



STUDENT PROGRESSIONS IN SCIENCE AND LANGUAGE DEVELOPMENT

Progress in Developing Language Fluency and Complexity

The Integrating ELD (English Language Development) and Science program, a partnership between the Exploratorium and Sonoma Valley Unified School District (SVUSD), offers elementary students wide-ranging opportunities to interact with and make meaning of natural phenomenon through science inquiry. In turn, students' individual and collective investigations create rich and varied opportunities for using language. The kind of student-centered and student-generated learning produced by the Integrating ELD and Science program happens in deep and complex ways, but often "below the radar screen" of what can be detected through formal standardized student assessments.

As an alternate construct to achievement testing, the concept of **student progressions** provides a view of how children build their knowledge over time. The **student progressions** lens can illuminate specific critical dimensions of ELD and science learning, such as developing thinking skills or science content knowledge, as well as affective aspects of learning that are critical precursors to students' academic success. The **student progressions** concept is presented here to show how SVUSD students at large fulfilled the primary purpose of the Integrating ELD and Science program—making positive and often dramatic progress in developing both their oral and written language fluency, as well as their communication skills. The data is gleaned from a range of sources: classroom observations conducted by researchers from both Inverness Research and the Research Group at the Lawrence Hall of Science; teachers' survey responses; teacher reflections from interviews and written testimonies; as well as exemplars of student conversations.

What does the field say about the kinds of learning experiences that support students' progress in language development?

Those who study the field of language acquisition and learning fall into two schools of thought. One believes that language learning is an individual cognitive process enhanced by direct instruction focused on the different building blocks of language—its grammar, vocabulary, pronunciation, and meaning. This

What Is the Partners in Innovation: Integrating ELD and Science program?

The goal of the Partners in Innovation: Integrating ELD and Science program was to enhance K-5 students' English Language Development and science learning. Over five years the program promoted the implementation of an integrated ELD and science instructional approach by providing concrete supports to teachers in four critical dimensions: curriculum, professional development, professional learning community, and district backing. With its focus on learning language in the context of hands-on science, the program aimed to establish a robust, districtwide elementary science program as well as to accelerate the language development of its English Language Learners.

view emphasizes learning correct form and structure. The other school of thought views language acquisition as primarily a social process occurring within authentic contexts among learners and speakers of the target language. It espouses the benefits of students describing, explaining, asking and answering questions, narrating experiences, etc., within meaningful settings. This view values expression of thoughts, ideas, and meaning over correctness of language. The latter school of thought served as the pedagogical underpinnings of the Integrating ELD and Science program.

Why does science provide an especially rich context for acquiring language in classrooms?

Firsthand, inquiry-focused science experiences grounded in real-world phenomena offer opportunities for rich discourse and literacy development by providing diverse and multiple ways for children to hear and use language. Such instruction also offers opportunities for working and learning cooperatively. Groups of students easily generate spontaneous, everyday language while thinking, talking, and writing about their developing understandings based on their investigations—thus developing their fluency with language naturalistically as they engage with the phenomena in front of them. As students engage more frequently with hands-on science they also hear, become familiar with, and eventually use precise academic language and even technical terminology.

The Integrating ELD and Science program deliberately capitalized on this mutually beneficial relationship between inquiry-based science and language development. It aimed to design student experiences centering simultaneously on science and immersion in language. Believing that contexts that support language learning are those offering diverse opportunities for engaging learners' interest and wonder, the program endeavored to generate excitement and enthusiasm, thereby deliberately reducing students' inhibition and anxiety about learning a second language. Observing, manipulating, questioning, conversing with partners and small groups, discussing with the whole class, illustrating and writing thoughts, reading a range of texts including their own, the teacher's, and published works—all of these experiences were intended to promote students' participation, raising their motivation and willingness to risk expressing their ideas, and leading them into active "language-ing."

How did SVUSD teachers expand their classroom practice to support the language development of their students through science?

