

**Exploring Science and English Language Developing:
Implications for Teacher Professional Learning**



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www.exploratorium.edu
Piers 15/17
San Francisco, California 94111
415.528.4333 telephone
415.885.6012 fax

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Participant comments may be paraphrased and the sequence of remarks reorganized. These are not exact quotes, rather they are an attempt to capture the content and meaning of the ideas presented.

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Cover and right: exploring science and the use of language on the Exploratorium floor

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Science, language, and exhibits





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Participants

Jessie Auger

Bilingual Teacher, Rafael Hernández School,
Boston Public Schools

Rita Bell

Director of Education Programs,
Monterey Bay Aquarium

Bronwyn Bevan

Director, Institute for Research and Learning,
Exploratorium

Cory Buxton

Professor, University of Georgia

Sarah Capitelli

Assistant Professor, University of San Francisco

Louann Carlomagno

Superintendent,
Sonoma Valley Unified School District

Tina Cheuk

Doctoral Student, Stanford University

Sarah Delaney

Science Program Administrator,
San Francisco Unified School District

Peter Dow

Chair, Firsthand Learning, Inc.

Patrick Dowd

Senior Science Educator, Institute for Inquiry,
Exploratorium

Angienette Estonina

Elementary Supervisor, Multilingual Pathways
Department, Division of Curriculum and Instruction,
San Francisco Unified School District

Chris Faltis

Professor, Director of Teacher Education, Dolly
& David Fiddymont Chair in Teacher Education,
University of California, Davis

Kim Gomez

Associate Professor, Urban Schooling and Information
Studies, University of California, Los Angeles

Susan Gomez Zwiep

Associate Professor, Science Education,
California State University, Long Beach

Kris Gutiérrez

Professor, University of California, Berkeley

Andrés Henriquez

Independent Professional

Paula Hooper

Senior Science Educator/Learning Research
Scientist, Institute for Inquiry, Exploratorium

Salvador Huitzilpochtli

Doctoral Student, Education,
University of California, Santa Cruz

Maite Iturri

Principal and SVUSD Project Director,
El Verano Elementary School,
Sonoma Valley Unified School District

Okhee Lee

Professor, New York University

Joey Lehnhard

Senior Education Specialist, Monterey Bay Aquarium

Karla Lomeli

Doctoral Candidate, Stanford University

Gennifer McDonald

Academic Coordinator, El Verano Elementary School,
Sonoma Valley Unified School District

Barbara Merino

Professor Emerita, University of California, Davis

Emily Miller

ESL/BRT Elementary Teacher, Madison Metropolitan
School District, University of Wisconsin, Madison

Judit Moschkovich

Professor, University of California, Santa Cruz

Naomi Mulvihill

Teacher, Rafael Hernández School,
Boston Public Schools

Planning Committee Members

Lynn Rankin

Director, Institute for Inquiry, Exploratorium

Paula Hooper

Senior Science Educator/Learning Research
Scientist, Institute for Inquiry, Exploratorium

Sarah Capitelli

Assistant Professor,
Teacher Education, University of San Francisco

Guadalupe Valdés

Bonnie Katz Tenenbaum Professor of Education,
Stanford University

Science, language, and exhibits



Evaluators, Documenters, Staff**Molly Campbell**Project Coordinator, Institute for Inquiry,
Exploratorium**Patrick Dowd**Senior Science Educator, Institute for Inquiry,
Exploratorium**Michael Fairchild**Program Manager, Institute for Inquiry,
Exploratorium**Jenifer Helms**

Researcher and Evaluator, Inverness Research

Paula HooperSenior Science Educator/Learning Research
Scientist, Institute for Inquiry, Exploratorium**Catherine McEver**Conference Documenter,
The Bureau of Common Sense**Katherine Ramage**

Senior Researcher, Inverness Research

Lynn Rankin

Director, Institute for Inquiry, Exploratorium

Wendy Slick

Documentarian, Wabi Sabi Productions, Inc

Mark St. John

Director, Inverness Research

Fred SteinSenior Science Educator, Institute for Inquiry,
Exploratorium**Katherine Neilsen**Co-Director, Science & Health Education Partnership
(SEP), University of California, San Francisco**Annemarie Palinscar**Jean and Charles Walgreen, Jr. Professor of Reading
and Literacy, University of Michigan**Helen Quinn**Professor Emerita of Physics, Committee Chair
for Conceptual Framework for New K-12 Science
Education Standards, Stanford University**Lynn Rankin**

Director, Institute for Inquiry, Exploratorium

Diego RománAssistant Professor in Teaching and Learning,
Simmons School of Education and Human
Development, Southern Methodist University**María Santos**Director, School and District Services, WestEd;
Co-chair and Senior Advisor for Leadership,
Understanding Language, Stanford University**Claudia Scharff**STEM Elementary School Science Content Specialist,
San Francisco Unified School District**Terry Shanahan**Science Academic Coordinator,
University of California, Irvine**Jerome Shaw**Associate Professor of Science Education Emeritus,
University of California, Santa Cruz**Lauren Shea**Director of Education, Outreach, and Diversity,
University of California, Irvine**Maria Simani**Executive Director, California Science Project,
University of California, Riverside**Rebecca Smith**Co-Director, Science & Health Education Partnership
(SEP), University of California, San Francisco**Fred Stein**Senior Science Educator, Institute for Inquiry,
Exploratorium**Savanna Susnow**Biliteracy-Bilingual Teacher, 5th Grade; Graduate
Candidate, Urban Education & Social Justice, and
Reading Specialist, San Francisco Unified School
District & University of San Francisco**Guadalupe Valdés**Bonnie Katz Tenenbaum Professor of Education,
Stanford University**Claudio Vargas B.**Elementary Science Coordinator, Oakland Unified
School District**Diana Velez**Professional and Leadership Developer (K-6),
Lawrence Hall of Science**Sharon Verhalen**

Doctoral Student, University of California, Davis

Sally WeisSVUSD Project Coordinator, Sonoma Valley Unified
School District**Karen Worth**Chair, Elementary Education Department, Wheelock
College

BACKGROUND

Lynn Rankin

Director, Institute for Inquiry, Exploratorium

As Co-PIs of this NSF-funded conference, Paula Hooper and I would like to welcome you on behalf of the conference organizing committee, which also includes Guadalupe Valdés and Sarah Capitelli. We are really honored to have you join us these next two days as we examine progress, issues and challenges that have emerged in designing professional development approaches that focus on integrating inquiry-based science instruction and English language development (ELD). We will primarily be focusing on science as the context for learning language, but we know that what we will be talking about has implications for other areas of the curriculum as well. It is just that science happens to be a very fertile ground for learning language, and we hope to illuminate the many ways why this is so over the next two days.

To start the day off I want to give you a little background about what inspired us to hold this conference. Dennis Bartels, Director of the Exploratorium, will talk about why this conference is critical to the mission of the Exploratorium, and then Paula Hooper, who is Senior Science Educator and Learning Research Scientist at the Institute for Inquiry, will focus on the specifics of the next two days.

As many of you know we have a very long history of providing professional development to elementary teachers and professional developers throughout the region and nationally. We have been doing this for 40 years through workshops, seminars, and professional development tools. I think we are some of the most fortunate educators in the world because we are situated in this wonderful museum, which reminds us every day how truly engaging and full of wonder science can be and how powerful it is to find things out for yourself, no matter what age you are. We frequently hear adults claiming, “If science had only been taught this way when I was a youngster I would have a different impression of what it is.” We draw our inspiration from the pedagogy and philosophy that exists on the floor and then translate it to the classroom, so our approach to inquiry in the classroom is deeply rooted in providing experiences in which students explore the natural world, ask questions, debate with each other, and come to some explanations, all in the service of some deeper understanding about the phenomena with which they are engaged.

Sonoma Science-Language Project

In 2008 we embarked on a new pathway of beginning to experiment with the notion of integrating science and language. We were

invited by the Vadász Family Foundation and the Sonoma Valley Education Foundation to collaborate with the Sonoma Valley Unified School District (SVUSD) to design a project that challenged us. They said, “Please design a project that would really improve the lives of K through 5 students.” Sonoma is a very small, rural school district about an hour north of here with a population of 1,900 elementary students and five elementary schools, and 60% of the students are English language learners (ELLs), primarily native Spanish speakers. So it was just the right scale to begin this project

Lynn Rankin



and brought us together in a way that was just right for each of us. Sonoma, like many districts with No Child Left Behind and English language development (ELD) pressures, hadn't had much time for teaching science, so they wanted to infuse more science into the school day. We wanted to understand how inquiry might serve as a platform for learning language, and colleagues had been telling us for years that it was the right thing to do.

So we came together and explored this idea of integrating science and language. It is an idea that is gaining momentum now, but it seemed like a very radical idea at the time. We didn't know of anyone else who was doing it and didn't really have a road map. I have to say how courageous I think the district was to take this step into the unknown because neither one of us really knew how it would work.

We started a two-year project with El Verano Elementary School and had the opportunity (and still do) of working with the whole school, which was really a treasure. This led to a five-year grant, starting in 2010, with the U.S. Department of Education's Investing in Innovation Fund (I3). What we are charged with is experimenting with professional learning focused on the integration of science and ELD to better understand issues of infrastructure, scale and dissemination within a whole district.

Conference Rationale

At this stage in our development there are several reasons why we wanted to hold this conference. We are now entering our fifth year of the grant and feel we have made enough progress to go public and to share some of our accomplishments. But at the same time, many issues, challenges and questions remain that we are struggling with, and we felt we should bring like-minded colleagues together to help advance all of our thinking. We want to make a substantial contribution to solving the disparities in achievement and academic opportunities between ELs and their non-EL peers and this seemed like a way to help us take another step.

Another reason for this conference is that there is a significant body of research that substantiates the synergy between science learning and language learning. On a practical level, this notion of synergy is gaining momentum nationally and a number of projects will be represented today. More and more attention is being paid by policy makers, funders, and academic institutions to the connections between science, technology, engineering and math (STEM) and language learning. And yet we find very little consensus or collective wisdom about what kind of professional learning experiences are really necessary for teachers to become adept at supporting language learners to engage in science so that students

may reach their full intellectual and creative potential.

Furthermore, we need to understand how these experiences can be scaled so that we don't just have isolated pockets of innovation. Another reason involves the advent of *Common Core State Standards* (CCSS) and the *Next Generation Science Standards* (NGSS), which we feel represent profound opportunities and equally profound challenges for English learners and their teachers. There is great optimism about these new standards to serve as a catalyst for significant reform in districts around the country. However, as so aptly noted in the article we sent you prior to the conference by Lee, Quinn, and Valdés that appeared recently in *Educational Researcher*, the traditional ELD approach of focusing on grammar and vocabulary as isolated skill development will not adequately equip English learners to participate in the scientific practices that are promoted by NGSS. So for all educators, but particularly educators who work with English language learners, the shift in instruction that is required will be truly revolutionary. There is an opportunity at this point that creates an urgency to advance our thinking so that we can seize the moment.

Conference Participants

With all of these things in mind it felt like the right time to assemble this group, which we

think is grappling with similar ideas. Looking out, it is an amazing group of people assembled here. You are all leaders in your fields, and while you come from many different fields you have a lot of commonalities. We felt the need to assemble people working in diverse contexts because the questions we are going to pose for ourselves are multifaceted and multi-layered. In order to make significant progress in a short period of time we thought it would be most advantageous to begin dialogue across disciplines and educational cultures, and we want to blur some of the boundaries that exist between research and practice.

Conference Goals

There are a number of things we hope to accomplish over the next few days. There are two main questions that will serve as our foundation.

There are a couple of goals related to these questions. We want to surface the research questions that will help us take the next steps, and we want to identify the professional learning design principles that will propel our work and the field's work for the next several years. We hope to seed rich conversations and debates that people are interested in continuing after the conference, and maybe we will spark some interesting new collaborations. We hope the conference serves as a catalyst for making as much noise as possible about the value of learning language in context, and we hope you will disseminate the insights and ideas gleaned from these two days to colleagues across your fields. In order to help all of us do that, we are documenting the conference in a number of ways. Those artifacts and findings from the conference will be put on a website about science and language development that is being

created on our Institute for Inquiry website, and it will include information about our work in Sonoma as well as this conference. That will be available in the fall of 2015.

Again, thank you all for being here and for taking this two-day journey with us. Lastly I would like to express a note of gratitude to the National Science foundation for their support, and to Bob Russell and Andrés Henríquez for giving us this opportunity to come together. I know this is a topic they are deeply interested in.

HISTORY AND CONTEXT

Dennis Bartels
Executive Director, Institute for Inquiry

What an honor to be in this room today. I have learned so much from so many of the people in this room. You are a huge part of my education, and just looking around the room I see so many members of the “inquiry Mafia”: Karen Worth and Peter Dow; Maria Santos, who continues to change school districts wherever she goes; Judit Moschkovich, who wanted to make sure that I understood everything about the importance of mathematics in these conversations; Okhee Lee, with her readings and her research; and so many others. What I think I have learned most of all from all of your collective work is that equity lives in thousands of learning moments and teacher decisions in every single classroom every single day.

Guiding Questions

- What do educators and researchers who come from a science inquiry perspective and educators and researchers who come from a language development perspective need to understand about each other's conceptual frameworks in order to arrive at strong visions, theory, and practices for learning language in the context of science?
- What are the key ideas that professional learning experiences need to embrace in order to support teachers to successfully adapt their practice to integrate science and language development?

I have to credit Beth Warren and Ann Rosebery for helping me crystallize that understanding.* It is always a treat to hear what they are up to, and I think some of you have probably seen that very well-worn video on Science Talk about a biology moment about how things grow. For those of you who haven't, let me walk you through my learning journey when I saw that video. In that video, a teacher regularly collected her kids a couple of times a week for an hour to talk about their science learning. The teacher posed the question, "How do we know that things grow even if we don't see them grow?"

This was a Cambridge, Massachusetts classroom that was very diverse, and one of the Latina girls put up her hand very quickly. You could tell she was the kind of student who always put up her hand first and she was very excited. She said, "Oh, you can measure it over time." When you see this third-grader on video what strikes you is not what a clever girl, what strikes you is, what eight-year old uses those words? You're a bit surprised and shocked by it.

Then there was another Latina girl who you could tell was one of the more hesitant, shyer students, deciding whether to raise her hand. She put her hand up and said, "Well, I don't

* Rosebery, A. and Ballenger C. (2008). "Essay: Creating a Foundation through Student Conversation." In A. Rosebery and B. Warren (Eds.), *Teaching science to English language learners*. (pp. 1 - 12), Arlington, VA: NSTA Press.

know about that, but I do know my socks get crinkly." You could see that moment where the teacher almost missed it, and then caught it and turned back to the student and asked her to explain what she meant. As the student described it, what was clearly obvious was that she knew she was growing because her shoes didn't fit. Suddenly the classroom erupted in conversation in which everybody was bringing from their own experiences how they knew that things grew without being able to physically see that they grew as a measurement.

It is in that moment—what we teach, how we teach it, and the relationship that every adult has with every child in that room—that is for me the key to how to really bring equity to every single child across this nation and around this world. I have learned from others of you in this room and from Uri Treisman that demographics is not destiny, that it is in those moments that, in fact, our vision and our opportunity lives.

And it is from Ann and Beth and others, including Paula Hooper, who has been part of this work, that I have learned that diversity is the notion that we all have different vantage points and different truths. When they are all brought together amazing transformative learning happens, and that is a genuine, if really difficult and complex, strength and practice to build upon. It is self-evident that is true, and it is also really, really hard to do

in practice for teachers. And that is the work that so many of you in this room are engaged in, how to bring teachers up out of that moment and get them to that metacognitive level where they recognize: "What do you mean your socks are crinkly? Can you say more?"

I am really proud of our Sonoma work and our Institute for Inquiry team and our school district relationship. I remember that meeting with Les Vadász at his dinner table many, many years ago. I think it is one of the best examples at the heart of the mission of the Exploratorium and its founding, and I want to hearken back to Frank Oppenheimer and some of his colleagues. His notion was that for a democ-

Dennis Bartels



racy, and especially a modern democracy, this “stuff”—science and engineering, quantitative and technical literacy—was far too important to only belong to the scientists and politicians, that it was essential to our democracy and belongs to all of us. They were teaching it too damn backwards and making it too mystical to help everybody realize that this need to figure things out and know is as much a human instinct as our language instinct and that these are birthrights.

It shouldn't be a surprise that this is where Frank came from because as many of you know, his story as an Oppenheimer brother is that they both went to the Ethical Cultural School in New York City, which was one of the leading humanist schools at the time. He and his brother were essentially blackballed for flirting with the Communist Party during the 1930s. It is important to note that for Frank, the reason why he was temporarily a communist was that he felt that it was one of the few organizations during the 1930s that was really dedicated to racial justice.

There is a great irony here that if he had not been blackballed and lost his job as a physicist at the University of Minnesota, the Exploratorium may never have happened. It was that experience that made him double-down on this notion that this belongs to all of us, and he wanted to create a public learning laboratory in which he could make that self-evident,

not just to children but to adults as well. And he wasn't alone in this effort. At that time there were a number of scientists, a lot of them coming out of Los Alamos, who really did believe they could take that prowess that helped them put together a bomb (which many of them felt very ambivalent about) to change this notion about how we learn and teach science.

In fact, it was born at the time out of a declaration by AAAS that science was for everybody. Now a lot of us think *Science for All* was invented by AAAS in 1989 but it wasn't, it was reclaimed by AAAS. They declaimed “science for all,” for every kid in every grade, in 1961. Before that science was just this obscure

topic that a few people in high school got to study—mostly men, and in this country mostly white. If you look back at the scientific community at the time, they didn't believe that science was necessary for every child in every grade because we needed more scientists and engineers. I think it's important to go back and look at the original words explaining why we got involved with the science reforms of the 1960s, so I will quote two scientists here.

One is Jerrold Zacharias, who as many of you know was the founder of EDC. He was the radar scientist at MIT who was the primary architect of the Physical Science Study Committee (PSSC) curriculum. He says the following.

“The reason I was willing to do PSSNC was not because I wanted more physics or more physicists or more science. It was because I believed then and I believe now that in order to get people to be decent in this world they have to have some kind of intellectual training that involves knowing about observation, evidence, and the basis for belief. It was largely a matter of social conscience, I believe, that motivated us scientists to work in schools. As scientists we seek evidence before we try to create order or orderliness, and we do not expect nor even hope for complete proof. We live in a world of necessarily partial proof built on evidence which,

although plentiful, is always limited in scope, style, and amount.

“Nevertheless, uncompleted as our theories may be, they all enjoy in a sense the benefits of the due process of law. Dogmatism cannot enter. An unsupported demagoguery has a tough time in such a society. A Hitler or McCarthy could not survive in a society which demands evidence which can be subjected to examination, to reexamination, to doubt, to question, to cross examination. It may have been what really gave us scientists our missionary zeal.”

- Jerrold Zacharias

I think it's important to know a little about the roots that directly apply to the conversations that we are having here and why we all felt that different kinds of science experiences really were essential for every single one of us, not just those who happen to go along and study it professionally and for the rest of their careers.

George Hein noted that one of the great ironies of the great '60s curriculum reforms is that a lot more of those activities and ideas were thought, fueled, founded, and continue to thrive in science centers. In effect it was the birth of the ESSNC and PSSNC that created the birth of the science center movement in the 1960s in the first place, and that is where they ultimately found their home. If you walk around our floor today many of you will recognize the old ESS curricula in things like the *Light Table*.

So we are all woven together and we are all working together in this common purpose, and for me that purpose is not for more scientists, as the current rhetoric goes, but actually to create better thinkers and decision makers. Anne Druyan describes what I thought was the best definition of scientific literacy I'd ever heard. In her view it is to equip every single one of us with a great big giant bologna detector so that we are not so easily fooled, manipulated, deceived, or lied to. Now if that was the purpose of our

science education, built on our democratic and equity ideas, what would those elementary classrooms look like and what skills and tools would teachers have, and what would we need to do to provide those tools so that every one of those kids has the chance that kid in Cambridge had to talk about her crinkly socks?

So for me it is really a desire not for more scientists and engineers, but that everybody has the technological and quantitative skills they need to be better decision makers for themselves, for their families and for their communities. You are doing some of the most important work of our nation right now. That should be self-evident if you really look at our context. What we should remember and never forget is that we have been committed to this goal for a long time, since 1961 when we declared it. And for all of our setbacks and all of our faults and all of our unfinished dreams, we should be encouraged that we had the foresight over 60 years ago to create communities like this one and to drive those forward.

It also comes at an important time for the Exploratorium. We are in the middle of a fairly large planning process that follows this incredible and historic move to this new facility and location here on the piers, and we are putting social justice into the foreground of our work. And this work here

is one of our best examples. What if we had that kind of authentic look at questions of equity and inclusion going across all of the strands of the work at the Exploratorium? What would it look like in our creative culture if we increase the cultural competency of all of the people engaged in designing inquiry-based learning experiences, whether exhibits, teacher programs, or online experiences? How much better would all of our work be? So we have launched a widespread institutional effort. It is early on, but we want to imagine what the possibilities could include and build those into our plan.

Part two of that planning process is a learning endeavor just like this one that you are about to engage in over the next two days. It is important for us to consolidate our learning from time to time so that we can share it with others. So please, please share what you know with those who can use it. The most important part is to not just come together for yourselves but to remember that your job is to consolidate and let the rest of us know what you are learning, and figure out how many different kinds of practitioners and decision makers you can get this information to so that they can leverage it to make differences in real people's lives. So thank you for your incredible work, godspeed, and great fortunes these next couple of days.

CONFERENCE OVERVIEW

Paula Hooper
Senior Science Educator/Learning Research
Scientist, Institute for Inquiry, Exploratorium

I agree with the feeling of excitement in looking out and seeing so many good friends, so many mentors, and so many people who have inspired our work over the years. My goal is to help us think about what we are going to try to accomplish over the next couple of days.

Eight years ago we started this work of thinking about science and English language development. We knew what we knew as science educators and what we believed about

Paula Hooper



inquiry-based science, and we knew that there must be something around how kids develop language that had to be similar because the way that we learn through making sense of the world is the same regardless of the content. We started talking to people, including Okhee Lee, Barbara Merino, and Guadalupe Valdés, and started seeing the strength of this thread. We also started seeing that there are a lot of people around the country who are realizing that this is a powerful thing, which may be similar to what scientists experience when they start realizing that some big theory is really right. When you start hearing a lot of people talking about it you know it is going to get you some place.

We feel we are at a point right now of trying to nurture this, and we have brought you together to look more deeply at the connections between the phenomena of watching kids learn science and supporting kids in learning science, and their work in learning language. We know that connection is a good thing, but we have to figure out how to make that go deeper, and we had to try to figure out the structures to help you to discuss and develop that depth. That is what our program is, and I am going to go through some of the highlights of how we structured our program so that you have a sense of how we are going to try to do this work over the next couple of days.

Session 1. Why is Science a Good Context for Language Development?

Session one looks at why science is a good context for language development, and we will hear from some of the key people engaged in thinking deeply around that, including Helen Quinn, Sarah Capitelli, and Guadalupe Valdés. We are also going to look at this from our own experience by going out on the floor to exhibits and thinking about how we are working with science and how we are using language when we are doing that.

Session 2. Comparing Approaches to Professional Learning

The second session focuses on the idea of comparing approaches, in this case comparing approaches to professional learning. We were lucky to find two other projects that have had a history of working with teachers and trying to design different types of professional learning experiences that help teachers bring together their understandings of science and their understandings of language. We will also have a working session, meeting in small groups to talk about what we think about approaches to professional learning. At the end of day one, we will have synthesis from Karen Worth and Annemarie Palinscar and hear their ideas about why science is a good context for good lan-

guage development and about comparing those approaches to professional learning.

Session 3. Exploring Classroom Cases: Science as a Context for English Language Development

On day two, session three focuses on examining classroom work and classroom cases with teachers who are experts in how to use science as a context for English language development. It is also important to note that these teachers are able to do this in the context of schools and districts, where they are not getting a whole lot of support for these efforts. The examples that they give will push us in thinking about classroom practices and professional development design and how we create experiences that help other teachers become like these teachers.

Session 4. Supporting Professional Learning for Language in the Context of Science: District and National Perspectives

The fourth session will look at some of the districts that participants in the conference have been working with, both Sonoma Valley and the Oakland Unified School District. Then we will hear the national perspective from Okhee Lee to help us think about how we can start to make these ideas that we've built really work. How can we start to make them work in districts, and what are some of the issues in making them work on a national level? Then we will have a synthesis of sessions three and four from Mark St. John and Andrés Henríquez.

Session 5. Developing a Research and Practice Agenda

Where this is all heading is to help us try to work together to figure out what kinds of research and practice agendas are needed for ourselves and for the broader fields that we represent. We are going to do that in working groups. Researchers will be grouped with others doing similar research and practitioners will be grouped with others doing similar things to try to answer and develop specific recommendations about what should happen next.

The conference will close with some synthesis from Kris Gutiérrez and Guadalupe Valdés about what we've accomplished in the last couple of days and where they think we should go next.

Session One:

PLENARY: SCIENCE LEARNING AND LANGUAGE LEARNERS

Helen Quinn
Professor Emerita of Physics, Committee Chair
for Conceptual Framework for New K-12 Science
Education Standards, Stanford University

Let's try to make this a little conversation-like because I know you have all been thinking about this subject just as I have over time. Before I go into my slides I would like to start with a little bit of my perspective on language learners, which is that every child needs support for language development. I don't care what home they come from, no kid enters kindergarten speaking like a fourth grader, and no kid comes with all the language they need to deal with all of the academic problems they are going to meet as they go through school. So supporting language and the development of language *is* part of the job of every teacher, independent of the mix of students in their classroom. Of course, those for whom the language of instruction is a new language need more support, but every kid needs some level of support, and thinking about how to support language development is a critical element of being an effective teacher no matter what you are teaching or what group of students you are teaching. That is a philosophical position I'm starting from in having this discussion.

I know all of you have been thinking about science and language learning, so I am going to go fairly quickly through what the *Framework* has to say because I believe when I say "the *Framework*" you all know what I mean. I want to talk a little about this idea of three-dimensional science learning because once you get the three-dimensionality, the language automatically is part of what you have to deal with.

As outlined in the three dimensions defined in the *Framework*, science is not just a collection of facts, it is a set of practices by which those facts were developed and which students have to engage in in order to undergo the conceptual change needed to understand the ideas of science. And it is a set of concepts which are broader than the disciplinary detailed facts that we are trying to learn here, and which we often forget to teach, yet they are crucial and I will explain that with a metaphor in a moment.

Then of course there are the facts which have been discovered through hundreds of years of intellectual work by millions of people. We don't expect the kids to discover those facts for themselves. We do expect them to work to make those facts their own through appropriate experiences at the grade level. That is very important. Inquiry does mean that they are engaging in the process of scientific inquiry

Why Is Science a Good Context for Language Development?

Pre-conference Reading

Science and Language for English Language Learners
in Relation to Next Generation Science Standards
and with Implications for Common Core Standards
for English Language Arts and Mathematics

Okhee Lee, Helen Quinn and Guadalupe Valdés

EDUCATIONAL RESEARCHER

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0013189X13480524](http://edr.sagepub.com/content/early/2013/04/08/0013189X13480524)

Helen Quinn



Framework and NGSS: Three Dimensions

- Scientific and engineering practices
- Crosscutting concepts
- Disciplinary core ideas
- **NGSS - standards as performance tasks that involve all 3**

Example (grade 3 PS -forces and motion)
Plan and conduct an investigation (**practice**)
to provide evidence of the effects
of balanced and unbalanced forces (**ccc**)
on the motion of an object (dci)

“Le savant doit ordonner; on fait la science avec des faits comme une maison avec des pierres; mais une accumulation de faits n’est pas plus une science qu’un tas de pierres n’est une maison.”

The knower must organize (the knowledge); one builds science with the facts (data), as (one builds) a house with the stones. But a collection of facts is no more a science than a heap of stones is a house.

Jules Henri Poincaré (29 April 1854 - 17 July 1912)

and they are discovering things for themselves, but at the same time they are learning accumulated knowledge and exactly how that plays together is a very important part of how do you do this work.

And then of course we have performance expectations, now adopted in California and 11 other states and probably more eventually, that integrate these three dimensions. That changes what we say we value as knowledge. I give you just one example here of a performance expectation from grade three: Plan and carry out an investigation (that’s a practice) to provide evidence of the effects of balanced and unbalanced forces (stability is a crosscutting concept) on the motion of objects (that’s a core idea in physics). This is not just knowing Newton’s Laws, which actually wouldn’t be appropriate for third graders anyway, it is a whole set of things which have to be put together to show not only that you know some facts, but that you can use them and can discuss an issue based on evidence. So there is a whole set of things that go into one performance expectation, which is very much broader than “know this,” which is what the old California standards said.

By the way, in working on the old California standards, the only part I’ll take real credit for is the investigation and experimentation skills. One of the things we learned from the old California standards is, if you make those a separate list and give them to assessors to assess, they make up items that assess whether

you know this or whether you know that about skills in investigation and practices, whereas here we are asking whether you can do this or whether you can do that, which is different.

Now we are going to start with a little French [see sidebar] which I have freely translated. This is Henri Poincaré from a paper called “On the Value of Theory,” and he is saying science of course is made of facts, but a collection of facts is no more science than a pile of stones is a house. You have to build the house out of the stones, you have to construct knowledge, and you have to organize the facts into some systemic understanding, which we call theory, or “explanation,” in the things we are going to ask kids to do.

Students must build 3D science
knowledge structures

Make conceptual changes from their
pre-conceptions

So students must build their own 3D knowledge structures, they must make conceptual change, and in order to do that they have to have all three of these dimensions. To build a house, of course you need the building materials, you need the pile of rocks. But the pile of rocks is not the house. You also need tools and methodologies and experience in using them in order to be able to build something. That is the role of the science and engineering practices in constructing your knowledge. And finally, you can’t build a house unless you know what

To Build a House

- Need building materials—stones, planks, bricks
Disciplinary core ideas
- Need tools and experience using them
Science and Engineering practices
- Need some idea of what you are trying to build, some big ideas about the nature of houses
Crosscutting Concepts

a house is and know what it needs to have in it and how those pieces fit together. You have to have some big concepts about a house in order to build the house. The crosscutting concepts are the big concepts about science that you need to have in order to place your scientific knowledge in the context of a meaningful structure. So the crosscutting concepts, which are often forgotten about, are a very critical part of how you construct knowledge. You cannot construct knowledge if you don't know what you are trying to do, if you don't know that you are looking for mechanisms of cause and effect, or that you are studying a system and trying to develop a model of it. Those are crosscutting concepts that you need to have and ask questions about in order to address the problems you meet.

That is my quick vision of why we need the three dimensions because all of these pieces are critical to the learning, which is the constructing of knowledge for students for themselves in their own brains.

Here is the list of practices. I've colored in red the ones that I think are not always common, even in inquiry-based classrooms, and there are a lot of them. I have also put a star that encompasses the whole list because to do any one of these you have to engage in conversation, you have to talk, you have to have communication going on in order to plan or carry out an investigation. You have to have communication going on in order to develop an explanation.

Those of you who read the paper I wrote with Okhee Lee and Guadalupe Valdés [see sidebar, page 9] know we took a few of these practices and really focused on what the language demands are of engaging in this practice. They are very real and there are some overlaps, but for each practice there are distinct features. Thinking about that is a very useful way to approach this. Can you tell when students are actually doing this? What should they be doing if they are doing this?

The same goes for the crosscutting concepts. One of the ways I think it is useful to think about these is as frames for questions. If you want students to be solving a problem, if they are experiencing a phenomenon and trying to explain it, these concepts give them the tools for asking questions that will help them develop their answers. What patterns am I seeing? What is the phenomenon and what caused what in this phenomenon? What is the system I'm looking at and what model do I need to make of that system in order to explain this

**Scientific and Engineering Practices

1. Asking questions and defining problems
2. **Developing and using models**
3. Planning and carrying out investigations
4. **Analyzing and interpreting data**
5. **Using mathematics and computational thinking**
6. **Developing explanations and designing solutions**
7. **Engaging in argument from evidence**
8. **Obtaining, evaluating, and communicating information**

**** Discourse intensive!**

Crosscutting Concepts

1. Patterns
 2. Cause and effect: mechanism and explanation
 3. Scale, proportion and quantity
 4. Systems and system models
 5. Energy and matter: flows, cycles and conservation
 6. Structure and function
 7. Stability and change
- All suggest ways to approach a problem, questions to ask**

How Science Understanding Develops

- Multiple opportunities to hear and use science ideas and practices
- Rich contexts (**phenomena and materials**) create desire and opportunity to engage and contribute
- Appropriate supports
- Acceptance of flawed (non-scientific) language and incomplete ideas

How Language Develops

- Multiple opportunities to hear and use language
- Rich contexts (**experiences**) to create desire and opportunity to engage and contribute
- Appropriate supports
- Acceptance of flawed language (while still supporting language development)

phenomenon? On what scale do I need to make that model? What relationships of quantity do I need to understand? Each one of these cross-cutting concepts raises questions that are tools for investigating any problem in science. And of course with different problems, different ones of these come to the surface more in terms of what turns out to be most effective in finding a solution, but if a kid has these tools, then they can tackle a wide variety of problems.

Previously in science education, for the most part we kind of expected kids to learn this by themselves, but they need support in doing it. And in doing it, again, they are going to be using language, they are going to be asking questions, they are going to be talking to one another to figure out the answers to those questions. So this notion of three-dimensional science learning is discourse-intensive science learning.

Now how does understanding develop in science? It develops because kids have multiple opportunities to not only be told facts, but to take those facts and use them in context to explain phenomena; to work through problems in rich contexts where there are real things going on, and understand why it is useful to talk about air pressure, or why it is useful to talk about gravity. If you just tell a kid, “Gas is this,” they can maybe recite it, but they have no possession of that knowledge and no ability to use it to explain a new phenomenon. They have to engage in that process in order to make the knowledge their own and to develop

the ability to apply it in new contexts.

And of course they need the support to do this. The classroom needs to be structured to give them the opportunities, to give them the rich contexts, and to accept both the language and ideas at the level that the kid is ready to use them. The students have to talk, they have to think, they have to suggest explanations, and it is not the teacher’s job to say, “That one is right and that one is wrong.” It is the teacher’s job to ask, “Why did you say that and can you think about something more?” Or, “Can you say what this person said in a different set of words so we can all understand it better?” Or, “Did you mean this? Can you expand on it a little further?”

The kinds of questions the teachers asks are very different from questions that have right or wrong answers. That is a language skill the teacher needs to learn, and that skill of not rejecting ideas because they’re wrong, but accepting ideas because they contribute to the discourse and help everybody try to resolve issues that they need to resolve in order to understand what is really going on here.

That is a very language-intensive exercise, but it is language used in the purpose of understanding science. Now how does language develop? You might notice that these two slides [sidebar] are more or less the same. You need multiple opportunities, you need rich contexts, you need appropriate supports, and you need acceptance of flawed language. If every time you speak you’re told, “No, say that again and

say it correctly,” you’re not going to speak very much. The whole question of how you moderate accepting the student’s contribution at the level they can make it, whether for the science or for the language, and how you support them to develop deeper understandings of richer language is very, very similar in the two cases. Given these parallels, I think it is really kind of obvious that we ought to be trying to work on both of these things together, and I think there are many people in the room who have done more work than I have which shows that is true.

But I think it is really easy to slip into, okay, now we are doing language support, or now we are doing science support, because that has been the traditional way. The challenge is figuring out how to help teachers do these two things together. Just the science is a very complex job, just the language is a very complex job, and now we are saying somebody should be doing both of those complex jobs at the same time? Well yes, they should, but it is not easy, so we need to figure this out and support teachers to come to the work with a deeper understanding of what the goals are both from a science perspective and from a language perspective in order to be able to support a group of students who may be at very different levels in their language development and at very different levels in their science understanding.

One of the things that doing this work helps teachers to recognize is, those two things are not necessarily tied together. A student may

have very limited language and very deep science understanding, and helping that student contribute to the science discourse supports all the students in the classroom in learning science at the same time it supports that student in developing their language.

Science class is a language development opportunity *if* the discourse is managed to be inclusive and supportive, and there are various levels of language development support offered to students as they need it. But all students need support at some level or another.

I won’t spend a lot of time on the specifics, these will come up as we talk, I’m sure, but as I said at the beginning, the fact that every student is learning language means that this is something every teacher must be thinking about as we teach science. The standard thing, which the textbook does, is have a list of vocabulary and you teach vocabulary before you teach the lesson, which doesn’t actually work very well.

Learning how to do it effectively, which is something we will be talking about during the discussions, is something that is really important for teachers, both the language support teachers and the science teachers, to understand how this proceeds effectively. That’s what this conference is about, and I think it’s very important—the importance of making meaning at any level, with any level of language, with any level of science understanding. The effort to make meaning of what you’re doing and seeing and trying to explain

Science Class Is a Language Development Opportunity

IF

Classroom discourse is managed for **inclusion**

Appropriate and varied language development supports for **all** students

Some Science-Specific Language Challenges

- Technical terminology (word redefinitions or inventions)
- “academic” usage (analyze, consequently ...)
- Multi-phrase sentence structure, many referents (it, that...)
- Nominalization (whole concepts turned into single words such as respiration, adaptation...)
- Need for precision

Every Student Is a Science Language Learner

- Attention to language challenges benefits all students
- What additional supports ELL students need depends on their language level
- Priority given to participation and **science meaning making** over correctness

Science-Specific Language Opportunities

- Diagrams, graphs and tables augment text
- Manipulation of real objects and phenomena
- Diversity of topics and associated language to be explored
- Design opportunities that connect to real world problems

Engagement in Practices

As a tool to learn science and engineering
As a way to understand the nature of science
(with reflection)

As a language development opportunity

CCSSO Resources: A Framework for ELPD
Standards Development -- Tables

is critical both for the science learning and for the language learning.

One of the things that science also offers in the written text is a lot of visual support for thinking. Science models are diagrams, and science text contains not only diagrams but graphs and charts and all kinds of pieces which are non-verbal but are part of the meaning. One of the things science teachers don't know enough about and need support in doing is helping students integrate the information that is given to them in all of these different ways. Most of the strategies you learn in language arts for how to use the text don't work for most science texts, partly because the language detail in a single sentence can be very great. The integration between the sentences and the diagrams is another separate task, the interpretation of material in a graph or an equation and how that fits together with material in the text. That is something the science teacher has to support the student in learning how to do. It is a literacy task, yes, but it is a science literacy task. It is literacy for science, which is different from literacy for language arts, and reading poetry is a different set of skills from reading science.

As students engage in practices they must talk, and therefore the practices are themselves language development opportunities.

I have included the table below, which is a document that was developed by CCSSO. In our paper [see sidebar, page 9] we made tables like this for four of the practices. I think it is

very helpful. It says the analytic tasks, the language productive tasks, and the language receptive tasks that students need to engage in as they engage in this practice.

Key NGSS Practice 2: Develop models	
Analytical Tasks	<ul style="list-style-type: none"> • Develop and represent an explicit model of a phenomenon or system • Use a model to support an explanation of a phenomenon or system • Make revisions to a model based on either suggestions of others or conflicts between a model and observation
Receptive Language Functions	<ul style="list-style-type: none"> • Comprehend others' oral and written descriptions, discussions, and justifications of models of phenomena or systems • Interpret the meaning of models presented in texts and diagrams
Productive Language Functions	<p>Communicate (orally and in writing) ideas, concepts, and information related to a phenomenon or system using a model developed for this purpose:</p> <ul style="list-style-type: none"> • Label diagrams of a model and make lists of parts • Describe a model using oral and/or written language as well as illustrations • Describe how a model relates to a phenomenon or system • Discuss limitations of a model • Ask questions about others' models

The document which CCSSO (ccsso.org) put on its website has a framework for developing English language development standards, for states engaged in that process. They did this for every science practice, for every math practice in the *Common Core*, and for a set of things that are not called "practices" in the Language Arts Common Core but are the practices of language arts. There are tables like this for all of them and I think they're very useful tables to use with teachers in thinking about how you need to think about language as you engage students in doing this work, which is completely science work, but it is science work which is language-rich and language-intensive, and therefore students need support

with the language elements of it as well as with the science elements of it.

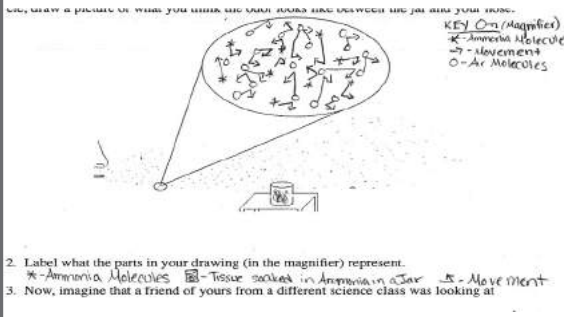
I wanted to give you an example of where this takes you. This is from a group in Michigan that developed a curriculum for science, and this is an assessment for fifth or sixth grade students learning about gasses.

IQWST Assessment: *Modeling Smell*

Your teacher opened a jar that contained a substance that had an odor. Imagine you had a very powerful microscope that allowed to see the odor up really, really close. What would you see?

