



Learning Language within the Context of Science: Creating a Professional Development Approach

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Implications for Teacher Professional Learning”**

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Introduction

Since 2008, the Exploratorium’s Institute for Inquiry (IFI), in partnership with the Sonoma Valley Unified School District (SVUSD) has been investigating the development of professional learning experiences for elementary teachers that focus on the relationship between science learning and language learning. The project is based on the premise that inquiry-based approaches to science require greater communication and more sophisticated uses of language, thereby engaging students in linguistic work that can support their English language acquisition. (Lee, Maerten-Rivera, Penfield, LeRoy & Secada, 2008; Lee, Quinn & Valdes 2013; Stoddard, Pinal, Latzke & Canaday, 2002).

In this paper we examine how the evolution of the understanding of the relationship between science and language by our professional development group affected the design and implementation of our work with teachers. We illuminate key insights, issues and challenges within our journey—how over the course of the project, the group has wrestled with how science learning and language development are symbiotic, how to convey this important relationship to teachers, and what kinds of experiences teachers need to have in order to understand the ways that inquiry-based science instruction supports language development. There have been many twists and turns along the way, but our investigation of the teaching and learning of language within the context of science has led to the development of a conceptual framework where science learning is at the center and language development is contextualized within making meaning of science. (The framework is described further on pgs. 6–8.) This framework now guides our professional development and is showing very positive signs of impacting the pedagogical practices of the teachers. Our understanding has emerged through collaboration between classroom teachers, science educators based at a science museum with expertise in inquiry-based science, and a university-based teacher educator with expertise in educational linguistics, bi-lingual education and teacher inquiry.

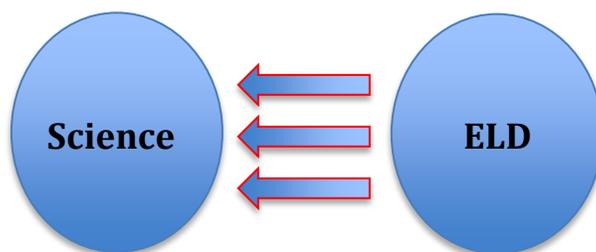
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Phase 1: Getting started with inquiry-based science & English Language Development (ELD)

During the first two years of the project, the Institute for Inquiry staff worked with all the teachers at El Verano Elementary School as a pilot to experiment with integrating science and English language development (ELD) before working with all elementary teachers in the district. The work revolved around the idea that integrating inquiry-based science and ELD would support the learning of both science and language. There was some evidence in the literature that engaging in the science practices or process skills that are involved in inquiry-based science encourages English language learners (ELLs) to use all of the language modalities (speaking, listening, writing, reading) (Lee, Maerten-Rivera, Penfield, LeRoy & Secada, 2008; Stoddard, Pinal, Latzke & Canaday, 2002; Rosebery & Warren 2008). Our approach was largely driven by: 1) the belief that engaging students in hands-on investigations of phenomena would engage their interest in communicating their ideas and 2) that an increase in students' interest in communicating their ideas would involve them in linguistic work that would increase their use and development of English.

Since the teachers had no hands-on science materials, we developed science units with facilitator's guides and accompanying kits with materials. The units were designed to serve as vehicles for student to learn how to plan and carry out science investigations and simultaneously develop conceptual understanding related to topics in the earth, physical and life sciences. To support the teaching of the units, professional development was designed to acquaint teachers with the fundamental principles of inquiry-based science. We also focused on how to embed opportunities for developing English language within the units by focusing on ELD strategies (e.g., grammar and vocabulary development) that the teachers had been introduced to in previous years of professional development.

The work was based on a conceptual model of teaching science and matching opportunities from ELD curriculum and district pacing guides to insert language work into science.