The Integrating ELD and Science program developed and distributed to teachers grade-specific, hands-on science kits that included activities for language development incorporated into the materials. The program also offered teachers professional development support for learning how to integrate science and language development teaching. As a result, SVUSD teachers reported that their participation in the program contributed to their ability to create rich language development contexts within the science lessons.¹ Teachers' ratings in response to the following question show the extent of pedagogical practices supportive of language development. Rating are based on a scale of 1 to 5, with 1 being "No change" and 5 being "Much more change." Percentages represent combined responses of 3, 4, and 5.

¹ For the first four years of the Integrating ELD and Science program, Inverness Research and the Research Group at the Lawrence Hall of Science, UC Berkeley, administered a teacher survey to participating teachers. The data cited here is from the 2014 teacher survey results, the last of the four annual surveys.

To what extent has your participation in the Integrating ELD and Science program increased the frequency with which you engage in the following practices?

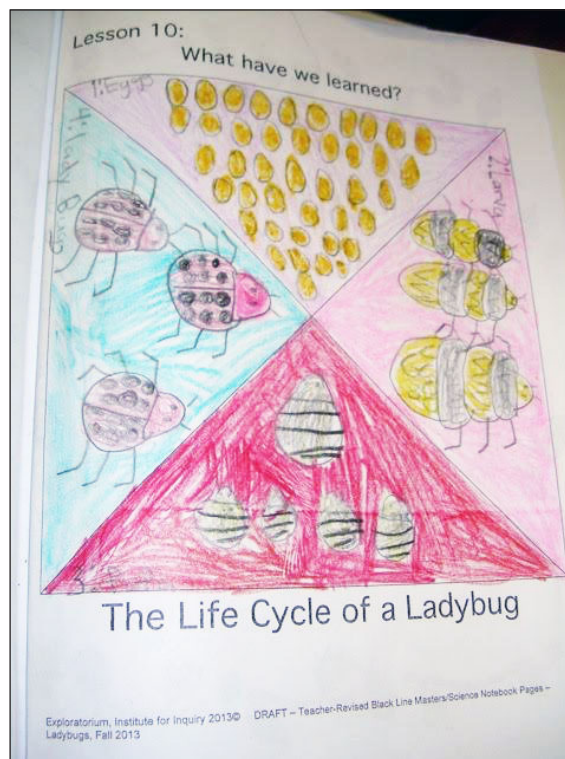
- ✓ 85% of teachers design scaffolded activities for **students to talk about science content** to each other.
- ✓ 83% of teachers design scaffolded activities to enable **students to demonstrate their aural comprehension of language** related to science.
- ✓ 87% of teachers design scaffolded activities for **students to write about their scientific thinking**.
- ✓ 83% of teachers provide visual supports such as real objects, pictures, demonstrations, etc. for **students to understand teacher explanations**.
- ✓ 83% of teachers design differentiated activities for students to **read about related science content**.
- ✓ 89% of teachers structure class time to listen to **students explaining their understandings**.
- ✓ 76% of **teachers adapt their English speech and language** to a range of levels of English Language Learners.
- ✓ 78% of **teachers provide extended wait time for students** to construct responses in English.
- ✓ 85% of **teachers design teacher-student discourse** to extend language beyond one word responses from students.

**What does an integrated ELD and science SVUSD classroom look like?
And how does it promote students' language development?**

Stepping Inside a Language-Rich 2nd Grade Classroom ²

Walking into Mrs. Galveston's classroom is like stepping inside Ladybug Wonderland. Her 2nd grade room is filled with everything ladybug—photographs of ladybugs, children's drawings of ladybugs with their body parts clearly labeled, posters, word walls with dozens of vocabulary words pertaining to ladybugs, books ranging from large colorful picture books to adult style reference books on insects, live ladybugs in petri dishes on each student's desk, hand held lenses, children's Science Journals open to pages with ladybug descriptions and illustrations, and even more ladybug books lined up on the portable book shelf near a circular rug. It is impossible not to smile and impossible not to become intensely interested in these colorful beetles. Twenty-one children, 12 of whom are classified as ELL and 2 of whom are "full inclusion" students, are preparing for a Science Talk, moving away from their desks to sit on the edge of the rug. They have been studying "The Life Cycle of a Ladybug" for several weeks.

