PD has] helped me to be a better teacher…Just opening my eyes to the ways kids learn a little better, a little more, being aware of not teaching passively and thinking of more active ways to… you know being able to do things and to make them more interesting for kids instead of just lecturing. I think I have really improved in that area."

One teacher abandoned her traditional teaching style and promoted active student to student interactions in her classroom.   She reported feeling like a better teacher because she was able to listen to her students' explanations of their thinking. Her confidence increased because the student-talk strategies allowed her to grasp her students' conceptual understanding and then, her new knowledge informed her instructional decisions.

"It has helped [me be a better teacher] because before, like I said, it was just paper and pencil. Now, I can see more into their thinking. So, if they're making mistakes, then I can find tools, such as hands-on or strategies… If they're on a test, and they're guessing right, I would never know that they had no idea of place value, because they didn't tell me how they got their answer. They just bubbled in or circled or saw on another person's paper that they had the right answer. And I would think that they know it, but they really don't know it because they didn't tell me, they didn't have to explain their thinking."

The three interview examples above demonstrate how teachers increased their confidence in science and language integration due to the accessible student-talk strategies promoted in the PD program. When teachers feel efficacious, they are more likely to continue to implement new ways of teaching (Guskey, 1988).

Improved pedagogy in science and language integration. Teachers who had high participation in the PD program (defined as 75% or more) were more likely to implement the student-talk strategies taught in the PD (Shanahan & Shea, 2012). Interview data demonstrated that teachers were cognizant of their efforts to implement these strategies in content lessons. Teachers reported trying the various techniques to focus on students' language production. One teacher reported,

"So, it wasn't like I was pairing them sometimes, I was pairing them all the time. And moving them around in their grouping. One strategy that they teach us is having them move around in groups- not just keep the same groups. So, make it innovative- change it up a little. The kids would get to talk to other kids that they usually never talk to and they gain language from not just the same groupings, so it's always a little bit more language and more discussion."

Another second grade teacher discussed how her teaching improved because she gave the students a chance to voice their conceptions.

"Now, I have kids explain to other kids different ways of doing problems and why they do it a certain way. They learn so much from each other and sometimes they come up with things I didn't even think about."

Student Outcomes in LUSD

From their increased knowledge, improved self-efficacy, and intentional focus on language through content, teachers perceived improvements in their students' language, including production of complete sentences, incorporation of academic vocabulary, positive changes in social interactions, and increased confidence in speaking. Student achievement was one of the driving forces to keep using the strategies. Teacher remarks included,

"At the beginning of the school year, they came in, they were so shy and reserved. They hardly even said one word. Allowing them to have discussions with other students enriched their ability to listen to the vocabulary and use the vocabulary with other kids. And before, if I would have taught the old way, those kids would

have stayed quiet the whole year and they wouldn't have gotten as much vocabulary and content."

"In their language and their self-esteem and their academic, they just flourished! Because it wasn't that they didn't have the knowledge, the academic knowledge, they just couldn't say it. It was amazing to see them become stronger."

"[I see changes in] social and even just English language development in general- being able to answer in a complete sentence and ask somebody complete sentences as a question."

One teacher found that increased oral language production led to her students' improved writing in science,

"Before, they would leave and there wasn't that much vocabulary within their writings, so now I see that they are writing about rocks, fossils, dull, the shinier rock…That's a big accomplishment that my students take with them."

Student growth in English Language Arts (CST, Grade 2). The following are findings of second grade student data from the treatment schools compared to second grade student data in the three comparison schools in the same district. Three years of data, a baseline year, Year 1 of the PD, and Year 2 of the PD, show that treatment schools made significant improvements in English Language Arts test scores. Table 8 shows the averages of three treatment schools and three comparison schools' percentages of students performing at proficient and advanced levels over the three years. The mean increase for the treatment schools was 19%, while the comparison schools' was only 7%. At the baseline year, the second grade students' scores between the groups were not significantly different from each other. By the second year of the program, the treatment schools' students scored significantly higher than the control schools' students.