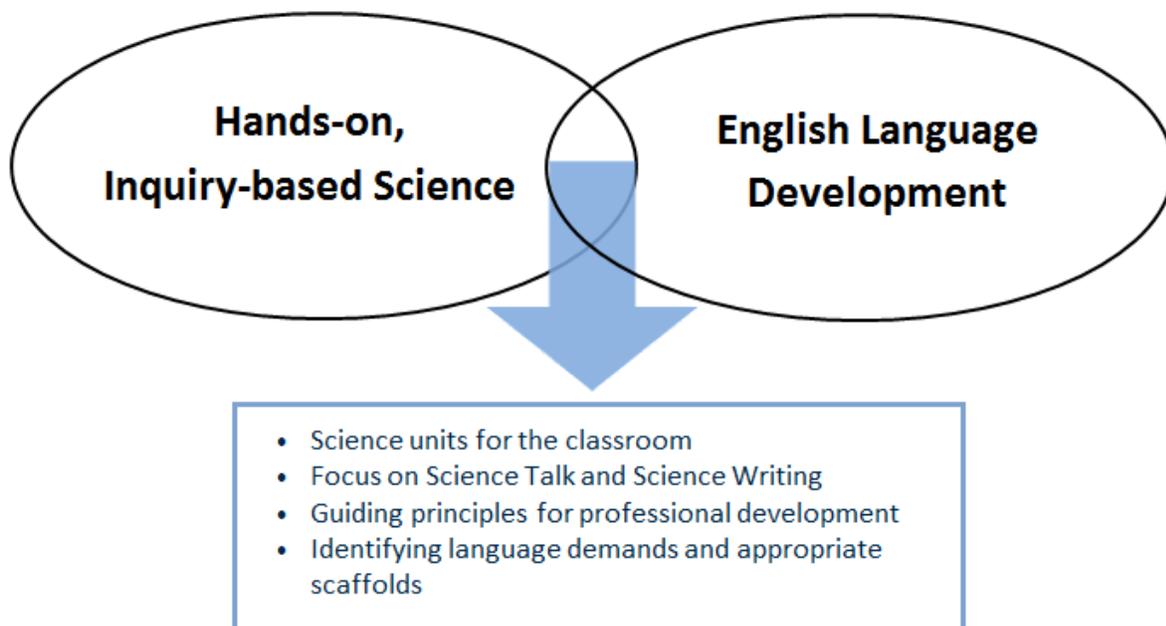
As teachers began to use the units, they realized that the hands-on experiences provided a natural arena for students to talk. They noticed how engaged their language learners were in conversations with other students as they explored and investigated, and how often the language they were using in the classroom was appearing in conversations on the playground and in other areas of the curriculum. “Let’s Give Them Science to Talk—and Write—About” became a project motto.

However, at the same time that teachers were highly enthusiastic about their students' motivation for learning science and the increase in oral language, they felt tenuous about how this was serving to advance students' language development. They saw the work as mainly science focused. There was great concern that despite attending to grammar and vocabulary within the lessons, by using scaffolds, sentence frames and concept maps, students continued to express their ideas using incomplete sentences and incorrect verb tenses. As teachers struggled with this disjuncture between learning science and developing language, we re-examined our approach to integrating science and ELD. We began to realize that we had not supported teachers to understand foundational principles about language acquisition and how these principles relate to an authentic connection between learning science and developing language. The unintended consequence of our approach was that we had reinforced teachers' reliance on traditional ELD approaches that fostered isolated skill development that is decontextualized. In the next phase of our work, we concentrated on how to develop language for making meaning and communicating ideas.

Phase 2: Supporting teachers with guiding principles and scaffolding—still not quite enough

When we began to expand our work to all elementary teachers in the district, we revised the units to feature science talk and science writing as two of the main mechanisms for making meaning of science and learning language in context. Our professional development focused on acquainting teachers with key pedagogical practices that could support language development in the context of science. We also focused on how cultural context—which acknowledge the importance of allowing students to use their “everyday” language—could be leveraged to support the learning of language and science,

The model of integrating science and language that we were operating with during this phase of our work included an intentional area of overlap between science and language. However, teachers still did not see the language work as completely situated within the science learning. This model also did not focus enough on the role language plays in communicating children's developing science understanding and sense-making.