Lesson 15: student models

- 75% of students create a particle model, 25% a mixed model
- 68% of students include odor particles that are moving in straight lines until they collide into each other; 32% include both odor and air



Students are asked what they would see if they looked through a microscope, and the part in the circle is what a student drew, with molecules moving around. You'll notice they didn't have to write very much, but they did have to identify that their diagram had ammonia molecules, it had the tissue soaked in

ammonia in the jar, and it had air molecules. In this exercise the jar was open at the front of the room and you raised your hand when you could smell it. The smell gradually progresses through the room, and this is a model explaining that phenomenon. You see that the student can really graphically think about it. Now this doesn't look like a language-intensive exercise, but if you think about the classroom where this understanding developed, there was a lot of talk that had to go on to get to the point where a student could produce this model and really understand that this is what's happening, that the molecules in the air are moving in straight lines until they collide with something else, and then go in another direction. And we don't have to call them "molecules," we could have called them "particles," it doesn't really matter. We're not distinguishing between atoms and molecules here we're just talking about the way gasses work.

Teachers need to know a lot to support both the science and the literacy, the language and the literacy development for learning science, and to include students in that. And that is going to be a conversation during this conference.

Key to supporting science discourse is setting up science problem situations in which kids get engaged and want to talk. Then there is supporting that discourse, knowing as a teacher how to support productive science discourse in the classroom, or Science Talk, as was said earlier. And there is how to prompt and question

What Do Teachers Need to Know How to Do?

- Support science discourse (in the context of science practices)
- Support science literacy development
- Ensure that process is inclusive, for students at all levels of language development and science knowledge

Supporting Science Discourse

- Set up **science problem situations** that prompt rich discourse
- Support productive discourse in varying group arrangements from whole class to paired students
- Prompt and question students to build on and extend science ideas and language usage (their own and that of others)

Support Literacy in and for Science

- Understand what makes science text different (discipline specific variants)
- Help students develop science-specific reading strategies
- Support students to keep and use science journals
- Assign formal science writing and verbal presentation opportunities

Teacher Challenge

Be aware of both the **language learning** needs and the **science learning** needs and progress of each student

Formative assessment during learning tasks, (not just separate assessment tasks)

How can teachers record and analyze progress?

(e.g., through photos, and audio or video clips of activity in the classroom, as well as written student products)

students to extend and deepen the discourse and support the language development as well as the science learning. That is a non-trivial exercise, but I think it is a critical exercise both for science learning and for language learning.

I think there are also some literacy-specific, writing-specific, reading-specific tasks, and the teacher needs to understand how science text differs from other text. And science text isn't what scientists write. A science article that I would write for a colleague is not something you would give to a fourth grader to read. Science text is what happens in the classroom, not necessarily the way scientists write, but it uses the language that scientists use and therefore it has its own peculiarities and needs support.

I will leave you with this challenge, which is what we are going to spend the next couple of days talking about.

Discussion, Q & A

3D AND PRACTICES FACILITY AND OVERLAP

- I have a question about how students develop facility in three dimensions simultaneously. It seems to me that students sometimes develop one facility in one dimension with more sophistication than in other dimensions.
 - Emily Miller, ESL/BRT Elementary Teacher, Madison Metropolitan School District, University of Wisconsin, Madison
- Or more sophistication in one practice than

in other practices. Development is never a linear process. Language development is nonlinear, knowledge development is nonlinear. It is iterative and recursive, and what you have to do is meet opportunities to learn which enrich wherever you are and take you further. That is true for the practices, it is true for the crosscutting concepts, so how does a teacher do this? When does a teacher focus on one or the other or bring them together?

For example, if you're trying to explain a phenomenon or you are trying to develop an explanation, one of the steps you have to take is to develop a model upon which to base your explanation. The practices are listed separately because they are separately important, but as you actually do them you have to integrate them, and there is the question of exactly which pieces a student is ready to do at which level.

My daughter works with preschool kids and what those kids do in the classroom is very much all of these practices. For example, they were trying to understand how the house next door was being built. The builder was digging a hole for the foundation and told them this hole in the ground was to hold up the house. The students went back and dug a hole in their schoolyard to try and figure out how a hole helps hold something up. They were doing science practices. And then they made cement out of porridge. All of these practices are practices which pre-

school kids can engage in at preschool level, and you wouldn't expect kids to have the language to talk about that as "I'm doing an investigation," but instead, "I want to know," and "I have a question," and "I'm curious about this."

So exactly how the language and the formal realization that this is a practice of science happens, and when and where it happens, is part of the skill of building knowledge, to use what the kids have and move them further. And it is going to be uneven for an individual child, and for a class of children even more so, and managing all of that is the art of teaching. • Helen Quinn

ROLE OF PRIMARY LANGUAGE/BILITERACY

- My question has to do with the language and the role that primary language might play into all of this as well. For example, Spanish. I'm sure many districts here have dual language programs, biliteracy. That is something that I am really curious about and whether your study addresses that. • Angienette Estonina, Elementary Supervisor, Multilingual Pathways Department, Division of Curriculum and Instruction, San Francisco Unified School District
- Again, most of my understanding of this is based on conversations with my daughter, who runs a Spanish immersion preschool. Language development, and also working with understanding language in any language

supports intellectual growth. It is actually as important to develop primary language as it is to develop English. Ideally, in my opinion, all dual language children should be developing dual language literacy and dual language development. As I said, even in your primary language, if your primary language is English for example, you still have language development to do through K-12. Language development both in primary language and in secondary language is important, and using what language resources you have. If a student is learning science and doesn't have a word for something in English but does in Spanish, you allow the student to use those words and communicate. Or maybe you have to use another student. Suppose it's a language the teacher has no knowledge of, how does the teacher support learning?

I remember Diego telling me he had a classroom in San Francisco of newcomers who were mostly Spanish speakers, but there was one kid whose native language was a Mayan language, Yucatec. There was another kid who spoke both Spanish and Yucatec, so that kid had to help him support the Yucatec-speaking student. So there is a primary language resource there, and the kid is thinking in their primary language. That doesn't mean they're not thinking and learning, and you don't put that aside and say they just have to learn English. I think it is critical to support whatever language resources there are and use them to develop the new language at the same time you use

Angienette Estonia (right)



BALANCING VISION WITH TEACHER NEEDS

I want to put a point on something that Helen said. I can't express enough how heartened I am by hearing a scientist speak like she does. I want to pull out this notion she said about creating this vision that is so important for science and language. We should have big visions and know where we are headed around those visions, but at the same time we have to respect teachers and give them the support that they need. So those are two sides of the equation, and as we go through this conference I just wanted to mark that we always need to remember both sides.

• Lynn Rankin, Director, Institute for Inquiry,
Exploratorium

Peter Dow



them to develop the knowledge and understanding. The idea that we just forbid them to use the primary language is counter-productive, particularly in a science classroom.

• Helen Quinn

COPING WITH 40 PRIMARY LANGUAGES

- Just to push a little bit further on that, I am working in a school where 40 languages are spoken. The teacher can't possibly handle that. How would you advise the teacher to proceed under those circumstances? • Peter Dow, Chair, Firsthand Learning, Inc.
- I am not the expert on how to do this, so you should ask these questions of the people working in language development, but I would say supporting the kids to express their ideas. Tell them to develop their ideas and think, if they like, in their own languages. And if there is nobody else in the room who speaks that language, how are you going to communicate it? With diagrams? With one word? With labels or words you can bring up? But you support that kid to begin to speak in that classroom, having done the development of their thinking in that other language, and recognizing and acknowledging that second language.

I did a workshop once with teachers where I paired them up so that everyone in the group was with somebody whose language they didn't speak. And then I gave them a physics activity and I asked them to converse about it in the language that only one of them spoke. You saw a lot of hands waving, you saw a lot of diagrams being drawn, but one of the language development specialists in the classroom said at the end, "I had never recognized before what my students are trying to do."

That experience of actually being in the situation where you didn't speak the language, but you had an idea that you wanted to express because something real was happening and you were thinking about it and understanding it, is a very important experience for thinking about how we deal with this situation. As is recognizing that it is not that nothing is happening because the language isn't there to express it in English. So figuring out what we can do to support that development of ideas and that expression of ideas even when the language is very, very limited is really important. • Helen Quinn

INQUIRY WITH EXHIBITS: EXPLORE SCIENCE & THE USE OF LANGUAGE

Activity Set-Up

Lynn Rankin

Director, Institute for Inquiry, Exploratorium

This experience of going out on the museum floor is a bridge between hearing from a scientist and then hearing a parallel language perspective. We wanted to give you the chance to personally experience doing science and thinking about language at the same time, and there is no better way to do it than getting out on the Exploratorium floor.

Investigating and Communicating at the Exhibit

Working in groups of four, participants focused on one or more targeted exhibits on the Exploratorium floor using the following guidelines.

Engage with the exhibit and have a conversation with each other as you observe and try to figure out what's happening, then reflect on these questions:

- What was your experience of using the exhibit? What came up for you about “doing” science? What kinds of questions came up as you were exploring?
- How did your group communicate about your ideas and understandings? What did you notice about how you used language?

Debrief

CONFUSED SEA: BEYOND ART TO THE PRACTICAL BENEFITS OF SCIENCE

• We first went to the *Confused Sea* exhibit, which didn't seem to be working. After asking staff and having them try plugging and unplugging it, we moved onto an adjacent exhibit. When some fellow participants arrived at the exhibit they noticed something: the switch wasn't on. One of the key ideas was that you can really benefit from a community of inquirers tackling an issue. We also asked a fundamental question of what this exhibit was about. It seemed a little like a washing machine that moved more as you moved the dial to higher intensity. We also considered the issue of this as very important science, and the significance of this being listed as the work of an artist. At the same time, in general, I thought about how the washing machine was one of the key sources of liberation for women, so in many ways it's an interesting dilemma. When we look at “science” (in quotes), think about all of the possible benefits you can get in looking at something that is clearly a piece of art but actually much more than that. • Barbara Merino, Professor Emerita, University of California, Davis

MAKING THOUGHTS EXPLICIT

- One of the things that I noticed was how much of the science talk was going on in my

Exploring Floating Objects



head and I wasn't making it explicit. I think when we think about language learners, that's really important because they're having implicit conversations with themselves. How do we get that out, but also what are the frames we can use to help them feel confident to express what they're thinking?

• Rebecca Smith, Co-Director, Science & Health Education Partnership (SEP), University of California, San Francisco

COMMUNALLY BUILDING SCIENCE LANGUAGE

- In our group we realized that the more we talked about the exhibit the more technical we got, the more specific we got in our language. We were trying to use language that was more specific as we went on with our discussion. We were discussing how collaborating in this community of learners builds up this knowledge, as Helen was saying, but at the same time we are building up this common language, this more specific language, to discuss this concept in a more scientific way. • Diego Román, Assistant Professor in Teaching and Learning, Simmons School of Education and Human Development, Southern Methodist University

PROGRESSION OF INTERACTION

- Along those same lines, one of the things I noticed is that our interaction with the exhibit changed. We went from exploring to playing, and then it moved into more structured experiments, and by the end we were just validating what we knew over and over, just repetitions of validation. • Salvador Huitzilopochtli, Doctoral Student, Education, University of California, Santa Cruz

SEQUENCE OF INTERACTION

- We were at an exhibit called *Sand Shaker*, and we went through a sequence I think a lot of kids go through as well, even though they need more help than we did. We started touching, just playing with the exhibit, with the little screen, and seeing what happened. From there a lot of questions came up and we shared the little communal knowledge we had about the physical phenomena. We began to realize that we needed to gather some data in a more systematic way, so we made a table and we changed frequencies and amplitudes and saw what happened. So we systematized our work, and that was a communal decision. We talked about it and we realized, hey, it's great what we're doing, but we need to figure out what's going on here, and the only way to do it is to be more systematic.

Then what came up was, why does it matter that this sand is shaking? How does it relate to real life? How is it important to us? So

Science talk at Downhill Race



we talked about erosion, about water, etc., and we had a little bit of trouble figuring out why that was important. Then we went back to more wondering: What happens if? What happens if we change the amplitude in a diagonal way? What happens if this happens? Finally we set up a question to investigate: What is the threshold of the frequency where this is going to happen? So we had a purpose for our investigation. Throughout all of this we were sharing and really communicating our ideas. • Claudio Vargas B., Elementary Science Coordinator, Oakland Unified School District

USING MODELS; ADEPT KIDS

- We had a similar experience, thinking it would be helpful for us if we could draw a model. We were looking at the *Giant Mirror*, trying to figure out if there was a way we could imagine which way the light rays were coming in and how they were being bounced off, if we could draw that model and then go back and use the model and compare it to what was really happening to test our model. That was one thing we looked at.

The other was in relation to the idea of children needing more help. We noticed that the children needed absolutely no help in trying to explore and play around with the *Giant Mirror*. We had been standing there for about 15 minutes trying to figure things out, and a whole bus-load of kids poured into the Exploratorium from the side door and immediately took over the space and figured everything out really quickly. • Rita Bell, Director of Education Programs, Monterey Bay Aquarium

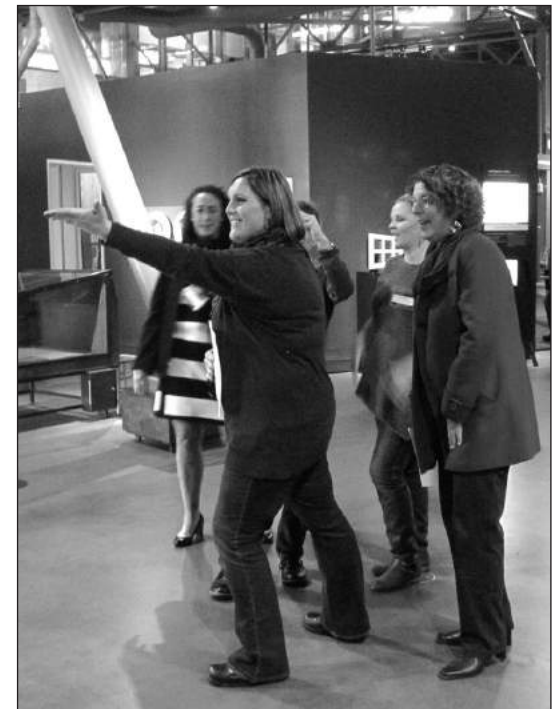
GROUP INQUIRY BREAKING THROUGH BIASES

- We were at the *Sand Table*, which involves a fan blowing sand around and creating sand dunes, or whatever you want to call it. We had been there a little while before we asked a simple question: Which way is the fan blowing? It's just an interesting moment. If you have a group, they are going to raise questions that your bias, or in this case my bias, wasn't even considering this question until it got raised. • Karen Worth, Chair, Elementary Education Department, Wheelock College

POINTING THE WAY

There certainly was a lot of talk at the exhibits. I know this is an exceptional group, but it's quite powerful the kinds of ideas that have come up with just 30 minutes at an exhibit. Embedded in those ideas are pointers to what we want to engage in over the next few days, so thank you for your personal reflections on this. • Lynn Rankin, Director, Institute for Inquiry, Exploratorium

Interacting with the Giant Mirror



Sarah Capitelli
Assistant Professor,
University of San Francisco

Guadalupe Valdés
Bonnie Katz Tenenbaum
Professor of Education,
Stanford University

The Shifting Landscape

- Common Core State Standards
- Next Generation Science Standards
- Increased Language Demands for ELLs
- Major debates in the second language acquisition (SLA) field

PLENARY: DOING SCIENCE WITH LANGUAGE: ACQUIRING ENGLISH THROUGH PARTICIPATION

Introduction

Guadalupe Valdés
Bonnie Katz Tenenbaum Professor of Education,
Stanford University

This is a two-part presentation and is really an exercise in speed reading because we have a limited amount of time. You will notice that we underlined “with” in our title. In Helen Quinn’s remarks we already heard a bit about what that might mean, that we are actually teaching science with language and that means something very particular.

Every one of us knows that everything is shifting. What is shifting? The *Common Core Standards*, the *Next Generation Science Standards*, and everyone says there are increased language demands for English language learners (ELLs), and we are scared to death. Simultaneously, there are major debates in the second language acquisition (SLA) field. All of those things are going on together, except that most of the people who are worried about the *Common Core Standards* or worried about the *Next Generation Science Standards* don’t know about the raging debates in second language acquisition. Because they are so new and be-

cause they are known to teachers, we decided this is something we wanted to concentrate on.

The questions for teachers of science are the following.

Questions for Teachers of Science

- How can teachers of science also be teachers of English?
- What does it mean to be a “teacher” of English?

How can teachers of science also be teachers of English? More importantly, what does it mean to be a “teacher” of English? That concerns us a whole lot because as soon as you use the term “teach” you are taking a particular perspective on language and what that means, and we are used to that perspective. We all took foreign language classes and we know what it is to learn a language in a language class in which, by the way, language is an academic subject such as any other academic subject, but language works very differently from other academic subjects as you all know.

In This Presentation We Will:

- Examine the notion of “teaching” English
 - Briefly review the two main positions on SLA
- Share videos of children “learning” language
- Consider how and why science instruction can provide a rich context for language acquisition

So in this presentation what we are going to do is problematize the notion of teaching English, briefly review the two main positions on second language acquisition, and we are going to share a lot of videos. And we want to consider how and why science instruction can provide a rich context for language acquisition because that is our argument.

Teaching English and Second Language Acquisition

Guadalupe Valdés
Bonnie Katz Tenenbaum Professor of Education,
Stanford University

The Field of Second Language Acquisition

- In the last fifteen years, the field of SLA has been divided into two parallel worlds
- One group of researchers sees the acquisition of an L2 as an individual cognitive process that takes place in the mind of individual learners
- Another group of researchers sees language acquisition primarily as a social process that takes place in interactions between learners and speakers of the target language

The field of second language acquisition in the last fifteen years was highly divided into two parallel worlds, and some people have called these worlds incommensurable and say we will never get it together. So where we were and the way most of us were thinking was that language is something that happens in the head, that it's an individual cognitive process, and what you have to do is order it and sequence

it and present the particular bits and pieces of language and children will acquire them.

What has changed is that there is another group of researchers thinking in social terms in what is called language acquisition who say, "No, no, no, it is not an individual cognitive process. What language is is a social practice." So it really matters how you conceptualize language because if you conceptualize it as bits and pieces, and particularly accuracy, then you are going to have one view of what you need to do if you are "teaching" language, and a view that is very, very different if you think of it as a social practice.

Here is a wonderful set of things that I want to walk you through to compare the main differences between the individually-oriented second language acquisition position and the socially-oriented second language acquisition position.

What it is that needs to be acquired is one of the key questions that we are asking, and how those second languages are acquired is a second question. And third, what is the end state of language acquisition? These are fundamentally different as you will see.

If you are in this individual, traditional way of thinking about language you are

	Individually-oriented SLA	Socially-oriented SLA
What is to be acquired?	A set of structures and forms	The ability to use the language
How are L2's acquired?	L2 acquisition is an individual cognitive process	L2's are acquired through experience and use
What is the end state of L2 acquisition?	Native-like mastery of the L2	The linguistic repertoire grows and changes as it is used

going to acquire the vocabulary, the form, the syntax, the whatever. It is bits and pieces of language. That's what it means to learn a language, right? So if you have a total number of these words, then we think you know more than someone who has fewer words. And you are also going to assume that it's an individual cognitive process, that somehow or other it gets into the mind and theories about how it gets into the mind—whether, in fact, in first language acquisition you are pre-programmed for language learning and whether some of that preprogramming remains when you acquire a second language. There are lots of debates around those issues, but that's mainly the idea, how the rules get in the head to use those particular bits and pieces of language.

And for many, many years we assumed that everyone who studied a second language was going to end up speaking like a native speaker. We continually held up the native speaker norm as the norm to which we were all going to get, sometime, somewhere.

In this other tradition of looking at the language, what you acquire is the ability to use the language, whether in written or in oral mode, but to use it, to do things with language. When I ask people what they can do with English they get uncomfortable with that and will say, "What do I know about English? I know the past progressive." I don't want to know about the past progressive, I want to know whether you can insult someone, whether you can buy and sell, whether you can

bargain. I want to know what you can *do* with language. Give me a function. Can you argue? Can you defend a position? And can you do it orally and can you do it in writing? That's what it means to *do* something with language as opposed to knowing a structure.

The second point is that languages are acquired through use. I need models of language, and now usage-based theories of first and second language are at the forefront. So we have abandoned the idea that we are pre-programmed. Many people have even abandoned the idea that you come in pre-programmed for a first language biologically, and it is usage of first and second language that adds to acquisition as we know it.

Finally, there is the idea that the linguistic repertoire grows as we use it, but we may not be native-like. I have been speaking English for a very, very long time. I am not indistinguishable from a native. I never will be, but I can do lots of things in English and I can do lots of things in Spanish. But I do not want to be held up or tested against a native speaker norm. And we can't do anything about the tests, but we can certainly talk about that later.

What I want to distinguish is assembly-line instruction versus intent participation. This work [below] comes from Paradise and Rogoff. What is individually-oriented, traditional instruction that you are all familiar with conceptualizes language as building blocks. You have to build it and if you don't start with the basic blocks, you're not ever going to acquire the other

Guadalupe Valdés



blocks. And you use it as a subject, so I'm going to grade you on the subject. How you did on that subject has nothing to do with how you did in ESL and whether you can understand teacher explanations in the biology class. The ESL teacher normally hasn't cared. As long as you acquired the present progressive it was okay, although you couldn't understand anything that happened in your classes.

“ASSEMBLY-LINE INSTRUCTION” VS. “INTENT PARTICIPATION” (PARADISE & ROGOFF, 2009)

Individually-oriented traditional language instruction:

- Conceptualizes language as building blocks (pronunciation, vocabulary, grammar and meaning [including discourse and pragmatics]) (vanLier, 2004)
- Views language as a subject that can be ordered and sequenced
- Is concerned with accuracy of form and structure

So it is concerned with form and structure, and that is of a huge concern because we felt we were doing our job. And again, I was raised in that tradition and I then tried for a very long time to teach form and structure, and obviously did not do it well, and I could come to several conclusions: the kids are stupid, I'm not doing it right, or maybe that's not how it's acquired. I like the third explanation.

Socially-oriented language instruction is grounded in theories of language socialization and usage-based theories, and engages care-

takers and other competent speakers to invite children to attend jointly to the world that surrounds them, to narrate experiences, to describe the world, to encourage questions and provide answers, to allow children to engage with less-than-perfect language. And it emphasizes intent participation that involves children attending and observing and learning cues, even to know when to enter the conversation.

Sarah will now offer some video examples.

Video Examples

Sarah Capitelli
Assistant Professor, University of San Francisco

To help us better understand the points that Guadalupe just related for us and to bring to life the idea of doing science with language or acquiring English through participation, we have chosen a number of videos that we feel will illuminate these ideas. We are going to introduce each video briefly, contextualize it a little bit for everyone, and then afterwards I'll do a little reflecting on what the adults were doing in these videos. In the last two videos I'll talk a little about what the children were doing.

In many ways we all kind of nod our heads and agree with what Guadalupe is saying, and still we see these practices out in the world that are treating language as this linear process of acquiring bits and pieces of language. It is not until we actually see what's happening that we are able to begin to interrupt that.

“ASSEMBLY-LINE INSTRUCTION” VS. “INTENT PARTICIPATION” (PARADISE & ROGOFF, 2009)

Socially-oriented language instruction:

- Is grounded in language socialization (usage-based theories of language acquisition)
- Engages care-takers and other competent speakers to:
 - invite children to attend jointly to the world that surrounds them
 - narrate experiences
 - describe the world
 - encourage questions and provide answers
 - allow children to engage with less than perfect language
- Emphasizes **intent participation** that involves children attending and observing and learning cues

Video Examples

What to look for and attend to:

- how the more proficient English speaker engages the learner
- evidence of engagement by the language learner
- evidence of understanding by the language learner

Sarah Capitelli



I would like you to attend to a number of things while you are looking at these videos, including how the more proficient English speaker engages the learner, either through talk or other ways. Look for what is evidence of engagement by the language learner. Often for the teachers, evidence of engagement is productive language, but we know that kids can be very, very engaged and not be producing a lot of language. And then evidence of understanding by the language learner, and again we know that kids can be understanding a lot and not have a lot of productive speech.

The first example I'm going to show you is me "reading" a book to my daughter when she was about nine or ten months old, and we are engaging with a familiar book that we read probably a thousand times. And again I put "reading" in quotes.

AN EXAMPLE: TALKING TO CHILDREN AS THOUGH THEY UNDERSTAND



"... Do you see number two hamster? I don't see him. He's in the back with the little boy. There he is..."

In this Type of Interaction, the Adult:

- **narrates** the book instead of **reads** the text
- assumes the child understands her talk during the interaction
- uses a familiar text and experience as the basis for interaction and engagement
- uses a book to talk about the world beyond the book

Let's think a little bit about what I'm doing in this interaction with my daughter. I'm not reading the book, I'm narrating the text, talking about what's happening in this book. I am also talking to her under the assumption that she understands everything that I'm talking about. I am using this familiar text and familiar experience, which is a bedtime book before bedtime, as a basis for this interaction and engagement.

You don't see this much here in this clip, but I think we often see it with mothers, fathers, care givers, grandparents with young children. They use the text and book to talk about the world beyond the book. It's not just what's happening in the book, it's a way to make connections between the text and the world beyond the book.

This next example I'm going to show you is a native English speaker, what we are calling an "English buddy," talking to a young English language learner as though he understands what she is talking about. He is in about third grade, and for those from California he is probably a sublevel two I would say, a beginning

two. He definitely has more receptive language than productive language, but he is beginning to produce more and more. And they are also looking at a book.

AN EXAMPLE: TALKING TO AN ELL AS THOUGH HE UNDERSTANDS



"... See the octopus?...now this creature is scary..."

In this Type of Interaction, the Adult:

- uses extensive amounts of learner-directed language targeted at a child L2 learner
- focuses the child's attention on a topic of joint interest
- provides information through narration, description and modeled language
- expands background knowledge

She goes on and on to narrate this one picture in the book and she doesn't read any of the text from the book, they are just talking about what they see in this picture. We can see that in this type of interaction she uses extensive amounts of what we call learner-directed language targeted at this L2 learner, language that

is specifically aimed at helping to make sense of what's going on in that page, and language that he is able to understand, lots of repetition and grounding all of the language in the picture.

She focuses the child's attention on a topic of joint interest. Imagine spending three or four minutes just talking about one page of a book. That's because it's all about animals, something he's very interested in. There was this kind of dead thing on the page which was also quite engaging and interesting for him as well.

And all of the information is provided through narration, description, and it's an opportunity for this child to hear modeled language, to hear what English sounds like. It is also an opportunity to expand on his background knowledge, to add to it. He came with a lot, he knows a lot in his primary language and can articulate a lot about animals, and this was an opportunity to expand that, for him to be hearing about that in English.

This next example is a less-than-desirable example, so I'm just going to show it very briefly. It illuminates what Guadalupe was talking about as assembly-line instruction. There are a couple of things to think about here. The other two examples I showed you were grounded in a book. This is grounded in a game, bingo, and we often think, what a great game to use for language development. They can learn all of the words on this bingo card and then they'll know these words. Think about what happens in this kind of interaction versus the other

AN EXAMPLE: ASSEMBLY-LINE INSTRUCTION



"... Hold on we're going to do that later, what is this? A clock....What's this? A chair, right?..."

In this Type of Interaction, the Adult:

- limits her talk to a series of questions
- uses language to **evaluate** rather than **narrate**
- does not engage the ELL through talk or the activity

kinds of interaction we just saw and the ones we will see.

She goes on and on playing that game. What we want to think about in this type of interaction is that the adult's talk, versus narrating, is really limited to a series of questions, and those questions have one answer, a right answer and a wrong answer. And her language is being used to evaluate rather than narrate: This is a bowl, this is a chair. And that is really the purpose of the language that's going on. She also doesn't really engage this student through talk or the activity. There isn't a lot of joint attention going on. The student is compliant, she is doing what she is being asked to do, but I don't think we would necessarily call it engagement.

In thinking about these videos and now moving on to think about science practices as language rich affordances, the next two videos I am going to show you are children engaging with science phenomena. We are showing these videos to help us think about how science instruction can provide affordances for participation in language-rich experiences. We know, and Helen talked about this earlier, that some science instruction does this by mirroring and doing real-life science; by engaging students in practices that are precipitated by their own interests and by wonder; and by providing students with opportunities to observe, raise questions, make predictions, test hypotheses, and create conceptual models. This reflects what Helen talked about earlier as well as

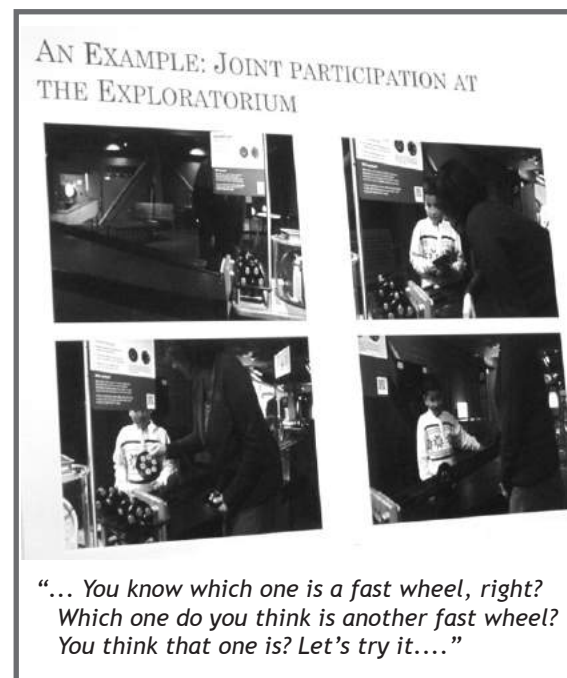
many of our own experiences out in the exhibits.

The first example I'm going to show you is four short snippets from a longer interaction that happened here at the Exploratorium. Many of you went to this exhibit, *Downhill Race*, the ramp with the wheels. I'm just going to tell you a little bit about Edwin. He is a newcomer to this country. When we shot this video he had been here for about seven weeks, so he has very little productive English and his receptive English is really just developing. I would say that it's developing quite rapidly, but he has very little productive language. He had never been to the Exploratorium before or to any museum for that matter. He is in fourth grade, he is in a Spanish bilingual classroom

Science Practices as Language Rich Affordances

How can science instruction provide affordances for participation in language rich experiences?

- mirror doing real science
- engage students in practices that are precipitated by their own interests and wonder
- provide students with opportunities to observe, raise questions, make predictions, test hypotheses, and create conceptual models



here in the Bay Area, and he's about ten years old. And I will say that for him and his mother it was a thrill to come to this space before it opened and get to play.

I want us to think, in looking at these four snippets, of the ways in which he engages and the ways in which I invite him to engage; the ways in which he begins to theorize about what's going on, and then how he's able to express it, for the most part non-verbally.

In this Type of Interaction, the ADULT:

- captures the child's interest aided by her own enthusiasm and excitement
- grounds her language in the phenomenon that is directly in front of the child
- asks and answers her own questions to narrate both the phenomenon and the scientific processes
- asks choice-questions to support the child's emerging productive speech

Let's talk a little bit about what I did and then what he was doing. Clearly part of it was capturing his interest, which in many ways was aided by my own enthusiasm and excitement, which was palpable, I think, for him, for his Mom, for Paula who was filming us. Also, everything I'm talking about is grounded in the phenomenon that was directly in front of him, so he could see everything. And there was so much repetition going on all of the time. Also I asked him many questions, but I often answered my own questions. I wasn't expecting an answer to my questions and often, asking

the question and then answering it myself provided me the opportunity to narrate both the phenomenon and the scientific processes that were going on. And then you see in the last video I am trying to think whether there are some ways that I can begin to elicit a little bit of productive language from him. Asking choice-questions grounded in the context gave him the opportunity to say just a little bit.

In thinking about what he was able to do, he was able to demonstrate engagement non-verbally. He was with me in that interaction. He also was able to demonstrate his understanding non-verbally, so we knew that he understood by his behavior, by what he was doing with me. He did begin to attempt to use a little bit of English in response to those choice-questions. He did say some things that were kind of unintelligible, but he was attempting to engage with me verbally. He made some predictions non-verbally, and he tested his hypotheses as well.

I want to note that he is a Spanish speaker and I am a Spanish speaker, so we could have done that in Spanish, which would have been a really different kind of experience. We were able to do things later on in the Exploratorium in Spanish, but I specifically asked him before we did this and told him we were going to do it in English. Angie brought that up earlier, the role of primary language in this kind of learning.

The last clip I'm going to show is of small group work in an elementary science classroom. This is actually the classroom of Jennifer McDonald, a teacher in Sonoma we have been working

In this Type of Interaction, the CHILD:

- demonstrates engagement non-verbally
- demonstrates developing understanding non-verbally
- begins to attempt to use English
- makes predictions non-verbally
- tests his hypotheses

AN EXAMPLE: SMALL GROUP WORK IN THE ELEMENTARY SCIENCE CLASSROOM



"... What are you going to look for to see if the snail actually does it eat it?...."

In this Type of Interaction, the ADULT:

- asks clarifying questions
- supports students in connecting their written work to the current investigation
- accepts students' flawed language when communicating their science understanding

In this Type of Interaction, the CHILDREN:

- use their L1 to explain their thinking
- demonstrate engagement both verbally and non-verbally
- demonstrate developing understanding both verbally and non-verbally
- make predictions
- use flawed English to communicate their developing science understanding

with a lot. It is a third grade classroom, it is a small group, and they are doing a snail investigation. This day they are trying to figure out what foods the snails prefer to eat. There are four kids in the group. There's a native English speaker and three English learners. The two girls are very reticent to speak, but they do use their primary language, so again there is that role of primary language in this. The two other students are boys, rather chatty, one a native English speaker, one a native Spanish speaker, and the native Spanish speaker uses his Spanish periodically, so it is interesting to see his role. The two girls never say anything while Gennifer is there, but when Gennifer leaves they start to use their Spanish to contribute to the conversation.

So what was the adult doing? She was asking clarifying questions, helping to push their thinking along. She was supporting them in connecting their written work in their science journal to their current investigation, making a link very explicitly between those two things for the kids. She also accepts students' flawed language or less-than-perfect language when communicating their science understanding. This was science in the service of science learning and ELD, but she was not interrupting them to ask for complete sentences or feeding them a sentence to get them to articulate their understanding.

And in terms of the children, they use their L1 to explain their thinking and they also demonstrate engagement both verbally and

non-verbally. You wouldn't say that those girls who you don't hear speak English were not engaged. They were engaged. The minute the teacher left they start speaking in Spanish. They have something to contribute to this interaction.

They demonstrate developing understanding both verbally and non-verbally, and they make predictions. And they are using less-than-perfect English to communicate their science understanding.

Concluding Thoughts

Guadalupe Valdés
Bonnie Katz Tenenbaum Professor of Education,
Stanford University

**Concluding Thoughts:
Language Acquisition**

- Language will be acquired in use
- Language will be acquired with and through interactions with others
- Language has to be rich and embedded in an engaging context

We think that language can be acquired in use. In fact, we know that language is acquired in use and that's what this work showed you. Language will be acquired through interactions with others and these interactions are very important, and these interactions take place in conversation, as Helen told us earlier. So in case you have been told that there is this big dichotomy between conversational language and academic language, you'll see that you

cannot have an interaction that happens in anything but conversation or exchanges because that's what's appropriate for one-on-one conversations, especially between children. If you were doing student presentations and had them ready to do presentations, they could have done so and they would then choose another way to talk, the way you do when you are speaking one-to-many.

So language has to be rich and embedded in an engaging context and we saw wonderful examples of that. Think if you come from a household in which you never hear English spoken. What you want is that model of language.

Discussion, Q & A

LINKS BETWEEN L1 AND L2 AND NARRATION

- I have a question for Sarah regarding the first video of you interacting with your child. Could you explain the connection between what you're doing there and the other work? Secondly, there was the video of the young boy whose mother was there at the Exploratorium. What would you say would be her interaction with her child? Would it be similar to the way that you interact with your child?
 - Chris Faltis, Professor, Director of Teacher Education, Dolly & David Fiddymont Chair in Teacher Education, University of California, Davis
- The explicit connection between showing the video of me and my daughter and the other

work we talked about is the way in which there was narration of the world and assuming understanding on the part of the person you're talking with. It involves thinking about the ways in which mothers and "motherese" help children to develop their own language, and thinking about L1 acquisition and how an understanding of L1 acquisition can help us understand L2 acquisition. Unfortunately we don't get enough of that kind of narration, that kind of talk happening in classroom settings. One, because it's one-to-many, but also because there's an expectation or a misunderstanding that production is equated with understanding. Even in that video with Gennifer, the two boys were doing a lot of narrating of what was going on at the table. It's obviously a different kind of narration than a mother does, but similarly offers a number of extended opportunities to hear talk. So that's the connection. • Sarah Capitelli

ROGOFF INTENT PARTICIPATION MODEL

- I'm really glad you picked Barbara Rogoff's intent participation because I think it's a really robust model. I'm thinking about some of the key things that are really important to that model, so first I'm going to think aloud and then ask my question. In that model, being engaged meaningfully in a valued practice is really important. Being in the discourse practice provides ongoing opportunities to not just be productive in the

DIFFERENCES IN L1 AND L2 ENGAGEMENT

- The morning at the Exploratorium was very interesting for me because it was the first time I had worked with an English learner on an exhibit like that. After we did it, then he and his mom and I spent the morning in the Exploratorium, and I would say that again there was this opportunity to engage with a phenomenon in Spanish, in their primary language. She doesn't speak any English either. There was obviously a different level of engagement, I would say longer attention to things. There is an exhibit here where you draw spirals, and he and I went and did it and one of the volunteers, a young Latina woman who was 19 or 20, spoke Spanish. It was an example of so many important things. One, to have him have the opportunity to have somebody in this space that looked like him and was interacting with the phenomenon. I speak Spanish, but I don't have a similar background to him. That was interesting. In speaking with someone from the museum who spoke his language, he carried himself with a different level of authority, which was very powerful for him, and I think it was very moving for his mom to see him doing that. • Sarah Capitelli

EXHIBIT STIMULATING
THINKING AND LANGUAGE DEVELOPMENT

- I just want to comment on the *Downhill Racer* exhibit. Bronwyn and Angie and I all had the opportunity to experience that exhibit. We're not particular readers, but we did see the scale, so we weighted the disks first. What is so powerful about that exhibit is that it's counter-intuitive. You expect that the heavier disk is going to move faster. That counter-intuitive aspect of that exhibit forces an explanation, forces you to think. It forces the kid, it seems to me, to figure something out. And what a beautiful illustration of the power of science to stimulate thinking and, consequently, language development. • Peter Dow, Chair, Firsthand Learning, Inc.

discourse but to observe, to monitor, and to listen to language, which is really important. I think most importantly, the goal is not just to learn the facts but to become a competent and valued member of that community of practice. So can you stretch those ideas out and say a little more about how it relates to the three parts that Helen talked about, how that helps us address the disciplinary core ideas, crosscutting concepts, and the practices? • Kris Gutiérrez, Professor, University of California, Berkeley

- How wonderful that you actually reviewed Paradise and Rogoff for us, and particularly Rogoff in terms of what that participatory thing means—the opportunity to observe, and the opportunity to observe a lot without necessarily having to produce and to be evaluated for your production. That probably for me is the most important lesson. As language teachers, and we've heard similar questions already in this meeting, we want to know how we get them to say things. They may not be ready to say things, they may not have observed enough.

When Helen tells us about these three practices and that they are going to be integrated, what I love about Helen's presentation is that she was really saying it is a challenge for teachers to set up. The activity we just looked at engages you and moves you towards asking a question. So you're going to have to set up the kinds of lessons that have that, that cause the child to wonder.

I happen to have a son who would take apart the lawn mower when he was three or so (that's how you know you have an engineer for a son, and then he can't put it back together). It is that whole sense of—I wonder how it works? Let me take it apart—which to me has to be integrated into whatever the practices are. The children have to be guided to see the crosscutting concepts, and clearly they also need to be introduced to seeing what the disciplinary practices are.

And they are in discourse, but the discourse has to be modeled if you've never participated in discourse. What worries us the most is if there are no real speakers of the language in the room. That is my biggest worry about a lot of settings in which, because of the segregation that we have, residential and otherwise, there are really no competent speakers in the room who can model that language. The only competent speaker in the room is the teacher. That then puts a tremendous challenge on the teacher to do that, to model the language. And sometimes that modeling of the language is not how we talk to kids who have already developed strengths in L1. It makes the kind of repetition and activities you engage in a lot slower. So there are some binds there, and questions that in the practice we will begin to see more of. When we begin to do that and we see videos of that, we will begin to understand it more. • Guadalupe Valdés

WORKING GROUP SESSION

Introduction

Sarah Capitelli
Assistant Professor, University of San Francisco

We have done a lot this morning. The conference was introduced to us and contextualized, we have heard from Helen Quinn, we had some time on the floor, and you heard from Guadalupe Valdés and I. We wanted to give people the opportunity to spend time talking in smaller groups to synthesize what they've heard, what they take away, and things they want to continue to think about. We also want you to inject your own experiences and the context from which those experiences come. We are going to ask you to divide into four working groups to think about the following question.

What do teachers need to understand about learning science, learning language in the context of science, and pedagogy to support both?