Table 8

CST- ELA: Percentage of Students Performing At Proficient And Advanced Levels

	Baseline	Year 1	Year 2	% Change
Treatment	43%	60%	62%	19%**
Control	40%	56%	47%	7%*
Difference	3%	4%	15%**	12%*

*p=.05, **p<.01

CST: ELA increases for ELLs. When disaggregate data was evaluated, the same trends held for English Language Learners. The treatment schools averaged a 14% increase in English Language Arts, a significant increase. On the other hand, the comparison schools averaged a non-significant 6% increase. At the baseline, the treatment and control ELL students' ELA CST scores were not significantly different from each other. However, by the end of the second year, the treatment ELL students' grade 2 ELA CSTs had improved enough that the two groups were significantly different from each other. Table 9 shows these results. Since all the schools were using the same district-approved curriculum for English Language Arts and English Language

Development instruction, the researchers propose that the use of student-talk strategies in science aided the teachers in extending their Language Arts time into content areas, thus resulting in greater increases for the treatment schools.

Table 9
CST- ELA: Percentage of ELL Students Performing at Proficient and Advanced Levels
Levels

	Baseline	Year 1	Year 2	% Change
Treatment	42%	60%	57%	14%**
Control	42%	57%	48%	6%
Difference	0%	3%	9%*	9%

*p=.05, **p<.01

  Student growth in English language proficiency. This study's CELDT data were collected at the beginning of each academic year. Therefore, the findings below reflect a student's CELDT test results in the year immediately following exposure to the treated or comparison teacher. For example, a Kindergarten student, in a classroom with a Kindergarten treatment teacher, was not post-tested on his language growth until the beginning of first grade. Therefore, we look at grade 1 results for Kindergarten students, grade 2 for first graders, and grade 3 for second graders.

  No conclusive findings were found with the CELDT student level data. Data reported to the state by the schools show that participating schools had greater mean increases than the non-participating schools. However, our analyses could not confirm or deny these findings. We found, in the speaking subscale and over the years of the program, the comparison schools averaged greater gains than the treatment schools in grade 1 and 2. However, in grade 3, the treatment schools made greater gains, so much so that the schools were not statistically different from each other in baseline, but were different after two years of the program. This suggests that there might be effects if the students are exposed to participating teachers in all three grades (K, 1, and 2).

  However, we found the CELDT, as the "proxy" student outcome measure, was less than ideal for Grade K-2 due to the timing of measures (beginning of the academic year). Secondly, the CELDT scaled scores could not be compared across grade levels. Additionally, once students are re-designated from the ELL status, they are no longer required to take the CELDT exam. Consequently, studies looking at changes in CELDT score only include students who have not yet been re-designated. Lastly, for determining gains in CELDT scores, because of the timing of this assessment, a student's fall CELDT score could be attributed to the teaching done by the previous year's teacher but the summer interval between the end of the previous school year in June and the fall administration of the CELDT, is cause for some concern because of the lag time between instruction and assessment. Table 10 shows these results.

Table 10
Average Improvement CELDT Speaking, 2010 Score – 2008 Baseline Score

Grd	TEST	Treatment (Average Improvement)	Control (Average Improvement)
1	CELDT-Speaking	7%*	13%**
2	CELDT-Speaking	-2%	14%**
3	CELDT-Speaking	2%*	1%

Note. Grade 1 measures changes in K. Grade 2 measures changes in grade 1. Grade 3 measures changes in grade 2.
*p<.05. **p<.01.

The PD program treated teachers at the participating schools in Kindergarten to grade 2. The grade 2 student test score data reflect the cumulative results of teacher PD participation not only in grade 2 but also in Kindergarten and grade 1. Many of the students who took the state tests in grade 2 were in 'treated' Kindergarten classes during the baseline year and, again, in grade 1 in Year 1 of the PD. Many the students had multiple teachers who participated in PD before they took the grade 2 tests. In other words, by the second grade test administration, not only did students have opportunities to be in several 'treated' classrooms, but the second grade teachers gained more pedagogical expertise during their sustained program participation.

Trends Across Both Programs
We have thus far presented data from each program separately in order to draw attention to the trends evident across both. In the following section, we will address the common trends within the teacher related outcomes as well as within the student related outcomes.

Teachers participating in both the HUSD and LUSD programs had significant improvement in their knowledge of science. Similar to other studies, both programs found that providing science content support for teachers was essential to their confidence and success in the classroom. This was not the case with the ELD strategies. Many of the teachers were familiar with the strategies but required support to integrate them into content specific settings. Teachers' perception of their pedagogy also changed over the course of the two years teachers participated in these programs. This change in teacher pedagogy and was evidenced either through how teachers were implementing the blended ELD and science lessons as well as through the increase in their use of student-talk strategies.

