Integrating English Language Development and Science

A Professional Development Approach

Competitive Preference Priority 7—Innovations to Address the Unique Learning Needs of Students with Disabilities and Limited English Proficient Students.

Integrating English Language Development (ELD) and Science is designed to close the achievement gap of limited English proficient students at the K-5 level by supporting the adoption of an integrated ELD and science instructional program. Its focus is implementation of a districtwide professional development program by the Exploratorium Institute for Inquiry (IFI) in the Sonoma Valley Unified School District (SVUSD), where 58% of the students are classified as English Language Learners (ELL). This approach addresses the serious instructional time shortage in elementary grades, especially for science, while positing the proposition that inquiry-based approaches to science require greater communication and more sophisticated uses of academic language, thereby accelerating English language acquisition. Because this is a novel approach for most teachers and schools, introducing the program through a thoughtfully designed and tested teacher professional development program is the most effective and efficient route to significant student-level impacts.

The linguistic diversity of pre K-16 has been rapidly increasing in every part of the country (TESOL, 1997, 2006). More than 5.5 million, or 11%, of public school students are now categorized as ELL (NCES, 2006). By most measures, students whose first language is not English do not perform as well in school as those proficient in English (Fry, 2007). The goal of ELD is to teach students the language that will enable them to reach academic and linguistic parity with their English-only peers. Schools, districts, and states are challenged to deliver high-

quality instruction to these students that crosses the barriers of culture and language (NSF, 2006). What students learn depends on what teachers know and do, so the development of knowledgeable teachers is the linchpin of reform efforts that improve student learning (Alliance for Excellent Education, 2004; NCTAF, 1996, 2003; U.S. Dept. of Ed., 2001).

Research has shown powerful connections between language acquisition and science, suggesting that a focus on the combination has the potential to reinforce both (Amaral, Garrison, & Klentchy, 2002; Fradd & Lee, 1999; Lee & Fradd, 1998; Pearson, Moje, & Greenleaf, 2010; Rosebery, Warren, & Conant, 1992; Stoddard, Pinal, Latske, & Canaday, 2002). The integration of ELD and science holds great promise for advancing student achievement of ELLs as well as mainstream students (Amarl et al., 2002; Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Lee, Maerten-Rivera, Penfield, LeRoy, & Secada, 2008; Thomas & Collier, 2002). Meaningful engagement with science in early years is a critical influence on the academic pathways students choose in middle and high school (Tai, Liu, Maltese, & Fan, 2006). Yet there has been a reduction in classroom time devoted to science at the elementary level (CEP, 2008). By integrating ELD and science, instructional time for each can be increased, and limited English proficient students can excel in both, leading to improved outcomes.

Data from a recent two-year pilot project by the Exploratorium Institute for Inquiry in SVUSD show promising results using an integrated ELD and science approach (see section B). Student scores on the California Standards Test (CST) for science increased from basic to proficient level for Hispanic students. Student scores on California English Language Development Test (CELDT) increased from intermediate to early advanced proficiency level. This developmental proposal is designed to study the introduction of integrated ELD and science to an entire district to better understand the issues of scale and dissemination.

Absolute Priority 1—Innovations that Support Effective Teachers and Principals

A) Need and Project Design

The Exploratorium Institute for Inquiry (IFI) in San Francisco, in partnership with the Sonoma Valley Unified School District (SVUSD) in California, proposes a five-year Integrating English Language Development (ELD) and Science project that addresses the need to increase the percentage of elementary teachers who are highly effective in supporting the education of limited English proficient students. The framing hypothesis for this project is that strategically designed professional development (PD) focused on integrated ELD and science will increase the percentage of highly effective teachers, as measured by both teacher performance and student achievement in English language development and in science.

Need

Professional development is a primary resource for realizing the potential to support language development needs of ELLs, as indicated by strong research (Lee, Maerten-Rivera, Buxton, Penfield, & Secada, 2009; Stoddart et al., 2002; Warren & Rosebery, 2008). It is also central to supporting student achievement in science education (Duschl, Schweingruber , & Shouse, 2007). Although research has shown the pedagogical potential of integrating ELD and science, the lack of widespread instructional materials and knowledgeable teaching staff impedes implementation. If this integration is to be widely adopted, more explicit professional development models are needed to support the creation of highly qualified teachers who can integrate ELD and science using existing curriculum. In the long term, the key to developing highly qualified teachers lies in enhancing the capacity and tools of the professional development staff responsible for developing the elementary teaching workforce.