Report Out Group A

Susan Gomez Zwiép
Associate Professor, Science Education,
California State University, Long Beach

Our group talked about the nexus that has occurred, where all of a sudden the language and

the science goals are starting to be the same. That is a nice thing for teachers to know and understand, but teachers need experiences to understand the shifts. Telling them about the shifts isn't going to bring about the change in thinking that they need to implement the shifts. We talked about walking the walk. The term "learning spaces" was used. It is important that all students be able to do science, but teachers need structure and protected learning spaces to develop this understanding.

Teachers need to understand the scope of the work and be critical users of curriculum. In terms of pedagogy, they need to understand how the shifts represent shifts in terms of pedagogy as well as shifts in how we are thinking about these things. Teachers need to negotiate theory into classroom practice.

We also spent some time talking about the current barriers that exist, and we need to help teachers think about how to move beyond the barriers so that they don't get stuck in the barriers in an effort to move forward.

Report Out Group B

Annemarie Palinscar
Jean and Charles Walgreen, Jr. Professor of
Reading and Literacy, University of Michigan

A lot of our discussion focused on the specialized knowledge for teaching science. In some cases this was captured as "knowledge about the phenomena the students are studying." Another statement captured from the discussion



Susan Gomez Zwiép

Annemarie Palinscar



was “understanding the nature of science.” So what does it mean to engage in science and inquiry that teachers have to be comfortable with? Related to that was discussion about learning how to support teachers and encourage them to have more confidence in their own capacity to engage in scientific inquiry themselves, as well as to teach science.

Consistent with that was the importance of having administrative personnel, school leaders, and in fact community members, parents as well, who understand what it is that teachers are striving to do when they undertake this kind of science instruction so that everyone is on the same page and there is a collective effort towards this goal.

An important theme in our conversation was

the role of thinking in science, the distinction between doing an inquiry versus engaging in the thinking and reasoning and problem solving. The fact is that because of time it can be the case that the group gets heavily engaged, and then the time disappears for the sense making and the reasoning following the inquiry itself, and I think all of us can resonate with that.

Finally there is this idea of science as a social process (we picked up on that theme that was introduced earlier this morning), and that children need the opportunity to use language. It should be very natural because of the social engagement in scientific inquiry, and the teacher is involved in scaffolding both the language as well as the learning of science in the context of investigation-based experiences.

Working group in session



Report Out Group C

Tina Cheuk
Doctoral Student, Stanford University

A lot of things have already been said, so I am just going to highlight some things we can add on. We talked about:

- How the processes between science learning and language learning are very parallel and what shifts we are moving from.
- How do we get teachers into students' roles, putting them in their shoes and those types of learning experiences?
- Peer influences and what the classroom com-

munity structure looks like.

- What seems intuitive to teachers, and is that intuition the best way to approach learning for our students.
- District and school support and what is needed in terms of top-down structures so that district and school leadership can collaborate.
- Meaning making and how we can help students with meaning.
- Preservice and inservice, and how do we prepare this next generation of science teachers so that they can enter the classroom and offer the support we are hoping for to their students?

Report Out Group D

Bronwyn Bevan
Director, Institute for Research and Learning,
Exploratorium

We started off talking about the need to help teachers to first of all recognize their own processes of learning through having authentic learning experiences in science, and we talked about the need to make those experiences authentic both in terms of creating a purpose and in terms of use of language in that process. We want to help them see that process and think about what learning is in that process

We also want to help teachers see what progress in the classroom actually looks like. Instead of giving teachers a long list of things

that have to happen or that one has to do, we want them to understand there are steps that can be taken and that shifts can happen in the classroom over time. We brainstormed several tools that could be developed to support that process. Mostly we talked about the need for video, videos of teachers in the classroom. One of the examples was giving teachers questions to interrogate their practice.

One of the last things that came up is that really the issue here, which gets back to the idea of science as a social process, is helping teachers think about how to create a classroom culture in which science and language are united. Somebody made the point that when you say “science and language,” first of all it’s usually not “language and science,” it’s “science and language.” I scribbled in my notes a diagram of the word “science” with “language” running through it, and we want to show that they are intertwined in a way.

The final thing that really stood out is that not only do we need to think about teacher practice, but we need to think about the practice of professional developers of teachers, but we didn’t delve into what that might look like.



Tina Cheuk

Bronwyn Bevan



Comparing Approaches to Professional Learning

Terry Shanahan
Science Academic Coordinator,
University of California, Irvine

Lauren Shea
Director of Education, Outreach, and
Diversity, University of California, Irvine

Pre-conference Reading:

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

White Paper for Exploring Science and
English Language Development: Implications
for Teacher Professional Learning

January 2015

Lauren M. Shea and Therese B. Shanahan

Available from Institute for Inquiry website:
www.exploratorium.edu/ifi

CASE STUDY PRESENTATIONS:

Introduction

Paula Hooper
Senior Science Educator/Learning Research
Scientist, Institute for, Inquiry, Exploratorium

I want to introduce you to the three cases you are going to hear about. Over the past several months, this group has shared and discussed each other's approaches and developed a sense of resonances and differences in our work. We worked together to develop a way of sharing our work that allows you to see and make use of the practical and theoretical implications for the fields that we represent. That is why there is a sense of story through each of these cases, because we wanted people here to think about some of the ways we got to the professional learning work that we are trying and thought it might be a good way to stimulate conversation in this group.

We Are Talking to Learn Science: Finding the Right Fit

PROGRAM OVERVIEW AND PD MODEL

Terry Shanahan
Science Academic Coordinator,
University of California, Irvine

We are going to talk to you about our

professional development model working with teachers in a school district in Southern California that has a high English learner population and a high number of children living in poverty. I am an English learner and English is not the language that I spoke at home growing up. I majored in chemistry in college, and when we were designing my lessons, my goal was to provide professional development to teachers, especially in physical science, because that was a content area that caused our teachers to look at us like a deer in the headlights. That's a reference from New Hampshire. When you're on a rural road in New Hampshire and your headlights shine on this animal that's crossing the road

Terry Shanahan demonstrates teachers' deer-in-the-headlights reaction to physical science



the animal just stands and looks at you, and that's how our teachers perceived physical science.

PD Program Overview

Our Story

- Over 3 Years - 3 Models
- PD Included Math and Science Content
- Embedded Student-Talk Strategies
- K-5 Teachers
- Research throughout the 3 years (Formative and Summative)

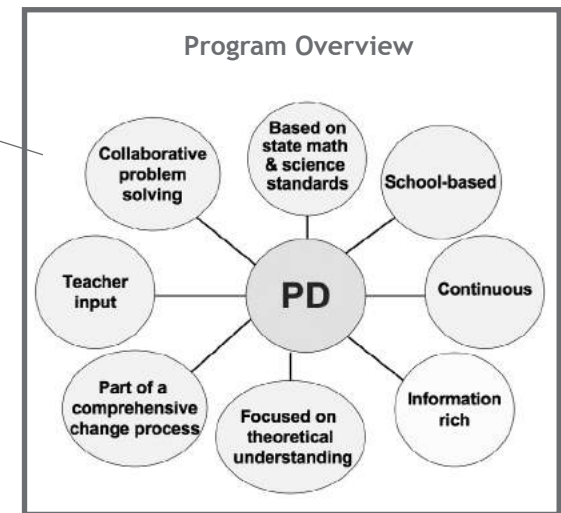
So we tried to provide lessons to teachers at grade level with the teachers participating as if they were the students so that they could see what the struggles were in the lessons, and they could understand where misconceptions might be introduced and where their own students might stumble in the lessons. We embedded student-talk strategies in the lessons, understanding that oral language is really important for the students to exchange ideas, and we will talk about that more in a moment.

This was part of a grant from the California Postsecondary Education Commission to work with teachers, first in K-2 and then in 3-5, over the course of multiple years, providing both math and science instruction. We are going to talk about the science content pieces of our professional development and how our vision of the professional development changed over time. We were very lucky to

have a linguist and researcher on our team. I'm going to talk to you a little bit about the professional development, which was detailed in the white paper we wrote [*see sidebar, page 36*]. Lauren will talk to you about the evidence that we have that this model works. We had an intuitive feeling that it would make a difference in the lives of the teachers and the lives of the children, but we have evidence that it made a difference in the lives of the children.

The professional development model that we used came from Halley and Valli as well as Garet and Garet's colleagues, including Andy Porter. In designing our professional development we tried to incorporate these aspects of professional development, thinking about content and what teachers needed at every grade level. So third grade teachers learned third grade lessons, second grade teachers learned second grade lessons. We focused on the school context and tried to bring in multiple teachers from every school set within the district. We had summer institutes as well as academic year Saturdays, so we were seeing the teachers continuously over the course of those many years. We tried to incorporate experiences for the teachers in these lessons that provided rich opportunities for them to learn through inquiry.

We used the 5E Roger Bybee instructional model for inquiry: explore, engage, explain, evaluate and elaborate. In the design of our professional development we also tried to



Research Tells Us...**Oral Language Production in Science Allows Students to:**

- Make sense of own thinking
- Listen to the ideas of others
- Become aware of multiple perspectives
- Re-think own ideas
- Evaluate another's ideas
- Frame own ideas before writing

(Worth, 2008)

have some theoretical underpinnings and were hoping, through conversations that the teachers had in professional learning communities, that they would have opportunities for problem solving within their classrooms and that they would change their practice.

We know that oral language production allows children in an inquiry environment to have authentic experiences in using language. The paper that Helen Quinn, Okhee Lee, and Guadalupe Valdés wrote [see sidebar, page 9] about providing these opportunities for students to use language as they are doing science came from some work that Karen Worth did, and we used her as some underpinning.

When we talk to teachers we talk to them about all of the different ways that students use language in inquiry science so that, as children are talking to each other, they're making sense of their own thinking and comparing their ideas to other children's ideas. They're rethinking their ideas based on what other people have said, so they're getting multiple perspectives on those ideas.

Most importantly, they are framing their ideas before they write. We think that oral language is a pre-writing activity and that once students have had opportunities for rehearsal and hearing ideas and hearing language they are more ready to read because we know that fluent readers have prior knowledge. These inquiry lessons that provide opportunities for language gave students prior knowledge so that now there was a reason to read because

questions came up during inquiry and they wanted to answer those questions. In doing the activity first, they had some opportunity to check what they were reading in text compared to their experiences in the inquiry.

In California, oftentimes when teachers are invited to go to literacy workshops, the literacy relates to reading and writing for the most part. Our premise is that oral language has to come first through inquiry.

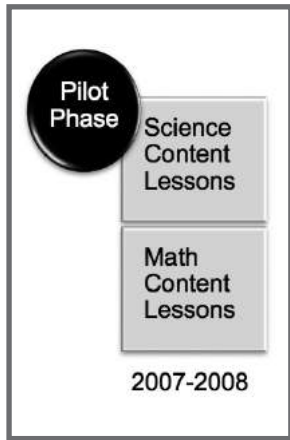
We know that if students talk to each other, the repetitive use of language provides a proficiency in that use of oral language. And then we know from research that oral language proficiency helps with decoding because it gives students prior knowledge of the ideas, and that decoding leads to later decoding of more complex texts, and all of that leads to academic success. So we think there is a very strong progression, but it all begins with the foundation of oral language and inquiry.

Research Tells Us...**Strong Oral Language Development...**

- Leads to oral proficiency
- Supports early decoding
 - Early decoding leads to increased early reading and writing skills and later decoding and comprehension
 - Early literacy skills translate to more successful academic experiences

(Achieve, 2005)





In our model we have these lessons that we wrote in the 5E design. We did them in science and math, and because I was in charge of the content for physical science in the first year, and actually for all of the sciences throughout

the program, I made sure that the content had student-talk opportunities embedded in them. We provided these lessons for the teachers, they engaged in the lessons as students, and then they had some time to talk about how they would enact the lessons and what the pedagogy was. Then they would go back to their classrooms and try the lessons out, and they became rather proficient in teaching our lessons in their classrooms.

This [upper right] is a model of a second-grade 5E lesson that we had about sound. We outlined what the teacher did during the lesson, what questions the teacher asked, and what the possible student responses were. Our intent was that rather than asking a question and having one student answer, the students would have opportunities to talk to each other in response to the teacher's questions and then report out what they had talked about. We thought we had designed really nice lessons that had engaged English learners.

Pilot Model

ENGAGE: Connect to Prior Knowledge and Experience, Create Emotionally Safe Learning Environment, Preview New Vocabulary
Estimated time: 2 min

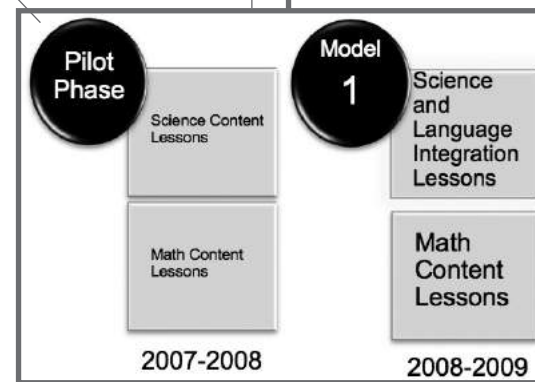
Teacher's Role	Teacher Questions	Students' Role
Tell students that you will play a guessing game with them. They will close their eyes and you will make a sound. They will point to the place they think you are standing. They will open their eyes and verify that they found the source of the sound. Do this several times standing in different locations.	How did you know where I was standing? What did you notice about the sounds I made?	<i>"We could hear the sound."</i> <i>"Some sounds were low and some were high."</i> <i>"Sometimes you hummed and sometimes you whistled."</i> <i>"Some sounds were loud, some were not."</i>

At the end of that first pilot year we found that the teachers had increased content knowledge. We tested them pre- and post- on their content knowledge and they did show increase in content but not in support of English language development within their classrooms. But in the course of this one year we got to know the teachers, we got to understand their needs, so we changed our model and were now more intentional in integrating the language but also telling the teachers why we were using these strategies, and why we were using these strategies that were already in place in the district.

We used what the district was already making the

Results

- Increase in Science Content Knowledge (Pre-post test)
- Not much movement in knowledge or use of ELD strategies (Observation and informal discussions)
- We got to know our teachers
- We got to know what they needed



**District ELD Curriculum
Hampton Brown
Avenues**

	Benefits and Purposes
<p>Three-Way Interview</p> <ul style="list-style-type: none"> Students form pairs. Student A interviews student B about a topic. Partners reverse roles. Student A shares with the class information from student B; then student B shares information from student A. 	<ul style="list-style-type: none"> This allows students to talk to different students in the class and gives each student an opportunity to share and listen to various answers and language structures. Talking one-on-one with a variety of partners gives risk-free fluency practice. Interviewing supports language development in question formation. Students participate in speaking and active listening. This ensures participation by all students.
<p>Numbered Heads</p> <ul style="list-style-type: none"> Students number off within each group. Teacher prompts or gives a directive. Students think individually about the topic. Groups discuss the topic so that only one member of the group can report for the group. Teacher calls a number and the student from each group with that number reports for the group. 	<ul style="list-style-type: none"> Group discussion of topics provides each student with language and concept understanding. Random selection provides an opportunity for evaluation of both individual and group progress.
<p>Roundtable</p> <ul style="list-style-type: none"> Teacher seats students in small groups around tables. Teacher asks a question with many possible answers. Each student around the table answers the question a different way. 	<ul style="list-style-type: none"> Encouraging elaboration creates appreciation for diversity of opinion and thought. Eliciting multiple answers enhances language fluency.
<p>Think, Pair, Share</p> <ul style="list-style-type: none"> Students think about a topic suggested by the teacher. Pairs discuss the topic. Teacher strategically chooses certain students to individually share information from their discussions with the class. 	<ul style="list-style-type: none"> The opportunity for self-talk during the individual think time allows for the student to formulate thoughts before speaking. Think time allows students to think about the concepts and the language before producing. Discussion with a partner reduces performance anxiety and enhances understanding.

Adapted from Avenues: Hampton Brown (2007)

teachers do so that we weren't giving them one more thing in their lessons. We incorporated the Hampton Brown Talk Strategies, and we incorporated them in every part of the 5E lesson, so there were multiple ways for the students to engage with each other. And the teachers had more structure, so they knew how to engage the children and they knew why they were engaging the children because they had seen that in the professional development.

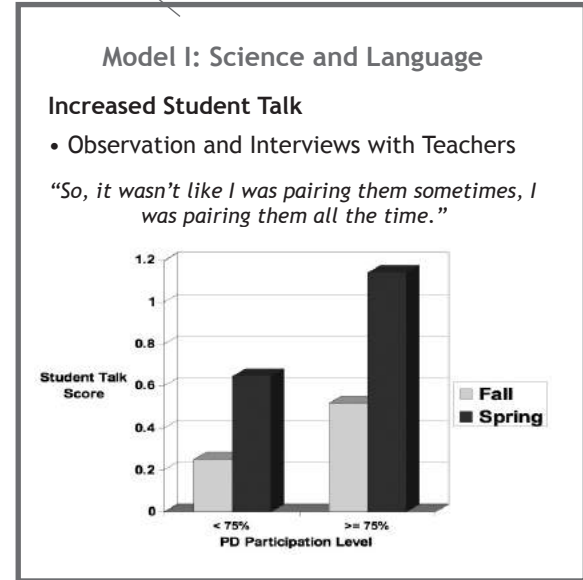
MODEL REFINEMENT AND EVIDENCE

Lauren Shea
Director of Education, Outreach, and Diversity,
University of California, Irvine

This was a big change in the program from the pilot model to this model. As the teachers in our program were sitting in the professional development engaging in the lessons, now

were not only given to them in the lesson plan, they were experiencing them as they went along in these lessons.

At the end of Model I we went into the classroom, we observed the teachers, we talked to the teachers about their own understanding of science and language, we talked to them about their classroom implementation and what they thought was happening with their students, and we saw an increase of student talk levels from pre- to post- in almost every classroom we were in.



We have volumes of field notes of students talking about science, relevant talk using academic vocabulary, and teachers were reporting that they were very cognizant of this happening.

Model I: Science and Language

ENGAGE: Connect to Prior Knowledge and Experience, Create Emotionally Safe Learning Environment, Preview New Vocabulary Estimated time: 2 min		
Teacher's Role	Teacher Questions	Students' Role
<p>Tell students that you will play a guessing game with them. They will close their eyes and you will make a sound. They will point to the place they think you are standing. They will open their eyes and verify that they found the source of the sound. Do this several times standing in different locations.</p> <p>Teacher and a partner model Report to a Partner with speaking and listening roles. Teacher and partner demonstrate turn-taking, complete sentences, questions formation, and vocabulary use. Prepare students to speak and listen carefully to be able to report on their own and their partner's answer.</p> <p>Throughout this component, the teacher formatively assesses student understanding and misconceptions as shown by the various responses. The teacher can acknowledge students' home language use and can provide students with the equivalent English word to support language development.</p>	<p>How did you know where I was standing?</p> <p>Report to a Partner: Tell the person next to you how you know where I was standing.</p> <p>What did you notice about the sounds I made?</p> <p>Three-Way Interview: Students ask their partner what they noticed. Then, the student shares his/her own answers with the teacher. Each student reports back to the class about the partner's not...</p>	<p><i>"We could hear the sound."</i></p> <p><i>"I listened to the noise."</i></p> <p><i>"Escuchamos el ruido."</i></p> <p><i>(Student Talk: speak and actively listen to a partner)</i></p> <p>Question: "What did you notice about the sounds?"</p> <p>Answer: "Some sounds were low and some were high."</p> <p>"Sometimes you listened and sometimes you whistled."</p> <p>"Some sounds were loud, some were not."</p> <p>"Loud"</p> <p>"Ex baja"</p> <p>"Aho"</p> <p><i>(Student talk; speak and actively listen to a partner to share with the class)</i></p>

their teacher presenter would stop after doing one of these Student Talk strategies and talk to the teacher participants about what the strategy was, why it was important, what language skills might be happening in that moment, and what science content was learned from that point. So these additions to the lessons were made very explicit to teachers in the moment of the science lesson. They

They were purposefully pairing students to talk at any moment they could so that it was not that approach of the teacher asking a question, just one student answering, and the teacher evaluating. Now the teacher asked a question and all of the students got to talk to each other as they moved on throughout the lesson. So it was not just the content that was increasing, the amount of oral language was increasing.

Model 1: Science and Language

Teacher Perception (Interviews)

- Knowledge of the Benefit of Academic Talk

"I realize how much more valuable it is to have them bouncing ideas off each other. This year, I found that I realized the value of really doing that with them."

"I've learned that allowing students to use the language that they are trying to learn in science... ...was allowing kids to engage and explore and while using academic language."

Model 1: Science and Language

Teacher Perception (Interviews)

- Student Gains

"At the beginning of the school year, they came in, they were so shy and reserved. They hardly even said one word. Allowing them to have discussions with other students enriched their ability to listen to the vocabulary and use the vocabulary with other kids. And before, if I would have taught the old way, those kids would have stayed quiet the whole year and they wouldn't have gotten as much vocabulary and content."

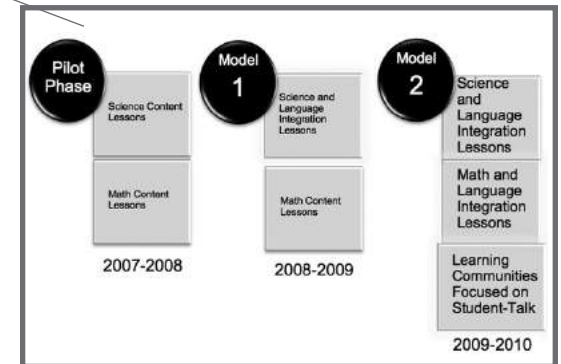
Teachers understood why it was important and they perceive that their students were improving, that they were gaining in language acquisition and science content.

At the end of that year we realized, wow, this is kind of working, but we wanted to make it better. We decided, okay, we're not only going to do this in science, we're going to talk to our math people, we're going to do some student-talk strategies with them, and they're going to do it the same way.

But we also felt teachers needed to really understand deeply why we are doing this, so we took those learning communities that Terry mentioned and we included academic readings and practitioner-based readings on student talk. Why was this important? What would students get out of oral language? Those same ideas Terry presented to you about oral language, we presented to teachers and have had talks with them about it. After the teachers went and tried the lessons they came back and said, "This is working." "This is not working." "How did you do this in your classroom?" "Oh yeah, I can try this."

This model had more focus and more research and this is where we kind of ended, with the bet that is going to get us a lot closer, with teachers taking these baby steps to the end result of language development and science being really embedded and intertwined.

Then we did more research and talked to teachers again, and they felt really confident at that point, saying, "I'm doing this across the board. I'm not just using these strategies in math and science, I'm using these strategies all the time. I want kids using oral language all over the place."



Lauren Shea

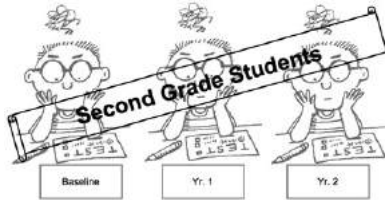


Model 2: Science, Math, and PLC Teachers' Perceptions of Student Outcomes

"Their communication skills have also improved. They're using that academic vocabulary when they're explaining certain concepts, or even, it's deepening their level of understanding of the processes that I want them to know about."

School Level Findings

- Students' Grade 2 California Standards Test
 - English Language Arts (as a proxy for Science)
 - Mathematics
- Measuring "Proficient" or "Advanced"
- From Baseline Year to End of the Model 2



We did some school-level testings and had treatment schools and comparison schools. We looked at the schools across the years of our program from the baseline from our pilot year to out Model I year and Model II, using the California Standards Test, which is not a great test but what we had available. We looked only at their English language development over these years because we're not testing in science in second grade. We looked at what was happening and whether students were increasing in English language development, and what we saw was yes. The treatment schools had students who were performing

significantly better in both English language arts and in math. We saw the same sort of significant findings across the board. These are all in our paper [see sidebar, page 36].

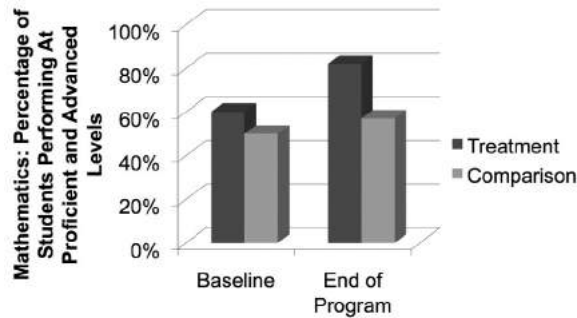
CLOSING THOUGHTS

Lauren Shea

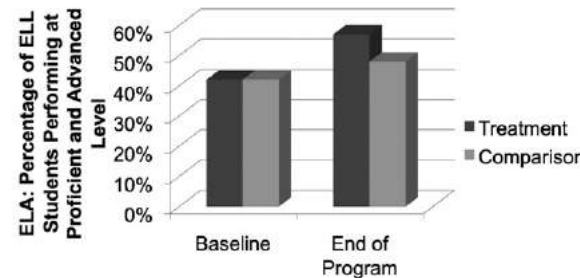
We learned a lot through this three-year process. We now know that one of the baseline pieces of information to start with is knowing your participants. If you want to get to the idea of science and language development together, you have to know where your

School-level Findings

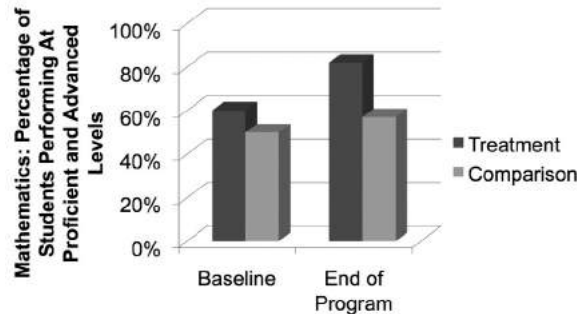
English Language Arts



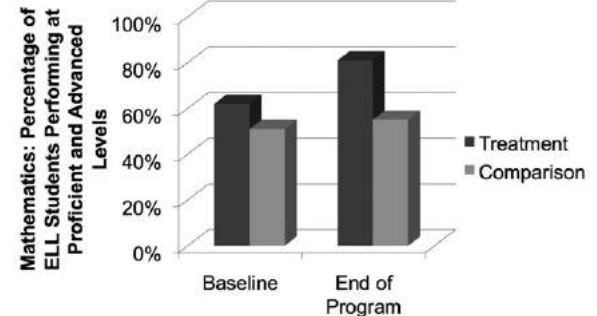
English Language Arts for ELLs



Mathematics



Mathematics for ELLs



teachers are starting. This came up in our work group at this conference also. You can't say, "Oh, I really want them to know that science and language belong together," and leap there because you'll lose them. We learned through this process that you take baby steps to get there. And of course schools have a context. We have to understand where teachers are coming from, what their baseline knowledge is, and how to slowly move those pieces.

Terry Shanahan

We also know that teachers need the research to be able to defend what they are doing in their classrooms. If the principal came into the classrooms and expected to see a language arts lesson, but the teachers were doing science, the principal might approach them and ask, "What are you doing?"

The teacher could say, "Oh, I'm doing language," and cite, for example, the Common Core Language Standards that they were dealing with the Student Talk pieces. The principal then wouldn't have much to say because the teacher was doing Common Core Language Standards, but in the science model. Before we started our professional development the teachers were doing a pull-out ELD program that was not as effective, we think, as our science inquiry program.

So the teachers need the research and our team was very well positioned because we had content experts, we had linguists who could help us with second language acquisition, and then we had science educators. That team of combined expertise helped to make our professional development work more successful.



Pre-conference Reading:**The Integration of English Language
Development & Inquiry Science into a
Blended Lesson Design**

White Paper for Exploring Science and
English Language Development: Implications
for Teacher Professional Learning

January 2015

Susan Gomez Zwiép

Available from Institute for Inquiry website:
www.exploratorium.edu/ifi

Susan Gomez Zwiép

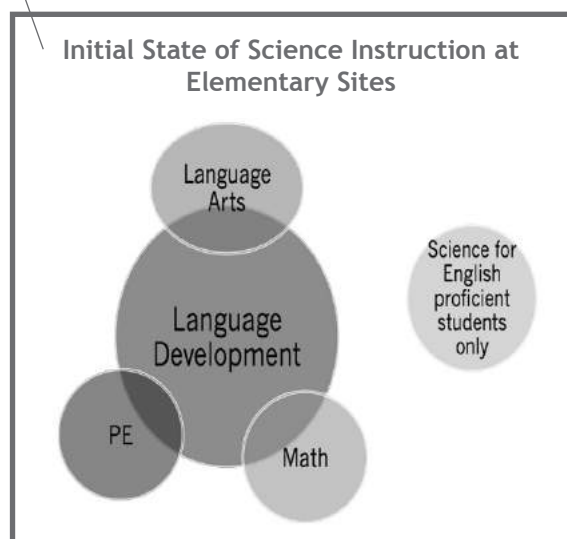


A Blended Science and ELD Lesson Design

Susan Gomez Zwiép
Associate Professor, Science Education,
California State University, Long Beach

I am going to tell you a story of mistakes. Thank god we made as many mistakes as we did because for each and every one we learned a great deal about how language and science together build a unique context for student thinking and learning.

When we entered the school district, this is a very good model of what was happening at the district.



The curriculum area of English language development was the overarching program overseeing all curriculum subjects, so there was no science department or math department, everything was under ELD. These

were the things that were taught, and if you were lucky enough to be an English-proficient student in the district you got science. If you were not English-proficient you did not.

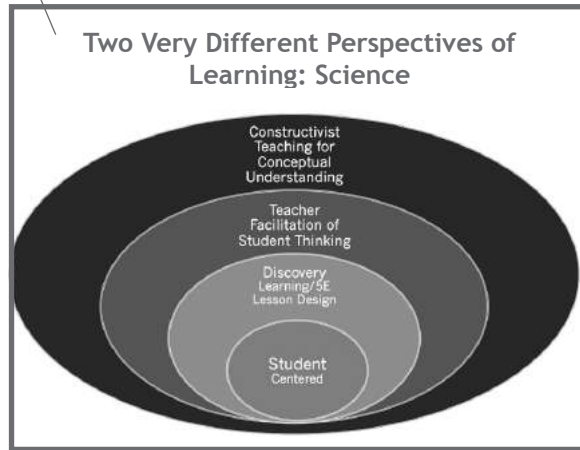
We applied for funding, and the funding is the same that Terry and Lauren spoke of, so a lot of that context is very much the same for this program and I am not going to repeat it. We applied for funding to do an elementary science project and what that would normally entail. Shortly after funding the district said, “Great, we don’t have any instructional time for science, so if you’re going to do science you’re going to have to do it as ELD.”

Our response was, “That’s not what we said we were going to do, that’s not who I am, that’s not what this project was, but okay, let’s try it.”

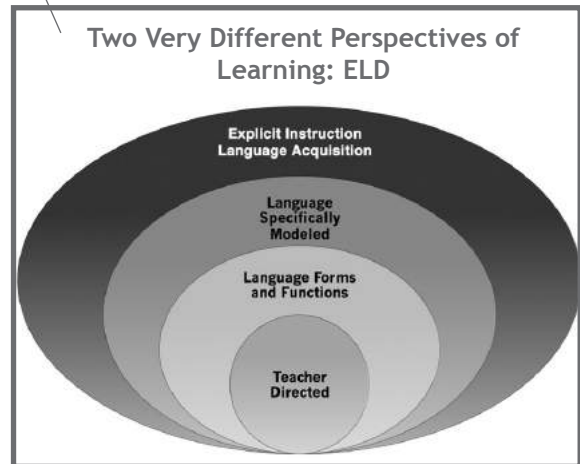
Keep in mind that meant that the district literally picked up the ELD curriculum that it currently used (and although they disliked it at the beginning, the teachers were now embracing and gripping with all of the strength they had as we tried to pull it away) and in its place said, “You’re going to teach science.”

We had a professional development team and I am simply one member of a team presenting this work. The science team came from the constructivist perspective on teaching and learning: that students come to a learning experience with ideas and experiences, and our role as educators was to provide a rich experience they could engage in. We would

facilitate their thinking through questions and responses so that they could construct their own understanding.



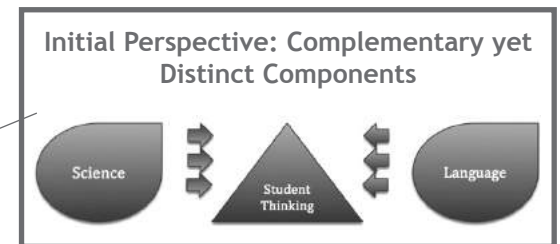
Our ELD counterparts were coming from what Guadalupe spoke of this morning as the more traditional framework. The teacher was more the center of the instruction, they focused on language forms and functions, the grammatical structures, to model language usage for the explicit goal of language acquisition. We



were working in an area in Southern California that had very few proficient English speakers and very few native English speakers, which meant the teacher was the primary model of English-proficient language. So in a philosophy that is already more teacher-centered than our constructivist view, the context we were working in pushed even more teacher-specific instruction.

So we talked, and I have to say it was the most rewarding experience I've had. We sat in this little office and we just battled. We battled what was important and what was needed, but we all had the same goal and that was a goal of equity. What was very clear was that the district was a mini-model in which certain kids got science and certain kids didn't, and that represented an even larger divide for students who were coming from more affluent areas than our students were. We were working in primary grades with the hope that students would begin to develop these ideas and these skills at a young age so that by the time they entered high school they would be able to compete and be able to have options open for science and other STEM fields.

So those battles were okay, but they resulted in this complementary yet distinct perspective of professional development. We had two separate weeks: There was a science week, there was a language week, and we literally high-fived as one group exited and the other group came in. Although we had had discussions originally, these were not designed



collaboratively, they were not presented collaboratively, and the teachers were left in the middle to put it all together.

There was one collaborative moment, and that was when we asked them to think about what it is that they do that is necessary for quality language development, and what is it that they do that leads to quality science learning. We were going to ask them to identify the overlap, where those are the same, and we never got to ask the question. They were doing these on Post-its and started to do it before we could ask the question. The understanding we came to through a lot of discussion and debate is that the teachers who were in the context came to it much easier. That is one of our first learnings, that the teacher expertise that they brought to the PD was something we needed to capitalize on because there is a great deal of expertise and understanding that they were bringing with them to the PD.

After that first year we licked our wounds and came back together. There was a summer institute similar to what Terry and Lauren described. There were also academic year components where they gathered and tried to put together blended science and language lessons. Then they would teach them, debrief them, revise them, and they did this several times.

What we found after the first year was a couple of important understandings. The first was that we needed to think about the science objectives first. When we initially did it we

were doing them simultaneously, but it led to artificial use of language and it led to watered down science. So we realized we needed to make sure that the learning goals for the students are clear, appropriate for the grade level, and rigorous for the students. Because we all believed that students could engage in really deep critical thinking about natural phenomena, we didn't need to water down the science. But if we didn't plan science first, the language conversations got in the way of the thinking because it wasn't natural.

The other thing that we realized is that if we would just listen to teachers as they discussed what they wanted to do in the lessons, conversations about the science and what kids would say and what kids would do, they naturally used all of the language that we could capitalize on in the lesson. So we started to have an observer track the language that teachers were using when they talked about sound in second grade, or when they talked about energy flow in third grade. They were using vocabulary that we realized the students were going to need.

We exited that first year with this understanding, that we needed to consider

Blended 5E/ELD Protocol: Science First

- The science content must be accurate and appropriate for the grade-level in order for the necessary language to emerge from students' thinking;
- language can get in the way of the thinking if it is artificially imposed on the content; and
- the details of the language development (forms and functions) can be pulled from the scripted teacher questions and expected student responses, guiding which language forms and functions would be used.

Revised Perspective: Establish Context First to Ensure Authenticity



the science goals first, then consider what language scaffolds are going to be necessary. What is the language that the students are going to need to engage in the scientific inquiry? We began to see a protocol for how you need to think about this in order to provide a rigorous scientific experience but also an authentic and natural place for language to happen.

We also used the 5E and started to refine our lesson template. Keep in mind the template is not supposed to be restrictive, it is supposed to be a place for teachers to come to consensus about the goals and the structure of the lesson. The teacher learning collaborative that we use requires that they come to collaborative decisions about what is going to happen in the lesson, and then evaluate the success of the lesson on student learning so they can make revisions.

So the focus is always on student thinking and the structure of the lesson, not the expertise of the teacher. Otherwise you could think, well he's a great teacher, and that's why the kids are going to get it because he's just a great teacher. This was our attempt to say, "Yes, but there are specific steps they are doing, strategies that they are using, sequences of questions that are happening that are leading to student learning. Let's analyze those."

So the Bybee model has what the teacher says and does to talk about what's happening. We started to add expected student responses so that we could think about not just what would

students say, but if we asked this question how do we know students interpret it the way we intended? We also wanted to include what they sound like at different proficiency levels so that we could think about the scaffolds that were necessary.

One of our learnings from the first year is this idea that the language function, the reason why they're talking about the science, or the reason for communicating, matches very closely to the practices of science. So the reason you might use language can often be the same reason why you're engaging in the practice.

So if you are going to do science (and we now have science and engineering practices), now you are going to also use language. If you go up to a person and say something to them, what might be the point of communicating? On the left are some science processes, but when you start to think about language functions they are pretty similar. This was part of the "planning science first." If we planned the science components first, we could then say we are asking students to compare different kinds of rocks. In that process, when they are comparing and contrasting, what are the language scaffolds that are necessary for the function of comparing and contrasting? So the

Language Objective:
Students will begin to speak with a few words or sentences. Students will use gestures to demonstrate new learning

Learning Sequence Concept:
Matter can change back and forth from one form to another. Matter changes form from a solid to a liquid.

SE	Teacher Says/Does	Student Says/Does			Science Concept/Language Function
		Low	Med	High	
Engage 10 - 15 min.	<p>Introduction: <i>Think about yesterday's lesson on Matter? How many different states were there?</i></p> <p><i>What were they?</i></p> <p>(Record student responses on board.)</p> <p>Gallery Walk- Post objects & pictures related to matter (e.g., water, a ball, pieces of fabric, craft sticks, lemonade, syrup) around room.</p> <p>(1 min rotations):</p> <p><i>There are objects and pictures of matter posted around the room. Observe each picture and tell your partner what you observe.</i></p>	<p><i>Three</i></p> <p><i>Solid, Liquid and Gas</i> (with gestures and/or native language support)</p>	<p><i>There are 3 state</i></p> <p><i>Solid, Liquid, and Gas</i></p>	<p><i>There are 3 different states of matter</i></p> <p><i>The three states of matter are Solid, Liquid, and Gas.</i></p>	<p>Science Observe solids and liquids. Solids and liquids have observable properties.</p> <p>Language Describing and Comparing</p>
		<p>Students walk in groups to each picture and describe what they see</p> <p><i>One word answers or Yo veo ____.</i></p>	<p><i>There is ____.</i></p> <p><i>I see ____.</i></p> <p><i>It is ____.</i></p>	<p><i>This feels ____ and looks ____.</i></p>	

What are the different processes involved in . . .

doing science?	using language?
<ul style="list-style-type: none"> • Observing/Describing • Asking questions • Analyzing data • Summarizing Trends/Patterns • Evaluating evidence • Constructing an argument • Creating explanations • Describing cause and effect • Predicting 	<ul style="list-style-type: none"> • Observing/Describing • Asking questions • Comparing/Contrasting • Defining • Evaluating • Generalizing • Drawing Conclusions • Creating Explanations • Describing cause and effect • Persuading

Embedded Vocabulary

- Words that will fold out of the lesson itself.
- This is vocabulary that can be developed through scientific exploration (sedimentary, liquid, precipitation).
- These words can be introduced during the lesson as students gain experiences related to the scientific concept being explored.

Front-loaded Vocabulary

- Words that need to be clarified prior to the lesson.
- These are words that you would expect English proficient kids to know, words that they would use when they are engaged in the inquiry lesson.
- Round, rough, spotted, smooth, above, around, etc.

ELD component matched what the kids were doing, and that was part of the authentic context.

We had huge fights about vocabulary. I can remember we had this granola bar and we kept holding the granola bar and talking about the granola bar because that was the science, but we had this huge debate about vocabulary. How much language did the kids need to engage in the inquiry? Our ELD fellows would say, “They need to be able to talk to each other because if they don’t have enough language to communicate, how are they going to do the inquiry?”

We kept saying, “But we don’t want to tell them all of the stuff, we want them to discover all of the stuff. How are they going to discover if you give them all of the words?”

So we came to the decision that there was this embedded vocabulary. Those were ideas and words that were going to come out of the lesson that we wanted kids to be able to use “kid language” to describe. We could then give them the academic language once they owned it.

However, there may be words that the kids need just to engage in the inquiry and that need to be sorted out. These are words that your English-proficient student would already know, things like “round,” “rough,” “spotted,” “smooth,” the words they would need to talk to each other.

These were some of the scaffolds that we

would use that were based on specific language functions that would be in the lesson. What you’ll see below is that we gave them a choice. We put these down on the tables and when the kids were going to talk to each other or when they were going to share out, we gave them these scaffolds. Often they have these really good ideas but couldn’t put them in sentences. Remember this is an ELD class and we are now responsible for ELD.

Scaffolds were purposefully selected and often included student choice to support inquiry

I see (hear, smell, feel, taste) _____

I observed _____

When I observed the _____ I noticed _____

I claim that _____

My evidence is _____

I claim that _____ because _____

I agree/disagree with your claim of _____

because _____

What I might do if I’m one-on-one with the student is ask the student to use the frame, but the student got to pick what level of scaffold they wanted to use, so there was some student choice in that.