A major shift in our thinking occurred during this middle phase of the project. We began to see and address the language demands that the science activities posed for ELLs. It wasn't until working closely with our language consultant (author, Sarah Capitelli, University of San Francisco) that we realized that the units of study, like most curriculum, assumed a native speaker of the language and did not explicitly address the language demands that would make it challenging for English learners to fully access and engage with the experiences in the units. This notion of how language intensive the units were was a new idea for Institute for Inquiry staff and required a shift in thinking about how to support teachers, and their students, to leverage synergies between science and language learning to their full advantage. It also became more clear that use of ELD strategies such as sentence frames, T-charts, regalia, and Venn diagrams could lead to a traditional emphasis on language conventions (e.g., grammar and syntax, etc.) and vocabulary rather than contextualizing language work within communication of ideas for learning.

As science educators, identifying and addressing language demands had previously not been part of the conversation when planning for professional development. As we developed a clearer understanding of the ways in which language demands play a critical role in accessing, engaging, and communicating understanding of science ideas for ELLs we were able to better communicate these ideas with our teachers.

An understanding of language demands required a pedagogical response. It was not simply enough to identify the demands but the demands had to be attended to in lesson planning and teaching. We came to see this pedagogical response as a place for supporting teachers to develop a deeper understanding of the role of scaffolds in learning science and learning language. We wrestled with different kinds of scaffolds, their purpose and how to help teachers see that scaffolding was more than a list of "best practices" but required a nuanced understanding of students' science and language development. A goal became to support teachers to understand how and what kinds of scaffolding could serve to support ELLs in both engaging with content and communicating their understanding of content.

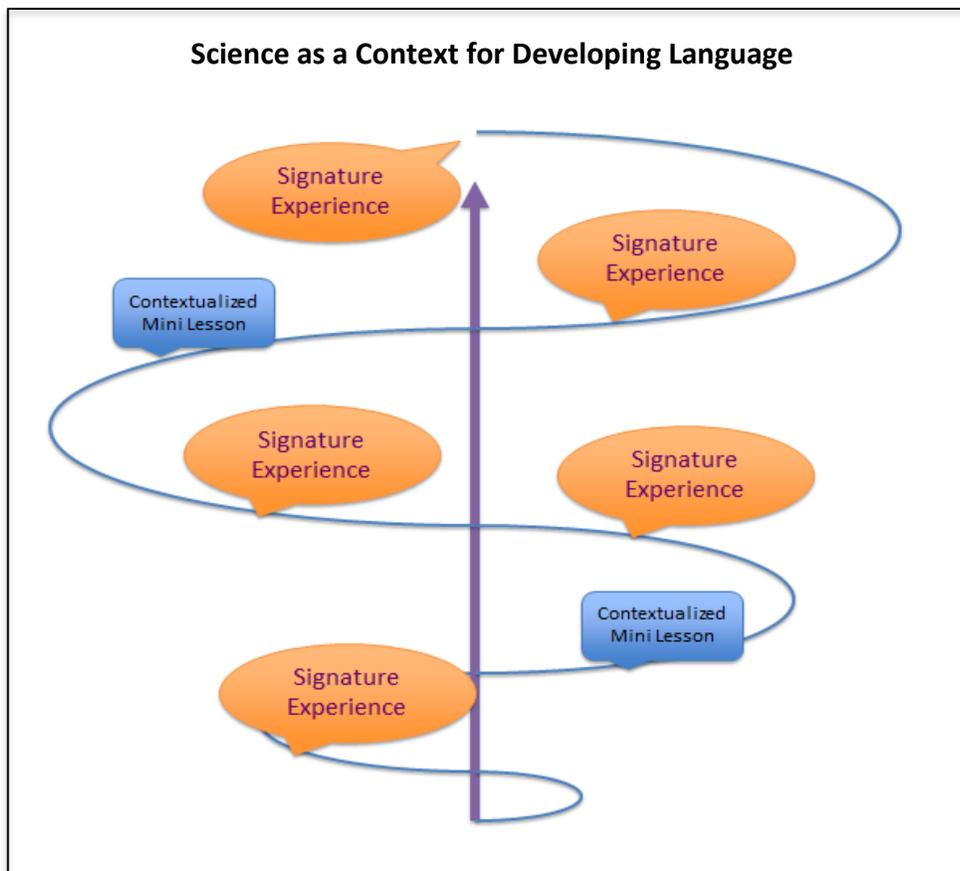
Initially, we annotated many of the unit's lessons, identifying the language demands in the lessons and making suggestions as to how those parts of the lessons could be scaffolded to make them more accessible. This resonated with the teachers as they also recognized that certain structures in the lessons were particularly challenging for their ELLs. They were already in the process of "tweaking" the lessons to make them more accessible for their ELLs. For example, Science Talks play a central role in the inquiry-based science curriculum but the language demands in science talks can make it very challenging for ELLs to participate. Once teachers got a good sense for how to conduct whole group science talks, they began to modify the science talks to support the participation of their ELLs. These modifications, or scaffolds, included building in partner talk, small group science talks, and charting the language produced during science talks. These additions challenged the notion of whole group Science Talks as the standard structure and acknowledged the need to make participation in them more accessible for all students based on language demands inherent in this discourse practice.