Project Design

Sonoma Valley Unified School District is a small district one hour north of San Francisco (five elementary schools, 90 teachers, 1,800 students) with a high percentage of high-needs students (an average of 58% ELLs, 58% free lunch, 9% reduced lunch at the elementary level). Four of the five elementary schools are in Program Improvement, which means they have failed to meet Adequate Yearly Progress at least two years in a row. For the past two years, IFI and SVUSD have collaborated on a pilot professional development project for K-5 teachers to integrate ELD and science instruction. Data from this pilot (see section B) show encouraging results in student and teacher growth in ELD, language arts, and science. This work warrants more systematic development and rigorous study at the district level because it addresses an issue of national importance and significance beyond SVUSD.

Goals and Project Outcomes

The goal of the project is to develop and study—at a district level—the effective professional development practices that support elementary teachers in offering integrated ELD and science that lead to greater student achievement. The strategies include:

- Provide professional development for 90% of SVUSD teachers
- Develop El Verano School as a district focal school of integrated ELD and science
- Implement and document a research plan to:
    - understand what teachers need to integrate ELD and science to improve student learning
    - understand the key components that lead to student growth in English language development and inquiry-based science
    - understand the key factors and principles for designing effective professional development that leads to increasing the percentage of highly effective teachers

- Produce a professional development guidebook of strategies and curriculum for the integration of ELD and science for teachers and professional developers

Project outcomes include:

- An increase in the number of highly effective elementary teachers teaching ELD and science
- A reduction in the achievement gap for K-5 students in both ELD and science

Work Plan

The project has a five-year timetable:

Year 1: Work with all 24 El Verano School teachers to refine the professional development approach developed in the pilot. El Verano will be a district focal school.

Years 2–5: Work with two cohorts totaling 60 teachers from the remaining four SVUSD elementary schools in two blocks (Cohort I years 2-3, Cohort II years 4-5). The iterative two-cohort design allows for design innovations between cohort I and II and control group testing.

Years 2–5: Develop a cadre of 15 lead teachers from the focal school and cohorts I and II. Through mentorship by IFI staff, this cadre will play a significant leadership role in the workshops and study groups and will continue the work in SVUSD beyond the proposed project.

Year 5: Project evaluators distill findings to determine results and communicate knowledge to the field. IFI staff develops a PD guide on the integration of ELD and science.

Professional Development Approach

The PD strategy is comprised of three interwoven components that we believe are essential for promoting and sustaining change within a district. **Workshops** provide the opportunity, through immersion, to develop a deep understanding of subject matter and pedagogical content knowledge, and they can be catalysts for transforming thinking about the nature of teaching and learning related to the content (Blank, de las Alas, & Smith, 2007; Garet,

Porter, Desimone, Birman, & Yoon, 2001; Saxe, Gearhart, & Nasir, 2001). IFI staff will collaborate with ELD experts to design experiences that help teachers learn core ELD strategies that reinforce the learning of language, literacy, and science content. **Study Groups** provide the opportunity to build a professional learning community (PLC) where teachers collaborate in implementing new strategies and ideas from the workshops to improve their practice. Teacher study groups encourage teachers to be self-reflective and continually renewed. **Leadership Development Activities** provide opportunities for teachers to take on leadership roles and practice important skills and behaviors in the PLC. The PLC provides the opportunity for wider scaling and dissemination of practice throughout the district.

Workshops (ten days over two years): Workshops are designed to immerse teachers in experiences that develop the knowledge they need to integrate ELD and science with their existing instructional materials. This knowledge includes fundamental ideas about ELD and inquiry-based science, the connections between the two domains, and pedagogical practices that support integration. The goal is to help teachers become competent in the content and reflective about how to best apply an understanding of the content to teaching practice.

Teachers will experience inquiry-based science firsthand, with a particular focus on how the use of the science process skills supports the development of a conceptual understanding of scientific concepts, and how students communicate these ideas to one another. These process skills, or ways of thinking, and the teaching strategies that support them are foundational to inquiry instruction. Participants will study key ideas in English language development, such as literacy (reading, writing, and speaking) and providing cues to support meaning making (visual representation, hands-on activities, real-world objects). These strategies will be derived from successful ELD models, such as Sheltered English (Echevarria, Vogt, & Short, 2004; Fathman &

Crowther, 2006) and Guided Language Acquisition Design (GLAD) (Brechtel, 2001). These ideas include students engaging in collaborative learning that supports them in using language to work with their peers and solve problems; using visual representations of ideas to scaffold associating new language with ideas (i.e., concept maps, etc.); providing vocabulary that will be encountered in an academic lesson; and providing structures such as sentence frames to support academic description and discussion. (See appendix H for examples of classroom practice.)