We are going to add some context to this. We found that teachers were the ones who knew best what was front-loaded, what was embedded, and what scaffolds to use.

Let's add some context

- You are going to teach a lesson to a first grade class on the states of matter.
- Your content objectives include:
 - Students can identify the three states of matter (solid, liquid, gas).
 - Students can support claims with evidence (observations).

For this understanding of what a fourth grade student is like and what a student with beginning language proficiency versus intermediate proficiency is like—this nexus of all of what was going on in the head—the teachers were the best judge. We could give them all of the theoretical framework, we could give them experiences, but when it came down to it they needed to be able to

The lesson involves students observing three Ziploc bags:



1. A bag filled with “air”.
2. A bag with water
3. The bag with water after an Alka Seltzer tablet is added.

plan the lessons. There was facilitation, but they had a great deal of expertise about what was happening in their own student’s head.

Consider the Vocabulary

- What vocabulary would you need to review PRIOR to the lesson in order for students to participate in the activity (front loaded)?
- What vocabulary can be taught THROUGH the activity (embedded) ?

One of the best things that we could do is ask these questions and then get out of their way and let them plan.

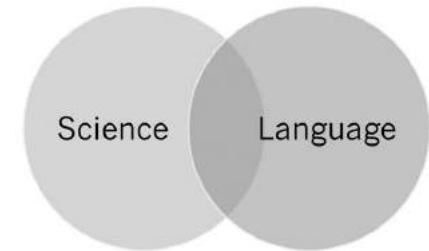
We ended with this level of understanding.

Finally, this is the sequence of planning. We always started with the “Explain.” What does it look like, sound like, when kids get it? And then we plan how to get there.

Consider Frames and Scaffolds

- What language functions are emphasized in the inquiry?
- What scaffolds are necessary to support these functions?

Final Perspective



Current Lesson Design

Science Lesson Objective:							
SE Stage	Teacher Does (Forms)*			Expected Student Response (Forms)			Concept/ Language Function
	Beg	Int	Adv	Beg	Int	Adv	
Engage							
Explore							
Explain		3			2		START HERE 1
Elaborate							
Evaluate							
Language Development Objective:							

I will leave you with a list of questions for consideration.

Questions for Consideration

- How can PD designs capitalize on the expertise that teachers bring to PD experiences?
- The major conceptual shifts in our project came from honest and sometimes difficult dialogue with colleagues from a different field in education. Should we reach out more often for these types of collaborations? How might inviting in other perspectives to our conversations benefit this work?
- The balance between providing freedom to explore and providing scaffolds for language is subtle and nuanced. What PD elements are necessary to foster an understanding of this complexity?
- The PD design was developed around previous standards and accountability systems that focused on low-level tasks and facts. Given the adoption of CCSS and NGSS, how can this program utilize the shift in focus to critical thinking and application of knowledge?

Susan Gomez Zwiép



Learning Language Within the Context of Science: a Professional Development Approach

OVERVIEW AND PHASE I

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

The context is our work in Sonoma Valley Unified School District and we are working in the same domain as the other case studies, experimenting with professional development approaches in terms of integrating science and language. When we first started with the district we found what I think is typical of most districts: language and science were thought of as separate enterprises, and there was very little time for science. What we had to do was develop a hands-on curriculum and materials, so there would be some experiences for teachers to provide their students so language could happen.

science was a good platform for developing language because there is so much talking and communicating involved, but a big part of our work over the past several years has been a complex and evolving challenge to understand where the connection really resides so that we are authentic to the science and we are authentic to the inquiry. And again, when we started we thought there was this analogous approach to language development that fit with inquiry. We just didn't know what the approach was, so we were on a search for quite some time to figure that out. You will see evidence of that search in a moment when we go through the phases of our development.

Lynn Rankin
Director, Institute for Inquiry,
Exploratorium

Paula Hooper
Senior Science Educator/Learning
Research Scientist, Institute for Inquiry,
Exploratorium

Sarah Capitelli
Assistant Professor,
University of San Francisco

Pre-conference Reading:

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

White Paper for Exploring Science and English Language Development: Implications for Teacher Professional Learning

January 2015

Lynn Ranking, Sarah Capitelli,
Paula K. Hooper

Available from Institute for Inquiry website:
www.exploratorium.edu/ifi

Overview of the Case Study

- Complex and evolving challenge to understand the theoretical and pedagogical connection between inquiry-based science and language development
- Looking for an analogous approach to language development to pair with inquiry-based science

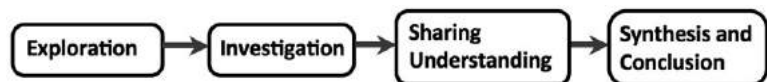
Project Background

- Collaborating with SVUSD since 2008
- All 90 of the district's teachers participating
- Experimenting with approaches to providing professional learning experiences to support teachers to integrate science and language instruction
- Teaching of hands-on inquiry-based science units

Also, as I mentioned in my opening remarks, when we started we had this intuition that

While we have had these major shifts in thinking about language development one thing has remained constant, and that is our view of inquiry-based science. Our framework that we worked from is represented by these phases. They are not linear as they are shown

Inquiry Framework for Development of Science Ideas



Underlying Elements that Shaped the Project's Phases

- Synergistic and productive relationship between expertise and experience of the Institute for Inquiry staff and SVUSD teachers
- Conversations and debates between inquiry-based science and language development perspectives

Lynn Rankin



here, but having this structure really does seem to help teachers get a sense of what it means to do inquiry-based science. There are many cycles, and you can blur the lines in all of these, but this is a way to get started. Our units are based on these as well, and they are very much related to the science practices that Helen Quinn talked about this morning. There is asking questions, planning and designing investigations, and a lot of discourse and debating and coming to explanations, all in the service of trying to understand something deeper about phenomena. That is where the marriage of science practices and the disciplinary core ideas (DCIs) come into play with each other.

There are a couple of underlying things that drove our work that I want to mention. One is the interplay between the Institute for Inquiry and the district. Here we are, very grounded in our thinking about inquiry-based science, and we come into a district and have teachers who are very grounded in their practices in the classroom and very knowledgeable about those classroom practices. The idea is to marry those and to create new knowledge from that. That is easier said than done.

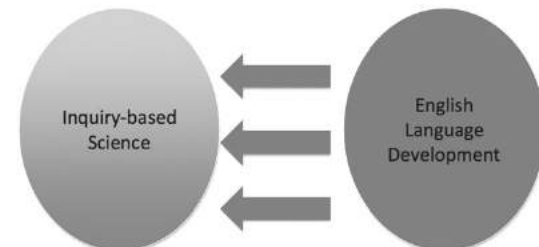
We had some major hard lessons to learn for ourselves because we were so used to providing these experiences. Teachers come here and they are all excited and then they leave and go away. We were trying to have an innovation happen in this project and it required a true collaboration. It took some painful lessons

for us to learn how to collaborate in a really authentic way and listen to what teachers were telling us about what their challenges and issues were, and then working with them to figure out how to create something that addresses those. And I can't make too much of trying to grapple with that because that is where I think the real payoff is.

Another place of grappling are these conversations and debates that happen between inquiry-based science and language development perspectives. Those are the debates that happened between the Institute for Inquiry and Sarah Capitelli, our language collaborator. We have very similar ways of viewing learning, but different pedagogical lenses about what it means to do science and what it means to do language, and we had to work hard to bring those together. Again, we feel that is an essential element of this enterprise.

Now I want to get to the phases. Where we started was thinking about inquiry-based science and bringing English language into

Phase 1: Getting started with inquiry-based science and ELD



that. What happened, because of the way that we set it up, is that English language development was seen as grammar and vocabulary development. We ourselves didn't know any better than that at the time, so we set up a situation that led to that. Also the district, as districts do, had pacing guides and their own language curriculum.

Phase I: Observations

- Language was conceptualized as something that is “inserted” into science instruction
- Language instruction was conceived of as grammar and vocabulary instruction and largely unrelated to the science content
- Thinking and practice were guided by district pacing guides and traditional ELD strategies and curriculum

- * Teachers noticed that their ELLs were engaged and talking about phenomenon and their experiences
- * Teachers were not clear about how this engagement and talk supported language acquisition

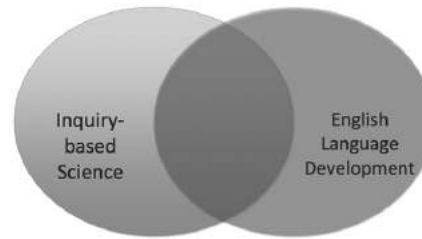
This is what happened as a result of that. There is no doubt that teachers were thrilled that their students were talking so much, and it elevated their sense of their students' potential. That is a really powerful thing. But at the same time, the teachers did not see the language development in the talking and the discourse, so there was a disconnect there. That will lead us to Phase II.

PHASE II

Paula Hooper
Senior Science Educator/Learning Research Scientist, Institute for Inquiry, Exploratorium

In Phase II we realized we needed to do some things to really support that overlap. One of the things was providing teachers with some curriculum so that they could do the work. Teachers needed hands-on materials and curriculum that they could use to teach inquiry-based science.

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

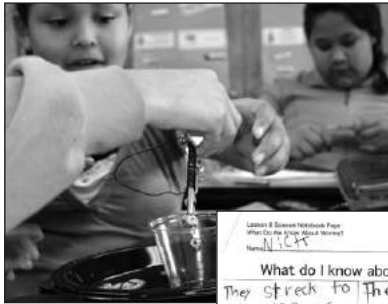


We developed inquiry-based science units, but there was that problem that we've talked about: the district had a particular view of ELD and we were sort of inserting ELD into science in the beginning. We knew we couldn't do that for the overlap because you can't just go through each unit and say you should address a certain piece of grammatical structure here or do particular vocabulary work there. That just doesn't work if you want language work to grow from what the kids' language needs are and what the affordances of the science are. You have to choose another way to focus your

Paula Hooper

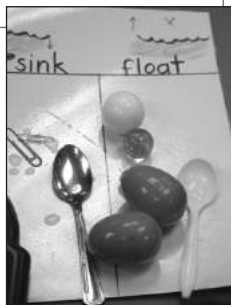


Phase 2: Examples



Samples of Guiding Language Principles:

- The **learning and doing** of science supports the development of language skills because it **requires** the use of language skills.
- Development of language skills requires teachers to **encourage, support, and create intentional opportunities** for language participation in speaking, listening, reading, and writing.
- Language participation can be **less than perfect** and still **support language development**.



work on language.

We chose one way to focus the language work, though we are not saying this is the best. In each of the science units that we designed we decided to focus on Science Talk and on Science Writing. We created different structures for Science Talks (including pairs, small groups, and whole groups), different purposes for Science Talks (i.e., gathering ideas and making meaning) and various ways of doing Science Writing.

We also recognized that one of the reasons you can't do that embedded piece is that you really want to step back and ask: What are the language demands of the science and how do you scaffold? You can use curriculum as one of the scaffolds, but you also want teachers to be able to develop other kinds of scaffolds. That is when Sarah Capitelli came in and started working with us, helping us to recognize the importance of framing language demands and having teachers be able to recognize what those language demands are so they can then make more design decisions about what kinds of scaffolds to use.

One of the things she helped us do was create a set of guiding principles that we thought might help teachers develop understanding of how to design for and support students in meeting language demands. There are some examples here. One of them was: "The learning and doing of science supports the development of language skills because it requires the use of language skills." It is the type of thing coming

through clearly in the themes today, but we wanted to hold that up in a way that teachers could use it. Another: "Language participation can be less than perfect and still support language development." That is a big thing for teachers to recognize. Those are the kinds of things that were in that overlap.

Phase II: Observations

- Development of inquiry-based science units
- Focus on *Science Talk* and *Science Writing*
- Recognition and understanding of language demands embedded in the curriculum
- Recognition of the role of scaffolding in making curriculum engaging and accessible
- Development of guiding principles for science and language learning

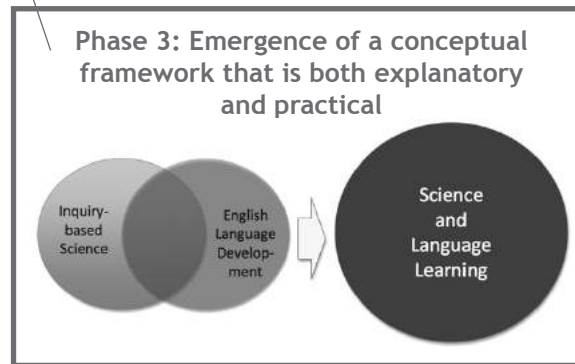
- * Continual tension to teach language as a separate content area
- * Uncertainty about direct language instruction vs. developing language in context

Then we were still left with these tensions. There were still tensions about teaching language in a content area because teachers felt an obligation to do things that were on the ELD test and make sure kids were learning that. There was also some uncertainty about direct language instruction versus developing language in context. What is that context? What does that really look like? That led us to where we are right now in Phase III.

PHASE III

Sarah Capitelli
Assistant Professor,
University of San Francisco

I'm going to talk about Phase III. As Paula mentioned, I entered into this project at what I would say was Phase 2.5, and now we are currently in Phase III. We have made a shift from seeing inquiry-based science and language development as something that is separate or even just slightly overlapping to something that is completely overlapping. In other words, you can't do science without doing language, and you can't do language without doing science.

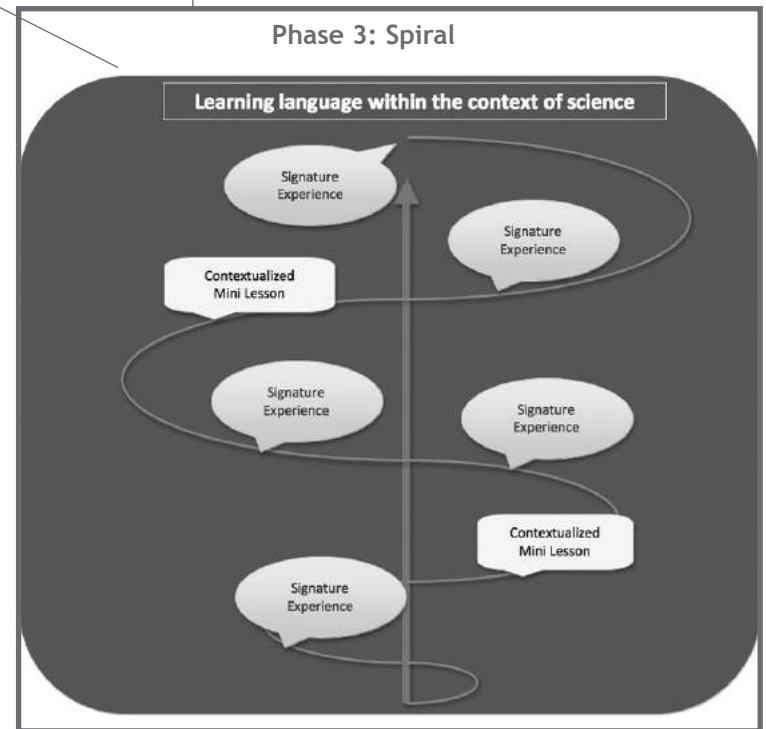


I would say the other shift that has happened in this phase for us is that we are really moving away from thinking about language development as ELD to thinking about how language develops during rich participatory experiences like inquiry-based science experiences. And it is hard. I am really ready to throw ELD out, it's gone for me, but for other folks still holding on to that it is difficult. That is a place where we are kind of mucking

about right now, thinking about science and language learning and moving away from this notion of science and ELD.

This was a big shift for the Institute for Inquiry. It was a shift in how we communicated with each other, but also with the teachers from Sonoma, and it was a shift in how professional development was structured. The shift required a conceptual framework or a model that we could share with teachers that helped articulate the shift. We have had teachers who have been working with us since Phase I and we have been shifting, so we needed another model to help us articulate where we are right now.

What we are currently calling our "spiral model" is what we are using with teachers to help articulate our thinking about the relationship between science and language. First and foremost in this model is that the model situates science at the center of teachers' work and students' work. Science is the "it," it's the "there there." It's the thing that students are doing, it's the thing that teachers are doing, and it is represented by this entire box here. It is really the driving engine of all of the learning, both the science learning and the language learning. With inquiry-based



Phase III: Observations

- Language development within the context of science learning
- Inquiry-based science is at the center of science learning and language development
- Important role of *Signature Experiences* in supporting students to communicate their developing understanding of science ideas
- Role of *Contextualized Mini-lessons*

Sarah Capitelli



science at the center of everything, the model really highlights the important rules in what we are calling “signature experiences.” Signature experiences are critical experiences that support the development of science ideas and also support students in engaging in the science practice, and they occur throughout these curricular units. Paula mentioned two of them, Science Talk and Science Writing, and there are also other ones. So hands-on experience with phenomena is a signature experience.

For us signature experiences are really important because they support children in communicating these science ideas, and they often require scaffolds in order for English learners to engage and make meaning of these signature experiences and during these signature experiences.

I am a little reticent to talk about the last part of the model, but I will. This is what we are calling “contextualized mini-lessons.” Because science is at the center of the teaching and the learning, opportunities to focus on particular elements of language (e.g., vocabulary or particular structures) can be better contextualized. I think all of us have had the experience, either as a teacher or working with teachers, that teachers want more support around thinking about direct instruction when it comes to language conventions, and this is a tension. This is a tension that I experience as a teacher educator and we experience doing the PD. In this direct instruction, what has been helpful for us is

that when situated in the context of science learning, I feel we are better able to talk about opportunities for what I am calling contextualized mini-lessons. It has helped us to help teachers in understanding why that kind of instruction has to be contextualized; that if you do an instruction on structure and it isn’t contextualized in the doing and learning of science, then it’s really an experience that is happening outside of here and it’s not going to serve learning how to better communicate science ideas.

So where are we right now? We feel like we are in a better place conceptually in terms of a relationship between science and language, and we have a clearer idea of what we want to be conveying to teachers, but we are

Phase III: Observations

- * Professional development that provides first hand science inquiry experiences can be transformative for teachers’ understanding and practice of science instruction
- * What are the parallel professional development experiences for language development within the context of science teaching?
- * Given current constraints (e.g. pressures of standardized testing, funding limitations, traditionally held views of language development, etc.), what professional development approaches to learning language in the context of teaching science are most likely to be effective?
- * We are supporting teachers to listen more closely to student talk about science and helping them think about what the talk tells them both about their science learning and their language development

still wrestling with the spiral and how to best support teachers in building the bridge between the spiral and practice. How do we build that bridge?

We know that professional development that provides first-hand science inquiry experience can be transformative for teachers' understanding of practice of science instruction, but we don't know yet what those potential parallel professional development experiences are for language development within the context of science teaching.

We know that teachers coming here and having really engaging, exciting and rigorous experiences with hands-on science helps them become better inquiry-based science teachers, but we are wrestling with what is that parallel experience or how to embed a similar sort of experience for them in terms of thinking about language.

And then, given current constraints including funding limitations and traditionally held views of language development, what professional development approaches to learning language in the context of teaching science are most likely to be effective? What kinds of experiences can we have during the PD that are going to be most effective for teachers and for their students given the constraints that we are working under?

I want to mention one thing that we have started to do which I feel is really promising. We are supporting teachers to listen more closely to student talk about science and

helping them think through audio and video, collecting audio and video data. We are helping them think about what the talk tells them both about their students' science learning and developing science understanding, and their language development, and doing those two things together.

Summary Discussion of Case Studies

THE NEWS: GOOD, BAD, OLD, NEW

Cory Buxton
Professor, University of Georgia

I was asked to reflect on the three PD cases and as I was thinking about these cases, it is very striking how across different contexts and different projects so many similar themes emerge. It is probably not surprising, but it is striking. There is some good news, some bad news, some old news, and some new news in all of this, and I have four brief comments.

The good news is, I think we are in a really exciting time because we are in the midst of developing and adapting and applying new theoretical tools both for thinking about science and for thinking about language, about the goals of science teaching and the goals of language teaching. NGSS gives us the 3D framework to replace older conceptions like the 5E model which, while it is still around, has to be on its way out or at least fundamentally reconceptualized.

Cory Buxton



Teacher Agency and PD

The bad news is that the teacher agency is continuing to decrease in our schools. There are so many forces that take agency from teachers and make them feel like they're just in this critical response mode to all of the initiatives that get thrown at them, so PD becomes just one more thing that gets put on their plate that they need to figure out how to fit in with what we want them to do with all of the other things that they're being told that they need to do.

We need to ask ourselves as professional developers, are we empowering teachers and instructional decision makers or are we just sort of piling on to their already over-full plate.? We need to rethink our positioning in this. We are a piece of the system. Though I don't think any of the cases talked about agency explicitly, to me this is a question of the structure and agency dialectic. Are we helping empower and give agency to teachers or are we detracting from that? • Cory Buxton

And when we think about new theories from second language acquisition that we heard about this morning, moving away from functions and more to thinking about usage of language, that is going to push out some of the older models of ESL instruction and second language acquisition that we have in the schools. So it is a really exciting time and I think this challenges some of the traditional relationships we have between everyday language and academic language and between L1 and L2. These new ways of thinking help us shake up and reconceptualize how we're thinking about the role of language in science.

That's the good news.

The old news is that with science learning (whether it is the three-dimensional model or the 5Es) and language acquisition (whether it is function or usage), theoretically we always paint them as complementary, but they tend to be treated separately in practice rather than really systemically integrated. So I think the work that this group needs to do is help all of us and the teachers we work with think about not just that these ideas seem to go well together, but how do we on the ground actually help them go together.

The new news relates to Guadalupe's term this morning about "language-rich affordances," which I love because our project is called Language-Rich Inquiry Science. The bottom line is that we need new models of professional development. All of these projects traced a path: We thought we knew what we were

doing and realized, as we started working with teachers and empowering teachers and trying to give them some agency, that in fact we needed to change how we were thinking about our model, and we need PD that looks at new contexts, new ways of doing PD, and brings together new players in our PD.

We get very comfortable thinking that as experts in PD we know best practices that have been around for years and we just do them. I think this work should cause us all to question what we think we know about where PD happens and what it looks like, and we need some new settings and contexts to think about it. I think this is the group to push the field, and not just for science. We can serve as a model for what a lot of other people need to be doing as well.

FLAWED LANGUAGE, BILINGUALISM, CHALLENGING THE ELD MODEL, JOINT SCIENCE & LANGUAGE LEARNING

Chris Faltis
Professor, Director of Teacher Education,
Dolly & David Fiddymant Chair in Teacher
Education, University of California, Davis

I had some of the same observations. There was a lot of old and new and overlapping among those three presentations. What really struck me is that the people doing these research projects, these case studies, learned as much about PD and about the teachers' lives as the teachers did about some of the content areas, and I thought that was really wonderful.

I thought what I'd do is talk about four points that struck me rather than going over the particular studies themselves. One is that there was very little discussion about what Guadalupe Valdés and others talked about this morning regarding flawed language or the role of emergent language. I know that Paula Hooper mentioned that a bit, the idea that students can talk about what are very complex ideas for them, depending on age and grade level and what not, with language that is sort of emergent language: that they are able to do that and participate and grow and actually do some of the things that are important for science learning in this less-than-perfect language. I think that is really hard for a lot of teachers and it may get harder as you go up in the grades. I don't have any evidence for that, but my experience working with teachers is that when students produce language that is less than perfect, there is almost an urge to check it and correct it because of this old idea that if we allow bad language to continue it will turn into a habit, the old Skinnerian ideas that keep living on.

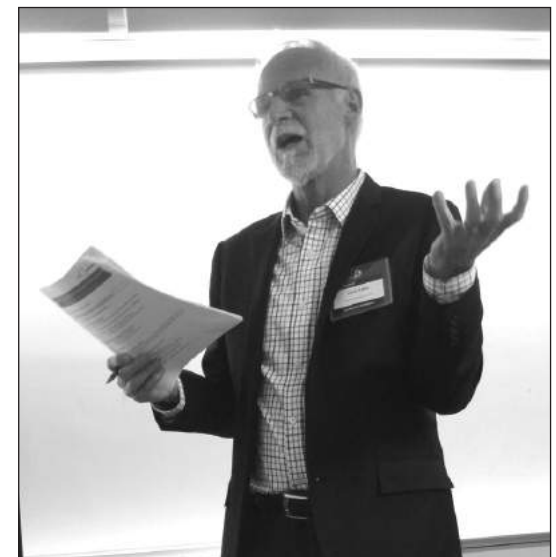
I was also really struck by the fact that I didn't hear a lot about the role of bilingualism, particularly how children use both languages. We know this, and some of the recent work on translanguaging and translingual practices talks about children who use two languages as they understand these concepts. I didn't see this in the PD, and I wonder to what extent those kinds of issues came up with teachers and how they advocated for children and understood

the role that bilingualism has in developing these science concepts.

I think that's an area that we really need to look at because that relates to the idea Sarah Capitelli expressed, that ELD may be obsolete. That's kind of nice to hear because look what it does. "ELD" is "English language development" as opposed to "language development." It privileges English. It also uses a separate model of English, or the idea that language is something out here that you count and manipulate and structure as opposed to something that belongs to a community, something that is socially developed through interaction with others. I think it is a time for us as language teacher educators, and for teachers and those involved in the lives of students and teachers, to really challenge those ideas about English language development, particularly separate-but-parallel monolingualism as the model for bilingualism.

The last thing I'll say is that I was also interested in the ideas I heard about what happens in science learning because I'm not a science educator myself. I'm a language educator who works a lot with teachers who do lots of things like this. I think about Barbara Merino, who did BICOMP so many years ago, which was such a wonderful bilingual science effort. But I have always looked at it from a language perspective. The idea that language emerges out of, flows out, grows and unfolds when you have these very rich kinds of science

Chris Faltis



things just makes so much sense to me. It is the way that we develop as people who can communicate and speak and argue and say, “Hold on, I don’t get this, tell me more.” That happens when you have these really rich kinds of experiences, and we know that.

To me it really interesting that we have these two worlds. There is science learning and there is language learning. What I love about this conference today is that we are really looking for ways to pull those things together and to show how they work together. So I am encouraged, even though there are lots of things we have to change—the 5E model and all of those things. We can do better than what is out there, and I am really jazzed about this.

Discussion and Q & A

A FOCUS ON TASKS

Honing in on What Student Do

- I think what every group was talking about is: What are the tasks that students need to do in order to learn science, and what are the tasks that students need to do in order to learn language? If we think about professional development, it is not about what teachers do but about what tasks they give students to do. It is thinking about learning tasks (and they can also be assessment tasks at the same time or in separate moments) in terms of what is it that students need to do in order to learn

this rather than what is it they need to learn.

I think maybe we need a common language for both groups. And then, what tasks provide both language learning opportunities and science learning opportunities? Which ones do we need to add to specific pieces that are not automatically coming out of these tasks? That seems to be the evolution approach from all three case studies towards thinking more about what is it that the students do and how they are doing that, and what supports they need in order to engage as their language develops. That’s a language we don’t use enough, talking about what it is that the students need to do.

- Helen Quinn, Professor Emerita of Physics, Committee Chair for Conceptual Framework for New K-12 Science Education Standards, Stanford University

Local, Meaningful Tasks

- I’m going to take Helen’s comments about tasks even further. According to the previous generation of standards, when we say “tasks” we typically think of matching the science content because the standards are typically information concepts, to those particular tasks. What is unique about three-dimensional learning, according to the NGSS, is that we are talking about “explain the phenomenon” and “design a solution to the problem.” They are talking about these tasks that are real to students. What that means

LEADING INTO THE NEXT WORKING GROUP

- These are the types of comments that are going to lead us well into the next working group, so don’t forget that. • Paula Hooper, Senior Science Educator/Learning Research Scientist, Institute for Inquiry, Exploratorium

for student diversity is that a problem is inherently local, it is what is meaningful to the kids. Solving a problem and designing a solution to a problem is something local. It is a change in the discourse of a task from the concepts to a problem and a phenomenon that is local and meaningful to students, and we need to push that to those local settings that are meaningful, and that goes into Cory's comments about agency. Kids own the problem. • Okhee Lee, Professor, New York University

LEVELS OF TEACHER AUTONOMY IN VARYING DISTRICT CONTEXTS; CREATING COMMUNITIES OF PRACTICE

- One commonality between the three cases is that there is a lot of coproduction going on with the teachers and the professional developers, and that is the way that it ought to be. In many ways I see that we push to get to strategies or to recipes that will work everywhere, and yet we have to recognize that it is always about the particular context that you're in and how you work that out. In many ways, who is involved in the conversation and who has power in that conversation will make a big difference in how much we respond to these different tensions that we see.

I think in some districts, in part because of the structure and because the district might have some history, there is more willingness

to let go and give teachers autonomy. In other situations the amount of teacher voice is very limited and that is very challenging. Professional development has to take that into account and perhaps build communities of practice across sites so that there can be more learning of lessons from others for dealing with the same challenges. In our teacher research studies at Davis, one of the things I've seen is that there are some districts that do give that autonomy to the individual teacher and others where teachers might have just half an hour of disposable time a day that they can control. So we need to help in building those communities of practice. • Barbara Merino, Professor Emerita, University of California, Davis

FORMATIVE ASSESSMENT TASKS; LEARNING FROM THE MATHEMATICS ASSESSMENT PROJECT

- I am following up on what Helen and Okhee said and want to share an example from math education because it's a good example and resource. Yes, we need to help teachers think about language differently and how it's learned and bring that into practice, yes, we need help teachers learn to think about mathematics and what it means to learn it (substitute "science" whenever I say "math"). However, when I talk to teachers they say, "Give me something I can work with and design and take apart and take into my classroom."

Judit Moschkovich



LEADING INTO THE NEXT WORKING GROUP

- The type of comments you've just made are the type that will generate discussion for the working groups. Each group will have a facilitator and you will have some questions to guide you in capturing these types of ideas. I know that everyone in here has some insights regarding things that were engendered by the cases as well as things that came up from the presentations this morning to really help us identify what we need to think about for developing this type of professional development. • Paula Hooper, Senior Science Educator/Learning Research Scientist, Institute for Inquiry, Exploratorium

So I'm going to share with you a website that was 30 years in the making, and I am a fan of this website. It is the Mathematics Assessment Project, the Shell Centre (www.map.mathshell.org). They have been designing tasks, problems, and lessons that are now called formative assessment lessons. I am convinced that one of the ways to support teacher inquiry is formative assessment so that teachers themselves come to understand first, "Oh, my students know more than I think they do." Second, "Oh, they're expressing it in imperfect ways." And third, "I'm going to build my teaching on what I just assessed," and that will be the formative assessment cycle. The Mathematics Assessment Project and the formative assessment lessons embody those design principles and invite teachers to become designers themselves, to be active in designing lessons.

These are the same principles we should be using to design lessons that support

language for English learners (and other students). My latest thinking is to continually ground the work I do with preservice and inservice teachers in these exemplary tasks and lessons. They are based on so much expertise, 30 years of thinking about formative assessment lesson design. However, we start with those tasks and, in addition, think about how to support language development. The math part is there, we don't need to do that again. What we need to do is take those wonderful tasks or lessons, and have people who work with language development, whether it's first or second language, help us make those lessons work in terms of the language development. • Judit Moschkovich, Professor, University of California, Santa Cruz

Launching into working group discussions



WORKING GROUPS

Introduction

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

As a transition from the cases that we just heard around professional development, we are going to give you an opportunity at your work tables to talk about these questions so that we can really start to refine some of the thinking we've just heard.

Working Group Task Description

Use the cases and your own experience as a catalyst to think about the kinds of professional learning experiences that need to be created to support teachers to develop language within the context of science.

Prepare to share highlights of your discussions.

- What challenges are surfacing about how to help teachers come to understandings that can help them to teach science and support language development?
- What conceptual and practical work can help to address those challenges?
- What patterns emerged across the cases?
- What pedagogical tools and resources will be supportive to the development of new classroom practices?

You are going to have a facilitator to move your group along because we want to get to a place where there are some concrete ideas. The sub-questions [above] can help you think about the larger question.

Report-out Synthesis

CONSTRAINTS, CHARACTERISTICS OF SCHOOL AND DISTRICT PD MODELS

- What does it cost? What is the budget?
- To what extent does the school have time for the PD?
- The role that school culture plays in providing this process of professional development.

OVERARCHING PD DESIGN

- What we would ideally love to see is not so much vertical professional development but some kind of horizontal professional development so that there is distributed expertise among teachers and we are availing ourselves of that distributed expertise.
- It should be continuous and long-term, not the type of PD conducted in isolation, focusing for three days on subject A and you're done.
- There could be summer academies where the teachers learn the practices and then get to try them with their students, get some feedback, and make adjustments, so it's more organic in the use of learning language and science together because they get to see how it affects the students' learning.
- When we collaborate across grade levels or across groups we have to be careful about the use of vocabulary because the vocabulary

BUILDING ON IDEAS

- As you report out, rather than repeating ideas the previous group just reported on, contribute ideas that your group came up with that add to and expand what we are thinking about. • Lynn Rankin

Working group discussions



CHALLENGES FOR NON-ENGLISH SPEAKERS AND THEIR TEACHERS; EMERGENT BILINGUALISM

- In California, their home language is not promoted and in some cases is forbidden by law. It is difficult for us because we are not advantaging language that the students bring to school settings, and we find this an unfortunate missed opportunity for students to be able to engage in science.
- We have to look at this whole sense of emergent bilingualism as opposed to moving kids from L1 to L2. It is sustaining languages and how that plays into learning both content and learning language. That is still an open discussion.

Working group discussions

may have different meanings, so we need to be explicit in the different meanings of those words.

- The three models that we saw were partnerships between universities and districts, and that is a very powerful model. At the same time, university folks and people like the Exploratorium, the Hall, etc., as well as service providers within the central office need support. They need support both from the district and they need other supports. In California there have been subject-matter projects and there was one of those projects here at the Exploratorium. It is important for us to reach out for those systems and structures that are there that will be there for the long run so it is not a one shot deal, and we all need that support.

TEACHER AGENCY AND CO-CREATION

- Is teacher knowledge at the center of these PD models, and to what extent is there a co-construction of what is happening in the model?
- The challenge of teacher voice was a pattern across all of the case studies.
- How do we design professional development so that there is co-construction, and what is the role of the teacher in the co-construction, but without reprising all of the debates of the lessons learned that led to the overarching design?
- Where do you come in with the professional development drawing on teachers' expertise, at the same time you're working within the broad range of teachers' zones of proximal development?
- The common thread through the case studies was shared experiences across the board, telling a story that blended science and language. The growing and learning of this concept over time is something that needs to be done in order to flourish. Coming in and saying here, we're going to combine and blend models would not have been successful. It wouldn't have had as much teacher buy-in.
- If there had not been co-creation of units and lessons with teacher input, professional development input, and expertise from the science and the language experts, it would not have been as successful and would not continue to be successful.
- How can this be done in a respectful way? How can co-creation of lessons validate the knowledge and expertise of teachers and scientists and language experts and really take that all in to create empowerment?
- What experience could more veteran teachers have, not in the "train the trainer" model but in a more localized and nuanced way, contribute in mentoring their peers? How do we take advantage of the knowledge of practice that excellent teachers have and use that as a tool?

NAVIGATING HIGH STAKES PRESSURES

- Teachers in general tend to cling to what they know and are familiar with. Principals are often under a lot of pressure from someone on top of them about test scores and the kinds of things that are still hanging around from No Child Left Behind. As we go through these shifts and challenges, teachers need to know what is okay to do and we need to be explicit about that.
- Because we still live in a time of high-stakes testing, even though we are in a pause in California, this will continue to be a difficult challenge for English language learners and emergent bilingual children.

**PD CONTENT: WHAT WE WANT
TEACHERS TO UNDERSTAND, KNOW AND DO**

- The importance of using student data, not test data but real data from what they produce, to inform teaching, and helping teachers to understand how to analyze that data.
- How to use curriculum overlapping maps between science and language arts standards.
- Science Talk moves and the testing out of ideas.
- Teachers, especially those in the upper grades, don't see themselves as competent language teachers. That is not as true in K-5, though it is still quite true except

for districts where there is an intentional push for putting science notebooks and the academic discussions as part of science instruction. Some districts have been able to do that, but there is still that dichotomy of language content and language as a separate thing.

There is a need for all teachers to set goals, both content goals and language objectives, that will be very intentional so that science instruction will be geared towards this process of answering questions and reaching goals to deal with both content and language. There is Kathy O'Conner's work around Teacher Moves and establishing goals for these academic discussions.

- Teachers and districts and principles need to have a broader understanding of what language means, that there are different representations of what language is, that a graph is language, that a drawing is language, that there are many different forms of communication that are still considered language. It is important to broaden our perspective of what language is and that language is fundamental to learning. Science is a language.

PD TOOLS AND STRATEGIES

- What are the catalysts for change?
- It is important that there be coherence and alignment.
- There is the value of video, but it is hard

THE IMPORTANCE OF WRITING

- There is the importance of writing for language development, not only for kids but for teachers to think about their own learning and also to think about their kids' learning. We felt writing sort of got left out of the last inquiry push in science education and it's really going to be critical in NGSS.

Working group discussions

AN INQUIRY FOCUS ON LANGUAGE

- We wondered, in thinking over the case studies, about looking at language as inquiry, diving into, “What do you see, what do you notice, what do you observe about language structures,” and looking at and talking about and investigating the language in the context of science, and using that science as a vehicle for really looking at language structures, usage, and knowledge of language in a way that is inquiry-based for students.

for video to make really transparent what is going on. Think of the image of ducks gliding smoothly across the water and onlookers never appreciating all of the churning that is going on underneath. Really exemplary teaching looks like that smooth gliding. How do you get below? There can be vignettes or narratives accompanying video.

- In a very practical sense, what needs to be done in supporting teachers? The idea is to be very intentional and explicit in the use of strategies, and stopping to make sure that we are asking the teachers what they noticed and what they think is going on so that they’re internalizing the message of the professional development and are engaging in active learning about the 3D model as well as the language infusion within that 3D model.

There are specific ways this could be accomplished. We could design a science lesson with some language elements in it and teach it to the teachers in a different language that none of them spoke, so they

could experience first-hand some of the struggles that their own students are facing. Then use some strategies to promote the language as well as the science to help them see how students can learn if they’re being supported with other strategies.

We could give teachers a task and not let them talk and let them see what that looks like. Then give them a task and let them talk. Then give them a task and let them only write. They could see the different language skills that are involved in each of those so that they could walk in the shoes of their students.

A FOCUS ON FORMATIVE ASSESSMENT

- What does it look like?
- Why do we say that good teaching is good assessment?
- How do we use that to really represent the progress that our students are making?
- There is the critical role formative assessment plays, both for teachers and for students, in using formative assessment to understand where they’re at and where they need to go. There were some great examples of funded formative assessments. Again, it’s a case of not having to reinvent the wheel every single time. There are a lot of good tools that have been developed out there. Are we systematically building on work that others have done?

Working group discussions



Ongoing Questions: Changes and Shifts

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

Good job everyone, and there are a lot of patterns that are emerging. Tomorrow afternoon we will be trying to synthesize some of our ideas so that we can feel comfortable making some statements coming out of this conference.

There is one thing I would like for people to keep in the back of their minds, and it is something we haven't discussed as an organizing group yet. Chris Faltis and Cory Buxton challenged us to think radically, in a way, about what we are doing, that it's time for a shift and a change. It would be great if we had some conversations, whether formally or informally, and put on the table for each other what some of those changes and shifts might be.

They identified a few places, like the 5E model and ELD instruction, that need reconceptualizing. What does that mean? What are we shifting toward? When I heard that I felt energized by it and wanted to get down to work and think about what changes the Institute for Inquiry might make in the way that we've been doing our work and be a little more radical about it. We have taken these incremental steps, but how can we propel ourselves into the next stage? However, we have to be realistic about the context that teachers and all of us live in, so I don't want to be ingenuous about that.

But hopefully we can have that conversation so that we don't just stay in the realm of what we know and instead put some of these changes and shifts on the table.

Working group discussions



Introduction

- Give yourselves a pat on the back. We are at the home stretch of day one. One of the things that I heard in one of the groups, and I think it was a theme across groups, was that in order to do this type of work you have to be grounded in the place that you're coming from, but you also have to be willing to recognize that you need to learn something.

If you're a middle school science teacher you have to recognize that what the English teachers are doing is something you need to learn and pay attention to.

In the work we have been doing as science educators, we had sense enough to know that we needed to find some language people to have that dialogue with, but it's really hard to find people who can do all of those things equally well. The synthesizers we have chosen are people who are dealing with multiple things from that place they are located in. We want to get their wisdom about the day so that you can let it soak in and think about it in preparation for what is going to come up tomorrow.

• Paula Hooper, Senior Science Educator/Learning Research Scientist, Institute for Inquiry, Exploratorium

SYNTHESIS OF THE DAY: SESSIONS I AND II

Expectations and Challenges

Karen Worth
Chair, Elementary Education Department,
Wheelock College

As this afternoon has progressed I thought, synthesis has happened here already, I don't need to say anything. So I want to share just a few thoughts and you tell me whether it's a synthesis. One of the things that struck me, certainly from this morning and also from this afternoon, is that there is quite a lot of consensus in this room about the nature of good science process. I am hearing a lot of consensus in the area of this idea of social acquisition of language. Some of this is new to me and I am delighted to be here to learn this because I come more out of the science of things. It seems that we have a lot of shared ideas here in this room, though not necessarily beyond this room.