Despite our progress with language demands and scaffolding, as a group we still struggled to convey how language was an integral part of science learning and not something separate to be addressed or taught. This struggle came from two places. The first was the pressure teachers were experiencing from outside contexts (e.g., districts, state mandates, curriculum, testing demands) to teach language as a separate content area focused on structure and vocabulary. Teachers understood that their work with the Exploratorium was to use the curriculum to teach ELD but they had a difficult time seeing where language development was happening in the science curriculum. They acknowledged that their students were talking more and more engaged with the curriculum but their students were not necessarily using the vocabulary from the units and they were still making errors in their language when they spoke and/or wrote. This understanding of language development reflected the stance towards language that is deeply rooted in the approach towards ELD instruction and language instruction used more broadly across classrooms and districts nationally. From this stance language development is viewed as learning of grammar, language structure, vocabulary words, and discrete skills in reading, writing, speaking and listening. The second place of challenge was a result of tensions in negotiating understandings in the professional development group between professionals whose background is in language development and bilingual education and those with backgrounds in science education. This challenging discourse made sense given how separate the fields have been but this challenge translated into difficulty in getting clear about the ideas we wanted to convey to the teachers we were working with. For example, there was a struggle in coming to understand that an ELD strategy is not necessarily a scaffold for learning science and language. How the scaffold functions depends on the context of use for scientific meaning making.

In the next phase of our work, we concentrated on understanding how to bring together both the contextualization of language during scientific meaning making and the contextualization of language conventions—and what this meant for professional development.

Phase 3: Emergence of a conceptual framework that is both explanatory and practical

We learned from the first and second phases of this project that we needed a conceptual frame for our professional development work with teachers that could address the role that language plays in engaging with and communicating understanding of science. The “Spiral Model” (see below) represents a framework that puts science learning at the heart of how we situate disciplinary work in science and language development. This conceptual framework guides our professional development work with teachers and the classroom practices that we suggest they design to help all students engage with activities in the science units. Science learning is the engine that drives everything else and all of the students’ experiences related to language are contextualized by the inquiry-based science experiences.