The effects on teacher science knowledge, science self-efficacy, and science pedagogy resulted in increases in student achievement. Across both programs teachers reported an increase in student confidence with regards to using English in school settings. This is paralleled by an increase in English language development as seen in both the CSTs and CELDT performance measures. The growth was seen across all students and, more specifically, with ELLs. In both programs, the teachers in the treated schools who participated in PD that blended ELL strategies and science instruction changed their practice to result in increasing school means on standardized tests.

Interview data suggests that one of the catalysts for the increase in English language production was student excitement and enthusiasm towards the new content and instructional approaches. Prior to these PD programs, science was not part of the standard curriculum and

when students did have access to science, it was through textbooks that were difficult for ELL students to comprehend. Furthermore, due to the strong presence of teacher modeling academic language, students often repeated what the teacher said but students rarely had opportunities to talk to each other about their own thoughts within cognitively demanding tasks.

Conclusion

This paper reports results from two K-2 professional development programs that incorporated language learning strategies into science lessons. Both programs engaged teachers in active learning experiences, promoted teachers' awareness of the synergy between language and science learning, and used the 5E inquiry learning cycle as their framework. Through similar programmatic goals to incorporate language learning strategies into science lessons, yet distinct methodologies, both of these programs demonstrated gains in student and teacher learning. Specifically, both programs found teachers to be more efficacious teaching science and felt more comfortable in general with their teaching of ELLs. Teachers perceived growth in their students and this was corroborated by improvements in students' scores on state exams.

Second language acquisition is most successful when there is sufficient opportunity to engage in meaningful use of language (Minner, Dobb, & Ostlund, 2006). Many teachers of ELLs do not have the pedagogical skills to successfully promote language learning within the context of academic content (Stoddart, et al., 2002). Since professional development programs have the ability to increase teachers' knowledge and practice, programs designed for teachers of ELLs should incorporate language learning strategies.

Findings from each of these professional development programs demonstrate that a professional development program can focus on content and language learning, while at the same time, potentially increase teachers' perceptions of their understanding of content and language integration, changes in their instructional practice, and student growth. Because context is the best environment to learn language, a critical component of professional development should be the integration of language development into content lessons. These results suggest that PD design, which addresses and integrates content and language goals, can be an effective method to improve teaching and student learning.

While each program contained unique components to the design and research protocols, there is a common overarching theory of action behind both. The findings presented here indicate that the use of science as a context for English language development can have a positive effect on student achievement. In addition, the PD structure that framed both these programs provide the necessary support for elementary teachers (science content knowledge, pedagogy, and changes in self-efficacy) to implement this new type of blended instruction with reasonable fidelity as indicated by the qualitative data collected.

Close work with teachers has provided important insights to teacher implementation of science/ELD integrated lessons. Many of these proved remarkable for individual teachers as they grew in their understanding of effective teaching and their ability to critique their own practice. Data analysis suggests that these major school-wide efforts have led teachers seeing the power of science instruction for motivating students and increasing student use of English – especially in oral language and expanded student vocabulary and academic language use. Additionally, the initial development of teachers as critical practitioners has been one of the greatest outcomes of the professional development work thus far. Teachers are now considering the range of student understanding. In addition, teachers were found to implement the language

development strategies in other content areas, suggesting that their pedagogical knowledge about language integration was transferable.

Research shows that there currently is a national overemphasis on language arts and math in elementary school instruction (Council of Chief State School Officers, 2000). The studies presented here show that students can have language opportunities beyond ELD support or English Language Arts classes. Science can be a forum to promote both content development and language acquisition. If administrators and/or teachers want to assist students in achieving gains in language acquisition, the content areas provide authentic, rich contexts for language development.

Just as ELLs' learning of content is complicated by the need to simultaneously learn language, professional development for teachers of ELLs is complicated by the necessity to learn how to teach content while focusing on language. Because students learning English have more specific learning needs than typical students, their teachers require specialized preparation to aid in student achievement in both language development and content. This has implications for in-service and pre-service teacher educators. When designing coursework, educators should integrate language and content to ensure best practices for teachers of ELLs. Both of these program models have shown success with ELL students and can be replicated, refined, or enhanced according to the specific needs of participating teachers.