Mrs. Galveston has been in the classroom for 24 years, and has gravitated toward teaching the lower grades where "teachers can make a real difference."



² Although names of teachers and students are changed to maintain anonymity, classroom descriptions and student examples are based on observations conducted over the duration of the Integrating ELD and Science program as well as on pre-observation interviews with classroom teachers.

*I was an art specialist in college, and still love art. After teaching a couple of years I became a reading specialist. I think it's important to try to include artistic expression in my classroom as much as possible. I always try to include art and language, and I think you can see that in the room and in the children's work ... I had 17 of these students in 1st grade, so I know them pretty well. We are all enjoying the Ladybug unit. I will open today's Science Talk with a question ... I love the questions!*³

Once the students are quietly settled on the rug the teacher refers to a nearby chart listing the guidelines for Science Talks, with students taking turns reading the rules. The teacher does not talk down to her students. She is using adult English, in a soft deliberate voice. She then refers the class to the large, blank Compare and Contrast chart.

Sample Chart: COMPARE AND CONTRAST⁴

	LARVA	PUPA	ADULT
Size	<i>Very small</i>	<i>Very small</i>	<i>Very small</i>
Shape	<i>Long, thin, pointy at one end</i>	<i>Sort of round</i>	<i>Round</i>
Colors	<i>Yellow and black</i>	<i>Red and black</i>	<i>Red and black</i>
Moves	<i>Walks, crawls</i>	<i>No</i>	<i>Walks, flies</i>
Eats	<i>Yes</i>	<i>No</i>	<i>Yes</i>

Students take turns reading the matrix on the chart. The teacher asks, "What's another word for 'adult,' what's a synonym for the word 'adult'?"

Teacher: *Luis, tell me what you think...*

She waits, looking kindly but expectantly at Luis.

Teacher: *Am I an adult?*

Student (Luis): *Yes, you're an adult.*

T: *What makes them adults?*

S: *They're big.*

S: *They're all grown.*

S (not Luis): *A synonym is grown-up.*

T: *They are at the end of their life cycle.*



Children nod in agreement, and the teacher directs the group's attention to the blank chart. The discussion continues with students contributing words that describe the size, shape, etc. of the ladybug at each of the three stages of its life cycle. As the class finishes up filling in the chart the Science Talk becomes more free-flowing...

³ Quotes are taken directly from interview transcripts and edited for both grammatical correctness and readability. The integrity of the quotes has been maintained; intent and meaning have not been altered.

⁴ This chart is copied from the Exploratorium's "The Life Cycle of a Ladybug" unit they provided SVUSD teachers. In Mrs. Galveston's class the chart was blank, awaiting ideas from the students. Here however the chart includes sample responses to help teachers understand how to proceed with the lesson and to give the reader a sense of the kinds of words students might use.