The workshop will develop teachers' understanding that there is an interaction between science and language learning that is synergistic in the case of inquiry-based science approaches. "Effective language instruction enhances the learning of science concepts and effective science instruction enhances language development. . . . Language functions to help students internalize ideas" (Stoddart et al., 2002, pp. 667-79).

- Learning language and science involve cognitive processes that are similar and support each other. Inquiry science activities create a context that supports learners in using language in many forms including reading, writing, discussing, and presenting. Language processes provide a medium for analysis and communication of science ideas that are emerging for students (Stoddart et al., 2002; van den Broek, 2010). This recognition will allow teachers to use experimentation as an instructional strategy for integrating science and language.
- Process skills that are key to science inquiry—including observing, predicting, communicating, classifying, and analyzing—are very similar to language learning and literacy skills—seeking information, comparing, ordering, synthesizing and evaluating. For example, teachers who recognize process skills as a link between science and language learning will view predicting as a process that good readers, language learners, and science learners all do (Stoddart et al., 2002). They will come to understand that using language to

make sense of science phenomena is similar to using language to tell a story.

- Learning in science provides a context for ELLs to explore complex ideas. Research shows that complex ideas can be catalysts for developing academic language (AERA, 2006; Crowther, 2010). This idea is important to keep in mind as teachers learn ways to use instructional strategies, i.e., vocabulary building, questioning, writing, and classroom discussions, to link science and language learning.

Study Groups (Ten two-hour sessions, over two years): Grade level groups meet regularly to reflect on their practice and assist each other in implementing new teaching strategies, based on their experiences in the workshops. Between meetings, teachers experiment with implementing these ideas in their classrooms. The discussions support teachers in sharing, generating, and distilling knowledge they gained from implementing ELD and science in their classrooms. Study Groups will be facilitated by IFI staff and Lead Teachers from SVUSD.

Leadership Development: The project will develop a supportive professional learning community in which lead teachers can build knowledge about effective ways to share their practice with colleagues. The project will also develop a cadre of lead teachers from the participants to support further development of colleagues. IFI staff will mentor them to play a significant role in workshops and study groups of Cohorts I and II. Their classrooms will be observation sites for colleagues. This cadre is designed to sustain long-term, ongoing professional learning embedded in a school or district culture.

B) Research and Prior Results

Over the past 15 years, a robust, growing research base has shown evidence of a synergistic relationship between ELD and inquiry-based science learning that can benefit ELLs' learning of both. Many studies indicate that professional development is the key to creating

pedagogical practice that successfully integrates ELD and science learning. Several lines of research support the hypothesis for this project—that strategically designed professional development that addresses the integration of ELD and science will increase the percentage of highly effective teachers as measured by their performance and students' growth in English language development and science. We do not know what PD designs/models/strategies are best suited to (1) educating teachers about integration of ELD and science that quickly shows results for students, and (2) helping them apply their understandings in settings most common in the real world—with separate ELD and science curriculum. Our strategy of creating professional development that enables teachers to enact ELD/science integration with a variety of curriculum will be a novel, productive innovation that contributes vital information to the field.

ELD and Science Learning Is Synergistic

Theoretical frameworks for ELD/science integration are based on explanations of how language is involved in meaning making. Theorists in cognition state language forms to make sense of the world and communicate it to others. Making sense of the world involves developing language to communicate meaning (Gee, 2008; Lemke, 1990). Science is a particularly good content area for language development because making sense of scientific phenomena requires using language to develop this understanding. Science learning creates a context in which language development is nurtured, and using language to make sense of science nurtures the development of language (Stoddart et al., 2002; Rosebery, Warren, & Conant, 1992; Warren, Rosebery, & Conant, 1994). The synergy between science and language learning is supported by practical as well as theoretical foundations (Pearson et al., 2010). Because learning science is a good way to learn language, and learning language supports the learning of science, it is preferable to combine time allotted for teaching the two (Stoddart et al., 2002; Webb, 2010).