“Spiral Model”

While the units provide a multitude of affordances for learning language—they are rich in opportunities for reading, listening, speaking and writing—it took us a number of years to figure out an approach where meaningful “language for use” and “language for communication” is seen as being as much a part of English language development as building grammatical and vocabulary skills. Supporting teachers to understand that language

learning occurs in a content-rich and discourse-rich classroom environment (Lee, Quinn & Valdes 2013) is our current driving vision. Strategic scaffolding provides the mechanism to support English learners to fully engage in the experiences where making meaning is at the forefront of the experience. Below we describe the strategic shifts that have contributed to our current vision of learning language within the context of science and the implications of these shifts for our professional development designs.

During Phases 1 and 2 of the project, we often addressed science learning and language development separately. A major shift for this current phase has been to bring the learning and doing of science to the forefront of our work and frame language development as a critical component to doing the science work. In other words, you can't "do" science without "doing" language.

The science units and lessons provide the content of the science learning. They are how the content is introduced and sequenced for the students. The units and lessons are the building blocks for the teachers—they are what they build from and expand upon. Throughout these lessons, we decided to highlight Signature Experiences that are key to students participating in the "doing" of science. The Signature Experiences are built into the curricular units and are integral to inquiry-based science curriculum but also offer important affordances for language development.

Signature Experiences

- Hands-on science inquiry
- Science Talk
- Science Writing
- Prior Experience conversations
- Environmental Print
- Collaborative Groups
- Vocabulary

The Signature Experiences are an essential part of the students' experience because they allow students to engage in the scientific practices (i.e., asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, engaging in argument from evidence, obtaining, evaluating, and communicating information) and that engagement requires the use of language. Putting science at the center of the framework and as the focus of student learning provides a context for focusing on specifics of language structure.

We call the learning opportunities that focus on language structure contextualized mini-lessons (CML) in order to support teachers in understanding how to design and implement them as scaffolds for language learning in the context of science. These mini-lessons provide teachers with an opportunity to intentionally focus on areas of language development that will help students to communicate their developing understanding of the science ideas covered in the unit. These mini-lessons might focus on structure or vocabulary but they are driven by the science content and the structures or vocabulary that are needed to

communicate the students' developing science ideas. CMLs also need to be designed in response to the needs of particular groups of students. For example, a CML on adjectives that can be used to describe snails might be done prior to work on snail diagrams with a small group of students who are emergent ELLs. Or, a CML on ways to analyze data might be designed for a whole class of fourth graders who are writing their first report about their observations of stream tables.

The "Spiral Model" is the framework that we are currently using with teachers to support their development of pedagogical practices that use science as a context for language development. Our professional learning sessions are designed to expand teachers' abilities to use and revise Signature Experiences and CMLs across science units. We have qualitative evidence that these pedagogical practices are useful for teachers (Capitelli et. al. 2015). During discussions in study groups, we asked teachers to grapple with how to design CMLs and how to modify science talks and science writing to support their coming to understand and use these practices to help immerse all of their students in learning the science ideas within the units.

Affirmations, Challenges and Next Steps

Our journey through the phases of design and implementation of professional development have led us to create an approach to professional learning that is affirmed and challenged by both analysis of our experiences and ideas within multiple literatures. These literatures address current theories of language acquisition and professional development for science education.

Our experiences have led us to believe that teachers need to develop an understanding of the relationship between science and language that could be applied to new pedagogical practices. And foundational to this understanding is the view that the use of language within the context of science learning *is* effective language development. Within the ELD field, this belief is affirmed by socially-oriented theories of second language acquisition (Block, 2003) as well as sociocultural theories of language development (Cook, 2002; Frawley & Lantolf, 1985; Lantolf, 2000) that concern themselves with understanding how second language learners become users (i.e., speakers, writers, readers) of a second language. These theories recognize that school and classroom contexts impact language growth and development, and we would argue pedagogy as well. Additionally, these theories view language development as intrinsically social, see language learning as a socially embedded process, and explain that the kind of talk ELLs engage in matters for language development (Gibbons, 2009; Valdés, Capitelli & Alvarez, 2011; Wong-Fillmore, 1991). Finally, language as action is emerging as a perspective that language is an expression of human agency or the ability to act within environments in various ways including physical, social and symbolic. The implication of this view of language for classrooms is that language learning is usage-based rather than grammar-based. (van Lier & Walqui, 2012).