T. *Can anyone remember that scientific word for their skin?*

S. *I was going to say the "M" word.*

T. *Good, so what does molt mean?*

S. *It means you shed your skins.*

T. *Let's talk about the adult ... what does it look like?*

S. *It eats aphids.*

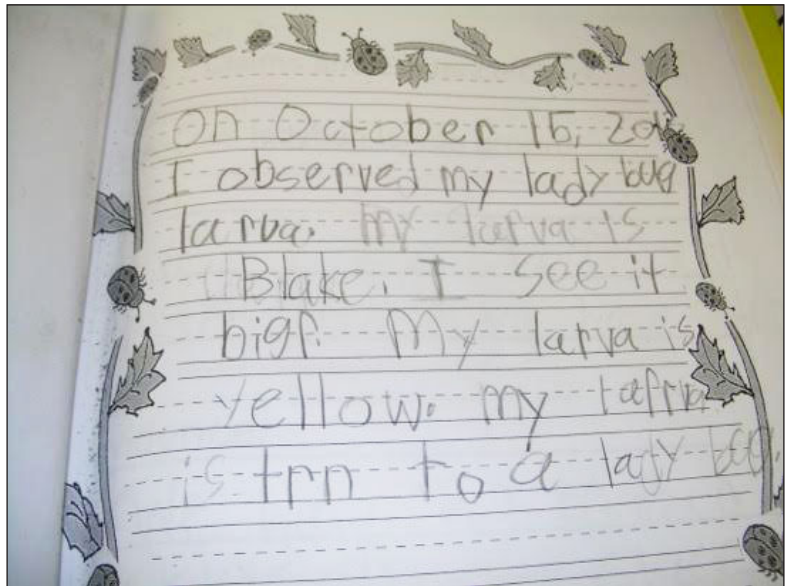
S. *They go through a metamorphosis*

S. *I wonder if ladybugs can fly.*

T. *Does anyone know if they can?*

S. *No, but I wonder why ladybugs don't taste good to birds.*

T. *My hypothesis would be that it's a form of protection.*



As the Science Talk concludes, the teacher directs small groups of students to return to their desks and to carefully observe the ladybugs in their petri dishes. She asks them to look for what is new, and to think about and be able to discuss why it's new. The children use their magnifying glasses and talk with one another. Mrs. Galveston spends some minutes at the overhead projecting her own ladybug specimen and demonstrating careful drawing of what she sees and what the students tell her to include in her illustration. The students then begin to create scientific drawings of their ladybugs in their Science Journals. The teacher encourages them to draw realistically, "No smiley faces please. Look carefully at your specimen and draw what you see." She points to a large poster, "Be sure to label the important body parts, just as you see here." And at the same time she hands out bright green "stickies" with key vocabulary words. The class spontaneously breaks into a chant ... Head! Thorax! Abdomen!"

This classroom vignette reveals the abundance of language surrounding these 2nd grade students. It also illustrates well how much progress in acquiring English language fluency and complexity the group had made by the end of February when this class observation occurred. Almost all the students participated in the Science Talk. They had learned the conventions of Science Talks, the sociolinguistic aspects such as taking turns, listening for meaning, and staying on topic by either answering a question that was posed or asking a related question.



Students also answered in complete sentences, which is characteristic of "classroom talk" that students learn at school but most have not yet mastered by the 2nd grade. Almost all of their responses were grammatically correct, with subject and verb agreement and with word order in standard English. The extent of their vocabulary was large. They understood and accurately used academic terms for language

concepts such as *synonym*, and scientific terminology such as *molt*, *metamorphosis*, and *aphids*.

Mrs. Galveston's classroom shows the symbiotic relationship between concept and language development. Students focused on the life cycle of ladybugs. Their verbal responses indicate that they had enough mastery of the language of the lesson to understand and talk about complex concepts such as metamorphosis and life cycle. It is not likely that at the beginning of the school year these 2nd graders were able to participate in the sophisticated discussion and investigation this vignette shows, but rather, that their language abilities and concept knowledge were developed through their participation in the "Life Cycles of a Ladybug" unit.

What do teachers say about how the program benefited student language development?

The Teacher Survey asked teachers to rate the extent to which the Integrating ELD and Science program benefitted their students in various ways. Using a scale from 1 to 5, where 1 = "Not at All" and 5 = "To a Great Extent," based on either 3, 4, or 5 ratings, teachers attributed the program to the following student benefits:

98%: Developing positive attitudes about learning English as a second language, e.g., greater attention, eagerness, and willingness to participate in activities.

There's more participation, more enthusiasm, more science, more language, more partner and group work!

98%: Increasing English oral language fluency, e.g., willingness to speak and participate more frequently and more fully.