The predominant rationale for integration of inquiry-based science teaching and ELD is that inquiry engages students in expressing their ideas about phenomena they experience and share. Engaging in making meaning of science ideas in hands-on inquiry encourages students to develop language structure and functions, because use of language is linked to objects, processes, hands-on experimentation, and naturally occurring events (Cuevas, Lee, Hart, & Deaktor, 2005; Rosebery et al., 1992; Stoddart et al., 2002). Use of language that is encouraged by inquiry-based science learning has also been shown to support understanding of science concepts (Gee, 2008; Hudicourt-Barnes, 2003; Rosebery et al., 1992; Warren & Rosebery, 2008). Examples of language functions elicited by inquiry-based science learning to support both language/literacy development and science include description, explanation, discussion, and interpretation (Lee & Fradd, 1998; Snow, 2008; Stoddart et al., 2002).

Integration of ELD and Science Can Improve ELLs' Achievement

A significant body of research substantiates the potential of classroom practices that combine inquiry-based science and ELD to help close the achievement gap in science and English-language learning and literacy between ELLs and students whose first language is English (Amaral et al., 2002; Buxton, Lee, & Santau, 2008; Stoddart et al., 2002). Both experimental and descriptive studies have validated the use of inquiry-based science as a productive resource for ELLs to learn science and English language/literacy skills (Amaral et al., 2002; Crowther, Robinson, Edmondson, & Colburn 2007; Lee, Maerten-Rivera, Penfield, Leroy, & Secada, 2008; Echevarria et al., 2004; Fradd, Lee, Sutman, & Saxton, 2001; Hart & Lee, 2003; Lee & Luykx, 2005; Reichardt & Crowther, 2005; Settlage & Southerland, 2007; Warren & Rosebery, 2008; Warren, Rosebery & Conant, 1992). Although there are questions about how to best help teachers connect what they learn in PD to specific changes in classroom practice

(Gomez et al., 2010), results from our pilot show it is possible to produce significant improvement in student outcomes using this approach (see study below).

Innovative Professional Development Design Is Critically Needed

Evidence suggests that a majority of elementary teachers are not highly trained in inquiry-based science teaching or teaching ELLs (Duschl et al., 2007; NSTA, 2010; NRC, 2000). There is such a great need for PD that can reach enough teachers to make a difference for the many ELLs in U.S. schools now, that many approaches are being tried. Few projects have directly addressed the situation that most teachers face—using district-mandated science curriculum that does not specifically support science/ELD integration. A large body of evidence suggests that PD can be designed to be valuable for strengthening teachers' abilities to improve ELL with science teaching. Professional development for teachers to learn how to effectively integrate science and ELD involves a complex weaving together of coming to understand learning through inquiry, strategies for ELD, and practices for integration of science and ELD.

IFI's pilot project reaffirms the power of thoughtful professional development. IFI proposes a strategy for PD that combines immersion experiences with ongoing work in professional learning communities (Danielson, 2006). This combination of PD 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 power of creating a professional learning community for developing self-reflective practitioners, knowledge generation, and professional development has been well documented (Cochran-Smith & Lytle, 1990, 1999; Darling-Hammond & McLaughlin, 1995; Feldman & Minstrell, 2000; Hord, 1997; Lieberman & Grolnick, 1999; Roth, 2007; Shafer, 2000). These mechanisms add to

the sustainability of educational reform when it is a component of an improvement in infrastructure within the system (Rowan, 2002; St. John, 2002).

Results of Pilot Study

This project is based on the outcome of a two-year pilot by the Exploratorium's Institute for Inquiry in SVUSD. The pilot studied the design and efficacy of a professional development program supporting the integration of ELD and science instruction at El Verano (EV) School, an elementary school in SVUSD with 24 teachers and 450 students. El Verano has a population of 80% English Language Learners (ELL), and nearly 70% of students are socioeconomically disadvantaged. In the pilot, El Verano teachers participated in various forms of professional development, experimented with designing ways to integrate ELD strategies into science lessons, and convened for meetings to critique the lessons and redesign. A program of workshops, study groups, and leadership opportunities lead by IFI provided EV teachers with the opportunity to develop an instructional strategy building on their existing science and ELD materials.

As a result of this project, students showed significant measurable achievement gains in English Language Development and in science. Science achievement was recorded using the CST (California Standards Test)—a test of California science standards administered to fifth graders and a cross-sectional analysis was used to examine whole school progress. English Language Development achievement was recorded using the CELDT (California English Language Development Test), a required state test for English language proficiency that must be given each year to students whose primary language is other than English. A cohort-matched analysis was used to see if individual students increased a proficiency level each year. In addition, locally developed district benchmark assessments were used to record proficiency in writing. After a year of participating in the Exploratorium led project, EV registered the greatest

change in achievement scores in science of all the schools in the district for the first time in more than three years. These changes in test scores provide evidence for the effectiveness of the project and its promise for further study. Details of the achievement gains are reported below.