We may also have a shared consensus about what it looks like in the classroom, but I'm not sure, and I think that's an interesting thought to have. When we talk about professional development and where to go, we are talking about how to take the shared ideas of science and NGSS and so on and translate those into the classroom, but I am not sure we have the consensus and the explicit description of what that looks like in the classroom.

And actually I would say "descriptions," because I don't think it looks one way. As I get older and older, I think that I know less and less about what the ideal way is and perhaps more and more about the range of ways in which the ideas we have in this forum translate into classroom practice. It doesn't all look the same.

Having said that, I want to think for a moment, because we are about professional experiences with professional development, about what the implications are for teachers from all that I've heard today and have been thinking about. I have put together a partial list of all of the things that we have been talking about that would be good for teachers to know and be able to do, and it is stunning. That is a humongous array of things. We talked about science knowledge as defined by NGSS and the three content practices and crosscutting concepts, about language acquisition, about formative assessment. We talked about pedagogy, about science instruction that is rich, about science inquiry and the use of practices, problem situations, tasks. We talked about the role of questions, and crosscutting concepts as a way of thinking about those questions, as Helen and Okhee have suggested. We talked about agency and responsibility.

We talked about facilitation and discourse. Think of the skills that go into facilitating the kind of discourse we are talking about, whether it's with young children or even with

adults. That is an enormously challenging pedagogical task to guide this kind of thinking.

We are talking about re-emphasizing the role of engagement and exploration as time for kids and adults to move freely in phenomena and ideas before moving on to other aspects of inquiry. We are talking about the role of visuals and how that plays into what we are doing.

We are talking about language and how it supports, and how we need to think about language and science as one thing, and how we have to think about the diverse levels of language knowledge that kids bring, that role of language. I loved Sarah's comment about the child who "carried himself differently" when talking to a Spanish-speaking adult. That phrase really struck me when we think about what we need to do as teachers, what that difference looks like. It is something we have to think about and teachers have to think about.

That is just a partial list of pedagogical stuff. Teachers also have to think about attitudes. Somebody talked about our own enthusiasm for something that carries into the classroom, and that matters. What if we are not very enthusiastic about that worm or that snail?

We talked about a willingness to let go of those narrower expectations of what language should look like or what science should look like. We (and I mean all of us, but also teachers—I don't like the we/they distinction) have to let go of it ourselves in order to move forward. That

speaks a little to what Lynn was asking about going in another direction.

In talking about expectations of children, something that came up a number of times that struck me was this idea of how often, if not explicitly then implicitly, we privilege language, and that is our evaluation of our students, through their language ability rather than the many other ways in which they express themselves.

If you take all of that and say, "This is what teachers need to know and be able to do, they have to do all of that and much more," what are we asking and how do we get there? A lot of things have come up here and I'm not going to propose any solutions, that's for tomorrow and fortunately I'm not synthesizing tomorrow. Rather, I am thinking about some of the challenges that have emerged from this vast terrain that we have described, very excitedly by the way. I think this has been a very vibrant and interesting discussion and all of this stuff has to be out on the table.

But in thinking about some of the big challenges, what experiences are most effective for teachers to access this knowledge? Direct interaction with science has been talked about. We had some examples of direct interaction with language that might parallel what we do in science. Are we thinking about it that way?

We also want to think about a trajectory. If you've got that massive amount of practices

Karen Worth



Teacher Involvement in the Science-Language Debate

Something that came up a lot in the afternoon session is how to include the voices and experience of teachers, and I think we are all on the same page on that, that this has to be.

But what struck me in listening to people this afternoon is that I heard in the work groups how the professional developers from the science side and the language side had to work together to find that common territory in order to be able to move forward. I wonder sometimes whether, as teachers and professional developers, if we do that first and then move into the professional development work, we have in a sense not only allowed our teachers and our colleagues in schools to be part of that debate. If they are not part of that debate then it is still received from on high. We have to be careful as professional developers (as in our work with children) that we are not doing the thinking for people, that we are engaging people in the same struggles and thinking that we are doing. Now how you enter that and where you enter that is the big, big question that came up at our work table.

• Karen Worth

and knowledge and so forth, whether it's preservice or inservice, how does it progress? What's the trajectory? What comes first? What comes second? Is there a sequence of that kind or is it organic what emerges? I'm not sure what the answer is to that. Maybe it's based on who those practitioners are and what they bring.

Parenthetically, because I meant to say it earlier, I think that we want to also be careful to not just engage the practitioners with us but really value what they bring. Way back in my experiences as a professional developer I had this quite wonderful experience of walking into the classroom of a teacher who had her desks in rows and looked like a very traditional teacher, and I formed a pretty quick impression of what this was. Then I sat in her classroom and I listened to her teach and watched the children whom she taught, and it was magnificent. The strategies she was using, some of the ways in which she interacted were not mine. I would not have used them. I probably would have said, "That's not the way to go."

So I think we have to be very careful not to be narrowing in our views of as we think of our professional development experiences. How can we not only hear where teachers are but also acknowledge that even if a teacher is teaching in a different way than we might think is the right way, the teacher's way is bringing something to the table that is absolutely critical and belongs to that person and should belong to all of us.

This whole question of curriculum has come up in several places. I do not think that teachers need to be curriculum developers on their own. At our table we went back to 1985, with the notion of "educative curriculum." We need new curriculum, we need new curriculum development work that really provides teachers and ourselves with the beginnings, with the "stuff" of what to do, with the constructs, which then over time become changed and belong to teachers. It is a huge task. As teachers and developers we need curriculum.

And there is the question of how much scaffolding for teachers and how much scaffolding for kids. There are a lot of parallels between professional development and our own learning and how children learn. How much do you scaffold for teachers? How much do you scaffold for kids? How do we think about scaffolding that doesn't turn into crutches?

We have talked about how we deal with the narrow, punitive, and constraining elements of the recent standards and assessments. We don't need to go into that, we all know what it looks like out there in the real world. I don't know how to solve that problem, I'm too old. But what we do need to think about is how we can help in any way to protect teachers, at least for a limited amount of time. How can we make a little space in time and pressure so that they have the opportunity to at least begin to do some of the things they and we

think are the appropriate things to do? That means working with principals, it means working with the politics, the economics, and all of what is going on in schools today. In my 45 years of experience, I have never seen a scene as destructive of teacher creativity as what we are seeing now. We have to be part of acknowledging that and helping to solve it.

The last thing I want to mention is something I think we don't necessarily talk about a lot but really need to in our work with teachers and amongst ourselves. All of what we are talking about in science and language learning has to do with what we think about learning in general, so as much as this is about science and language and how they work together, it is also about the nature of schooling. It is about values and what we think the purpose of schooling is. I would suggest that some of the "stuff" that's coming down from the outside suggests a view of schooling and an outcome of schooling that is in tension with the kind of constructivist, developmental, etc., culture and community that we want to have in our classrooms.

If we don't talk about those values, if we don't talk about those principles, and if we don't talk about those desired outcomes, I think we are missing a foundation level of discussion amongst us and with teachers that is key to the shifts that we are asking for. I don't see a lot of classroom communities that permit that kind of discourse, that kind of risk taking, that kind of exploration, that kind of mistake-making,

whether it be flawed language, flawed science, flawed pedagogy, flawed anything. It's not there in this environment. We need to think about that as we think about the rest. How does that enter into professional development so that, at a minimum, we validate it and then move from there?

Lessons from the Literature

Annemarie Palinscar
Jean and Charles Walgreen, Jr. Professor of
Reading and Literacy, University of Michigan

I'm in a most unenviable position here. Not only was I similarly struck, as Karen was, that the whole experience this afternoon has been this amazing synthesis and consensus building and then disrupting this idea of consensus building, which has been really exciting, but I have the task of following Karen who made so many wonderful points that resonate with points I had been thinking about as well.

I was thinking today about similar efforts. There's no question but that what we are talking about here today is extraordinarily ambitious, and of course we are not the first group to try and undertake very ambitious educational transformations and reforms, so I was thinking about some of the literatures about this process and lessons learned and what they might mean for us.

Examples would be the *Studies of Instructional Improvement*, for example, or *Schools for Thought*, and the ways in which we've learned

Annemarie Palinscar



Forming and Working as a Learning Community

We have to be capable and experienced in working as members of a functional learning community and forming these communities in the settings where we work. For me that is what is very exciting about this work and thinking about who are the other participants, who are the other linguists, science educators, literacy educators. All day I kept thinking about the work of folks who are doing work that ought to be informed by these conversations, and they are doing work that can inform these conversations.

How are we going to begin to go beyond these walls, this particular effort, so that it can be sustained and supported across multiple disciplines and across multiple communities?

• Annemarie Palinscar

lessons about what's going to be necessary if, in fact, this very ambitious work that has been launched and is represented in this work today is going to be sustained. When we look at this literature, and I was thinking about a framework that Lee Shulman and Judith Shulman shared with us in the *Journal of Curriculum Studies* about what we know about efforts that have succeeded, it is more likely that we are going to be trying to identify what we know about specific educators that have succeeded with these efforts.

One thing that we know is that these are educators who are ready to pursue a vision. I think what was very exciting today is that we are getting some clarity about that vision. I don't think it's spot-on yet because I'm still hearing, "What is the role of English language in this learning of science?" Is it that there is this interweaving? Is it this overlapping? Is reading, writing and oral language being used as a tool, or is it all, both science and language, reasoning and critical thinking?

I think we still have some way to go there, but we are certainly working in a shared problem space where I think we are coming to a shared vision, which is actually going to be integral to being able to make this work. We know that in those efforts that have been more successful it is because the participants were willing to expend the energy and the persistence to sustain such thinking.

Certainly the points that Karen was making in her comments speak to that. What is it

going to take to sustain? It is not enough to have good intention, there has to be the alignment of the assessment, the support, the standards, and yes, the curriculum. It is clear in those cases that the curricula are wonderful invitations to teachers and students, but teachers are not going to be able to invent curriculum. They need strong curriculum and we need conversations with curriculum developers to support them in their efforts to put that kind of good invitation out there for teachers and students.

But teachers are willing, educators are willing to engage in that energy and persistence if they have a deep understanding of the concepts and the principles that are needed for teaching. I think we've begun to identify what those principles are, but I'm going to be listening again tomorrow for the principles. What are the teaching principles? What are the specific practices? I think we've been talking in very general ways about these, we've begun to get a glimpse of them, but one of our challenges will be how to be much more articulate.

I think about Pamela Grossman's work on the deconstruction of practice and the representation of practice, and how we need to support educators to approximate practice. I think in our conversations, if we can get to that level—this is what we're representing when we show this particular video vignette, or this is the lens that we are trying as a community to develop so that we can get a

deep appreciation and be able to articulate what we see in practice—that is going to support us in supporting educators and ourselves as a community to acquire those principles and practices.

Again, successful educators in these efforts have been able to engage both in pedagogical and organizational practice. It's not just a matter of teaching practice, there is a whole lot that has to do with the culture of the classroom, which came up repeatedly today, the culture of the school, the culture of the district, the culture

of the community. There is a lot that has to do with this alignment, this shared sense of culture. Karen picked up on this when she asked: What is it we aspire to do in schools? What is it that we are there to do? What does it mean to educate? I think that is related to this issue.

Successful educators were capable of learning from their own and others' experiences through active reflection. One of the challenges there is where do we find the time for teachers to engage in thoughtful reflection, not only on their own practice but also the practice of others?

Participant Feedback and Reflections on Day One

CROSS-DISCIPLINARY LEARNING CURVE

- I assume this is a group of people who know a lot of about science learning, the conceptual change model, and the old model of misconceptions that we now see as having initial conceptions that then get refined. I just want to share my own conceptual change in coming to understand language conversations, sometimes through conversations with people who are here at this conference. We will go through those same stages as when people learn science concepts: thinking we understand when we really don't, using words with shallow meaning, and needing to have conversations that push our thinking forward. I wanted to share that to remember that if we come from understanding science learning, we may need to go through some uncomfortable stages of learning where we are lay people again in terms of understanding language. • Judit Moschkovich, Professor, University of California, Santa Cruz

- I am glad you made that point because during our final working group session on day two we will be discussing the implications of thinking about science and language for research and practice. You will be mixed up in those different domains and we will have to push to make sure we are understanding each other. You are talking about what took us years at the Institute for Inquiry and working with Sarah Capitelli to have those debates and so on. It takes time, but we shouldn't over-expect and we should clarify for each other. • Lynn Rankin, Director, Institute for Inquiry, Exploratorium

ENLARGING THE LEARNING COMMUNITY

- As well as thinking about how to bring the community together more, we want to think about how to enlarge the community, how to find others who are on the cusp of this transition of thinking about how language and science

fit together, who can be brought in and can spread the word more broadly. • Helen Quinn, Professor Emerita of Physics, Committee Chair for Conceptual Framework for New K-12 Science Education Standards, Stanford University

- That will be woven into day two. There is a short questionnaire asking you to think about how we in this community stay in touch. I would add to that Helen's question: How do we broaden the community? The second part of that questionnaire is how to get the word out, but I would add a third part. Who are the people you know already that we would invite if we did this again? Let's capture that now before we forget. Be thinking along those lines for the questionnaire. • Lynn Rankin

Exploring Classroom Cases: Science as a Context for English Language Development

Gennifer McDonald



Day Two

CASE STUDY PRESENTATIONS:

Introduction

Paula Hooper
Senior Science Educator/Learning Research
Scientist, Institute for, Inquiry, Exploratorium

I get to introduce some absolutely wonderful teachers. If we could just clone them and replicate them, we would be all set and would be at least 90% through that list that Annemarie and Karen gave us. I have seen three of them teach, so I know that it's true. These four amazing teachers have a commitment to education, particularly in supporting the education of children whose first language is not English. Each has developed classroom cultures where all students are engaged in learning science and have a voice in developing understandings about phenomena. That's why we asked them to be here today. Each has made unique contributions to education in their school communities, their districts, and on national levels.

We also wanted them to speak about the relationship between professional development experiences that they have had and how professional learning has helped them come to be the teachers that they are because that's

Session Three

what we need to understand more. During our Q & A and also in conversations, I hope we'll get that sense from them. They are all very articulate and their extensive experience and their own hard work has helped them develop these kinds of classroom cultures.

Science & ELD: Providing a Context for English Language Development

Gennifer McDonald
Academic Coordinator, El Verano Elementary
School, Sonoma Valley Unified School District

Prior to becoming an academic coordinator I was a classroom teacher and spent all of my years with the first cohort of the Exploratorium project with the SVUSD, improving and co-creating the science and ELD program guide to spread throughout the Sonoma Valley School District. My presentation today is on my beliefs and my journey and my story through this, and why I love this program and truly believe that science is the vehicle for learning language and providing a context for English Language Development. I know we are thinking about getting rid of that term and changing it to "language acquisition" or "language development," but this is my story.

Why combine science and ELD, and why have science and language together? Science

provides multiple learning opportunities for students, it's there, it's experiential. They can use the language repeatedly and in urgency. It's a connection to a content area. The science is so rich that the language turns out to be rich as well, so you can't help but combine the two. It gives students a purpose and urgency for using specific types of language, whether it's adverbs, verbs, complete sentences, incomplete sentences, or certain language structures to communicate through all of the language areas, including speaking, listening and writing. All of those are ways of communication where the language is so rich in science that they can't help but have all of those opportunities to use language to talk about the science.

Why Combine Science & ELD?

- Science provides many learning opportunities for students to use language repeatedly and in connection to a content area
- Science gives students an urgency and purpose for using specific types of language and language structures to communicate through speaking, listening and writing
- Science provides an immediate opportunity to practice language in a safe, equal and non-punitive manner

It is also an immediate opportunity, right there in front of them. It's giving them "something to talk about," which is one of our mottoes. It is there, ready, and available, so that language can't help but be used, and it's safe, it's equal, it's non-punitive. There are no corrections. Whatever they say there are no wrong answers.

It's all correct, it's all right, and it's a level playing field. Everyone is a language learner when we are doing science.

How do I teach science that supports language acquisition or ELD? For me it really came alive when we started working with the Exploratorium and I was introduced to the inquiry-based model for science, all about questioning and investigating and exploring. That's where it really happened for me because my students started coming alive. They started questioning, they started participating, they started talking, they started doing things that I had not seen ever before in my teaching.

It was student-centered, it was all about the students. It was not what I was giving them, it was what they were doing that was really giving me something, and we were working and learning together. And it was all about what they wanted to learn, what they were curious about, what they wanted to talk about, not what I was supposed to give them. It was what we were doing together. So it was based on student interest and what they needed, their language needs but their science needs as well.

This model of exploration, observation, investigation and explanation really takes us through all of the facets of our inquiry process. I give them a phenomenon to explore so that we can talk about it, we can question, we can wonder, we can think. It is something we can observe and look at and go even deeper into the learning. And then when they get

How Do I Teach Science that Supports ELD?

- Inquiry Based Model for Science
- Student Centered
- Exploration, Observation, Investigation, Explanation
- Strategic Planning of Units and Lessons
- Strategic Implementation of ELD Lessons throughout the Science Unit

to question and investigate they can really make meaning from the science concept or phenomenon but also explain it to their peers. It is during those processes where all the rich language comes out.

For me it also takes strategic planning of the units and lessons. As a teacher, I have to really think about how to plan all those learning opportunities in science, and plan all the learning opportunities for language to support the science learning but also support the language development. So for me it is really strategic. I have to really think about what I want to accomplish and how I as a teacher am going to provide all of those learning opportunities. But I see myself during all of this not as a teacher but more of a facilitator of the learning of science and the learning

of language because it is about the students and what they need and how I can provide these opportunities for them.

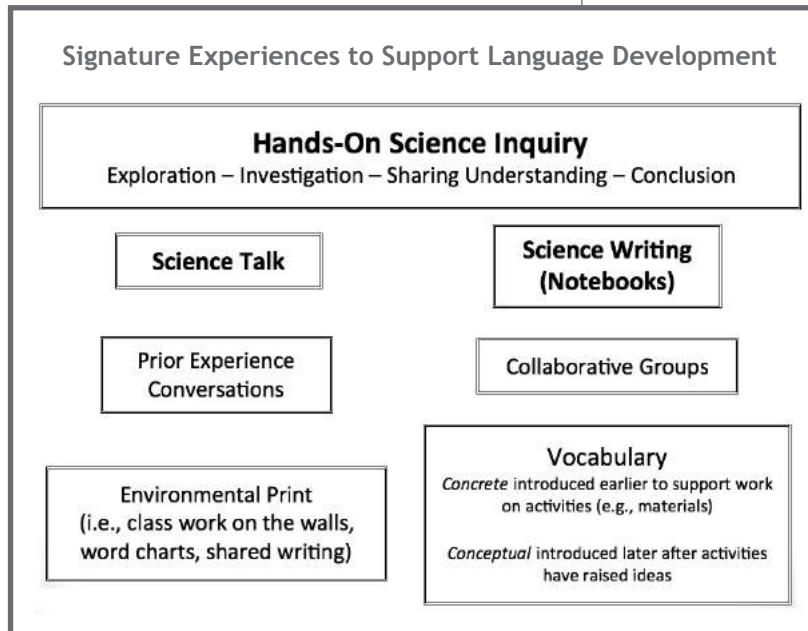
Then there is implementation of ELD lessons throughout the science unit. I have been trying for many years, putting in mini-lessons of language that I feel is important for them to acquire the science and talk about it and write about it. It is the

vocabulary and the language structure that is crucial to them in acquiring the science content but also mastering language.

For supporting the science inquiry process and the language development the two areas that I have really focused on in getting that rich language development are Science Talk and Science Writing in the notebooks [see diagram lower left]. These two areas support the hands-on science inquiry that we do because all of these things require talking about the science, whether in small groups, partners, large groups, or teacher-student conversations. They also require writing about the science: data charts, responses, graphs, models. Any of those things are writing and communicating and learning through science and language.

Science Talk includes all of the students' prior experiences. They come to me with knowledge, but then I'm also building prior knowledge for students who may never have seen or touched a snail. So I am both building prior experience and also adding to the experience they have brought to the table. We have conversations, we talk about things, all of these are related to the exploration and the hands-on science inquiry.

Another important scaffold for all of these is my Environmental Print. My classroom is lined with posters, pictures, diagrams, vocabulary, word banks, grammar, verb tenses and things they can use. The language is up and the words are up so that they can use these during



Science Talk and Science Writing, so it is a very language-rich environment that is all connected to the hands-on science learning that they are doing.

All of those things also connect to the Science Writing because they can use that Environmental Print to write in their notebooks, but they also have the freedom to write their own thoughts and their own opinions in the science notebooks. They can work with their group, they can work with their partners, they talk, they write. They also can use the vocabulary that's up to support the work that they're doing.

Strategies to Support Understanding of Language

- Environmental Print
- Different Types of Questions
- Science Notebooks
- Science Talk
- Teacher-Student Conversations
- Student-Student Conversations

These are some strategies that I use in my classroom to support the understanding of language. There is the environmental print, and I have all of those posters and charts and words readily available up in the classroom. Also, at times we have glued them into the science notebooks so that it's readily available and they can flip back and look.

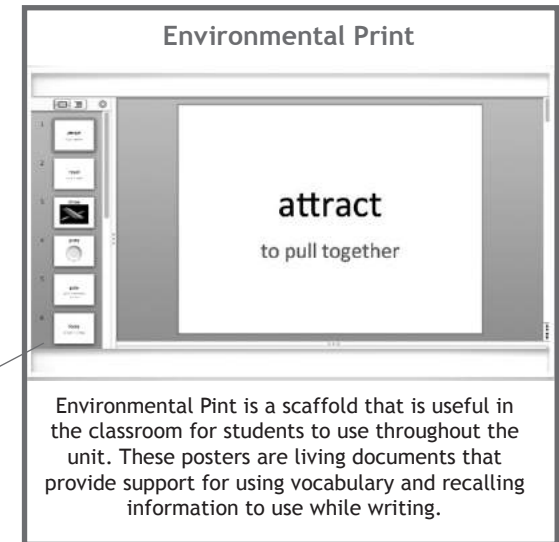
I am a constant questioner and call it “rapid-

fire questioning.” I have different types of questions that I ask the students to get them to use the language that I'm looking for and really understand the meaning that they're making from the science.

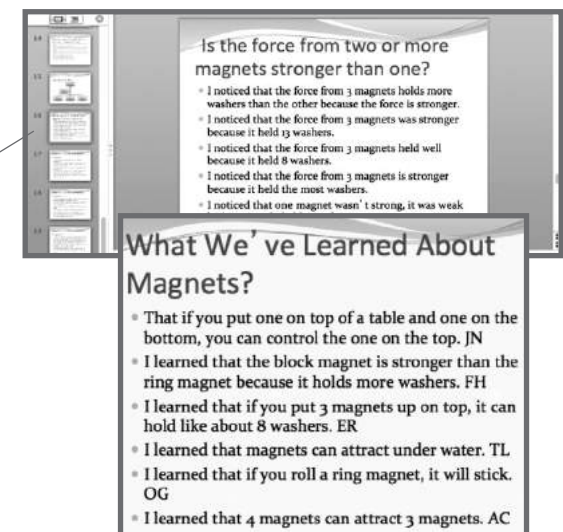
There are the science notebooks and Science Talk, and then all of the content-rich conversations. Whether it is the students and me or students together, those conversations are truly important to the learning of the science but also using the language.

These are some examples of my Environmental Print. I've dabbled in a lot of things including posters. This is an example of a PowerPoint presentation that has the vocabulary with both words and pictures. I print them out and put them in the classroom but can also press “play” and we can repeat and go through them. It is a useful scaffold for students to have and it's a living document. We add, we edit, it never really goes away. We continually add things into our posters. They can add words in and can always be using it and they never come down.

Here is another example of using a PowerPoint. I have diagrams and charts. These are transcripts from the Science Talks where I've posed a question and type a transcript of the conversation and put it up in the classroom. I type verbatim what the students' say. At times I've put their initials next to it so that they have validation that what they've said is up there. Sometimes that is a really great



Environmental Print is a scaffold that is useful in the classroom for students to use throughout the unit. These posters are living documents that provide support for using vocabulary and recalling information to use while writing.



Science Notebooks

Science Notebooks are a tool the student use to enhance their conversations, review the unit and work on their writing each day.



Questioning

- **Subject Centered:** Why did the snail eat more pasta than lettuce?
- **Person Centered:** What do you think caused the snail to eat the pasta?
- **Process Centered:** Can you predict what food the snail will eat?
- **Other:** What is it about the pasta that is different than the bacon?

technique because they all want to raise their hands because they want to see their name or initial up there.

I put up the transcripts of the Science Talks so we can go back and resource all of the information. “What did we say last time? Oh yeah, we said this.” We can go back and use it as a tool for Science Talk and for Science Writing.

Here are some samples of science notebooks. I have tried several different things—composition books, spiral notebooks—and I have tried gluing in work sheets. I have tried having them write the charts on their own. These are just ways for students to keep record of all of the work that they’ve been doing. They are so proud of these journals. They can go back and look at their charts, look back at what they wrote and use it as a reference tool, and they write in them every day. Writing is a component every day.

I talked about my rapid-fire questioning. I learned through my experience at the Exploratorium about all of these types of questions and make sure that I try to do a variety of these when I am talking to my students and when I am posing questions. Whether it is a question that I leave at a table and have them talk amongst themselves, or it is a question that I am asking an individual, I try to make sure that it is one of these types of questions to really get at the root of their thinking and what meaning they’re making.

One of my Exploratorium professional development co-creators said to me something I’ll never forget: “You get what you ask for.” Ever since I heard that I make sure that I get what I ask for, so I’m strategic in how I ask questions to get at the root of their thinking and the meaning that they’re making.

Science Talk & Student Conversation

Science Talk Guidelines

- Listen carefully to each other
- Take turns talking
- Speak one at a time... without interrupting
- Agree and disagree politely... and explain why
- If you are confused... ask questions
- Stay focused on the discussion topic
- Respond to one another

What can I say during Science Talk?

- Ask a question
- I agree with _____ because _____
- I disagree with _____ because _____
- My answer is similar to _____ because _____
- I observed _____
- I noticed _____
- I saw _____
- I am curious about _____
- I wonder _____
- That’s interesting because _____

Then there is Science Talk and student conversation, and it is not an easy journey, let me tell you. It took years of me trying and not doing so well and really reflecting on my own teaching practices to improve and get to a place where I feel comfortable and successful in Science Talk, and not only that, but my students are being successful. I’ve had some of the best Science Talks in the last two years that I’ve ever had, and it took that journey of not doing so well at the beginning to get me

where I am, and along the way we've created these things. For example, these Science Talk guidelines. These are not rules but agreements that we've made as a class, as a group, as a team, as co-creators, to make sure that everyone is listened to and validated and their thoughts get out there.

We encourage the students to listen carefully and take turns and really learn that role of conversing and having conversations with each other. Another scaffold is "What can I say during Science Talk?" I give them sentence stems so that they can participate in appropriate ways and respond to each other. They can ask questions, they can use language like "I agree," or "I disagree," or "In my opinion." When you see little second graders or first graders using these words it's amazing. This is another scaffold of things you can do as an educator to facilitate those opportunities for using language during a Science Talk. We review these every time.

In terms of Science Talk and my own learning, I wanted to know what language the students were using, I wanted a way of finding out the language structures where I really needed to provide opportunities for my students, and I wanted to know more of what they were getting out of a unit. During Science Talk I was always a listener, I was always asking questions, but I never had a way of really documenting what the kids were saying and where I could provide more opportunities for learning the science concepts or improving the language

development. So I created a recording form.

I planned out my questions, which you can't see very well here, but I made sure the questions fit with what I was looking for out of the Science Talk, and document the answers. I would write down the things the kids were saying and who was speaking. At the bottom are words I was looking for. "What Is a Pupa?" was part of our ladybug science unit and I would look for words like "molt," "grow," "ladybug," "larva," "egg," and I put little tally lines every time I heard those words so I could see what words they were frequently using and what words weren't coming up at all. Then I could go back and really plan some language lessons for them to get these words or this usage of vocabulary and word structure appropriately in the science unit.

This is another example, "What do snails eat?" Again, I was making sure that I have the right types of questions to prompt conversation and really get at the meaning that they are making from the science.

I have a video regarding Science Talk and student conversation from last year. It is a whole group Science Talk and I don't always do those. Sometimes I have done small group Science Talks to support conversations amongst my students because not everyone wants to talk in a large group of 25 to 30 kids, so having smaller groups at times was successful. I think the most important thing I've learned about all of this is that there really is no right way. It depends on my students and what their needs

Science Talk Language Recording

What Is A Pupa? – Science Talk

What do you observe today?

Are there any changes?

Are there any things that are the same?

What do you think happened to the larvae?

SHOW PICTURE OF PUPA. READ THE LABEL & EXPLAIN THIS NEXT STEP IN LIFE CYCLE TO STUDENTS.

How does the pupa look?

Is it moving?

	Molt		Ladybug
	Grow		Larvae
	Shed		Pupa
	Life Cycle		Shed
	Insect		Changed
	Alive/dead		

What do snails eat? – Science Talk

What did the snails do when you put them on the plate?

What did the snail do when it got to a food?

Were there any foods the snails did not find?

How do you know the snail ate the food?

What evidence did you have?

Why do you think a snail might like one food more than another?

What would you do differently next time?

Science Talk & Student Conversation

What are students talking about and how are they talking about it in this clip?



<https://www.youtube.com/watch?v=djSjJ5fZsbg>

[McDonald questions students about a hands-on experiment to find out what snails eat by trying different bits of food and observing results.]

Video clip discussion

are. It's not about what I want to do or what is easy for me, it's all about them.

This year I had really successful whole-group Science Talks, so that's how we did them, but in other years it didn't always work and I had to do something else to make my students feel successful. I'm going to go ahead and show you a video clip of my Science Talk and while you

are listening I want you to think about what the students are talking about and how they are talking in this video clip.

Then I would like you to talk in your table groups about what the kids talked about and what language you heard them using during the Science Talk.

Debrief on Discussion Regarding Video Clip**McDonald:**

What kinds of things did you notice or hear. Did you see students using language in this Science Talk?

Participant:

I think it was very nice the way that you actually provided a pattern in the conversation, but then the children themselves were presenting patterns to each other. I wondered about how you organized the grouping. It seemed like the more talkative people were not just all clustered together they were distributed throughout the group, which

is a good idea. It was clear that everyone was listening and engaged and seemed to be observing. We were discussing what is the nature of engagement and how can you tell when you've got engagement. I think eyes-on-the-speaker is one kind of engagement, and certainly the other is topic relevance, and everything was topic-relevant.

McDonald:

There is no assigned seating for this, so it's interesting how you picked up that they were scattered. For strategic grouping, yes, I make sure that I have talkative with non-talkers and different language levels and experiences all mixed in one group, but for this they got to pick where they sat (as long as they were making a good choice_.

Participant:

Another piece of engagement is that there is nowhere in what we saw where you said, "Johnny, come and sit next to me." Or, "Take your hands off of so-and-so." They were all caught up in the conversation and weren't manifesting other behaviors as ways to keep themselves busy.



Debrief on Discussion Regarding Video Clip *(continued)***McDonald:**

They have jobs to do. They have their journals, and if they hear something that adds to their thoughts they are encouraged to write it down, so they have a tool there so they can actively be listening. At the end of certain Science Talks I say, “Okay, if you heard something that was really interesting or something different from what you thought, go ahead and take a minute and write something down.”

Participant:

I noticed that the students are all describing similar things, but the words they use and the grammatical structures they use vary greatly. When they were talking about how the snail was eating, or that it was avoiding the strawberry, they were saying very similar things, but from a language perspective it was varied and it was nice for the students to be exposed to all of that.

Participant:

This is obvious, but there was the fact that they all observed snails eating, that they had something to talk about. It makes the importance of that real stuff absolutely key. They are all there and whether they are saying anything or not, they had the same observations or the same experience from which to draw observations.

McDonald:

Equal opportunity for all language learners.

Participant:

Even within that it was still unique because they had different stuff on their plates and different ideas about it. That was really important. One of the things we were talking about was how they used their own vocabulary, even when it wasn't necessarily a very scientific vocabulary. They were considering the shape of the noodles as a criterion for what the snail would choose to eat.

Participant:

I liked that you didn't correct them, that you let them talk. You didn't correct them either linguistically or conceptually, you just allowed them to talk and say what they were thinking, and children were using their imaginations just based on prior experience. You didn't have them use specific words or arrive at specific conceptual understandings at that moment, you just allowed the conversation to flow.

Participant:

She invited it.

McDonald:

As I was saying, I'm the facilitator. There are times where I don't get a word in. As their conversation in this video clip continues they get into a discussion about snail noses and I didn't get a word in.

These are the language things I noticed when I watched the video. There is so much more, but I think we all realize there is vocabulary that is learned and studied or from prior experiences.

Language Used by Students

- Use of learned and studied vocabulary
- Appropriate language conventions and sentence structure
- Questioning on each other leads to arguing with evidence and discussion of the phenomena

It is appropriate for their grade level and for where they are linguistically in language usage. For example, we heard “avoided” and “didn't like.” And they question each other and it leads to citing evidence from their experiences that really gets to the root of making meaning of the science concepts and what language they are using to do so.

I definitely didn't get to this point on my own. I got there through professional development with my school site and with my district and with my colleagues. I wouldn't be where I am

Professional Development: Teaching as an Inquiry

- Consistent training and support
- Reflection of my teaching
- Freedom to experiment
- Experimentation in my own teaching
- Structured Professional Development sessions and collaboration with colleagues

without the sustained training and support from administration, from my team, from my co-creators, my professional development group. And then there is reflection on my own teaching. I take my teaching and treat it as inquiry now. How can I best support my students and what opportunities can I give them to support their success and learning?

There has been freedom to experiment. I take something and I run with it, and I don't have the constraints that unfortunately other people do, which limits them (e.g., "You can't do it that way, you have to correct it," or "What page of the curriculum is this from?"). I don't have those constraints and I am super-lucky that I have the freedom to go ahead and try things in different ways that might not be the norm for other people. That comes with support and encouragement.

With experimentation, I take something, I get it, I run with it. And if it doesn't work I try to find a way to get it to work and find how I can improve, and I can always make things better.

The structured professional development sessions and collaboration with my colleagues is ongoing. It is not a drop in the bucket, where I got this professional development and then I'm on my own and I have to make it run for six years and be successful. Instead it's a consistent, ongoing thing where we are all growing at the same time and learning with each other and from each other in order to have success opportunities for our students in language and science.

It was a long journey, but it's the best journey I've had.

Q & A WITH GENNIFER MCDONALD

Notebooks and Science Writing

Q:

You mentioned that they are writing in their notebooks every day, so I'm assuming you are teaching science every day? Is there hands-on investigation time and then writing time, and having them be two separate chunks of time?

A:

Yes, every day, and yes, they are two separate chunks of time, but they are also writing during the investigation. They always have their notebooks out. If they don't get to finish their writing, we review and they can start writing and then we go into the hands-on, but there is always a combination of those three things: some sort of experience, some sort of writing and some sort of talking. That happens in each session.

Posting Transcripts of Science Talks

Q:

I think I really like the idea of capturing the transcripts of the Science Talk and then posting it up as a discussion points for students to then refer to later. Do you find though that some students are put off by that and don't want to talk because they're afraid it's going to be captured and their mistakes will be visible?

A:

No, not really. That sample you saw was one of something like 28 pages worth of transcripts. The reticent speakers, the ones who very much don't want to talk in front of the group, it takes them a lot longer. I had this one student during this time who really did not want to talk. It took her six months to raise her hand and say a comment. After six months, with the encouragement of her partner, a student I strategically partnered here with, she finally spoke. She raised her hand and her comment got up there, but it took time. She did not have very much English language but in time, after six months, she did it. It just depends on the situation of course.

Males Dominating Conversation?**Q:**

It seemed to me that in the video the males were dominating the conversation. Now is that just in that segment or are they more eager or capable of responding?

A:

It depends on the year. I've had in the past more female dominant speakers. This year happened to be more male dominant in that classroom, but there were a couple of females who started speaking up more towards the end. The two girls you saw sitting next to me started speaking up more towards the end of the school year. In other years I've had some girls that just dominate the conversation, but this was a more male-dominant classroom.

Continuation from Grade to Grade**Q:**

What happens to this cohort of kids after they go to the next grade, and how are these conversations sustained? Do you have a sense of what happens?

A:

In my school we are all doing the Improving Science program, so these types of things are also happening in the fourth grade and the fifth grade. It is a continuation with different types of science phenomena or units but the same structure: science notebooks, Science Talk, and experimentation and exploration.

Q:

You commented yesterday that you're noticing that the kids coming in already know the language.

A:

Yes, because we are K-5, so the students come to me with certain language structures.

PD and Building Capacity for Language**Q:**

Regarding the type of professional development that was offered, was it science and language combined? I was curious about how you built your capacity for the language part. I know that you had been doing professional development at the Exploratorium. What was happening at the district level with professional development?

A:

I look at it as similar to what I have done in my classroom. We started our trainings with inquiry. The first inquiry I did with the Exploratorium was with parachutes. I was sitting there with my colleagues, my second grade and third grade team, and we were making parachutes: "Here are these materials, how can you make parachutes?" We dove in and started doing it, and then it is, "What language did you need?" and putting the language in to get through that inquiry.

So it wasn't until we had to do an inquiry ourselves that we really got to figure out how to provide it for our students. Me learning that enabled me to create it for my students as well.

Context

- Science opportunity gaps persist
- A substantial number of students are excluded from STEM careers and college
- National and international need for equal opportunity



Emily Miller

Supporting English Language Learners in Sense-Making During Science

Emily Miller
ESL/BRT Elementary Teacher,
Madison Metropolitan School District,
University of Wisconsin, Madison

Thank you all for being here and collaborating. I am honored to be here too, and I want to thank Okhee Lee for being an amazing mentor to me.

I think we are all familiar with the context, that we have students who are basically excluded from STEM. I agree with the idea that we need more students to be informed citizens and make better decisions as a democracy, but I feel that this generation's challenges are such that we have to come together with diverse voices from our scientists and engineers in order to solve these problems. We have to have diverse perspectives. As a teacher I feel it's really important to also see my diverse students becoming scientists and engineers. We have to come together with lots of voices to solve these problems. The same-old hasn't been working.

Focus on Science Practices

The practices support **collaborative sense-making** about natural phenomena.

1. Practices are language intensive
2. Build language and science knowledge
3. Sense-making gets ELLs/L1s working to understand each other

This is a review of what we know so far. The practices are language-intensive and they are where language and

science understanding are built together. Most importantly, I think, we are having students come together and make sense of each other's ideas through the practices for NGSS.

I am going to be focusing primarily on modeling and how modeling can serve as the key practice where every other practice comes into play. Here is a question for you. Think about your average science class, not just modeling. When does the conversation most meaningful to the students occur? When is that dialog most meaningful to the students? I think the most important and meaningful time when conversations occur between students is when the teacher is not there. When the teacher is gone, that is when students feel more safe and that is when they are trying to express their own ideas.

I want to present my problem statement here. When it is between students (and when the teacher is talking also), all students ideas are sought, listened to and valued. A second grade students' perspective is, it is introducing my idea that is real motivation to me. If I can have my idea understood by others, I am motivated to produce language. And the collaborative sense-making that occurs through the practices can only occur if more than one idea is on the table.

It is really difficult to get adults to listen to each other, right? If an adult has an idea and another adult is listening, you have to do a lot of work to understand those ideas sometimes. And if it is kids whose ideas are abstract

and they don't have as much to go on, some students ideas are taken up and some aren't. I think this is where equity comes into play with the practices.

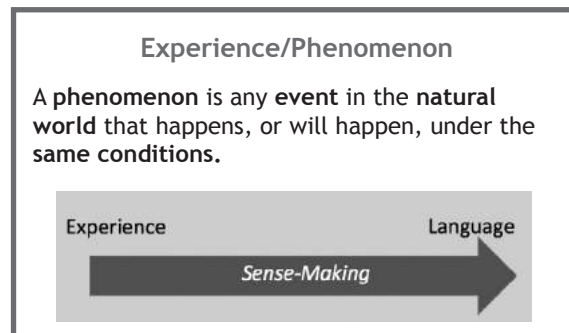
I want to give one example. I had a group of four students who were talking about developing a model, but first they were talking about what would happen if you were pouring a bucket of water on a hill and there is grass there and then gravel at the bottom, which is the way it is at our school. Some of the students said, quietly, "I think it's going to roll down the hill and it's going to go into the gravel."

Another student who had high science status said, "It's going to evaporate, I saw that on *Bill Nye*," and all of the kids took up his idea. He wasn't trying to understand what the other students were saying. This is what happens all the time when students are talking. They are not really working to understand each other and that status comes into play.

I'm going to talk about how, when students are making sense of phenomena, modeling can serve as a way towards equity in conversation and sense making, but the phenomena have to be place-based and engaging. I has to be something that the students have encountered at home and are going to continue to encounter at home while it is taking place in school. We need to have phenomena that students can build on at home, and I as a teacher have to encourage those conversations at home too, so that sense-making is happening

at home and at school. It could be something as common as a bee pollinating a flower, or how the sun peeks above the clouds, or a balloon going across the sky.