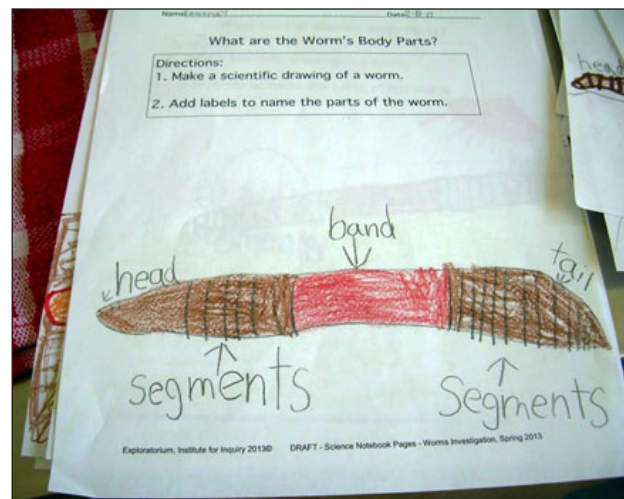
Context embedded and high interest activities are getting my first grade students excited about class. They have more comments to contribute...

89%: Increasing writing competency in English, e.g., more confident fluent and grammatically correct writing.

I think the writing component in the science notebooks for the investigations was beneficial. A lot of [the program] was just fun, so it made me wonder how much my students were really getting out of it. When I could actually see their writing or hear their Science Talk I knew.

96%: Increasing vocabulary in both oral and written language.

My class is excited by the investigations and they look forward to them. I would also say that they continue to use science



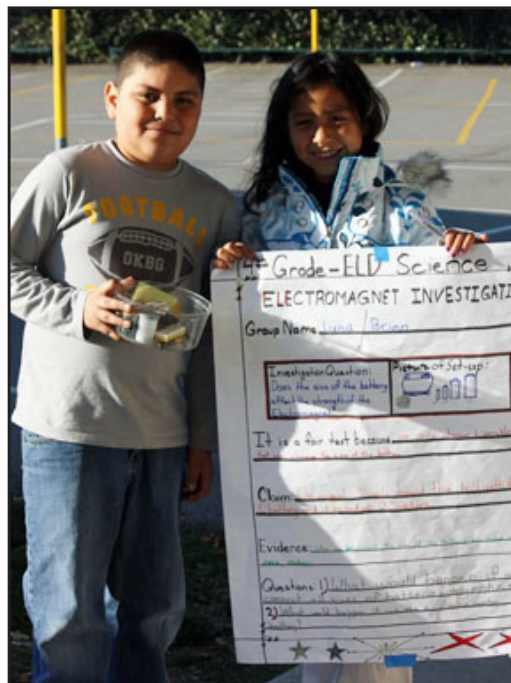
vocabulary—they refer to concepts learned in investigations long after we have finished with them in class.

83%: Improving grammar, syntax, and word usage in both written and oral language.

I'm seeing my students explaining their ideas and questions in complete sentences. They're elaborating more...

98%: Constructing new understanding from listening and speaking and reading and writing.

My students not only own their knowledge and apply it outside of school, they also internalize an inquiry process through which they can approach any new phenomenon.



What are examples of student progressions in developing language fluency and complexity?

The following descriptions of two very different English Language Learners who benefited from their participation in the Integrating ELD and Science program are told in their teachers' words. Both stories reveal how as Maria, a first-grader, and Jesus, a fifth-grader, progressed in developing English as their second language, their teachers were able to learn more about them and understand their special needs better.

MARIA

Although Maria is already 7 years old she is a first-grader, one with an eager and outgoing personality. She isn't shy about speaking in front of the class, but she often has difficulty finding the words to say what she wants to communicate. When I call on her she rambles on for a long time and strays from the topic we're discussing. Frequently it's hard for her to finish her thoughts. She was classified as an Early Intermediate according to her CELDT scores, and that seems about right to me. She often uses a mix of Spanish and English, especially when she's a little nervous. But from those mixed conversations I can tell that her comprehension in English is often adequate, but her expression, her oral language, is much weaker.

At the beginning of the year we used the Liquids unit, and then in the second semester we studied Worms. During the written assignments at the beginning of the year Maria often copied from others or waited to hear what someone would say and she would repeat that. And often her responses just didn't make sense. For example when the children experimented with how fast three different liquids flowed (water, glue or oil), she said, "I think glue and aceite went fast and glue staying on top."