CST science scores at EV increased substantially between October 2007 and October 2009, and they increased more than in any other school in the district. The increase was particularly evident among Hispanic and special needs students, narrowing the achievement gap at EV while this gap widened in other district schools. At EV, scaled scores went up 35 points—from basic to proficient level. Hispanic students' scores went up 47 points compared to white students, whose scores rose only 3 points. Resource students' scores increased significantly—most advancing to proficient from a below basic. In other district schools the average gains for all students were only 5 points. The school with the highest gain after EV gained 23 points.

CELDT (English Language Development) scores increased throughout EV between May 2008 and May 2009 (before and after the treatment year). The increase was particularly evident in fifth grade student scores. EV fifth graders outperformed district cohorts despite having the highest percentage of ELLs. They were the only school whose scores jumped from intermediate to early advanced proficiency. This is particularly noteworthy because it is notoriously difficult for students to avoid becoming "stuck" at the intermediate proficiency level (Castillo, 2009). In addition, locally developed district benchmark assessments for writing between July 2008 and September 2009, scored on a common rubric with consistent cut points for proficiency, showed third grade students improved from an average of 43% to 71% proficient.

C) Experience of the Eligible Applicant

The Exploratorium's Institute for Inquiry has a well-established record of working successfully with districts, schools, and teachers across the country. IFI was founded in 1995

with National Science Foundation (NSF) funding to be a national center filling a critical gap in the nation's science education reform effort—namely, the tremendous lack of professional development capacity at the elementary level. IFI provides professional developers with workshops, strategies, tools, resources, and an intellectual community of practice supporting high-quality science instruction. IFI has worked with more than 5,000 lead teachers and professional developers from districts, universities, and museums from 160 projects in 850 districts and 46 states. These developers have experienced 30 to 100 hours or more of development in inquiry-based approaches to teaching science. IFI conservatively estimates that each professional developer/lead teacher has, in turn, provided PD to 30 teachers, and each teacher provides instruction to an average of 30 students a year, therefore, IFI participants have influenced at least 150,000 teachers, and the teachers have influenced 4,500,000 students.

IFI has created an online curriculum for professional developers (funded by NSF), including the series *Fundamentals of Inquiry* and *Formative Assessment in Inquiry*. These guides <www.exploratorium.edu/ifi> are used by professional developers to give workshops that introduce elementary teachers to inquiry-based approaches to science teaching, ensure appropriate use and explanation of science content, and improve the quality of professional development in elementary science education. To date, more than 4,000 educators have requested downloads. Inverness Research evaluation shows that IFI plays an important role in improving the quality of professional development that districts offer in science. Overall, respondents rate the quality and value of the IFI Web site very highly, with 94% saying it is better than other resources for elementary inquiry-based science. They also say that IFI plays a very important role in supporting district efforts to improve science (in 74% of districts).

Extensive evaluation of IFI shows work of high quality, greatly valued by participants, and that measurably adds real value to local reform efforts. In 2001 Inverness Research conducted a triple-blind study to assess whether Local System Change (LSC) projects funded by NSF that participated extensively with IFI were distinguishable from LSCs that had not. Inverness randomly selected five LSC projects from both categories. The results show that IFI-involved LSCs are distinguishable in a statistically significant way in priority and depth of **understanding of science inquiry** ($p = .002$), attention to and sophistication of **leadership development strategies** ($p = .026$), sophistication and evolution of the **professional development design (**$p = .082$); and amount the LSC was deemed to benefit from the assistance of an **outside resource** (such as the Exploratorium or NSRC) ($p = .065$).

The Exploratorium's work with schools has produced measurable student gains as well as significantly improved teacher instruction. IFI led the pilot project in SVUSD to integrate ELD and science instruction (2008 to present). This project showed significant measurable student gains in ELD and science (see detailed results in section B above). Scores of fifth grade Hispanic students on the California Standards Test (CST) in science increased dramatically from basic to proficient. Student scores on California English Language Development Test (CELDT) increased from intermediate to early advanced proficiency. District benchmark assessments for writing showed third grade students improved from an average of 43% to 71% proficient.