So experience of the phenomenon happens at home, it happens at school, and I'm going to give you an example. I am really obsessed with watershed. I focused on watershed with my kids, and we looked at the rain after a rainstorm. We checked where the puddles happened and looked around to see if we could find any patterns for what was happening with the puddles. The meaning of what is happening is contained within the experience and when students make sense of that experience, that's where the language happens.



So we look around at the puddles (all second and third graders love puddles) and then do the sense-making of that experience, and we develop language.

Now let's talk about modeling a little bit. I'm going to try to figure out modeling to equal that conversation. Models have three components. First they have variables. For our

Focus on Making Sense of Phenomena

A **phenomenon** is any **event** in the **natural world** that happens, or will happen, under the **same conditions**.



Engaging and Place-Based

Student scientists collaboratively explain and predict phenomena.

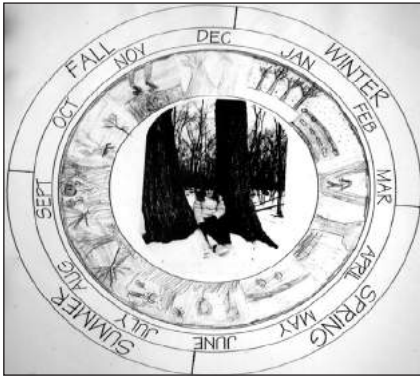
Meaning is contained within the experience. By making sense of the experience together, we build language.



"Where does the water go?"
"How does the water move across the land?"
"Why is there so much water in this spot?"

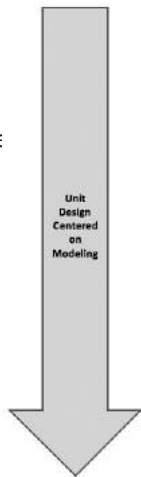
Core Components across Models

1. Identification of the *components* or *variables*
2. Representation of the *relationships* among the variables
3. These relationships provide a *causal account* of the phenomenon



How I Do Modeling in My Classroom

Collaborate
Explain/Share
Investigate
Revise/Write
Assess
Engineering



watershed we had the surfaces, we had the water, and we also had some things on top of the surfaces that could be moved, like wood chips and gravel.

They have representation of the relationships among the variables. So we might show how the rainwater interacts with the surfaces. And the model has to show these relationships explaining the phenomenon, so my model is going to show why puddles happen in certain places and not others.

This is how I do modeling in my classroom. I've been working on this and this is just preliminary, but I really like this one. First we look at the phenomenon itself, we engage in it, we talk about it, we get excited about it. Then the students develop an initial model. Each student develops an initial model. I look at the models and have children collaborate who have similar ideas of what's important, and then they develop a model together based on what they've already made.

After that they group with another team and share their models with another group. Then I devise an investigation that causes students to deepen their understanding. They already have an existing understanding, so I can build on that. They use that investigation to revise their models and write about why they revised it. At this point students have a lot of language to write about why they revised their models.

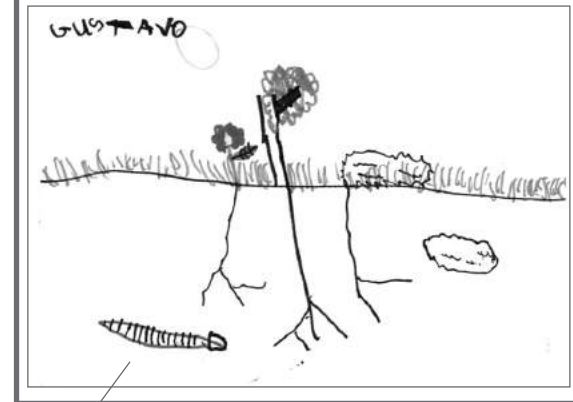
Then I like to assess with an engineering model, so I give them a problem that uses the

same ideas as the science concept and they have to show me an engineering model that shows their understanding. I will go into all of these really quickly.

Connections Between
Below and Above Ground

How are the below ground and the above ground connected?

What is below the ground?

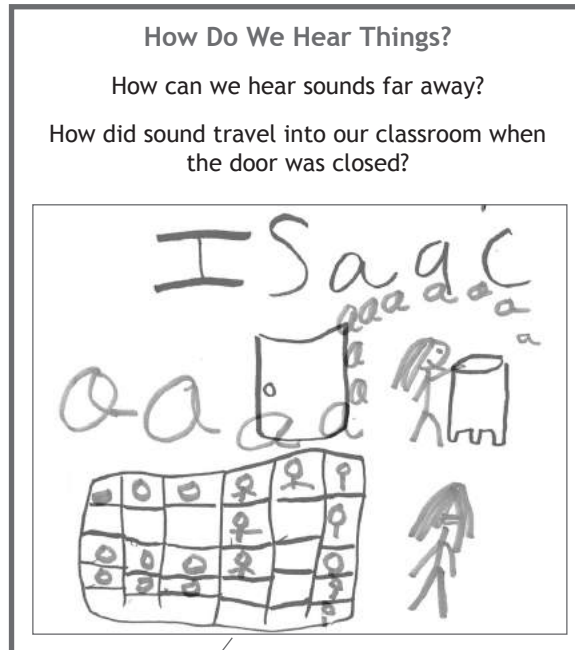


This is Gustavo's initial model of how above ground and below ground are related. There are no words on here but I can already see a lot of what I can build on, and I also see what words are important to Gustavo, what language is important to Gustavo. He sees that there are organisms above ground and below ground, that there are rocks above ground and below ground, that there is that similarity. He also sees that there are roots that connect the below ground and above ground.

I can also see a little bit of where he needs to build. Gustavo doesn't have soil in the picture,

so as a teacher that might be one experience, to have him experience soil so he can add that to his model. What I used to do was to have a fish tank. You can put soil in the fish tank and then stems of plants. If you pour water in the fish tank the stems shoot the water down into the soil, so you can see how plants cause the water to go down into the soil.

In the next step Gustavo and his partner can go back and revise their model. So let's say they include water now, and they include water coming down.



Here is another one. This is Isaac. At the bottom is another teacher in the classroom and I am at the top, standing outside the classroom door. I closed the door and pounded a drum and the kids could hear the sound even though

the door was closed, so I had them explain this phenomenon. I'm going to ask you to turn to the person next to you and discuss: What does Isaac have to build on? What do I have to build on with what Isaac has drawn and where am I going to go next?

Group Feedback on Isaac's Drawing

Miller:

We know that teachers are effective if they're building on what kids already have, right? They have to know where the kids are in order to build on that knowledge, correct? Isaac hasn't written anything here. He could be level one to five, but I already know as a teacher what I can build on. Who wants to share something that they see we could build on?

Participant:

He has a way of representing sound and how sound is getting from the drum into the room. That needs to be elaborated to the sound actually reaching the students. Can his representation of the sound be used to talk about which had the loudest and which had the softest sound? There is a whole set of questions you could ask him based on this picture.

Miller:

Yes, and Isaac has shown me what is important to him.

Participant:

He has the locations of the kids in the room.

Participant:

It was interesting. First I thought I have no clue, then I realized that there is movement in those "A"s. It's not a wave propagating, but it's some-

thing moving. I am really curious about the big and the little "A"s and what they mean to him.

Participant:

And why the "A"?

Participant:

And why is he using a letter to represent the sound, even though it's a drum? For him, he uses the letter to represent a sound, so it's an interesting kind of language science rather than a wave or sine. It's worth looking at.

Participant:

Paula made the interesting observation that Isaac is not representing sound traveling through the door. That might be an interesting thing to ask.

Participant:

That's why it the "A"s have to be smaller outside, so it can get through the cracks.

Miller:

When I saw this I saw two places to go. A lot of the kids had sound traveling in a straight line like a car or something like that. So we had a few kids positioned in different parts of the hallway and asked them, "Did you hear it?" And they had. Isaac's next example was the straight lines going in other directions.

Continued...

Group Feedback on Isaac's Drawing (continued)

Miller:

Yes. There was also a conversation in which some kids thought it might have gone through a vent in the door. So the next idea is to use a wooden pole and have someone tap it to see if sound can go through wood. And some of the kids could then think, well maybe the sound actually went through the door.

Participant:

It's also interesting to me that he is really drawing from his perspective versus yours. Arguably the sound would be louder for you, so the "A"s would be bigger closer to you because you're the person who is making the sound. If he's doing it from your perspective the "A"s would be larger. If he's doing it from his perspective the sound would be getting bigger for him.

Miller:

Yeah, which tells us something about what he understands about sound.

I have been experimenting with having kids develop a model alone, and then collaborating with a group of students who have similar ideas to develop a collaborative model. This drawing was just him and he sat up front and presented it, and his motivation to explain his ideas was really strong. Also, he had the model to point at things, and some of the other students could provide some of the words for him because they saw what he was trying to say.

Why Modeling is High Leverage for ELLs

Modeling Provides For:

- Authentic and meaningful discourse around science ideas
- Student-centered language scaffold
- Avenue for other practices
- Assessment opportunity for ELLs

Why is modeling high leverage for ELL? It provides avenues for authentic and meaningful discourse around science ideas. I want the students to do the work of really understanding each other, even if the idea is different from what theirs is. A lot of times students will present an idea and no one is really listening, no one is doing that work to understand what they are saying. That's hard work. I want to incorporate that notion of hard work, that talking together is hard work.

Modeling is also a student-centered language scaffold. The scaffold is built by Isaac. He made it, and the language that he needs to

express he made himself, so it's a perfect scaffold.

Modeling is an avenue for other practices, and modeling can be an assessment opportunity for ELLs. Regardless of language level I can see their understanding build over time.

3-D Performance Expectation

2. Earth's Surface Systems: Processes that Shape the Earth

- 2-ESS2-b *Develop an explanation about the kinds and shapes of land and water in the area.*
- 2-ESS2-a *Use drawings and physical models to test, compare strengths and weaknesses, of design solutions that slow or prevent wind and/or water from changing the shape of the land.*

This is a case study. This is a little bit different from what I have been working on lately. It is Okhee's and my first attempt to do NGSS in the classroom. One of the performance expectations is to develop an explanation about the kinds and shapes of land and water in the area. Or use drawings and physical models to test and compare strengths and weaknesses.

Opportunities Through 3-D

Core Ideas NGSS

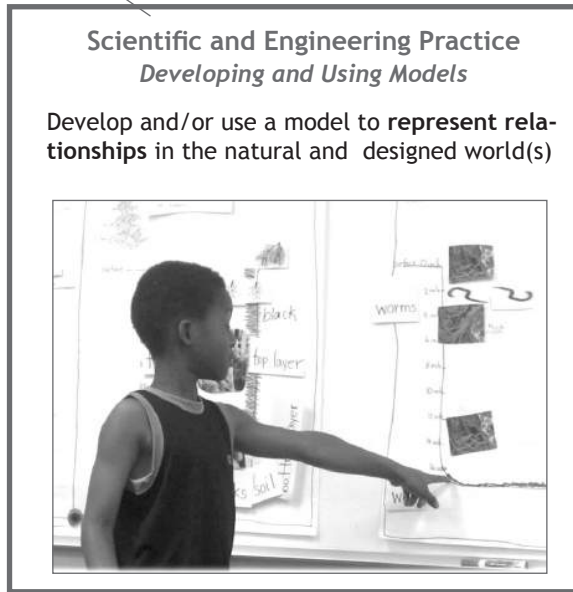
ESS2.A Earth Materials and Systems

Wind and water can change the shape of the land.

The core idea is that wind and water can

change the shape of the land. That is from NGSS.

Models are used to represent relationships in the natural world.



So this is my first unit trying to use NGSS in a diverse classroom. The scientific question was: Is all soil the same?

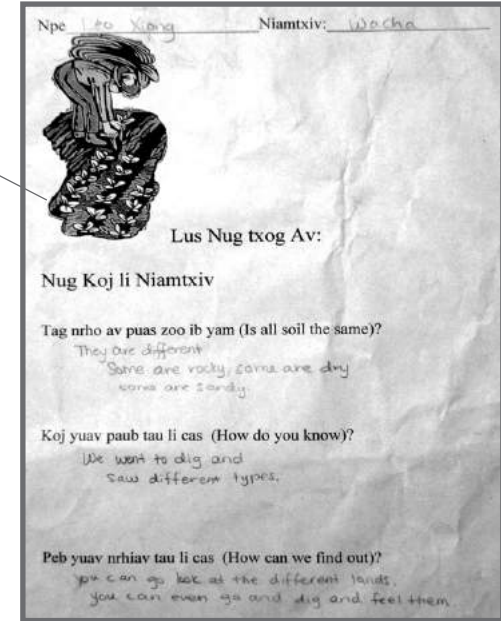


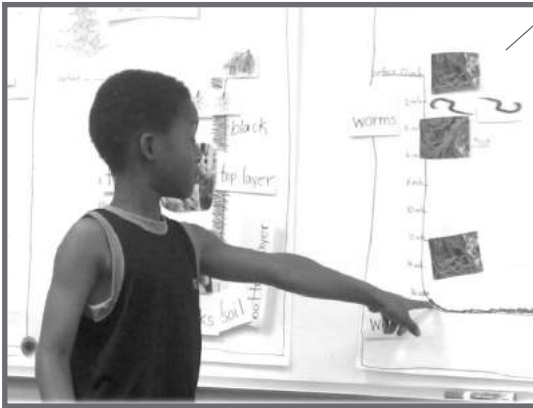
We went outside and got a bunch of soil from the schoolyard field and we used it to develop a conceptual web and talk about the phenomena of what soil is.

Teachers often struggle with what to translate because you can't translate everything. This is the most important thing to translate, I think, this first connection with the home about the phenomenon that is under study. This was translated into Hmong and it says, "Is all soil the same?"

The students brought this home and they asked their parents, "Is all soil the same?" They had to interview their parents and this was done by a Hmong family, but an older sister wrote in English: "They are different. Some are rocky, some are dry. Some are sandy." This is a huge, important connection between the home, and they are going to continue to talk about soil at home and I've set the stage for it.

The students talked about what they discovered and decided that soil was different in different countries. That was the agreement they came to. But they needed to know if soil was different in the neighborhood around the school. This is an aerial map and we used a topographical map to find three different locations where we thought the soil might be different. We chose a high elevation point on a hill under a coniferous tree. The kids lived in apartment buildings and there was an expressway, and under the expressway was the lowest point on our map. We called it an "urban marsh" and thought it might





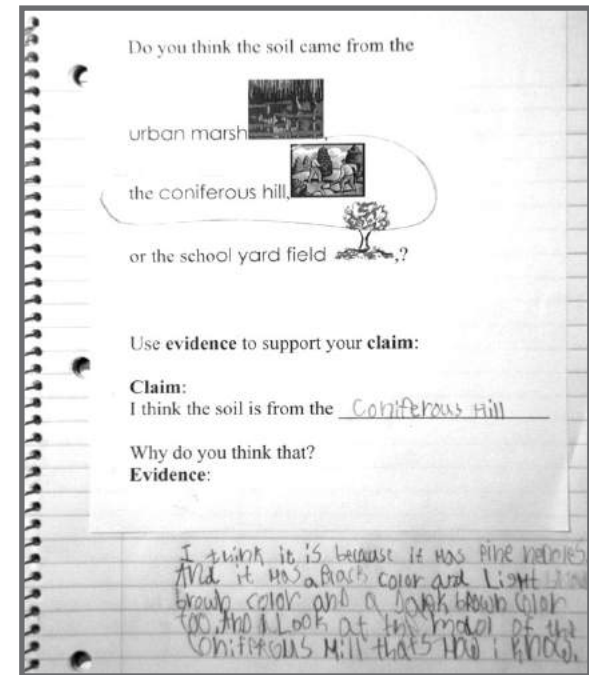
be different because it was so low on our topographical map. And then we kept the schoolyard field for another comparison.

Then we went to each site, we dug a ditch, we took data about the rocks, the roots, the organisms, and whether we found water. We discovered something really amazing, that soil actually has layers, that there are different colors of soil in layers. We also found a lot of trash in the urban environment.

This is the first time we tried this and this is the first one I made with the kids. Then there were groups working on the other two locations. I was trying to make the kids experts in certain locations, so some students worked on the urban marsh and some student worked on the coniferous hill and then we put those up as models.

All students got a plate of soil and they had to use evidence from the model to decide where the soil had come from, so they had to use evidence and develop a claim. They found something like, “the soil was dark,” and that corresponded to something in the model. They were solving a puzzle.

Here [upper right] is an example of a student who said the soil came from the coniferous hill: “I think it is because it had pine needles. And it is a black color and light brown color and a dark brown color too. And I look at the model of the coniferous hill that’s how I know. “Almost all of the students except a few were ELL in this classroom and we have a



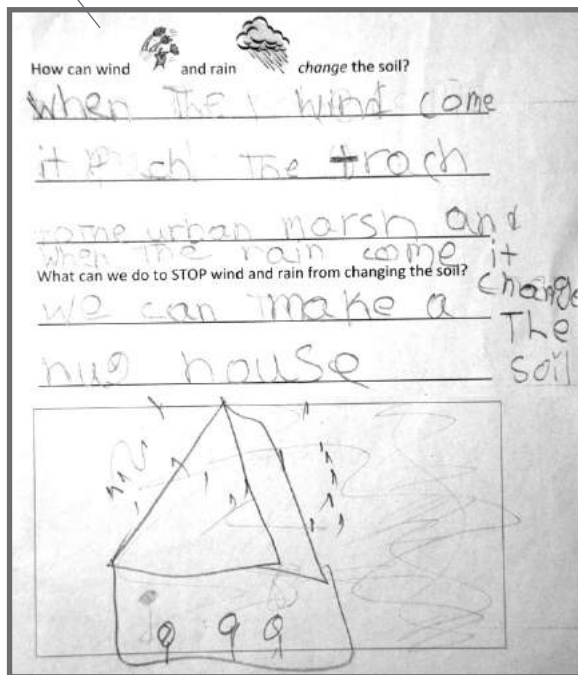
fair amount of students who are from Western African countries. This is one of the students from Gambia.

So do you understand how this works? The students had the language. This is actually an ELL but a higher level ELL. They had the language to develop a claim and they supported each other.

Next was engineering assessment. In the soil in the urban marsh the kids saw the wind blowing trash into the urban marsh. Also, in Wisconsin we have sand on the roads and it took a lot of figuring out. The rain flows the sand into the urban marsh and changes the soil.

Our question for engineering and to check for understanding was: How can we stop the rain

and wind from changing the soil? This is a level 2 student from Gambia who said it would be good to put a house on top of the urban marsh to keep the wind and rain from changing the soil. He said, "When the wind come it push the trash to the urban marsh and when the rain come it change the soil," which to me was like, wow, great. I also think it shows a really sophisticated understanding of what's going on.



The next student shows a group of people holding umbrellas. I thought it was great and cute, but it also showed me that maybe she didn't have as strong an understanding because I don't know if the umbrellas are going to stop the trash from blowing into the

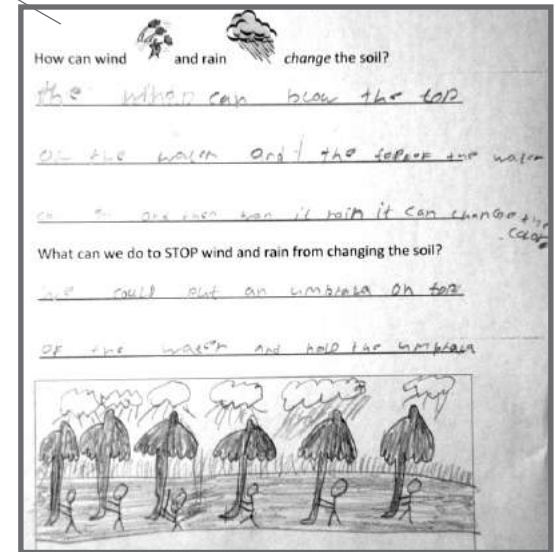
soil, and also the wind is still going to change the soil.

This is a video of when they had soil samples and were trying to decide where it came from. You're going to hear Abubucarr talk, who was the level 2 from Gambia. Remember they are trying to figure out where the soil came from using the model.



You saw three students and they were really engaged with the problem of figuring out where the soil came from. Did you know soil could be that engaging?

This is the teacher's role and this is kind of a shared question mark. As a teacher I'm really concerned about this and I've been experimenting with how to fill this role. One thing I've experimented with in facilitating students' collaborative meaning-making is to have one student in the group sit back and put a check on the whiteboard every time a student said, "What do you think?" That



Teacher's Role: Shape the Discussion to Promote Collaborative Sense-Making

- Create the need to meaningfully interact
- **Facilitate students' collaborative meaning-making:** use prompts to clarify & deepen student reasoning, to promote student-to-student idea-focused interactions
- Ensure that every student's ideas are sought and valued
- **Model** complex/precise language and discuss reasons behind linguistic choices
- Design for ELs to be initiators, as well as responders, of meaning-making in groups
- **Support tenacity/perseverance** in understanding and meaning-making

was one way I tried to get them to talk more and really be interested in what others were saying. A lot of times they really do talk but don't listen. Adults do that too.

I am still having to model how we get more precise as we get further on in our units. We start off broad and get more precise.

I have to design for my ELLs to be initiators, as well as responders, of meaning-making in groups. This is really tough because we spend a lot of time making sure our ELLs are listening but don't have the kids who are not ELLs, who are L1, spend a lot of time trying to understand our ELLs. I want to underline that. As long as that's not happening we're missing a lot. How do we make sure that our lesson is designed specifically so the ELLs are making significant contributions and those are taken up by the classroom?

And then there is what I am calling tenacity or perseverance in meaning-making. How do I model that, how do I reinforce that? This student said something and we are going to have to work really hard to understand it because understanding each other is work. It is valuable work, but it's work, and it's not going to be easy. We can't let it go, we can't just let people talk and not understand. We have to know what people are saying.

Then they wanted to see how we became interested in the importance of modeling. This is something I am asking the group. Some people have to write an NSF grant for some

of this stuff, so what are some ideas about how to actually engage ELLs and L1 students to collaborate in meaning-making? How do we get them to really collaborate, not so just one student pronounces what they are going to do, but so they are really collaborating and understanding each other's ideas?

How can the teachers expect equal accountability for discourse and ideas? How can teachers teach both ELL and L1 the perseverance needed to make sense between each other? And if the teacher is more aware of students valuing each other's ideas, trying to get the kids to listen, does the teacher actually listen more as well?

The conclusion is that all students need support in the language of collaborative sense-making. If we are going to make NGSS work we have to know how to really support that collaborative sense-making. And teachers can use modeling to value ideas and disrupt the status.

More Things to Consider:

How did I, and other teachers on my team, begin to value the importance of modeling for ELLs?

What are some more ideas about how to actually engage ELLs and L1 students in **collaborative** meaning-making?

How can teachers expect **equal accountability** for all talk and ideas?

How can teachers teach both ELL and L1 students the **perseverance** needed to sense make between ELLs and L1s?

If the teacher is more aware of students valuing **each other's ideas**, does he/she become **more aware** and value all student's ideas?

Conclusion:

All students need:

- Support in collaborative sense-making
- Language to do science practices as part of learning science



Q & A WITH EMILY MILLER**Enhancing Status****Q:**

There is a whole literature around enhanced status and the pioneering work of Elizabeth Cohen. Did you do something to enhance the status of the ELLs that we don't see yet in the conclusion? How did you think about that?

A:

I've been experimenting with taking students' ideas that normally wouldn't be taken up as a collaborative model. We've been looking at why trees drop leaves in the fall, and one student was sure that it was because lightning hits the tree. And I was thinking, well, there is something in there, there is stuff to build from. I think a lot of times those ideas get dismissed and we go with one that feels closer to where we're headed. Instead I started with that one. How is the idea of trees dying because lightning is striking similar to what is actually happening in the fall? Can I use that and show that their idea really is awesome? That is one thing I've tried.

I tried doing those expert groups where I give certain kids expertise in something and then give other kids a problem. With that soil problem I was trying to have the expertise of the different locations.

There is something else I've tried, which sounds really contrived, having kids go around the table and they each speak for two minutes

or 120 seconds. I time them, and everybody has to respond. One kid speaks and then everybody has to respond to that idea before we move on. That has gained some traction, but it still feels heavy-handed and I would like it to feel a little more authentic.

Good question—I'm wrestling with it too.

Distinguishing Conceptual Modeling**Q:**

One question that comes up for me is how do you talk to the kids about their process in constructing models? What I'm talking about is the conceptual model, and what you're doing with them is representations. This is for a lot of reasons because the NGSS is conflated with a lot of other science practices, but it is one of the science practices, at least the way I think of modeling. So when you're working with the students how do you talk about what they're doing in the process of creating their initial idea and then move to refine it? Do you say we are building sets of ideas or we're building a model? And if you do talk about modeling how do you distinguish it from what they usually think of, which is an airplane model.

A:

I've never had kids talk about a model in terms

of an airplane model. When I start out with modeling, usually I will pick one model and put it on the overhead and we're all talking about this model, and everything that we do relates back to that model from the beginning. So I always use the language "modeling" and "revising," and kids can pick up those words. But we are collaborating together working on the first one, and then it becomes something that is really second-nature to the kids because we do so much of it. Does that make sense to you?

Q:

Yes, you're giving your version of what it means to them, and that's what it means in your classroom.

A:

I've never had someone ask, "Is there another kind of model?"

Jessie Auger, Bilingual Teacher, Rafael Hernández School, Boston Public Schools

Naomi Mulvihill, Teacher, Rafael Hernández School, Boston Public Schools



Jessie Auger (left) and Naomi Mulvihill (right)



Language and Science: Boston Public Schools

INTRODUCTION

Jessie Auger
Bilingual Teacher, Rafael Hernández School
Boston Public Schools

We are going to build on our two new colleagues' work, Gennifer McDonald and Emily Miller, and we are going to talk a little bit about the curriculum that we have developed together that spans two years, kindergarten and first grade. For the past 15 years we have been at the Hernández School, a dual language school in Boston, and have the enormous advantage of working in both English and Spanish every day.

We have designed these year-long interdisciplinary themes as a catalyst for wonder and learning. The science content is really the backbone of our literacy work with our students. What we want to provide for our students is a coherent set of contexts for simultaneous science and language learning.

We designed the curriculum to follow a progression that builds over two years. In kindergarten the study for the whole year is birds and in first grade it's the ocean. We chose these two themes because we wanted students to observe and experience living things and phenomena in their natural environment. It also enables us to use primary resources that are available to us in our community for free, which is a very real thing,

and it obviously has local relevance.

Our curricular design consists of structured, inquiry-based experiences and discussions, and actions built around those experiences that consist of making and doing, the completion of projects designed to deepen and broaden scientific understanding and language development.

Naomi Mulvihill
Teacher, Rafael Hernández School,
Boston Public Schools

Our basic premise is very similar to what we have been talking about during this conference. Even though I feel like we have been doing this in some isolation we have been doing it a long time, so this is great and very stimulating. What we basically think is that if we engage kids with scientific matter, they'll need to communicate their excitement, curiosity, confusion and wonder. And if we follow a theme that builds across the course of the year—we start the first day of school and don't stop until the last day of school—there will be a need for language and along with that need there is an increasing complexity of ideas, experimentation and language use.

Jessie Auger

Over the years of developing this we have acquired a really wide range of resources, from simple picture books and posters to really sophisticated texts, websites, diagrams and videos. We also facilitate student-made resources. In addition, we have built



relationships with experts in the field who play a dual role. One is to support us as educators and the other is to provide direct context for our students as learning resources through emails, letters and field site learning.

KINDERGARTEN: BIRDS

Naomi Mulvihill
Teacher, Rafael Hernández School,
Boston Public Schools

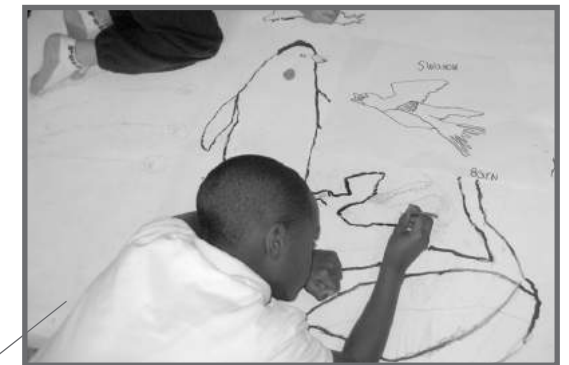
I'm going to begin with kindergarten and show you some of the experiences, things that students do and make, that generate science learning, an understanding of birds, and help develop them as speakers, active listeners, readers and writers.

We spend a good deal of time conducting experiments to try to figure out how to attract

birds to our playground. We try to find out when and where the birds seem to congregate just by observing. We try to figure out what seems to attract them. Is it a sunny spot? Is it a protected spot? How does the playground serve the birds? We try to figure out what kinds of foods and feeders they prefer and what seems to scare them off. You would think a schoolyard wouldn't be the most favorable environment, but a lot of birds come, including robins, red-tailed hawks, and a lot of pigeons.

Once we've made lots of visits to our school playground, we start going up to the park at the top of the hill and then to the zoo, which is beyond that. We can do all of this walking. At that point kids have become familiar enough with different kinds of birds and have gotten excited about some bird and its characteristics, and we invite them to draw their favorite bird. They use the resources that Jessie mentioned to select their bird, and they also use the computer to watch videos and look carefully as they draw their first sketch.

Julian [upper right] is working on his first sketch there. And here you can see the sketch serving as the basis for a drawing of a barn swallow on the canvas for a group mural. As they work on the mural, part of what I do to facilitate is work on the language by asking what part they are drawing, getting them to use words like "crest," "beak," "tail feather," "scales," all of the words that are part of the anatomical structure of a bird, and then descriptive words to describe some of the





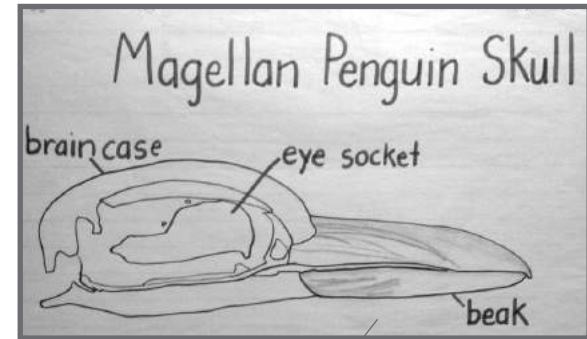
distinctive characteristics of their bird.

The work continues and the detail continues. Even though this is a dumb idea, getting the books and the paint right next to each other, we have to.

They know that they are going to be displaying their work in a public space. They have a night when all of the parents are invited and they decided they should definitely make bird hats for themselves and their parents, which they did. Their work is displayed and they learn to read and say all of these names of birds.

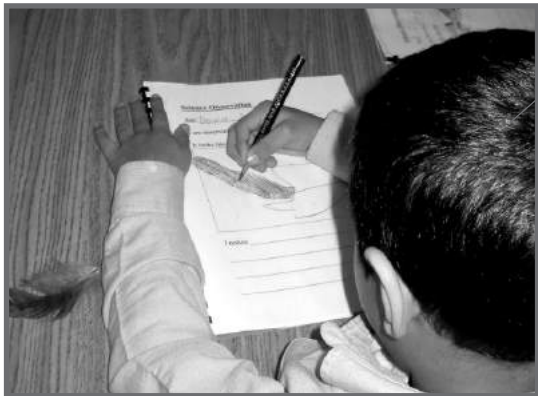


this thing. Where do I start? What do I do? They direct me in drawing the salient features of whatever we are looking at.



We happen to have a collection of skull replicas that are good for looking at the morphological differences with bird skulls. That also provides the opportunity to repeat some of the same language with variation and with more specificity as we go along.

Once we have done those two things, we work with groups of students, one group every day, and intensively work on building language for them to be able to speak to one another about what they notice and then draw and write.



This is a structure we use. We use science observation ever other week in kindergarten and in first grade every single week. The way it works is that we look at a specimen in a circle with the whole group. The question is, what do you notice? Students share what they notice using their own language. Then, after there has been some discussion about what they notice, I ask them to tell me how should I start to draw



Children also use resources. We focus on penguins in the winter, and I'm just going to read through what we do, the parts of the study, so you can have a sense of it. We view and discuss the movie *March of the Penguins* in 10- to 15-minute increments over several weeks. During those sessions students raise questions that guide the course of the rest of our study. We visit the aquarium to see penguins, we talk to the caretakers of the penguins. We make videos and we return to those videos repeatedly to look at how they move, how they preen, how they feed what they're up to.

Based on those experiences we make posters to teach others what we've learned. We choose three types of penguins, it's up to them what they're interested in, and then we make posters with shared writing which provides lots and lots of opportunities for re-reading and getting familiar with vocabulary.



To get a sense of proportion they are doing life-size drawings and then paintings of the penguins. I project it on paper and they are

looking at my projection and drawing it on their own. He is telling her what he is noticing about the lines for the markings, delineating the markings. And they use that language because we've used it all along.

They decided that we should also make a life-size stuffed penguin. We do a lot of sewing because neurologically it's the same path for writing. It was great because lots of people could do it at once.



On the family night they read their posters to family members and everyone needs a yardstick to do that, it just makes it better. They make a poster individually, drawing a penguin and writing what they feel is most important. The room was super-saturated with resources the children used and one child wrote: "Emperor penguins regurgitate through their beak to feed its chick. The emperors can't find each other unless they know each other's song." That was a huge concern. They look alike, how do they even find a mate? It was like physical torment until we could find an answer to that.



Naomi Mulvihill



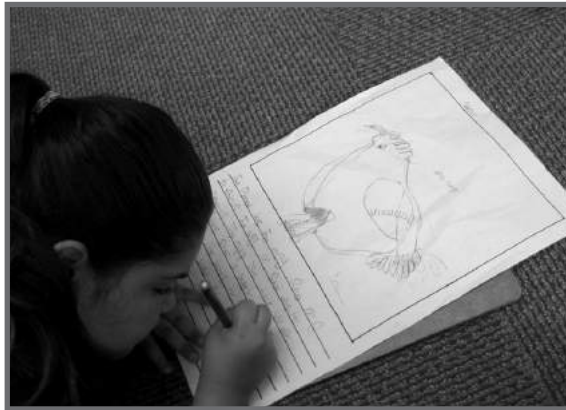


Another child writes: “Emperor penguins toboggan....” It happens during the first week of the study, watching the movie, and then you hear the word “toboggan” a lot of times. “...on the ice. When their feet get tired from walking. They lay one egg. The male incubates the egg.”

The third part of the study is chickens. It starts with chicken visits to the classroom. The chicken visit offers the opportunity to watch how adult chickens behave, how they eat, how they move around. One laid an egg while she was visiting.



The chickens work the same way with these experiences, with the resources, and with writing.



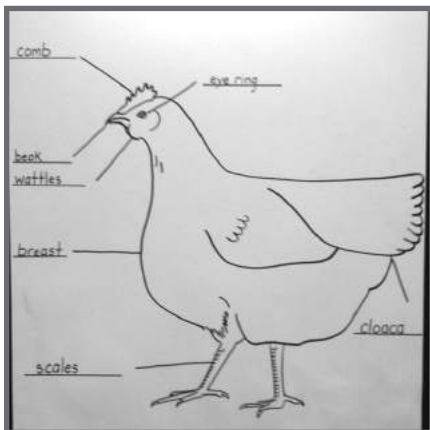
Then we incubate eggs. We get a variety of breeds and watch the development and study the embryo development leading up to the hatching. We have had the luck of the chickens hatching while we were there, which is great, but we also take videos of it. Parents stayed

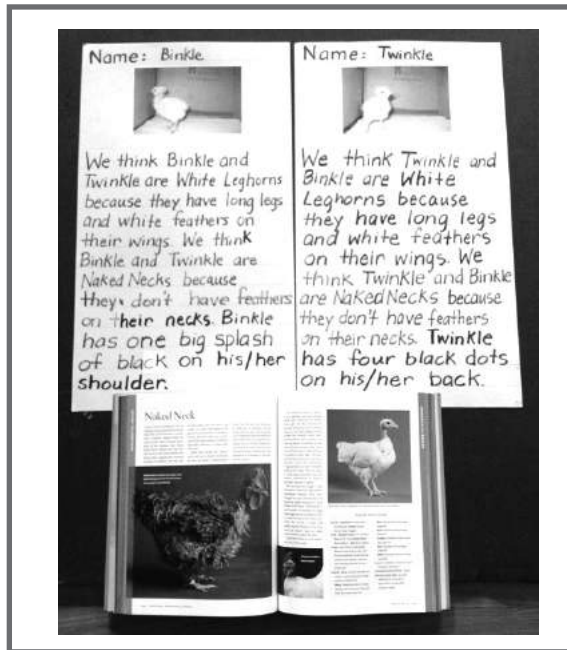
late until they were forced out of the building, writing notes and videotaping, so we got to reuse those videos in our studies.



Students know that the chickens are different breeds and here they are trying to figure out what breed is this chicken, what does it belong to? They are looking at different characteristics of the chickens and they are also doing experiments to find out how they are going to behave. If we put a big beetle in the chicken box what happens? If we take one of the chicks away from the brood what will it do? We ask different questions and just explore what will happen.

Finally, the kids look for evidence and make claims and assertions about what breed they think the chicken belongs to. They give evidence, they give counter-evidence, their arguments, and when we finally reach consensus, even though we’re not quite sure, but everyone finally gets tired and agrees, we write up our rationale for what breed the chicken belongs to.





And you can see in the classroom the very, very rich print environment.



FIRST GRADE: OCEAN

Jessie Auger
Bilingual Teacher, Rafael Hernández School
Boston Public Schools

Prepare to learn about the ocean and first grade and the entire year in one minute. For the ocean curriculum in first grade I use the same kind of structures, beginning with a collection of shared experiences. These field work experiences are what form the base of science and language development work that we carry throughout the whole school year.

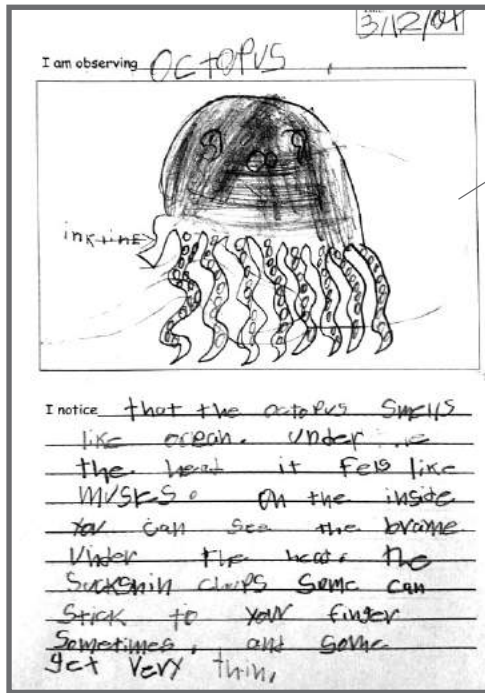
We are fortunate in Boston to have a number of different kinds of beaches. We go to a sandy beach, we go to a rocky beach, we collect specimens, we do a beach clean-up. We work with the Northeastern University Marine Science Center. We go to the Boston Harbor and observe the boats and cranes and goings-on in the harbor. We get to visit the New England Aquarium twice and are able to apply for free passes and use their kits. They have an amazing teacher resource center that we use all the time.

We've had a lobsterman come in and talk about his work and interactions of humans with the environment, and kids get to have their hands on live and cooked lobsters.

I follow through and build on the scientific observation work that Naomi and her kids do in kindergarten, and again it is teacher-facilitated inquiry with a focus on noticing, forming questions, making connections to

Jessie Auger

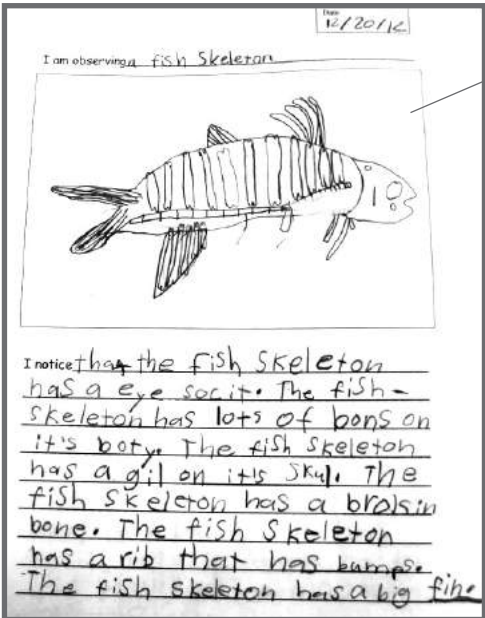




previous experiences, and continual language development in the service of expressing ideas more and more precisely.

I'm going to read two scientific observations. This student wrote: "I notice that the octopus smells like ocean. Under the head it feels like muscles. On the inside you can see the brain under the head. The suction cups some can stick to your fingers sometimes and some get very thin."

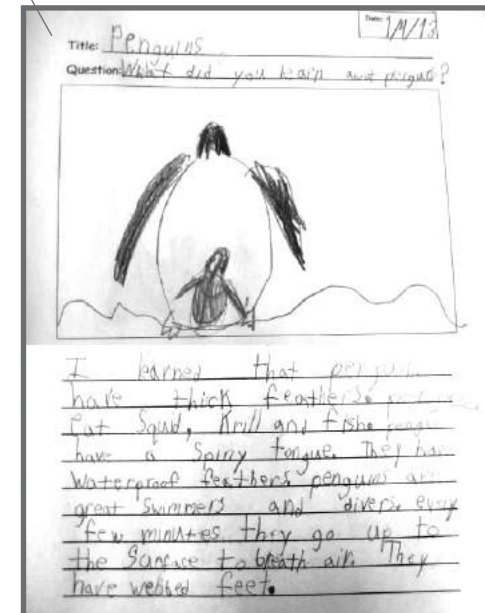
There is this idea of approximating language to express what you mean. In that last sentence, "some get very thin" was at first confusing to me and I was not clear on what this child was talking about, but if you look at an octopus tentacle you see that it tapers and gets smaller on the ends. So how do we create scientific language out of what we have to express our ideas?