Then when we began with the worms she was genuinely engaged in observing them and did so carefully. Slowly, very slowly, she began to draw on her own experiences and to try to contribute those to whole-group discussions, although she still almost always depended on her partner's language. For example, in a paired share, Andres, her partner, said that worms are slippery. Maria said the same thing in our Science Talk, but later in the day in her Science Journal added a little of her own thinking, writing that worms are "slipre no feet." As the worm unit progressed her oral language improved a little. She was observant. I transcribed what she told me on an index card—"I see a worm that is wiggling. They can make a hole. They eat leaves and water." But it seemed impossible for her to write down what she described to me. She had great difficulty transferring the notes she had taken onto her writing paper; some words were missing that would have made her written ideas more complete. Finally she just asked me to give her the index card and then copied what was there. That was resourceful, but it showed me how difficult generating her own writing was for her even as her oral language was progressing.

I referred her for bilingual assessment that showed that she has learning disabilities. She has difficulty expressing her thinking in either Spanish or English and will receive speech and language support next year. She is very determined. I feel confident about her future. I also think the program, what we did in class, benefited her—by that I mean, she had the hands-on experience of actually observing and handling worms, she had things to say about them, she had her Science Journal where she could capture her ideas, mostly through drawing which is easier for her, but also through copying some words she knew—and there were the partner paired shares where she learned vocabulary and terms, which she repeated and elaborated in the group discussions. So I think all those opportunities for language supported her and I'm glad she'll be getting the extra services she needs.

ALFONSO

Alfonso is very well liked and has many friends in the fifth grade. His peers regard him as an excellent athlete. He will likely be reclassified as Fluent in English Language Proficiency in the spring of this year because his oral English language is quite good. He is also a very strong math student, though language arts, especially writing, are more challenging for him. During science he is reticent to offer verbal answers during Science Talks, but with some encouragement he will.

Alfonso does very well in "partner shares," so I have made an effort to match him up with bright and verbal partners, and at the beginning of the Dissolving unit with a GATE student. They were equals intellectually, even though one was English fluent, and the other wasn't of course. I always advocate for GATE testing for second language learners if I feel they might qualify. In public schools we focus

so much on the language demands and levels of ELLs that we skip over the possibility of their exceptional talents. Alfonso is a perfect example.

But back to this paired share strategy that worked so well for Alfonso. There were so many benefits. Most especially there were ELD benefits in terms of the practice of developing language fluency. The partner Science Talks in general involve listening and speaking with a partner where one idea builds on the others. So there is a collaborative construction, a construction of ideas that build as the sharing and the speaking happens. In my experience ELLs express themselves more confidently when they are working in these small teams and then expanding that circle slowly. So I think having that partner team is very rich because there are no right or wrong answers, it's just open-ended questions. That is a rich and fertile soil for ideas and language, so that when the ELL student moves out to the larger group share they feel greater confidence. They have tried out their ideas with this other person, and now they can share in this larger setting. The paired share is a pretty effective scaffold for gaining science content knowledge, for thinking like a scientist, and for having the confidence to share out loud like a scientist.

As his partnership with Jackson, the GATE student, developed over the hour and a half of our first lesson on Dissolving, Alfonso's thinking surfaced and blossomed. Here's an illustration... I did a demonstration mixing salt in water and posed three questions to the students, right out of the Teacher's Guide: 1) What do you notice when the salt is added to the water? 2) What do you think made the salt disappear? 3) Where do you think the salt is now? Jackson and Alfonso talked readily. Alfonso wrote in his Science Journal describing the process, "... My friend Jackson came up with the best ideas. We worked as a team to get our ideas. Then we came up with an idea that led to another idea and more ..." Later in his Science Journal, in response to the prompt—"What questions do you have about disappearing?"—Alfonso wrote:

What things mostly disappear?

I wonder if things that disappear can reappear?

Can everything disappear?

What makes things disappear?

Does something have to have something special to disappear?

So you can easily see from the tone and quality of these questions he expressed what a scientific thinker Alfonso really is. He is asking big questions concerning classification, conservation of matter, change and cause and effect. This shows me never to underestimate the learning capacity of English Language Learners. The Integrating ELD and Science program shows us teachers that the thinking is there.