D) Project Evaluation

Inverness Research Inc. and the Center for Research, Evaluation, and Assessment (REA) at the University of California, Berkeley's Lawrence Hall of Science are the independent evaluators. They will provide implementation research and performance feedback through:

1. collection and analysis of information about the key elements and approach of the project

to facilitate further development, replication, or testing in other settings

2. periodic assessment of progress toward achieving intended outcomes.
3. data and analysis of student achievement and teacher effectiveness at the completion

The following questions will guide evaluation research:

1. Teacher Learning and Practice
    a. What was the project impact on teachers' knowledge of and comfort with using ELD strategies in science instruction and using science strategies in ELD instruction?
    b. What was the impact of the program on teacher practice related to use of ELD strategies in science instruction and use of science strategies in ELD instruction?
2. Student Achievement
    a. What was the impact of the intervention on ELL student achievement in science?
    b. What was the impact of the intervention on ELL student achievement in language arts and ELD?
3. System Scaling and Sustainability
    a. What are the costs of the model—both near term and long term?
    b. What are the key components of the model? What are the requisite supports needed to implement, replicate, and sustain the model?

To answer the questions about intervention impact, we will engage in a quasi-experimental comparison study methodology (Shadish, Cook, & Campbell, 2002). To assess benefits to teachers and change in classroom practice, we will gather qualitative and quantitative data from several sources and use pre-post comparisons to understand the impact of the intervention on teacher outcomes. Program developers plan to select teacher cohorts purposively

for programmatic development, rather than selecting randomly for research purposes. Accordingly, we selected the interrupted time series methodology to allow us to use the district as its own control group by comparing student achievement patterns before, during (analysis will take into account the two waves of teacher cohorts), and after the intervention. In addition to the experimental component of this study, qualitative (observation) and quantitative methods (surveys, participant data collection) will support investigation of program implementation.

Goal	**Data Sources**	**Description**
Increased Student Achievement in Science	•California Standards Test: Science (5^{th}) •Student Science Notebooks	*California Standards Test (Science)* test scores will be collected for all students in participating and control teachers' classrooms prior to, during and upon completion of the intervention. *Student Science Notebooks and District Writing Prompt Responses* (sample of treatment students only) will be scored, assessing science learning. Prompts and scoring rubrics have been developed and validated.
Increased Student Achievement in English Language Development	•California Standards Test: Language Arts (All grades); •CELDT •Student Science Notebooks	*English Language Arts and CELDT* test scores will be collected in participating and control teachers' classrooms prior to, during, and upon completion of the intervention. *Student Science Notebooks & District Writing Prompt Responses* (sample of treatment students only) will be scored, assessing language development. Prompts & scoring rubrics have been developed & validated.

Improved Student interests and attitudes	•Student Science Interest and Attitude Survey •Student Focus Groups	*Student Surveys* will be administered at the beginning and end of each school year. This survey instrument has already been developed and validated. *Student Focus Groups* will be conducted annual to probe the nature and quality of student engagement and thinking.

Increased Teacher competence and confidence	•Annual survey of all teachers	*Teacher Attitudes and Practice Survey* will be administered at baseline and every-year districtwide to treatment and control teachers. It will include questions related to teachers' attitudes about science instruction, time spent on science instruction, comfort with and practice of integrating ELD strategies and addressing ELA/ELD standards during science time.
Increased Teacher engagement and commitment	•Annual focus groups	*Teacher focus groups* will be conducted annually learn about the quality of professional development; teacher learning; teacher interest; levels and adequacy of supports; changes in beliefs, and changes in practice.
Improvement in Teacher practices	•Classroom Observations using Horizon Research protocol	*Classroom Observations* will be conducted yearly with a randomly selected group of project teachers to provide concurrent validation of the Attitude and Practice Questionnaire and to provide formative feedback to the program staff.

Data analysis will take multiple forms in order to answer the research questions above. Baseline teacher data will be analyzed to achieve a matched sample of control teachers. To examine changes in teacher attitudes and practice over time, we will use repeated measures ANOVAS to examine differences between baseline, year 1, year 2, and year 4 scores. In order to determine the impact of the intervention on both student quantitative outcomes, we will employ a two-level hierarchical linear model (HLM) with students nested within classrooms (see Raudenbush & Bryk, 2002). This analysis will enable us to estimate the effects of relevant variables such as amount of exposure to treatment teachers and teachers' classroom practices, while controlling for demographic and prior achievement data.