Throughout the phases of our work we have affirmed that immersing teachers in their own learning of inquiry-based science helps them to come to understand that engaging students with investigating phenomena is a productive way to teach science. This professional

development approach is based on a well-documented strategy that combines immersion experiences with ongoing work in professional learning communities (Danielson, 2006). This combination of professional development activities has been used to support the growth of teachers in coming to understand learning in content areas and inquiry-based practices (Loucks-Horsely, Stiles, Mundry, Love & Hewson, 2010). The potential for participation in a professional learning community to develop self-reflective practitioners, knowledge generation, and professional development also informs our work (Cochran-Smith & Lytle, 1990, 1999; Darling-Hammond & McLaughlin, 1995; Feldman & Minstrell, 2000; Lieberman & Grolnick, 1997).

We are currently deepening and expanding our exploration of the kinds of experiences teachers need in order to understand the synergistic relationship between science learning and language development. These experiences include reflecting on the language that ELLs use during science activities, developing a deeper sense of what it means to scaffold for ELLs to meet the language demands of an activity, and learning about different forms of contextualized mini-lessons that support language learners at various levels. These efforts will build on the fact that teachers in our project have developed both the perspectives on learning science and language and ability to enact pedagogical practices that support their ELLs in developing language while learning science.

We now see our work as affirming existing literatures on professional development and posing new challenges because of the hybrid areas of theory and practice that overlap in the process of teachers shifting their views of science learning and language learning and develop teaching practices that are resonant with these new views. We aim for to contribute to an emerging niche at the intersection of theory and practice about teacher professional learning that is focused on understanding what teachers need to know and become able to do so that science teaching becomes a productive context for the acquisition of language by their students.

Appendix: Project Background

Sonoma Valley Unified District Profile

The Sonoma Valley Unified School District (SVUSD) is a small, semi-rural district one hour north of San Francisco (five elementary schools, 90 teachers, 1,800 students) with 60% ELLs, 58% free lunch, 9% reduced lunch at the elementary level. Four of the five elementary schools have a history of being in program improvement, which motivated district administration to partner with the Exploratorium to explore new approaches to working with English language learners.

Funding

In 2008, the Exploratorium received two-year funding from the Vadasz Family Foundation and the Sonoma Valley Education Foundation to initiate a pilot project to experiment with the integration of science and English Language Development (ELD) at El Verano Elementary School. In 2010, the Exploratorium received a five-year grant from the U.S. Department of Education's i3 (Investing in Innovation) fund to work with all elementary teachers. The Vadasz Family Foundation and the Sonoma Valley Education Foundation provided matching funds.

ELD and Science Instruction Prior to the Project

At the start of the project, ELD and science learning were not seen as synergistic and were treated as separate areas of instruction. For ELD, students were re-grouped into homogenous grade level groups for forty-five minutes per day, four days per week. The district provided a pacing guide based on California's ELD standards, with an emphasis on forms (e.g., adjectives, nouns, etc.) and functions (e.g., compare and contrast, etc.). Methods of instruction varied among the schools. But generally teachers relied on ELD materials and ELD strategies (e.g., concept maps, sentence frames, etc.) learned from several years of professional development. The focus on ELD, ELA and math, left very little time, if any, for science instruction. When science was taught, most teachers relied on a textbook or gathered activities and materials themselves. Teachers had not had access to professional development in science for a decade.