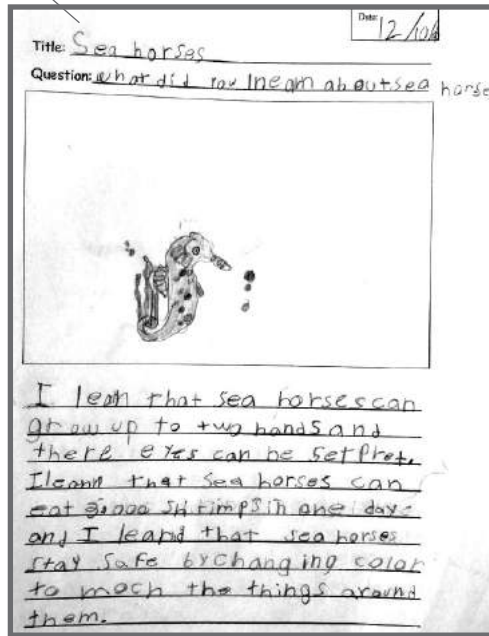
Here is a fish skeleton. We look really closely and do a lot of work with vertebrates and looking at skeletons. "I notice that the fish skeleton has an eye socket." This relates back to their earlier work with birds. "The fish skeleton has lots of bones on its body. The fish skeleton has a gill on its skull. The fish skeleton has a broken bone. The fish skeleton has a rib that has bumps. The fish skeleton has a big fin." So you can see built in there is all of our enormous amount of language development. And there is a sense of importance that they are noticing. The fish bone is broken and it's important.

Because there are lots of excellent books that are at reading levels that are too difficult for my students to read yet, I use a Listening Center. We will read a book and all talk about it as a whole class. I record it and read it onto a tape or CD so they can have a second or third round of listening to it.

They have Listening Center journals where they respond to an open-ended question: "What did you learn about penguins?" Obviously they studied penguins the year before, but this is a new book for them. "I learned that penguins have thick feathers. Penguins eat squid, krill and fish. Penguins have a spiny tongue. They have waterproof feathers. Penguins are great swimmers and divers. Every few minutes they go up to the surface to breathe air. They have webbed feet."



Seahorses are in another Listening Center book. “I learn that seahorses can grow up to two hands and their eyes can be separate. I learned that seahorses can eat 3,000 shrimps in one day and I learned that seahorses stay safe by changing color to match the things around them.”



To me this is an example of a student expressing new knowledge that she had learned about how big seahorses can grow. The book taught us that they can grow as big as the length of two adult human hands placed together. If I didn't understand that, I would not feel like “I learned that seahorses can grow up to two hands” was a scientific communication of an idea because they don't grow hands, right? Also they say that “their eyes can be separate.” The meaning that the

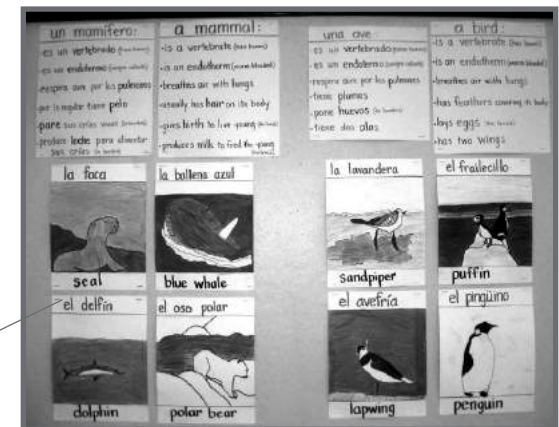
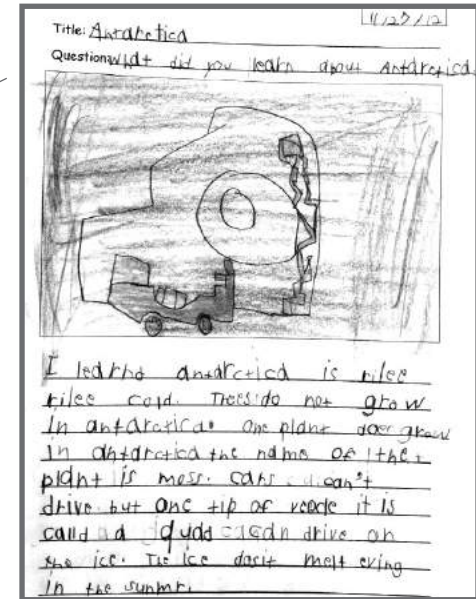
child is expressing there is that seahorse eyes can move separately at the same time. One can go one way and the other side can go another way.

We also study Antarctica. “I learned Antarctica is really, really cold. Trees do not grow in Antarctica. One plant does grow in Antarctica. The name of the plant is moss. Cars can't drive but one type of vehicle it is called a quad can drive on the ice. The ice doesn't melt even in the summer.”

As Emily noted, parent involvement is very, very important. We have parent nights with parents coming on field trips and students sharing their work with their families and working on that language. It values the language and it involves families in the process and the wonder.



I'm not going to have enough time to go through everything else that we have, so I'm just going to run through pictures so that you get a visual, and we'll just have questions or comments. Kids do lots of work with classification and how scientists

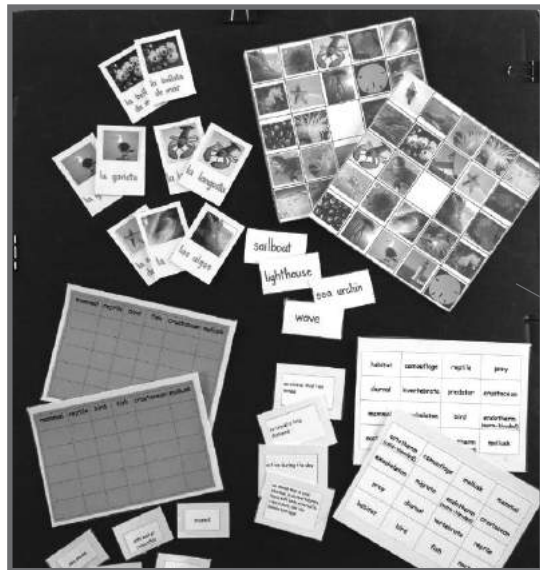
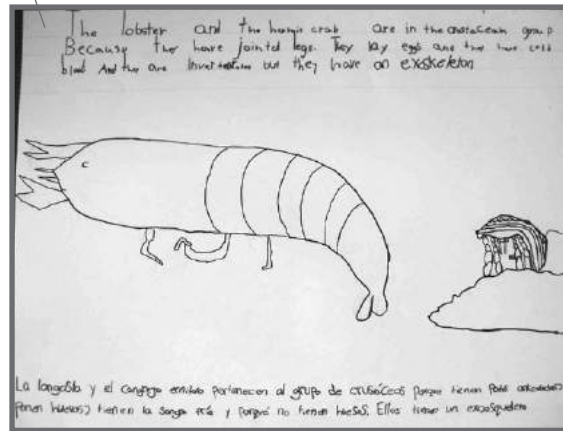




use classification as a tool to understand phenomena.

They do their research projects, they write books of their own, which involves study and use of a wide range of resources so that they can develop language and make this knowledge their own.

Kids work in groups. If one kid studied a lobster and another kid studied another kind of crustacean, they become the crustacean expert group and make posters about that animal to teach the school community and our families.



We also create tons of games that kids can use that integrate the science and the language learning, and kids have to negotiate the ways of figuring out how to solve the problems in these games. And we study and build boats, and we paint our cafeteria walls to be a mural of all we've been learning. That is a start of what we do in our classroom.

DISCUSSION AND Q & A

Dual Immersion Model

Q:

What is your Spanish-English dual immersion model?

Naomi Mulvihill:

We should say what it was at that time; it's evolving. It was about 60-40, so three days in Spanish all day, with the exception of children working in literacy groups with their more dominant language, and that has always been a bit dicey how that is worked out.

Jessie Auger:

So they would have their literacy learning for their first three years, K1, K2 and first grade, in their more dominant language, and outside of those literacy blocks it was three days Spanish, two days English. We are in a transition right now at our school, which we can't talk about because it's not crystallized yet.

Q:

How does that get negotiated, that language pattern? How much teacher voice is there in that negotiation?

Jessie Auger:

I wish I could answer that, but I don't know how to answer that right now.

Varying the Content Focus; Physics

Q:

So you have two very rich examples that include a lot of resources that you have developed over time. Do you ever feel like—hmm, birds again—and think about other areas you might want to build some more learning experiences around?

Naomi Mulvihill:

I like this question. The years are different depending on what children seem to need. One year we made a movie about pigeons and it was a huge endeavor and it was what that class needed. But there is one thing I notice about my practice that I feel critical of. You would think we would do something with flight and physics, but because of my own feelings of needing someone else to facilitate me in inquiry with that I haven't dared to try it out. It's obvious, right? But I need someone in my building to say, "We're taking this on. You guys don't do any physics." I feel I need that opportunity first to bump into all of these important ideas, so I can then facilitate children, recognize their questions, validate their ideas, and really make something wonderful out of it. So I love that question.

Jessie Auger:

With the ocean we definitely do different things different years and vary it. Because it's so broad and we've developed these resources over time, the kids' questions can guide where

we go with it. But we have this conversation a lot: A lot of animals—where's the physics? There are waves, and we do a little bit of that, and building a boat, and sinking and floating, and trying to figure that out, but not enough. So it is definitely something that I need to work on too, for myself.

Bringing in Math

Q:

How do you bring math into this?

Naomi Mulvihill:

The truth is that the kindergarten also has recycling as one of the stipulated pieces, the study of wood, which we use in an all-school recycling program. That has been a big link to math and data and to data analysis, reporting back to classes on how they are doing, trying to study waste in the school. So we do a lot of math integration through that science.

Jessie Auger:

For the ocean we do data collection in terms of looking at data regarding animals and that kind of thing, but I actually designed another big, long, integrated project that is about house building and making models for math. That is a different day.

Naomi Mulvihill:

The literacy block is something like two hours to two-and-a-half hours, and a science theme dominates that. Then recycling is also science,

Teacher Autonomy, Administrative Support

Q:

I'm wondering where you get the support to do what I think you may be doing, which is to ignore the Boston curriculum. Bravo is all I can say, but how do you manage that?

Jessie Auger:

That's a good question, and it is sort of both, we do both. As a teacher you've got to be able to say, "Oh yeah, I'm doing that, and here's how I'm doing it." The three kits I received for first grade are weather, sink and float, and organisms. Got it, did it. So part of it is being able to say, "Okay, we've got the weather patterns, we've got the organisms." Also, we had been given a good amount of autonomy by our principal, Margarita Muñiz, who is kind of a legend in Boston. She was at the school for 28 years and she loved science and was a big believer in trying to create equity in science.

Though one year we were studying turtles and the students wanted to make a habitat in the room, and I felt it was wise to sneak all of the sand into the room. When it felt like it was ready and the habitat was done, then Margarita could be invited. So even with that much autonomy there is the need for some negotiation.

but science and math, and I put that in the afternoon. Since I have them all day, I have control of the time.

Q:

So you have science and literacy and science and math, both in a thematic content.

Reflecting on Classroom Practice and Professional Development

Paula Hooper

Senior Science Educator/Learning Research Scientist, Institute for, Inquiry, Exploratorium

I would like you to reflect on all of these amazing presentations from teachers we have just heard and think about the question below. Talk with others at your table and record your thoughts and save them for our final discussion this afternoon.

What ideas about effective classroom practice and professional development design emerge from close examination of classroom practices?

CASE STUDY PRESENTATIONS:

Introduction

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

The three case studies we just had were such rich and compelling examples of the kind of thinking around science and language and teaching around science and language, so it's going to be a hard act to follow. However, we know that teachers can't do the kind of work that was shown without thinking about the context of schools and district and national policy. Their work does not exist in a vacuum and we need to acknowledge what happens in these other contexts to support teachers.

We have two district cases, and they are going to explore the opportunities and challenges that exist for districts to embrace innovations that lead to supporting the kind of practice we want to see for teachers. These districts come from two very different contexts. One, Sonoma Valley Unified, is a small rural district, and Oakland Unified is a very large urban district, but they have a lot in common as much as they have differences.

They both have the courage to step outside the traditional boundaries of how science is taught

and how language is taught, and we know that is the exception rather than the rule. The other thing I admire so much about each of the presenters and their work is that they really understand how important motivation for learning is for students, and that is what I think drives a lot of their reform. I am speaking for them, but that is what I have noticed about how they approach their work.

Then to bring us up to the national level Okhee Lee will talk to us about some things that need to be in place at national levels to support this work.

Sonoma Valley Unified School District

INTRODUCTION

Maite Iturri
Principal and SVUSD Project Director,
El Verano Elementary School,
Sonoma Valley Unified School District

I am the principal at El Verano Elementary and the project coordinator for the Exploratorium and school district's relationship. Our relationship began with the Exploratorium in 2008 and it has really been an amazing journey. Yesterday we heard from the researchers and the theorists and today we are hearing from the practitioners, which is a very nice way of setting this up for all of us to get a deep

Supporting Professional Learning for Language in the Context of Science: District and National Perspectives

Maite Iturri, Principal and SVUSD Project Director, El Verano Elementary School, Sonoma Valley Unified School District

Louann Carlomagno, Superintendent, Sonoma Valley Unified School District

Maite Iturri



Louann Carlomagno

understanding of the kind of work we do. As you've heard, it's not easy and it's not common.

Today we are going to talk about some of the structures and other things we have put in place to make this work happen. We are going to talk about the vision, the professional development, and then the conditions that we have in place for this kind of change to occur.

Louann has really led the way in making sure that all of our district's K-5 teachers have been trained via professional development to do this work, and she is going to talk about the vision.

VISION AND INFRASTRUCTURE

Louann Carlomagno
Superintendent,
Sonoma Valley Unified School District

Vision for Learning

All students have access to science at the elementary level and the opportunities science provides for students to produce and develop language.



It probably doesn't hurt to have a superintendent who was a science teacher for nine years.

It was so critical for me to have science back in our schools because we are a high-poverty district with many, many English language learners. Under No Child Left Behind, there was this weight put upon us around math and English, and science just got left in the dust. At that time I was principal at El Verano, where Maite is currently principal, which is our highest poverty elementary school in the district. I had this experience around this lack of science and it was truly heartbreaking and we said, "We have to change this."

Fortunately we are in this small community and we had a member of our community who has many resources say, "How can we change this?" It was his initiative that got us in a room together with Lynn and others from the Exploratorium, and a mandate saying, "Please make science happen," that got the ball rolling for us.

Infrastructure

- Leadership: District, staff and community
- Science and Materials: Kits, materials and coordinator
- Professional Development: Ongoing, consistent & feedback loop

Regarding our infrastructure, there is no new news here really. The district has about 4,600 students and we live in a kind of isolated valley, Sonoma Valley, so we have this really great capacity in terms of the district, the staff and the community all working together. Our community funded many of the initiatives when

we first started with our Exploratorium work. We went through our Sonoma Valley Education Foundation and they helped to seed a lot of the work that happened. We have kits, we have materials, we have a coordinator who is helping us with this program, and we have professional development, which has been mentioned many, many times. It is ongoing and consistent and there is a feedback loop so it is not just, “Get in the door and we’re going to give it to you in one day.” It is ongoing.

That has transcended all of the professional development work we do in the district, even with *Common Core* implementation. We have a whole cadre of team leaders who are driving the work around *Common Core* because it can’t happen from the outside-in, it has to happen from the inside into the classroom. We feel the Exploratorium work has now driven the work we are doing throughout the district at all levels because of this model we have for professional development.

We have had incredible professional development thanks to the Exploratorium, and here [see sidebar] you see some different groups of teachers doing their own learning around science experience. As I’m sure everyone in the room knows, our K-5 teachers do it all. They don’t just do science, or English, or math, they do it all. Getting them to really understand the content of science is an ongoing challenge but also a real opportunity too. As our previous presenters just shared, “Yeah, physics in waves, wouldn’t that be great?” But first you

have to know about physics in waves and that’s hard because again, elementary teachers have so much on their plates.

PROFESSIONAL DEVELOPMENT

Maite Iturri

We have heard today about professional development and the importance of it. These are some of the components that have led to our professional development and have provided us with a tremendous amount of success.

One factor was that a lot of our professional development happened here at the Exploratorium, which led to great opportunities and was really inspiring to teachers. It also put the teachers in the position of the learner, and many teachers have said over and over how important that was for their own understanding, and they were then able to take that back into the classroom. These experiences were shared and they were hands-on.

The other really important piece has been that Inverness and the Lawrence Hall of Science have been third-party reflection partners. They have been able to offer us some insight into what we are doing and help facilitate the conversation, which allows us the opportunity to really think about what we are doing.

And then there is a lot of validation of our work. It is set up for us to be able to take risks, and we have been doing a lot of experimenting

Professional Development

- PD at Exploratorium important for inspiration
- Being put into position of learners. This created initial ownership and made a case for learning in context
- Shared hands-on experiences
- Reflection using a third party
- Validation of work by colleagues





Professional Development *continued*

- Setting the stage for Common Core
- Transfer of knowledge to other content areas
- Setting conditions for language to develop through experiences
- Promoting wondering through “I wonder” statements
- English Language Development
 - First: communication/collaboration
 - Second: how English works - mini lessons

and a lot of learning. As Gennifer mentioned, it has been a journey and there have been some ups and some downs. Through all of this we have a tremendous amount of respect for each other and are able to talk to each other in a critical manner to push our thinking a little more.

Here are some more of our teachers. Some of this happens at the Exploratorium and some happens at Sonoma Valley. The Institute for Inquiry comes to Sonoma Valley four to five times a year and provides professional development for three different cohorts as well.

There are some other things that have contributed to our successes. It has really set the stage for *Common Core*. We started this work in 2008 and it started to shift teachers’ thinking about the way we instruct, so when *Common Core* hit the stage it was pretty fertile ground.

We started with Visual Thinking Strategies and I wanted to make sure that got mentioned. Visual Thinking Strategies is a program that uses fine art to help kids question what they are seeing. That also set the stage for some of this to happen.

Some of the question work that is going on with the Exploratorium is also transferring into math. They are using literacy circles and math talks to help extend the work.

And the language is developed through experience. The kids feel a sense of urgency behind what they want. They want to know the vo-

cabulary, they want to be able to explain what they’re seeing.

And there is prompting wonder through “I wonder” statements. I remember a teacher saying to me, “My husband is tired of hearing me say ‘I wonder’ because I’m walking around the house saying, ‘I wonder why that happened?’” So it has bled through everything we do.

The first part of the English language development piece was communication, with kids working together and collaborating and communicating with each other. The second piece was actually providing some opportunities in how the language works.



CULTURE AND TEACHER LEADERSHIP

Louann Carlomagno

Maite mentioned Visual Thinking Strategies, and through the process of the work we have been doing, all of the teachers have been involved. All of our K-5 teachers receive training in Visual Thinking Strategies, and again it was

ongoing, it wasn't just a one-shot. It has been doing on for years now and that set the stage, really, for our Exploratorium work. And it is the same with the Exploratorium work. It is K-5 and every one of our teachers are participating.

And believe me, there was a small group that would rather not have left their classrooms, but at that point for me as superintendent it was, "Everyone is doing it because we are so far in this everyone needs to participate." Even though we had some teachers who were hesitant, when they got in the room and participated they were rock stars. It was just getting them out of their classroom, but once they participated it was wonderful.

A Culture for Changing Practice

- Trust in teachers
- Peer support/leadership
- Creating space for teachers to experiment
- Make mistakes and take risks
- We are all learners together
- Sharing practice and student work
- Teacher conversations about the conditions for learning: John Bransford
- Learning language in context

You can read through this yourself. I am trusting teachers and allowing them to take risks. Even though with NGSS we are going to have to recalibrate, look at the units, and look at what kits are being used for each grade level, that's okay. That is part of our learning and

figuring out what we need to do. Our learning of language and context, which we've talked about here, makes a big difference. And we really come back to that idea of letting people take risks, myself included. I have a board of trustees that lets me take risks and so I am able to infuse that through the culture of our school district.

With teacher leadership, it probably didn't hurt that I was a teacher in our school district many years ago, that I actually graduated from our high school. I am in deep in this situation. It reminds me of the power of our teacher leadership. They teach me all the time. It is giving them an opportunity to study together—we have the study groups Jennifer talked about—and allowing folks the opportunity to experiment. It is also creating a culture of risk-taking because that then allows our students to take risks.

CO-CREATORS, COLLABORATORS, PARENTS

Maite Iturri

As Jennifer also mentioned, we have been co-creators in this whole process and have really felt like our work has been valued, and there has been this level of collaboration. In addition to that there has been a consistent evaluation of the program. We do pre- and post-surveys throughout every year. We have also had several researchers and guest speakers come to inspire the work. Kris Gutiérrez was there, Claudio and Diana came and also spoke to the group.

Teacher Leadership

- Teacher leadership development
- Teachers given opportunity to study
- Featuring a teacher for study groups
- Creating space for teachers to experiment
- Classroom observations/peer coaching
- Culture of sharing-practice and student work
- Innovative way of teaching in multiple subject areas



Co-Creators & Collaborators

- Collaboration with Exploratorium and teachers
- Consistent evaluation of program
- Reliance on researchers and guest speakers to inspire
- Constructivist model - open to some ambiguity



Include parents in the conversation early in the process



“My daughter is coming home and asking why when I ask her to do something. We are not accustomed to this sort of response”

- EV parent



Also, it is a constructivist model and we were open to a little bit of ambiguity. We don't always know what the next steps are, we don't always know exactly where we're going, but somehow we end up getting there.

One of the things I wanted to make sure that we highlighted, though it is not necessarily part of this conversation is that parents are a big piece of this. I had a parent come to me after their child came home and the parent had said to the child, “I want you to do...”

The child's response was, “Why?”

“Because I said so.”

“But why?”

So the parent came to me and said, “What are you doing? Our child is coming home and questioning us. We're not accustomed to this. We give a direction and they do it, and now they're asking why all the time.” One of the things we want to make sure to do is bring parents into the conversation early, so they have a clear understanding of what's going on. We do science inquiry with parents just to make sure that they're aware of what we're doing, and they are completely engaged. It has been an amazing journey.

CHALLENGES

Louann Carlomagno

Our challenges have been trying to figure out the following.

Challenges

- Reporting to funders
- Assessments that do not accurately measure what we are teaching
- Teacher motivation/burn out
- Time - competing interests
- One school at a time
- Units need to be created/available for an entire year

We had a lot of funders supporting these programs, and reporting to our funders has been a bit of a challenge—knowing what they want and how we articulate what we're doing to address their expectations. It has been an interesting process. Super supportive, but interesting.

Our assessments don't always accurately measure what we are teaching. California Science, CSTs, all of those things have been a frustration for us because we know they're not reflecting what is actually happening in the classroom, and a lot of times we are judged by those assessments. That has been difficult.

We know that this teaching game is a tough process, so sometimes teacher motivation and burnout is a challenge.

Then there is “one school at a time” and how to get something implemented district-wide. Again, we have five elementary schools. We're not looking at Oakland Unified where there are many, many schools. So it is a challenge, but it is also a blessing.

Finally, there are the units that need to be created for the whole year, which is challenging for us.

KEY CONCEPTS

Maite Iturri

There are a couple of things that we found were important in starting this process. We piloted it at one school and were able to make mistakes and start to figure this out. What it did was lay a foundation for teachers from other schools to ask, “Hey, what are you guys doing over there?” That helped infuse the enthusiasm. It wasn’t: “You are going to do this.” Eventually we got to that point, but it was really about inspiring teachers to participate.

We have a superintendent who communicated, “This is what we do. You have some options on how you’re going to make it happen, but this is what we do.”

There was having those third-party people be our critical thinkers and being able to have the ownership and the balance between outside experts and our teacher experts. Parent

education was critically important. And there was having those kits and having that constant communication. Lynn and I spend an hour on the phone every week making sure things flow smoothly. And finally, having a coordinator to support those teachers. Those are some of the key things that we felt were important to highlight in terms of what makes this a successful program.

And in closing, I knew this was profound when I saw kids running out of the classroom after a science day yelling, “I love science!” You don’t hear that. You don’t hear kids running out of their classroom screaming about content, you hear them screaming about who’s going to race for the swings. So it is profound, it is amazing, and I thank you all for your time.

I knew this was profound when children were running out of classrooms yelling, “I love science.”

-El Verano Elementary School Principal,
Maite Iturri

Sonoma Valley Unified School District
www.svusdca.org

Key Concepts

- Starting with pilot allowed us to develop program
- Mechanism for inspiring others. Starting at one school and people taking notice. Teacher interest: “Hey, what are you doing over there?”
- Superintendent ~ all schools will participate but choices on how participation would take place
- Third party with Inverness in being thinking partners
- Ownership and balance between outside experts and valuing teacher expertise
- Parent Education... “Why are our children asking us why?”
- Curriculum/Kits ~ all teachers have easy access
- Constant communication ~ staff and parents
- Coordinator to support teachers

A Serendipitous Aside

I want to mention that one of our school board trustees, who just left the school board recently, is here at the Exploratorium today with his wife, who is a high school principal, and their daughter, who was a student in our district and has just graduated her first year of college. We are so fortunate to have this support system right here. • Louann Carlomagno

María Santos, Director, School and District Services, WestEd; Co-chair and Senior Advisor for Leadership, Understanding Language, Stanford University

Claudio Vargas B., Elementary Science Coordinator, Oakland Unified School District

María Santos



Oakland Unified School District Elementary Science

SYSTEMIC TRANSFORMATION

María Santos
Director, School and District Services, WestEd;
Co-chair and Senior Advisor for Leadership,
Understanding Language, Stanford University

When Lynn approached me, she invited me and I invited Claudio because we don't do anything by ourselves, it's all about collaboration. At the same time that we're in collaboration, we are constantly focusing our attention on building leadership capacity and making sure that the folks in our system are constantly stepping up to leadership positions. And sharing our work is very important, so we really appreciate this opportunity. As districts take on risks and move forward in certain directions, the more we can tell our story the more the story comes back to our own districts and validates the work of the district, so getting these stories out is really important for our work.

Ours is a story of transformation, a district that has transformed itself. It is a story of systemic transformation focused on a core vision of quality instruction for all students, gearing that instruction to make sure that every one of our students is college- and career-ready. And you can't have a college- and career-ready agenda without science. That is really breaking the mold in terms of just thinking of language arts and math as central to prepping kids. That is part of this story in terms of really looking at all of the curriculum areas and making sure the

kids are fully engaged with the study.

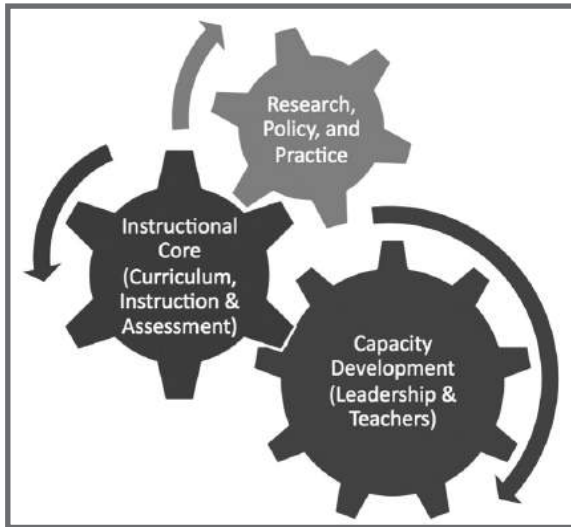
It is also a study about leadership development, about capacity development. It is about co-construction, creating an environment of experimentation and co-construction so that we learn together. It is also about building capacity, lots of capacity. Central to all of this, it is about creating a system that is coherent. This is critical to our work as we think about it.



Oakland is right across the bay, and yet Oakland is such a unique place, very different from San Francisco. I worked for many years in San Francisco and had a major "Aha" moment when I went into Oakland. There are about 40,000 kids. Traditionally, people think of Oakland as a black-white city, but it is a city that has changed over time. Over 40% of the students are Latinos, over a third of the students are English language learners, and there are about 49 languages being spoken in Oakland. So there is that demographic shift, which has not really been paralleled by a mind-set shift, so even the adults in the system have difficulty

wrapping their heads around the fact that our student population has changed and continues to change radically.

Oakland is not only a wonderful place it is also a welcoming place, and the professionals in the system are anxious to move the system forward. As we approached this, we focused on a work that really looks at policy, research and practice and how to bring those together to really drive the change within the system.



In our framing of the work we took a real look at the instructional core as central to this work in moving the system, and we focused on bringing in all of the key constituencies and developing their capacities. All of this is centered on kids, it is all about student learning. Everything we do is framed around how to hone our understanding of what kids are understanding. How do we actually listen to students and understand the sense-making.

This is a major shift for a system that was very much driven by basic skills and scripted curriculum.

When we looked at the policies, we really took advantage of the advent of the *Common Core*. We were also very familiar with the work around the *Next Generation Science Standards*, and were also engaged with Understanding Language and said, “We need to advantage all of this new thinking and use this as a platform for experimentation and for learning together.” So our position with our adults is that we are all in this together, we are all learning, it is all new. We don’t have all the answers, so let’s take some risks and learn together.

We also put in place policies establishing minutes requirements in science, which was a critical thing to put in place in the system. Everybody was doing language arts and math, while science, of course, did not have its time in the classroom.

Then we established graduation requirements. Actually, in Oakland the students drove the changing graduation requirements. It wasn’t the adults, it was the kids who surveyed their peers and did an action research project and presented it to the board and requested that the board adopt graduation requirements that ensured that every student graduating would meet the A-G graduation requirements. This was a major positioning of student voice in the advocacy, and if you know anything about Oakland, there is a lot of advocacy that goes on and community engagement.

Research-Policy-Practice

Policy to Practice

- Understanding Language, CCSS, NGSS
- Minutes Requirements in K-5
- Graduation Requirements
- Strategic plan - STEM, new Standards

Research-Policy-Practice

Practice to Policy

- ELD/literacy/science > Integrated ELD/Content
- Assessment task > Collaborative Developments
- Teacher Leadership Collaborative > NGSS/CCSS

Then one of the things we did early on was to work collectively on a strategic plan. We had over 5,000 people involved in designing the strategic plan as Oakland was coming out of state receivership. We had to build confidence in the system and in our community for an instructional program. Within that plan was a focus on the new standards as central to that plan as well as STEM. Nobody really knew what STEM was, but it was included in the plan and became a place for conversations to happen with our community. It was interesting how that little acronym prompted incredible conversation throughout the system.

As part of our work in terms of integrating research, policy, and practice, we have taken advantage of practices to then inform policy and move the system forward in different ways. One approach is to create the policies, and then the practices follow. Another approach is to advantage the shift in practices and create new policies.

We have been doing a lot of work with English language development, literacy, and science, and the integration of that. Now the conversation in Oakland is about integrated English language development and content in all of the disciplines. So we have less of a designated English language development period, and more focus on getting everybody aboard in an integrated way.

We have also moved a lot in terms of now having teachers co-constructing assessments in language arts, integrated writing assess-

ments. That also prompted a lot of work in co-construction and development, not only of assessment but curriculum units, professional development, etc., using the talent and using that expertise.

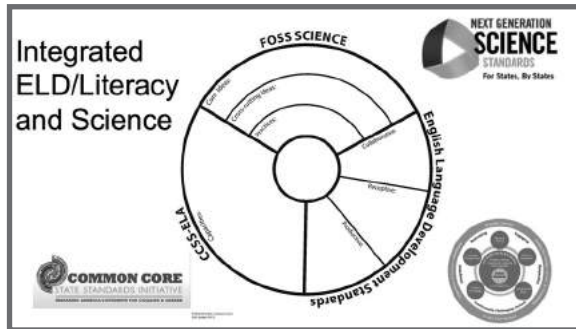
To really build our capacity as a system, we started developing lots of teacher collaboratives. This was critical and important because in Oakland most of our teachers were doing scripted curriculum, 12 years, very structured math curriculum, and pretty much felt disenfranchised and were really pained because their professional expertise was not valued. So we brought teachers into the fold, starting with the strategic plan, making sure teachers were involved in all elements of the strategic planning process. Then there was building teacher collaboratives in all of the different discipline areas and bringing them in to design the instructional program that they were then to offer for our students.

THE INSTRUCTIONAL CORE

Claudio Vargas B.
Elementary Science Coordinator,
Oakland Unified School District

In terms of the instructional core, we used a model that has come up again and again in this room, which is an integrated model of ELD, literacy and science. We borrowed the graph below from Lawrence Hall of Science and it is very applicable to our work.

We started with FOSS Science and NGSS, looking at the practices. A couple of years ago



we started to embed the practices through working with our teacher leaders and our FOSS curriculum. That is what we have been using for seven years and will continue to use for two or three more years in this current version.

We are also looking at crosscutting concepts as a way to understand phenomena and to link phenomena in different strands of science. What we are focusing on now is looking at the practices and making them explicit. We look at English language development as a way to bring about content understanding. In other words, using language to understand content. That is the driving force. Finally there is the *Common Core* and the skills of literacy, the reading and writing, the speaking and the listening that has to be part of the science learning because science is a language and there is no way around that.

In order to really implement the science program we need science curriculum. Maria just talked about the minutes that were adopted by the board in 2010, the minimum number of minutes of hands-on science that has to

happen every week: 60 minutes for K-2, 90 minutes for 3-5. After the board passed this resolution we saw a decrease in the once-a-week science teaching and increase in the two or three-times-a-week science teaching.

So we saw an immediate effect of that board policy, and this also followed an intensive professional development effort by our science department that really looked at teachers and giving them access to their own adult learning in all strands of science, so they could go back and really teach this in the classroom.

We also have materials management, as another district already mentioned. We have a warehouse full of FOSS kits that we take out to all 54 schools three times a year. So we do rotation and refurbishment of all of these kits. Without these materials there are no experiences for kids.

We integrate science, ELD, and literacy first and foremost through science notebooks (not “journals,” we call them “science notebooks”). At this point over 90% of our 884 teachers in our 54 schools use science notebooks as an integral part of their science instruction. These notebooks are used not just to write down procedures, which they also have to do, but data collection and conclusions, so they are using this as a tool for making sense, writing to learn.

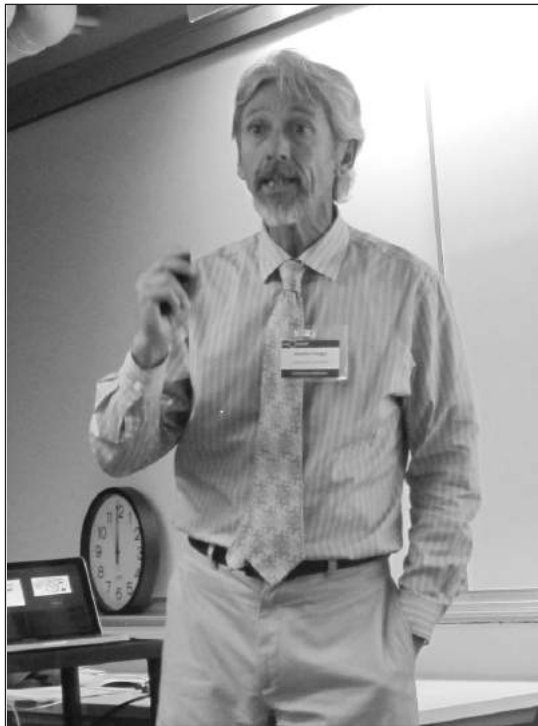
The other emphasis that we started in the district as a systemic change was academic discussions, whether pair share, group talk, or



Instructional Core (Curriculum - Instruction - Assessment)

Integrated ELD/literacy and science

1. Science Notebooks
2. Academic Discussions
3. Science Writing Tasks- Prompt driven by relevant big ideas
 1. Prior to task - science investigation using Foss
 2. During - science instruction, using diverse text, writing and academic discussion to write a reason-based essay
 3. After - teacher calibration and scoring to gain information on student science understandings and writing competencies



Claudio Vargas B.

science talk with the whole group. There were protocols put in place and we did professional development around academic discussions. In other words, we were giving voice to students, and we saw a transformation as we went out to schools from the teachers talking, to student voices, to students talking.

Two or three years ago it was mostly student observations, and students sharing but not really listening to each other. Last year we saw a shift, where a conversation was not just individual. Instead kids were starting to add to each others' ideas, co-constructing knowledge and using language to understand the science. It has been very powerful for the teachers to realizing the power of releasing that control to students, to shifting that dominance in the classroom.

Finally, and this was one of Maria's brainchildren, we pushed the ELA department and the science department to co-construct a science writing task, an assessment that was not just a summative assessment but an instructional model of how to teach, both formative and summative. This was a performance assessment that was anchored in the class curriculum, so in order for students to achieve and achieve well, they had to have the science investigations, they had to have those learning experiences. It started with students having the FOSS, then they were offered video and reading materials.

And it was based on opinion-based evidence, so it was different from what existed before.

Science Writing Task: Supporting English and Standard English Learners

Oral and written production:

It is through **authentic acts** of speaking, listening, reading and writing that we most improve our expressive language.



Teachers were used to doing assessment and writing assessments on information-based texts. Now it was around opinion-based texts and experiences, and it was a shift, but because they had had experiences before it wasn't a huge shift. It was a beginning step.

There were also different supports for language learners, and they began to really use language for making meaning and using writing for understanding. After the SWT or the science writing, because we couldn't measure only writing we shifted to an assessment that measured science content. We are in the process of developing what we are calling the Science Instructional Reflection and Assessment (SIRA) tool that measures content understanding, the big ideas of science, in

grades three, four and five. We are done with grade three, and this year is the first year in the history of the Oakland district that a science assessment is part of the calendar, so it is forcing every third grade teacher to provide this assessment to kids and therefore to teach the modules being assessed. The issue is not that assessment is driving instruction, which happens, but assessment itself is based on good instruction, and it is both formative and summative. We are really looking forward to the results of this assessment.

To finish this part of our presentation, here is our learning frame. At the beginning are the phenomena, and many of you have already talked about the idea that you need a common experience for students. The phenomena provide those experiences. But we can't leave it at that, that's just the beginning, the springboard. We need to add all of these other components where language really comes in.

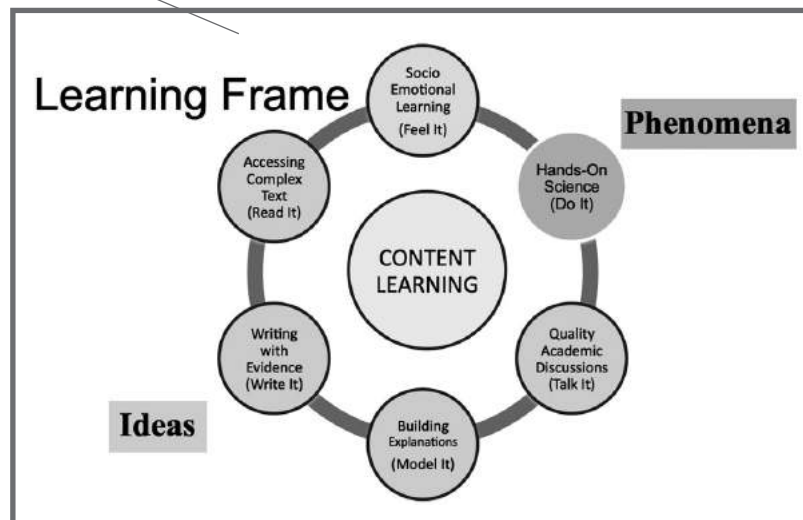
We have academic discussion where students talk. We have building explanations through models, which is critical. We have writing with evidence, assessing complex text, and around all of it is the socio-emotional learning, which provides that relationship-building where conversations and learning can take place, all in the service of ideas. That is the outcome. So we start with phenomena but don't leave it there, we go through to ideas.

How do we sustain this program? It is through leadership.

CAPACITY DEVELOPMENT

María Santos

We have invested a lot in leadership, and in our district everybody becomes a learner in the discipline areas. So if you are a principal or a supervisor of principals, a curriculum specialist, a special education specialist, or a content specialist, you are engaged in learning across the discipline areas. We engage everybody in learning, and learning together. We have learned quite a bit about how to do this and what some of the push-backs are. Not every principal wants to actually engage in an experience. We've had a lot of push-back from principals who say, "Why am I doing this hands-on expe-



Capacity Development - Leaders

Dedicated hours (Integrated ELD/literacy/science)

- Principals
- Teachers
- Cohorts Teachers
- Instructional Rounds



rience? Why do I need this? This is what the teachers do, this is what the kids do.” We’ve actually forced the issue and made sure they engaged in it.

So principals and principals’ supervisors as well as teachers engage in learning, including myself. It has to start from the top, right? You have to get in and model that you are a learner too.

We bring principals together for learning, and over the last three years we’ve had 60 hours of professional development for principals focused on science. That’s huge, to do discipline-specific professional development around a particular area, something that most principals were not engaged in.