The qualitative analysis will triangulate data gathered by interviews, surveys, and focus groups, as well as participant observation. Following the principle of multiple measures, conclusions about the efficacy of the program and the key program components will be checked by multiple sources of data and reviewers. The classroom observations will use the protocol developed and validated by Horizon Research (2000)—an instrument that emphasizes the quality of the content, pedagogy, and intellectual engagement of the students with important scientific ideas. Teachers will give input into the development of the assessments.

By synthesizing what they have learned from the data, the evaluation team will independently identify and describe features of the model most critical to its success. The final, summative report will include key project design principles, essential components, project accomplishments, identification of strengths and weaknesses of the model, and lessons learned. In addition, it will illuminate key factors, necessary capacities, and important considerations for sustainability and scale up. (See Appendix H for more detail on the Project Evaluation Plan.)

E) Strategy for Further Development and Scaling

The Institute for Inquiry has two mechanisms for implementing PD approaches to integrating ELD and science beyond Sonoma Valley and bringing this work to scale. First, IFI is a lead partner in BaySci, a regional project supporting elementary school science development in the more than 85 elementary school districts in the San Francisco Bay Area. The strategies developed in this proposed project will be incorporated in future BaySci work, leading to implementation in these districts. Second, the Institute for Inquiry will incorporate materials and processes developed in this project in its national PD workshop offerings.

The approach does not depend on a specialized student curriculum, but focuses on developing strategies that teachers can use with their existing science and ELD instructional materials. This means scale up can happen through the application of PD strategies and materials in a variety of district situations. IFI's test work with El Verano School shows that this approach can work effectively. We will also experiment with developing online virtual workshops.

Total project cost, including research and development, is $3,590,166, or $211 per student per year, based on a class size of 20. Of this, $800,000 is for research, and $1,650,000 is for one-time costs in prototyping and development of professional development materials for dissemination and scale up. The remaining $1,140,166 is for PD activities and is an example of mostly non-recurrent expenses because teachers will implement this work over many years for many students after the project. We estimate that implementation will cost about $3,000 per teacher for PD and study groups over two years (100 hours total), depending on the development of physical and online versions of PD materials. This amounts to an implementation expense in the first year (because it is for one-time professional development that impacts students over the

teachers' active lifetimes) of $15,000,000 for 100,000 students, $37,500,000 for 250,000 students, and $75,000,000 for 500,000 students.

Dissemination encompasses multiple channels for communicating with a variety of constituents invested in improving the science education infrastructure (including researchers, policymakers, funders, professional developers, science education leaders, and district administrators). Project results and findings will be submitted to publications that reach key audiences, including foundations and agencies funding science education and professional development, people who design improvement efforts, and organizations in PD design. The project team will present findings and PD strategies in publications and presentations at established channels such as NABE (National Association for Bi-Lingual Education), CABE (California Association for Bi-Lingual Education), National Clearinghouse for English Language Acquisition (NCELA), National Science Teachers Association (NSTA)**,** the leadership of the Council of Chief State School Officers, and ELL, bi-lingual, and science divisions of state departments of education. We will also work through clearinghouses developed by the U.S. Dept of Education. Inverness will publish research in peer-reviewed education research journals.

F) Sustainability

The official partners, the Exploratorium and SVUSD, have a history of successful collaboration and are enthusiastic about continuing this work beyond the proposed five years. Both have extensive experience partnering with community organizations, county offices of education, districts, universities, and consultants to bring about innovative programming. These represent avenues for project dissemination.

The SVSUD superintendent estimates that 90% of the 90 K-5 teachers will participate, reaching 3,400 students in all five elementary schools over five years. All principals will be

encouraged to support staff to attend all PD opportunities, and to implement strategies for ELL/science integration in classrooms. The project has strong support and involvement of El Verano School Principal Maite Iturri and all El Verano teachers. The SVUSD Board of Trustees and Superintendent Carlomagno have strongly endorsed the project. Carlomagno will provide strategic planning and implementation. She has clearly articulated her vision of bringing the integration of science inquiry and language development to all students. SVUSD is committed to continuing support beyond the proposed five-year project for a half-time coordinator and for teacher study groups to ensure integration of ELD and science continues throughout the district.

SVUSD is committed to the continual improvement of teachers and students over the long term. The district plans to include the eight middle school teachers in the future because of the interest in developing a continuity of approaches between elementary and middle school teachers. Leaders developed in the project will continue to work with their colleagues and thereby continue to evolve the practices of integrated science/ELD instruction.