Providing Inquiry-based Materials for Teachers

In order for teachers to provide, hands-on, inquiry based science experiences that could serve as a context for developing language, the Exploratorium developed two science units per grade level based on earth, physical and life science topics. The units included facilitator's guides and kits with hands-on materials. The units are organized around framework that has four stages: exploration, focused investigations, sharing ideas and developing understandings and conclusions. The lessons emphasize student collaboration in small groups to experiment with hands-on materials and to make meaning and communicate about discoveries through oral discourse and writing. Teachers are encouraged to form heterogeneous groups with mixed language fluencies in recognition of the language learning that happens through interaction between more advanced and emergent ELLs. Lessons are designed to support teachers to gradually shift more ownership and responsibility to the students for asking questions and planning and carrying out investigations. Several whole group "science talks" are built into each unit—early on for the purpose of gathering students'

ideas and later on for making meaning of the experiences. Writing in notebooks, to capture and communicate ideas, happens throughout the units. Teachers are encouraged to support students to share their work at the end of a unit, through posters and presentations. Relevant trade books were included in unit work to support literacy connections. Each unit is taught over a period of twelve to twenty days.

Professional Development Program Structure

In order to accommodate participation by all teachers in the district, we have developed two options for participating in professional development. The first option, an intensive approach, is voluntary, and is comprised of two interwoven strands that take place over the course of two years (six days of summer workshops and twelve, two hour after school Study Groups for a total of sixty hours). During summer workshops, teachers are immersed in the fundamental principles of inquiry-based science, language learning, the relationship between the two domains and pedagogical practices that support integration. During the academic year, Study Groups focus on the translation of ideas and principles explored in the workshop into practical strategies for classroom implementation. Participants share lessons learned from using the units and collaborate on enrichments, share student work and reflect on their practice. Graduates of a two-year cohort have the option of continuing in the study groups; about one-third choose to continue.

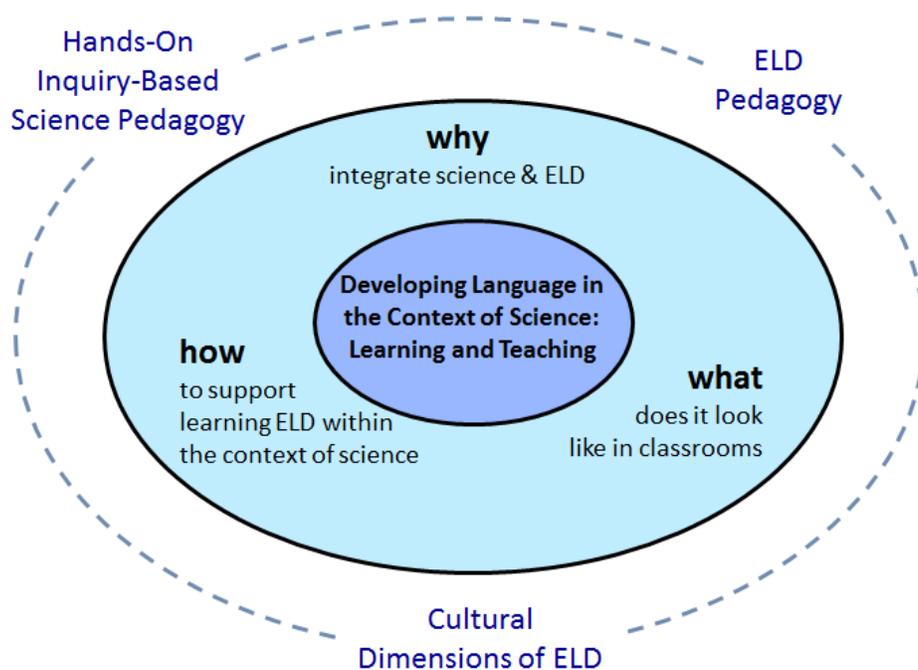
The second option, release day workshops, is required for all teachers who have not participated in the intensive workshops. They are released for ten half-days, over two years, for a total of thirty hours. In each of the workshops, learning about the fundamental principles of inquiry and ELD are interwoven with strategies for classroom implementation.