How do teachers sum up the benefits of the Integrating ELD and Science program to their students' language development?

A 3rd grade teacher:

There is a lot of discussion about children's misconceptions in science. I don't worry too much about that because they are going to have misconceptions, but it is only a misconception that day. Over the course of the year, the more chances students get to practice with the inquiry process embedded in the Integrating ELD and Science program, the misconceptions begin to diminish. That's because their observational skills start clicking in and a misconception they might have at the beginning of the year just doesn't exist at the end of the year. They've had to construct new understanding based on their experiences... children just need time. I don't want to interfere in that teacherly sort of way, by telling them the way it's supposed to be... that's not sticking up for the kid.

The objective is language development and having children make sense of things for themselves—focusing on letting them communicate and give their own reasons according to how they see it in that moment. Over time, the misconception straightens out. I notice the same thing with grammar and mechanics development in their writing. I don't focus on direct instruction, because through the program I am trying to create an atmosphere that lets children feel safe and comfortable writing and speaking. The advantage over time is that because they are so comfortable, they generate a much greater volume of language. By virtue of all that practice and spontaneous usage—the more they have had to share their work with other kids at their table, they begin to self-correct over time. So in that way, 90% of the grammar, the spelling, sentence structure, and other usage like plurals and tenses begin to occur correctly very naturally over time.

A 2nd/3rd grade teacher:

I think each lesson in the Integrating ELD and Science program was very good with language development—reading, writing, speaking. The students loved having their Science Journal. Every time we did an investigation they all had their Science Journals. They all were able to collaborate with each other and get help if they needed it from each other or from me. The quality and quantity of academic language they got from the science investigations was huge, especially towards the end of every unit where students were asked to summarize what they had learned about the topic. So for example, they had to write to the prompt—“What do you know now about ladybugs?” They could refer of course to their Science Journals. They were able to go through all of their vocabulary words that they had written down on their pages throughout the investigations and refer to their notes and diagrams. The amount of information that we had at the end of the unit versus the beginning was huge!

Their language grew so much during the course of each unit, through talking, through Science Talks especially... there was never really a dull moment because the kids loved the talk. Even the children who don't typically answer questions spoke. The Science Talk lends itself to that shared experience and created a very welcoming environment to converse with each other. So in summary, I would say the Science Journals really helped with the academic language and content of the science topic, and then the Science Talks really helped with making kids feel comfortable sharing their ideas and expressing themselves freely.

A 2nd/3rd grade teacher:

Doing the investigations in the Integrating ELD and Science program became our regular practice in the classroom. As the students were engaged in the investigation, the language happened. It's all of that talking and communicating, that's where the action is. As the children are talking to each other, they are also hearing what somebody else is thinking. They are listening to someone else's thoughts and learning from that. They might not have had the vocabulary of how they wanted to describe what their snail was eating or how it was eating or how it was moving, but their partner said it in a really cool way, so they internalize—"Oh, okay, that is the word that I wanted to use." It's that talking with each other that builds their vocabulary. And it's hearing how somebody describes what is happening or what is going on in the investigation, that is helping students reorganize their thinking if they didn't have (the concept) in the beginning.

Partners in Innovation: Integrating ELD and Science
Exploratorium/Sonoma Valley Unified School District

Project Portfolio

INTRODUCTION AND OVERVIEW
The Innovation and Its Contributions

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WHAT ARE THE CONTRIBUTIONS TO TEACHERS?

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STUDENT PROGRESSIONS IN SCIENCE AND LANGUAGE DEVELOPMENT:

An Introduction and Rationale

Progress in Developing Positive Attitudes and Confidence

Progress in Learning Science Content

Progress in Developing Science Practices and Thinking Skills

→ **Progress in Developing Language Fluency and Complexity** ←

Inverness Research, a national education evaluation and consulting group headquartered in Northern California, has over 25 years of experience studying local, state, and national investments in the improvement of education.

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