Prior 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, Porter, Desimone, Birman, & Yoon, 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 has the potential to not only increase teacher outcomes but improve student outcomes as well. This paper demonstrates how the combination of these attributes can enhance student growth. Therefore, the researchers conclude that not only is the PD design effective, but the results show that integrating science and language development strategies is a viable and important method to promote the academic success of language learners.

Key Recommendations

Focus on Content

Both programs held inquiry science at the core of their interventions. This model requires that teachers understand the science content at and beyond the grade level they teach. Significant science content support was provided to our teachers during intensive summer institutes and during the year. Often, teachers entered these programs with minimal science knowledge; therefore one of the primary goals of both programs was to deepen participants' science knowledge both for the grade they taught but also at an "adult" level. Content focused PD often dealt with "big ideas" that spanned several grade levels, addressed misconceptions and modeled inquiry practices. As teachers' science content grew, their ability to plan and implement science and ELD integrated lessons also improved. Deepening teachers' science content knowledge was central to the success of the programs and we highly recommend that any future programs include this element.

Scheduling Opportunities

Many teachers find providing high-quality inquiry science instruction challenging just as they find implementing effective ELD instruction challenging. Providing both simultaneously requires a great deal of skill, knowledge, and planning. As mentioned earlier, the programs presented here included PD during the summer and the school year. Summer (or other vacation times) provides protected time away from the demands and stresses of teaching. It also provides extended time, in this case a minimum of a week, for teachers to slowly contemplate new information and integrate that into their existing teaching. However, teaching is a "contact sport", thus teachers also need opportunities to implement, revise, and refine the strategies and methodologies they have worked on during the summer within the reality of day-to-day teaching. Not only did the programs provide PD during both these critical times but the PD also focused on both pedagogy and content. We also recommend that future programs provide PD both during the summer (or other long break) and during the school year to allow teachers the time necessary to develop the needed knowledge and skills (Loucks-Horsley et al., 1998; Garet et al., 2001). We also suggest that teachers be provided multiple years of PD support.

Providing Time and Space

In this paper and in our PD programs, we argue that science is an appropriate context to learn language. We contend that teachers need to have a thorough understanding of its rationale and its implementation. However, thinking about language objectives and science objectives simultaneously can be a difficult task for many teachers. Therefore, a key recommendation is to allow teachers' time and a space to learn, reflect, and debrief through this process. It takes practice, requires support, and can be overwhelming.

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Appendix A
Blended 5E Lesson Template in Use (HUSD)
Language Objective:
Students will begin to speak with a few words or sentences. Students will use gestures to demonstrate new learning
Learning Sequence Concept:
Matter can change back and forth from one form to another. Matter changes form from a solid to a liquid.

5E	Teacher Says/Does	Student Says/Does			Science Concept/Language Function
		Low	**Med**	**High**	
Engage 10 - 15 min.	Introduction: *Think about yesterday's lesson on Matter? How many different states were there?* *What were they?* (**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): *There are objects and pictures of matter posted around the room. Observe each picture and tell your partner what you observe.*	*Three Solid, Liquid and Gas* (with gestures and/or native language support)	*There are 3 state Solid, Liquid, and Gas*	*There are 3 different states of matter The three states of matter are Solid, Liquid, and Gas.*	**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			
		One word answers or Yo veo ____,	*There is ____, I see ____, It is ____.*	*This feels ____ and looks ____.*	

The figure represents the Engage phase of a teacher-designed 5E science/ESL lesson.

Appendix B
Student-talk 5E Lesson Template in Use (LUSD)

EXPLORE: Hands-On Learning, Contextualize Language, Use of Scaffolding (Graphic Organizers, Thinking Maps, Cooperative Learning), Use of Multiple Intelligences, Check for Understanding Estimated time: 20 minutes		
Teacher's Role	**Teacher Questions**	**Students' Role**
Teacher demonstrates how students should record their observations by drawing and writing on the observation sheet.		In pairs, students explore the solid objects and describe them in terms of their shapes, sizes, weights, and textures.
Teacher uses the *Three Way Interview* to assess student exploration and vocabulary use.	*Three Way Interview*: Teacher asks partners, "What did *your partner think* the **texture** (then **size**, **shape**, etc.) of this object is?"	*Students ask their partners*, "What is the texture of this object?" Partners answer, "The texture of this object is ____."

The figure represents the Explore phase of a teacher-designed 5E science/student-talk lesson. The student-talk strategies utilized in the LUSD PD program are exemplified here by Three Way Interview.