A Professional Developers Guidebook based on project activities will be published for dissemination. The guidebook will provide step-by-step instructions on conducting workshops and study groups, facilitator hints and scripts, and handouts and samples of teacher and student work. The guidebook will also contain video-clips of classroom interactions. The guidebook will be part of the IFI Professional Development Web site. This site provides active dissemination of IFI's work and has downloads by more than 1,000 teacher professional developers each year.

G) Management Plan and Personnel

The Exploratorium is the nonprofit applicant and is responsible for overall direction as well as professional development design and implementation. Sonoma Valley Unified School District is an official partner and is responsible for co-design and implementation, participant

recruitment, onsite management, and classroom implementation. Inverness Research plus Research, Evaluation, and Assessment Center are partners for research and evaluation.

Lynn Rankin, Director of IFI, is Project Director. She provides oversight of all project elements and design, and she supervises project personnel. Lynn has served as a PI on many NSF-funded PD projects of comparable scale and is a nationally recognized expert in inquiry-based learning, having served on the National Standards Committee for the Inquiry Addendum and on many panels and committees related to inquiry-based science learning

Louann Carlomagno, Superintendent of SVUSD, will lead district strategic planning, development, and oversight as well as integration of the project districtwide. Louann is an 18-year veteran of SVUSD and has experience as a high school science teacher, elementary and middle school principal, and Director of Curriculum and Instruction. She is at the helm of a district with a $40 million budget, 4,250 students, and 12 schools.

IFI educators will lead design of professional development activities, study groups, and leadership development. **Dr. Fred Stein,** biologist/senior science educator and **Dr. Paula Hooper**, senior science educator and learning research scientist, each have more than 20 years of experience in inquiry-based professional and curriculum development for teachers and professional developers, as well as expertise in professional development design and programmatic development.

Tonya Ward Singer is the ELD consultant. She has collaborated with SVUSD for five years and with IFI for two. Tonya is a nationally recognized expert in language development and literacy. She co-wrote the *LBook* with Kate Kinsella, Ed.D., which is an interactive academic language and literacy development curriculum for Scholastic's Read180 intervention program. She is codeveloping pedagogical guides for Longman and Oxford University Press.

Dr. Mark St. John, President of Inverness Research Inc., will lead evaluation. He has more than 25 years of experience researching systemic reform initiatives (local, regional, and statewide), infrastructure development, and PD for teachers and professional developers. **Dr. Laura Stokes** and **Dr. Pamela Castori,** senior researchers, have extensive experience studying science education reform and have studied the National Writing Project and PD infrastructures.

Dr. Rena Dorph will conduct research on student achievement. She is director of the Research, Evaluation, and Assessment Center (REA) at the Lawrence Hall of Science. Rena has fifteen years of experience studying school restructuring and the relationship between learning experiences and outcomes, paying consistent attention to equity and impact. **Dr. Ardice Harty** and **Dr. Juna Snow,** REA research specialists, have more than ten years of experience each in methodologies for learning assessment and outcomes measurement.

The iterative formative assessment is critical to provide ongoing analysis, synthesis, and redesign of the work in conjunction with project evaluators. Design review-and-revise sessions held in June each year with all project staff and consultants will be major milestones.

Full funding for the pilot was provided by the Vadasz Family Foundation. Significant matching funds have been raised for the proposed project through the Vadasz Family Foundation and the Sonoma Valley Education Foundation. The Exploratorium is seeking additional matching funds from foundations and corporations that have funded its education work in the past, such as the William and Flora Hewlett Foundation, Carnegie Corporation of New York, Wells Fargo, S. D. Bechtel, Jr. Foundation, Gordon and Betty Moore Foundation, to offset the in-kind staff time supported by the Exploratorium general fund. In addition, it will seek new funders for the match, such as those identified in the newly formed i3 Foundation Registry.

Timeline

Activity Name	Text 1
El Verano (Focus School)	24 teachers
Workshops	3 day 2 day
Study Groups	9 2hr 3 2 hr 3 2hr 3 2hr 3 2hr
Leadership Team Activities	
Cohort I	30 teachers
Workshops	5 day 5 day
Study Groups	6 2hr 6 2hr
Leadership Team Activities	
Cohort II	30 teachers
Workshops	5 day 5 day
Study Groups	6 2hr 6 2hr
Leadership Team Activities	
Design Review Meetings	Project staff and evaluator
Development Guide Production