The Design of Professional Learning Experiences

Our professional learning experiences are based on the premise that inquiry-based approaches to science provide learners with the opportunity to engage in doing science as well as develop conceptual understanding of important science ideas. This requires significant communication and more sophisticated uses of academic language, thereby accelerating English language acquisition. A number of theoretical perspectives inform our work: socially-oriented, sociocultural, language as action theories as they pertain to second language acquisition and scientific sense-making, and professional development approaches that establish the connection between science inquiry and language development.

The following diagram reflects the conceptual framework that serves as a roadmap for developing workshops and Study Groups for the integration of science and language development.

A Framework for an Integrated Science and ELD Professional Development Curriculum



The curricula for intensive and release-day workshops are based on six main design principles:

- Experience inquiry-based science firsthand, with a particular emphasis on how the use of science practices (as instantiated in NGSS) can lead to developing scientific understandings and communication about these understandings.
- Examine inquiry-based science experiences from a language learning perspective, in order to illuminate how the experiences create a language-rich environment that provides affordances for language learning.
- Create lesson analysis and planning tools to identify the language demands of a lesson and the scaffolds that support students at various language levels to achieve the lesson's goals.
- Explore the links between the Next Generation Science Standards (NGSS). Common Core State Standards (CCSS) for English Language Arts.
- Create a balance between input from professional development providers and teacher participants.
- Provide ample time for reflecting on and sharing teaching practices.

The following ideas are introduced within the principles:

- The importance of student collaboration in small groups for exchange of ideas during experimentation, discussion and writing; the advantages of heterogeneous groupings with mixed language fluencies for interaction between advanced and emergent ELLs.
- Science talk and science writing serve as fundamental vehicles for developing scientific understanding and language—especially if students are allowed to utilize native and “everyday” language as a bridge to academic fluency.

- The learning of science and the learning of language in the context of science, places the emphasis on making sense of experiences and the expression of ideas; while focusing on developing fluency with grammar, vocabulary and sentence structure is important, it is in the service of using language to communicate ideas.
- Cultural contexts are important to consider when engaging in ideas about teaching and learning.

Growing Leadership

As project has developed, a cadre of seventeen leading teacher , who participated in intensive professional development, has emerged. They play a critical role in advancing the understanding of learning language within the context of science and how to better serve teachers’ needs to support this approach. The activities they engage in include presentations at workshops and conferences, serving as mentors to new teachers, teaching “model” lessons for colleagues and visitors observations and program documentation, enriching science units and engaging in research projects to understand classroom practices at a deeper level. The leaders are an important resource for supporting the current program and its development and improvement in future years.

Preliminary Findings

The Research Group at Lawrence Hall of Science has been conducting quantitative assessments of the project, in concert with US DOE i3 evaluation guidelines. Inverness Research. has been conducting formative and qualitative assessments of the project. Together, they are producing a diversified portfolio of measures that will include findings from interviews, classroom observations, teacher surveys and student test scores. Analysis of qualitative and quantitative test data will be completed in Fall 2015.

Below is a sample teacher survey by Inverness Research. The data is extracted from a portion of the survey that focuses on science instruction.

To what extent have each of the following factors been barriers to your ability to teach high-quality science? (before and after your involvement in the program)

- Lack of time for science learning (before: 70%, after: 27%)
- Lack of my own science content knowledge (before: 31%, after: 3%)
- Lack of understanding of language demands and language functions (before: 46%, after: 12%)
- Lack of materials for science learning (before: 68%, after: 0%)
- Lack of lesson plans for science learning (before: 68%, after: 3%)
- Lack of opportunity to share ideas with other teachers (before: 73%, after: 3%)
- Lack of access to outside expertise (before: 70%, after: 17%)
- Limited district support for science (before: 76%, after: 3%)

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The Institute for Inquiry (IFI) is a professional development program that addresses the theory and practice of inquiry-based science education. IFI workshops and seminars are tailored to a variety of participants, including professional developers, administrators, lead teachers, national education reform leaders, out-of-school educators, and educators in the museum and university communities worldwide.

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.



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