All of our professional development with principals focuses on the discipline areas, whether it is science, English or math, but is very targeted around the science area. We started out the first year with 30 hours on science, and most of those 30 hours involved having experiences together and really talking about the science and getting engaged with it. Later on we adapted and included learning walks and instructional rounds in the professional development, so we could move from the static experience to what it looks like in the classroom. And then, how do you turn around and give feedback? What are some of the patterns that you’re seeing in the shifts in instruction in your school?

Teachers have had over 120 hours over three

years. And then we created cohorts, trailblazer schools, 13 schools that stepped up to the plate and said, “We want to be at the front and center of this work and we want to focus on science instruction as our main instructional focus activity.” Not only have these cohorts received 180 hours of professional development (and this is all last year’s data), they also receive the support of a coach at the school site to help them implement those practices. These cohort schools are the places where a lot of the co-construction goes on, the testing of the new curriculum. In any type of new activities, the teachers are engaged in the development, in testing, refining, and building up the resources.



Another activity we’ve engaged in is instructional rounds. We are now in our third year of instructional rounds. They happen two times a year, they are all focused on a problem of practice, and we focus on academic discussions in the discipline areas. As we do the instructional rounds we make sure that the teams engaged in these instructional rounds include

teachers and principals from three schools visiting each other, plus science specialists, plus central office instructional leaders, supervisors of principals, etc. We spend about two or three weeks. Everybody goes out and does instructional rounds, and we spend two-and-a-half to three hours at the school site visiting a set of classrooms, focusing on their problem of practice around the academic discussion. Then we talk about the patterns and have discussions regarding next steps for that school. And then we come back in the spring to revisit that school and the classrooms again: Where are you now based on that problem of practice?

All of this has created a culture of teachers and principals and leaders all talking, focused on the kids. Nobody is going into those classrooms to evaluate teachers, it's about seeing whether the practices that we are trying to get in place are making a difference for the students in how we see the kids experience the shifts in the curriculum and the practice. We are very excited because these are sustained going forward, even as I have moved out of that system.

Capacity Development - Teachers

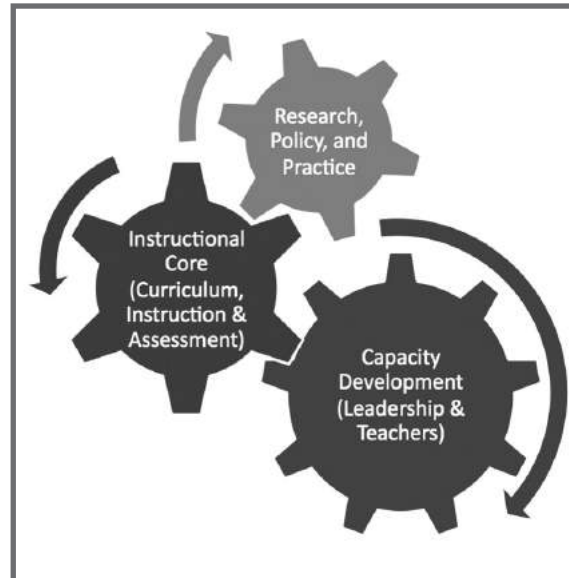
Teachers (K-5 generalists, ESL/Bilingual, SPED)

- 13 Inquiry Schools
- All Other Schools

We have focused significant attention on these 13 inquiry schools. We have a set of them exploring becoming a corridor of STEM-focused

schools. They are having these rich conversations of what it is to become a STEM corridor, which is very exciting and hard work.

What I want to close with is that our journey is one where we have integrated research, policy, and practice, and our focus on students is one that is shared by all in a learning community that is taking risks and is collaborating. Collaboration has made a huge difference in this because everything that we construct in our work is done in partnership and is vetted by so many people.



One of the tools we've developed is a five-by-eight card that we use in our observations. It is a very quick and easy tool for focusing the observations, and we use these in our walk-throughs and in our instructional rounds. We have also created a suite of videos focused on



the classroom that help us look at students' thinking and conversations, and help us calibrate what we're seeing. Those are some of the resources we've worked on. We really

believe that new work requires new tools, so we are always pushing ourselves to create new ones.

K-12 Science Learning Principles and Actions

Principles (Practices)	Vital Student Actions
1. Questions guide inquiry (1, 4, 8)	Students ask meaningful questions relevant to the science topic or lesson.
2. Learning occurs through investigations (1, 2, 3, 4, 5)	Students use materials, tools, and texts to explore, gather data, and answer questions .
3. Explanations are evidence-based (2, 4, 5, 6, 7, 8)	Students use evidence to interpret observations, support ideas, and construct explanations.
4. Science is a community endeavor that evolves with new evidence (4, 5, 6, 7, 8)	Students collaborate to build understanding and revise their thinking when presented with new evidence.
5. Application is essential for building understanding (1, 2, 3, 6)	Students apply science knowledge <i>and</i> practices to respond to open-ended and novel problems.
6. Academic success depends on academic language	Students use discipline-specific academic language, models, and mathematics to communicate understanding orally and in writing .
7. ELs develop language through content	English learners produce language that communicates ideas and reasoning, even when that language is imperfect.
8. Equitable participation	All students are engaged in learning and choose appropriate scaffolds for learning.

Oakland Unified School District, Science Department

Version 2.5 – August 5, 2013

Practices for High Quality K-12 Science Education

The Next Generation Science Standards (NGSS) define eight scientific and engineering practices for students as they engage in science learning. Not all practices will be evident every time, in every activity. Evidence of the practices exists through student activities and interactions. See reverse for student behaviors.

Scientific and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Next Generation Science Standards (2013). Achieve, Inc.
<http://www.nextgenscience.org>

Additional Information:

“Oakland Unified School District: A Vision for Elementary Science,” Diana Vélez, *FOSS Newsletter*, No. 42, Fall 2013

National Policy Perspective: Science and ELP (ELD) Standards

Okhee Lee
Professor, New York University

I am very delighted to be here and would like to ask you to think with me about the national policy perspective in science and English language acquisition, and particularly think about how that policy context either affords or constrains practices for PD, classroom instruction, district policies and state policies positively or negatively. It is out there like an 800-pound gorilla and we need to know what to do with it.

From my vantage point as a science education person, I would like to address the national policy perspective from science education. It would have been really nice to have a counterpart to talk about the national policy perspective from the language acquisition vantage point. That is the next step to take.

I would like to travel a little down memory lane, and I am old enough to say that now. We still have previous standards in science and now we have new standards. What lessons can we learn from the previous standards and the transition in the science education community? Think about the fact that the previous generation of science standards started from the document called *Science for All Americans* that was published in 1989. The *Benchmarks* document came in 1993, and *National Science Education Standards* by the NRC was published

in 1996. That is the previous generation. That stimulated the state standards in science.

And then we are in a transition of new standards, starting from the *Framework* that was published in 2012, and then the *Next Generation Science Standards* in 2013.

As I think about the previous generation and the new generation, I would like to draw just a couple of lessons for us to think about. One is, if you do the math right, that reform takes time to take root. We are talking from 1989 to 1996, just for the science education standards document to be published before even talking about the state implementation and adoption of the standards. So when I hear Steven Pruitt, my good friend, saying, “We need to be patient,” we need to be patient not only because of this *Common Core*, but also simply because a new wave of reform takes time because it is generative, it is organic.

Now when you think about the fact that we started reform in 1989 and just had the *Framework* document in 2012, do the math. How long did it take? Twenty-three years, two decades, that’s how long it takes for any wave to take root and for the wave of reform to last.

The standards are very personally meaningful to me as a transition. That is, 1989 is when I got my doctoral degree, so my entire academic life is in the context of the previous standards. And when I got invited to be part of the new standards I had the choice: Am I going to complain about it or am I going to do

Introducing Okhee Lee

Okhee Lee is a professor in the Steinhardt School of Culture, Education, and Human Development at New York University. Probably everybody in the room either knows Okhee or has read her work because she is a prolific author. When we were first embarking on this enterprise and were searching the research, almost everything that was out there was from Okhee. There were other things, but it was predominantly from Okhee. Of course that stimulated a lot of the work that we are doing today and now there is much more out there in the field, but I think that is a compliment to her. • Lynn Rankin, Director, Institute for Inquiry, Exploratorium

Science Standards

Previous science education reform

- *Science for All Americans* (AAAS, 1989) and *Benchmarks for Science Literacy* (AAAS, 1993)
- *National Science Education Standards* (NRC, 1996)

Current science education reform

- *A Framework for K-12 Science Education* (NRC, 2012) and *Next Generation Science Standards* (NGSS Lead States, 2013)

Lessons

- Reform take time to take root (from 1989 to 1996)
- A wave of reform lasts for years (from 1989 to 2012)

Science Standards

Science for All Americans and Benchmarks for Science Literacy

- Scientific inquiry
- Common themes
- Concepts in science disciplines

National Science Education Standards

- Science inquiry
- Unifying concepts and processes
- Concepts in science disciplines

Framework and NGSS

- Science and engineering practices
- Crosscutting concepts
- Disciplinary core ideas

Framework and NGSS for Student Diversity

Central Position of Engineering

- Designing solutions to problems in local contexts relevant to students' lives and future

Explicitness of crosscutting concepts

- Expected of all students (not just "gifted," "honors," or "advanced" students)

Focus on Science and Engineering Practices

- Refining and deepening of science inquiry as broadly defined in previous documents
- Language intensive

Three-dimensional learning as the keystone of NGSS

- To explain phenomena and design solutions to problems
- Local contexts that capitalize on students' everyday language and experience

something about it? And I said, "All right!" So the new generation of standards is something I intentionally undertook, so it is personally meaningful to me.

I would like to remind you of what we all had in *Science for All Americans and Benchmarks for Science Literacy*. This is particularly relevant for language acquisition people who may not be quite familiar with these, and then I will move into *National Science Education Standards* and the *Framework* document. When you look at the document, *Science for All Americans*, it really had multiple components that make up science literacy, and three of the components included scientific inquiry. There were common themes and concepts in the science disciplines of earth science, life science, physical science, engineering and technology, and all of the other areas.

The *National Science Education Standards* also included, among others, science inquiry, unifying concepts and processes, and concepts in science disciplines.

Next Generation Science Standards, along with the *Framework*, had science and engineering practices, crosscutting concepts, and disciplinary core ideas. The labels might look somewhat different, but the spirit of those three domains is similar.

I think the *Framework* document is really very clever and ambitious at the same time. What I meant by clever is that because the science education community has been thinking about

those three components, when those three components are addressed it something we have been dreaming of doing, blending and merging those three components together, not just as separate. But it also makes the new standards so familiar, and palatable enough to say, "Okay, we know what it is." And then it took the next and bold steps, huge and big. So there is this little bit of familiarity and there is a boldness of taking it to the next step. Does this sound like, "Scottie, beam me up"? Yes, I am a Trekkie.

The *Framework* and NGSS have many unique features, and I would like to highlight several key features that are particularly relevant to student diversity, which is my charge as part of the NGSS. There is a central position of engineering that is designing solutions to problems in local contexts of how to make things work in my local setting, which has a relevance to students' personal lives and future that is absolutely critically important.

Why is engineering important? I just visited Korea two weeks ago, one of the countries international benchmarking might have taken into consideration, and saw the technology. When I came to the U.S. 30 years ago, kids would ask me where I was from. I would tell them to take a guess, and they'd guess China, Japan, and then stop. The reason why Korea has been surviving is because of engineering, technology. So it makes all of the technology that kids are aware of that we may not even know about.

The next one is the explicitness of crosscutting concepts. These crosscutting concepts are what used to be expected of smart kids, what they figured out on their own. *Next Generation Science Standards* said that these crosscutting concepts are out there, explicitly and intentionally expected of all students on a playing field that is equal.

I would like to highlight two important concepts that are particularly relevant to diversity and especially ELLs. One is this science inquiry into science and engineering practices. Science inquiry was proposed in the previous standards, but the analogy people think of regarding inquiry in the previous standards is that it is a little like the blind man trying to figure out the elephant. We are all trying to figure out what it is and it depends on the parts that you touch. The contribution of the NGSS and *Framework* documents is that they are refining what science inquiry is, that these are the most important components of science inquiry that we expect students to do because these are practices scientists do.

It is also a deepening of science. There was a question earlier about modeling. We tend to think of modeling as a physical modeling of a replica or a presentation, but what NGSS is asking of modeling is conceptual modeling of a causal explanation. Every single little detail in a model of where a drawing goes or where the arrow goes, how thick, how thin, all of that has a conceptual meaning. It is language-intensive

because you have to use language in various models.

The most important part of NGSS is the blending of three dimensions as one in the service of phenomena and solutions to problems. I don't need to give explanations or examples because Emily did that in her presentation. Why is it important? Because in the previous standards, when you had multiple components, typically there is a long list of science concepts students must learn in some manner, and inquiry tends to be used as a means to learn the concepts. And by the way, by doing it, kids may learn inquiry, but it's "in the service of."

In the new standards when you put the three things together, all three of them are mastered. There is no "master in the service of," they are all together. Now it is in the service of figuring things out. What does it mean in the natural setting, and particularly in local contexts? Emily talked about those families from Laos and Gambia. It is a local setting that capitalizes on students' everyday language and experience, their home language and home culture.

So when we think about NGSS I would like us to think about not only the academic rigor or the language intensiveness, but also the meaning that it gives the diversity, and what it means for different groups of students. It really has so much to offer for all students.

This is the way I think of integration, having been in the field. This is my theory, naive

Integration of Science and English Language: From a Science Education Perspective

Earlier Work:

- Hands-on science for process skills activity-based ESOL/ESL strategies (concrete, experiential, contextual, comprehensible, communicative during group work)

NSES (1996):

- Science inquiry skill-based ESOL/ESL strategies (academic language; academic vocabulary; tier 1, 2, and 3 words; Academic Word List)

Framework (2012) and NGSS (2013):

- Science and engineering practices language use while engaging in science and engineering practices

thinking about what science and language acquisition integration means. A few decades ago when we started, we thought of it as hands-on science for science process skills, so when you thought of hands-on it resonated with the second language acquisition community because they were thinking of something concrete, experiential, contextual, comprehensible, and communicative. It provides the context. For that hands-on activity there is this context where kids are engaged.

When you think about NSES science inquiry, it is more “analyze,” “predict,” “explain,” and that seems to relate to academic language or academic vocabulary like tier 1, 2 and 3 words; like discipline or general academic word lists. You do the analyze in science and you do the analyze as a language function.

Okhee Lee



When you think of the *Framework* and the intersection between the two, then you have science and engineering practices. Guadalupe was talking about theories of usage-based approaches to language acquisition, not about the strategies *per se*, but language as doing science. It’s a new way of thinking about it.

When Lynn talks about the contribution I have made up to this point of the existing literature, I don’t know if I have made a contribution or hurt the field. If we think about new ways, it’s a fog in my mind. I am really not sure whether the new way of thinking about it is based on the previous work, or replaces the previous work, or replaces parts of it. It is something we need to think of, what that means in terms

of a new research agenda. It just makes me ponder. I feel very blessed that I have lived the previous and I am living the new, two ways of thinking about it in one’s life.

Examples of Science Standards

NSES (1996)

- **Structure of the earth system for grades 5-8**

- Water, which covers the majority of the earth’s surface, circulates through the crust, oceans, and atmosphere in what is known as the “water cycle.” Water evaporates from the earth’s surface, rises and cools as it moves to higher elevations, condenses as it moves as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. (p. 160)

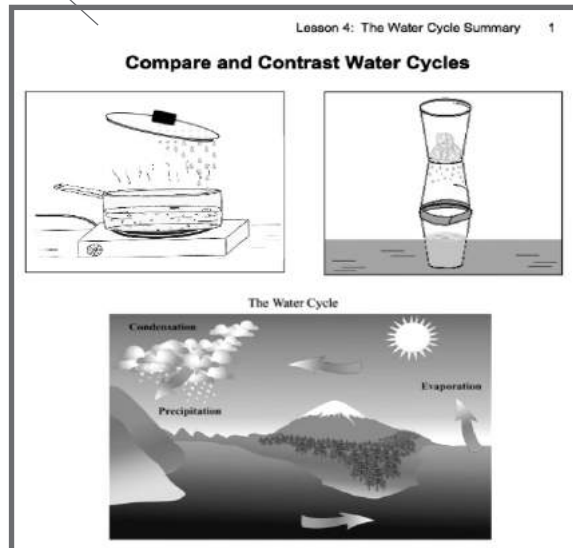
One State (2011-2012)

Earth systems and patterns for grade 5

- SC.5.E.7.1 Create a model to explain the parts of the water cycle. Water can be a gas, a liquid, or a solid and can go back and forth from one state to another.
- SC.5.E.7.2 Recognize that the ocean is an integral part of the water cycle and is connected to all of Earth’s water reservoirs via evaporation and precipitation processes.

Here are examples of science standards. The NSES example uses a common and favorite topic: the water cycle. You read it, it’s about content. Inquiry is out there, but it’s about content. Below that is one state’s example of the water cycle for grade 5 that was revised in 2011. It says, “Create a model to explain...” I think we may all be thinking of a water cycle model. Next, “Recognize that the ocean is

an integral part..." "Recognize" is low level, meaning you can think of a drawing of the water cycle and recognize it. It may be something like this.



There is a hands-on, and the hands-on is concrete and experiential. You can think of it as an inquiry, so there is compare and contrast inquiry, and there is the academic language of compare and contrast. There is a model shown.

You may be wondering what the water cycle might look like in the new standards, so you go through the NGSS, you do all of the searching, and guess what? You will not find the water cycle term the way it has appeared in the past. Instead, this is what you see [sidebar]. It has the "Earth's Systems for middle school" and it says, "Develop a model to describe (practices) the cycling of water through Earth's

systems driven by energy (that is a crosscutting concept of energy and matter) from the sun and the force of gravity (that is a disciplinary core idea)." Then when you look at the clarification, it has emphasis on the ways water changes and refers to the "hydrologic cycle." It could be somewhat physical, but there is a conceptual model of the water cycle. It is a new way of thinking about the three dimensions blended together. It shows the more rigorous knowledge, not just of the water cycle but the intersection of matter and energy.

So we pause and we think about the landscape of the science standards. As of mid-December West Virginia adopted the NGSS, so we have 13 states that have adopted NGSS along with D.C., and implementation plans are in progress, so when you visit the websites of the 13 states it has all of the process of developing the framework, implementation patterns, and all of that.

That means, by subtraction, 37 states are still using the previous version of the standards. Some states or districts may adopt the NGSS as a whole, some may adopt parts of NGSS, or they may adapt parts of NGSS. For example, Massachusetts is going through adopting disciplinary core ideas and practices but not cross cutting concepts. New York is proposing something of a combination of *Next Generation* and the state. And then some states may not adopt. It is an evolving landscape with the science standards.

Now what does that look like in ELP and ELD

Examples of Science Standards

NGSS (2013)

- Earth's Systems for middle school (grades 6-8)

MS-ESS2-4. Develop a model to describe (practices) the cycling of water through Earth's systems driven by energy (crosscutting concepts) from the sun and the force of gravity (disciplinary core ideas).

[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]

Landscape of Science Standards

- NGSS adopted states - 13 states and DC
 - Implementation plans are in progress
- NSES-based standards - 37 states
 - Some states (or districts) may adopt NGSS as a whole
 - Some states (or districts) may adopt parts of NGSS
 - Some states may not adopt the NGSS

Landscape of ELP (or ELD) Standards

- WIDA - 37 states (according to WIDA website)
- ELPA21 - 11 states (according to ELPA21 website)
- Other (e.g., California ELD Standards)

Science and ELP (or ELD) Standards Across States

Science Standards	ELP (or ELD) Standards
<ul style="list-style-type: none"> • NGSS • NSES-Based 	<ul style="list-style-type: none"> • WIDA • ELPA21 • Other

Broader Policy Contexts

- Science as part of state accountability system currently
- NGSS three-dimensional assessment
- ELP (or ELD) assessment
- Common Core State Standards for ELA and math
- PARCC and Smarter Balanced Assessments for ELA and math

standards? Here is what little I know through the Understanding Language initiative. According to the WIDA website there are 37 states that are part of the WIDA consortium. It could be 36, I'm not quite sure, because it's a moving target. ELPA21, which is closely aligned to *Common Core* and *Next Generation Science Standards* has 11 states according to the website. Then there are others like the California ELD.

When you combine the two together, this is the landscape that you have. On the one hand you have science standards, on the other hand you have ELP and ELD standards and these other mutations. When I give a presentation to a state to talk about the science standards, NGSS, diversity and equity, I need to think about whether this is an NGSS state, an NSES-based state, a WIDA state, or an ELPA21 state so that I understand the policy context to be able to relate to the audience.

These are mutations, and that means that every state is going to be different most likely, in different ways. How much, how much is common, how little, we are not sure, but there is one thing I want to address to this group particularly: This group might be the group to think about what contribution we can make, how we address national policy perspectives in science and ELD as it relates to ELLs. That is the charge that I hope that we will undertake this afternoon.

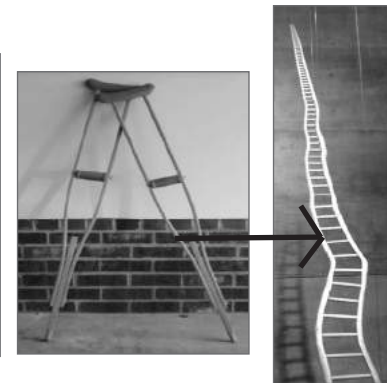
Just to make it a little more complicated, is science currently part of a state accountability

system? I know that California is trying to borrow the ELD time or ELA time for the sciences. Suppose that a state has a science accountability that counts towards accountability. A state could teach science at the fifth grade level every day for 45 minutes. The question is, how do you make use of that time? Now that we have NGSS three-dimensional learning, what does it look like to think about NGSS three-dimensional assessment? Now that we have ELP or ELD standards, what does it look like to think about the assessment? And we all know about *Common Core* and state.

I am going to borrow a quote from Helen Quinn. Early on in the Understanding Language initiative, we were talking about science and language synergy and Helen made a point that stayed with me. She said that when we think about ELD or ELP or ELL strategies, we tend to think of a crutch to help us lean on. Instead we need to think of a ladder the students can climb to soar.

Using Language While Doing Science

Rich language use and rigorous science learning to support each other



When I put that into imagery, what I see is that if you have a crutch it pulls you down, but when you have a ladder it pushes you up. So I think our charge is, given the context, what do we need to do to help the students to soar?

SYNTHESIS OF CASE STUDIES

Reflections: Leading Teachers, Rich Classrooms

Mark St. John
Director, Inverness Research

I have a couple of thoughts on today's conversations, both the teacher cases and the district cases, and they are literally thoughts and reflections, but hopefully they will stimulate some of your thoughts.

The Teacher Cases

- Gennifer McDonald
- Emily Miller
- Naomi Mulvihill and Jessie Auger

All are **leading teachers**

I thought the teacher cases were really compelling and I think everybody in the room thought they were compelling. They are extraordinary people doing extraordinary work, articulating their work clearly, and engaged in an inquiry about the work. To me that is a center point of an effort, and I want to say

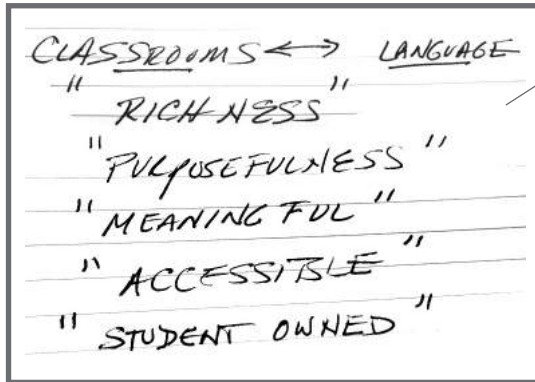
more about that. A concept that might be useful to you is that sometimes we talk about "teacher leaders" and I think that's a little bit of a misnomer in this case. These are "leading teachers" in the same way you would have a leading doctor or leading surgeon or leading musician, someone leading in their field. They are people who are concerned, very much, about improving their own practice, just as a doctor or surgeon would be concerned about improving their practice, but they are also concerned about sharing that practice with others, bringing in the knowledge of others into their practice.

So they are leading practitioners in their field, and I think "leading teachers" is a better description than "teacher leaders." If you are a teacher leader you are anointed by someone who wants to use you as an instrument to implement their initiative. A foundation says, "We've got to get some teacher leaders because we've got a plan and we want to implement our plan, so we need some instruments. Teacher leaders! They can do the work."

That is very different from a leading teacher who is responsible for the design and learning and so forth. And they are smart about getting support. They are not independent, they are very collegial in their work. So the idea of leading teacher is a really important one, and I thought we saw brilliant examples this morning of leading teachers. And their stance is an inquiry stance to their practice, and we

Mark St. John





saw brilliant inquiry stance. These were really central examples and ideas and crucial to going forward in the field. In my mind, this is the stuff we have to share with people.

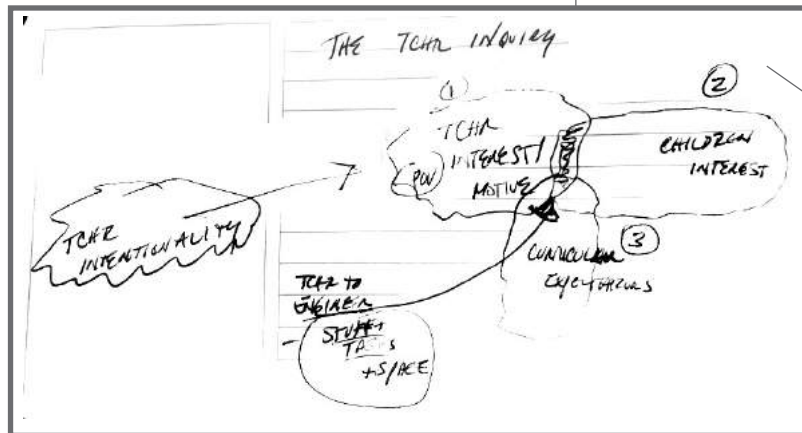
These are some sketches from my notebook. In the language used to describe the classroom these words came up over and over again and I thought they were very good words. And I think the classroom, the quality of the classroom, the quality of the opportunity to learn is a crucial thing. "Richness" is a lovely word and a good word, and even though we might ask what we mean by "rich," if we were to spend time defining it we would all come up with a similar definition. I've done this exercise many times. We know what rich classrooms are, and these classrooms are rich in science, rich in language, and rich in the interaction of science and language, and that is the goal. The goal is: How can we create rich classrooms that have these kinds of qualities? So we are looking for classroom spaces that have these kinds of qualities. That is what we are trying to do here.

developing a practice that is important. If you listened to Emily talk, she has an interest, she has strong motivation, she has a point of view. She is not a blank slate, just teaching, she is a person with a point of view. Someone else might have a different point of view.

When I was listening to Emily in particular I thought, there is a strong motive, a strong interest, and what she is trying to do is say, "Gosh, can I find some way to take my passion, my interest, and overlap it with children's interests? If we were both interested in the same thing, wouldn't that be cool because then they would be excited about it, we get this overlap of interest and motivation and passion." So be it the environment, the watershed, whatever it is, we have this overlap.

We are trying to plug into children's interests, where they are, their skills, and so forth, and what Emily and the other teachers have to engineer (and engineering is a good term for this) is how to create this overlap between what they really care about and what the kids might really care about. And you do it with three things: with stuff, with tasks, and with space.

When I was watching the videos of those classrooms, the thing that struck me is what a remarkable space, with kindergartners, first graders and second graders sitting there attentively and paying attention—much better than Congress ever does. That is not by accident. Those people have created



There is one thing I was struck with, particularly in Emily's case. It seems to me we've left out a piece of the puzzle and Emily made it very clear to me. What we have happening here are teacher inquiries into their own practice, into doing things better, into

those cultures, those spaces, those classroom infrastructures. It was just extraordinary.

They also thought very carefully about the tasks that they would give, and at the center was stuff: good, rich, interesting stuff. So interesting stuff, appropriate tasks, a range of tasks and strategies, and then a lovely space in which it all comes together. And that is what creates the overlap between the teacher's interest and the students' interest.

Then (and this relates to the question about the Boston Public Schools) you have to be smart enough also to say, hey, there are curricular expectations. We can't just do Civil War history for kindergartners, we have to do something about curricular expectations. So they also have to be smart enough to engineer in the curricular expectations that come with the job, with the policy context, and so forth. But the point of this is that teacher motivation is a critical piece of the puzzle.

There is another thing that struck me that relates to engineering. Stanley Podgrou wrote an article about technologies, and he doesn't mean computers, he means the strategies, the techniques, the scaffolding, there are lots of words for it. Some of these came up: textbooks, notebooks, charts, rapid-fire questioning, science talks, scaffolds. There is a lovely list of technologies and ways to engage so that the vision we have of things only gets enacted through specific techniques, specific technologies, specific ways of doing something. These are really specific technologies, and

that is another piece of how this is all going to happen.

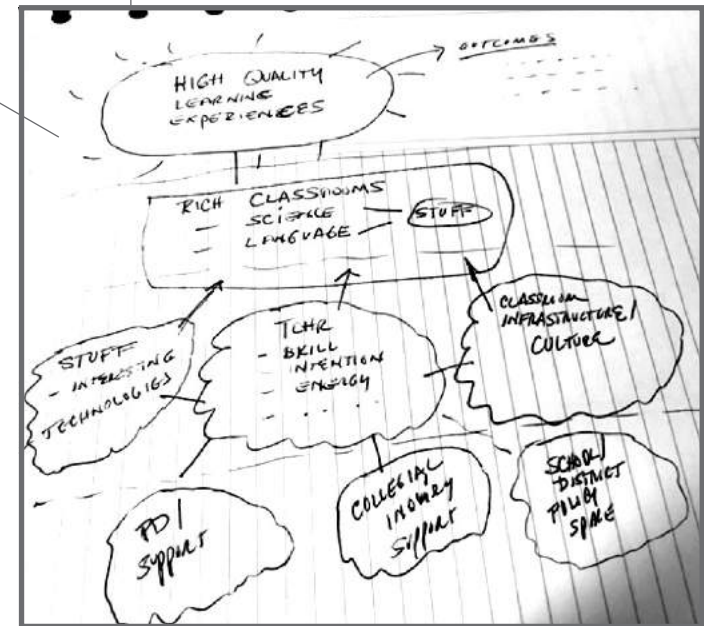
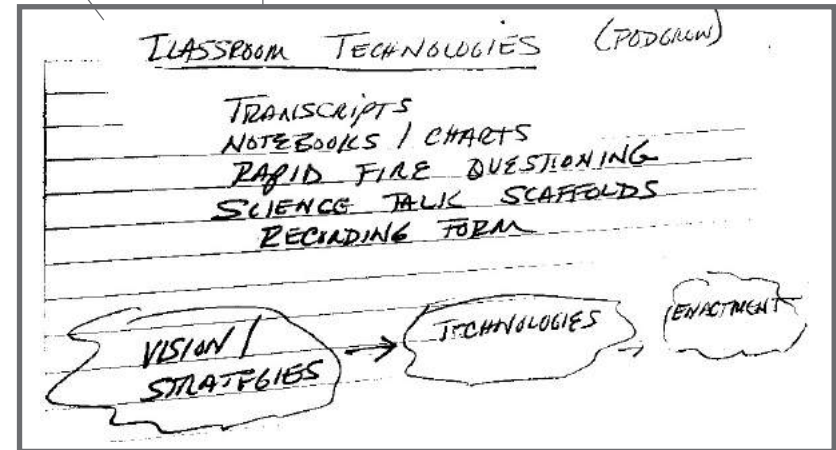
That is a really crucial piece of the whole thing in my mind, these leading teachers, their knowledge. That is the driving engine of us learning how to do this work.

The District Cases

I have a few thoughts about the district cases, and then I am going to let Andrés talk more about the policy environment and so forth. I think what we really want to focus on, and Maria and others talked about this, is what is the high quality learning experience, the rich classroom. What are we trying to create for our kids?

We want them to have these kinds of learning experiences through being in rich classrooms, classrooms that are rich with science and language, centered around stuff, but where our focus should be is on those high quality learning experiences. Maria and others talked about things like the walkthroughs. This is where the focus has got to be.

Where our focus is now as a national policy group is on distal outcomes.



Creating a Supportive Context: District Strategies and Technologies

- Learning Walks
- Instructional Rounds
- Observation Protocols
- Assessments
- Kits and Warehouses
- Trailblazer, Pilot Schools
- Principal Trainings

This is a disaster because often the distal outcomes, as we were talking about measuring on a test, don't match our high quality learning experiences. Also, if you try to go straight to the distal outcomes you teach to the particular outcome. It's like saying, "I want a physical education program that produces really fit people, but I don't have much money, so I'm just going to assess push-ups and everyone is going to do push-ups." Well guess what your program is going to look like pretty soon? Push-ups, right? Not a rich athletic program.

My point of view after all of these years as an evaluator is that if you get this high-quality learning piece right, the outcomes will come. Focusing on the outcomes does not make high-quality learning right. It is better to say, what we really have to do is have a way to study and share these high-quality learning experiences, and that is why the cases are so great.

And you have to have the rich classrooms. How do you get the rich classrooms? As I said, the leading teacher is the person with the skill, the high intention, the energy, and that is how these rich classrooms come about. And, as a necessary but not sufficient condition, as all of these are, we need interesting stuff, we need the technologies applied, we need the classroom infrastructure, the culture, the space, all of those have to go into rich classrooms.

These things don't happen accidentally, they happen because there is professional

development support, there is collegial learning support, and that bottom right bubble [School/district policy space] is covering all kinds of engineering demands. The school and district policy space, the state policy space, the national policy space—it is the environment in which you have to do this work, and it is either positive or negative and it is very powerful. If this is negative it is very difficult. You heard Maite and Louann talk about their policy environment for teachers in their schools. It was completely positive, it was very supportive, they did everything they could to make a safe space, a supportive context.

That is an engineering problem as well. If you want a supportive context, the district strategies and technologies include all kinds of things that Maria and others were talking about doing [see sidebar]. There are all kinds of techniques for creating a place where constraints are removed, a place where capacity is built, a place where the messages are strong and consistent and positive. If we don't have supportive contexts, then we are only going to get those teachers who can buck the headwinds. I will stop there and let Andrés continue on talking more about the supportive context. This is all a piece of work as well, but I've come to see more and more that it is leading teachers that we need to be supporting, and all of this has to happen so that they can do their work.

Expanding the Dialog, Engaging in Advocacy, Reexamining “ELL”

Andrés Henríquez
Independent Professional

I want to build off of Mark’s comments because I think it is exactly where we want to get with the teachers and how we get there in the long term would, to use a fancy term, be a “slog.” This is a lot of work, it’s a heavy lift, it takes time, it takes money, it takes resources. And it takes political will, to tell you the truth, and right now we don’t have that in our country unfortunately. We have these tools called the *Common Core* and the *Next Generation Science Standards* and there is a moment in time for us at this point to really figure out how we can use this tool set to do the kind of things around language and language development that we can embed in our school systems.

One of the things that was not discussed very much is something Maria talked about a little—her system of the way in which she got things done, which was beautifully illustrated in that interlocking chart. My question to her afterwards was, “How did you get this done? How does this happen at a systems level? What were the incentives you used in order to do that? What were the hiring practices and the capacity building that you used to do that? How did you reorganize your money, your resources, in order to actually do the kind of things that you needed to do?” There is a story behind that, and I won’t go into details because I

don’t know the details, but it is a rich, juicy story that needs to be documented and needs to be shared across the country because that is what it is going to take to move the needle in a sense.

I am not going to talk about what the papers talked about, but I want to talk about the advantages we have, or again, this moment in time and how we can leverage language development at this point in time. When we talk about who is here and who is not here, we have a number of organizations—NCTM, NSTA, even NCTE, the National Council of Teachers in English, as well as the International Reading Association—that really have some interest in language and language development, but they talk about it in very, very different ways. The teachers there are very interested in many ways in terms of engaging these youngsters who are from different language backgrounds in their content. They are doing it in a variety of ways, but they are not really engaged in the discussion that we are having here today. It is an opportunity to think much more broadly and get out of our bubble to try and figure out who we need to engage in these conversations as a way to really ensure that this gets embedded in the discussion we are having.

I was talking to Annemarie Palinscar yesterday about the work that has been done in literacy and the practices of adolescent literacy that we were so involved with, and Kim Gomez as well, and that rich talk and how much people really understood that comprehension

Andrés Henríquez



A Call for Advocacy

I want everyone to advocate for this. It's not like we've got plenty of time. I want everyone to advocate for this, not just for yourselves but for the country in a sense. One of the things I was talking to people about is the number of people who are interested in this work, the number of funders who are interested in this work. You can count them on one hand and I can actually point them out to you. That is a very sad commentary on the amount of work that needs to get done and the lack of resources that we have to do it. There is not a lot of understanding, even in some of our really wonderful federal agencies, about what this work is and the direction it needs to go. There are not enough people to review proposals who care enough about this work and can push the work to a different level, to go into different agencies and say, "You need to pay attention to this."

So all of you in this room are really advocates for this work, and I want you to be obnoxious and go out and tell people what this actually means, not only to schools but to the future of the ways in which we are going to engage in the *Common Core* and *Next Generation Science Standards*, to have the high-quality skill set that these youngsters need to engage in this.

• Andrés Henríquez

and understanding and understanding of content. What domain person does not want comprehension and understanding in their content? That is the draw we can offer these different domain experts and also these professional organizations to bring them into this context.

And there is an opportunity as well as the nation turns its attention finally to the reauthorization of the Elementary and Secondary Education Act. There is language in that act that talks about birth through 12th grade reading. What we don't have there is the fact that language and language development within reading is actually very, very important. We have a danger in this too because a lot of the work that has been going on in language and language development, unfortunately or fortunately, has really been with little guys, with elementary school, with babies. We were talking about the Hart and Risley study yesterday. There is a whole lot of movement about the number of words that youngsters can get in their language and the language deficit problem that lots of youngsters are coming out of.

This is a good thing in terms of the way in which we need to go, but what we need to try and figure out is how we frame the argument. How do we frame this issue so that it is not just an issue for little guys to assure that they have 30,000 words by the time that they're in the third grade or after first grade, that this is a progression that we need right up through

adulthood? To ensure that youngsters are getting into career- and college-ready work, this is an issue that we need to focus on in middle schools and high schools.

What we also don't talk about a lot is how do we do this in high schools, which is really, really tough. This is an issue I know some of you have been working on for a very long time, and the issues are exacerbated by the domains, by the teachers who are very proud owners of their content and are unwilling to expand their domains to include the kind of language skills that we are talking about. So we need to reframe this.

The other thing that we are missing that we need to clarify is the issue around English language learners and second and third generation language learners. We pay a whole lot of attention to kids who are just arriving to this county, but we know that over 55% of our youngsters who are still considered English language learners are second and third generation kids. Now these kids are native speakers. Do we do different things with those students? And of course these are long-term ELLs at the same time.

We haven't figured out a way of talking about that in terms of language and language development. It becomes really complicated for policy makers when you actually talk about this because we don't want to talk about it as bilingual education. That is a red-hot firework, just stay away from it, it's not going to go

anywhere. You can keep it amongst yourselves, but it doesn't travel very well.

But when we talk about English language learners we have to be very careful because it's not a monolithic group. It's very broad, and when you are trying to convince policy makers regarding what needs to get done in terms of language and language development and the kinds of new literacies that need to be developed, we need to be very careful about that.

Then there is the issue of time. This is a short-term and long-range problem that is going to take time. We all saw these unbelievable examples in schools and in districts, but what we know is that it takes courage. As Maria talked to me about on the side, it takes courage to reform the system to do the kinds of things that we are doing. And as I was talking to some of the teachers I asked them, "Are you a lone wolf in a school that is doing this? Do you have the kind of supports that you need from leaders up above?"

But what we need to do is focus not just on the sole school or the sole district, we need to focus on this in every state. What I would like to see in the future is a whole network, a hub-and-spoke idea, a national network of language development taking place in every state because there are enormous numbers of teachers who need the kind of expertise that's happening here and who want to share the kind of knowledge that we are sharing amongst ourselves. The state may not be as friendly

toward this kind of work as California is, but they still need the help and the guidance from many of the experts that we've heard from today.

Discussion and Q & A

ADVOCACY ON THE FEDERAL LEVEL

Helen Quinn, Professor Emerita of Physics, Committee Chair for Conceptual Framework for New K-12 Science Education Standards, Stanford University:

What is likely to influence the language in the upcoming ESEA around language and literacy?

Andrés Henríquez:

The folks who have been working on the literacy side of the equation meet every Tuesday in an office in Washington and have been talking about this birth through 12th grade literacy issue for 10 years straight, even when ESEA was not being promoted. I think what they are thinking about now is how to actually make it much further within the *Common Core*, but there is not a whole lot of talk around language and language development. If people remember, back in the *Blueprint* when the administration first took office, there was some language around that, and Kris Gutiérrez was involved in that work, but I don't know if it made it into the ESEA. Could you say more about that Kris?

Kris Gutiérrez, Professor, University of California, Berkeley:

The thing that we proposed was to push them

FEDERAL PRIORITIES

Terry Shanahan, Science Academic Coordinator, University of California, Irvine:

A number of years ago we had an NSF grant and were invited to Washington, D.C. to attend a meeting of like-minded grantees, and we had a presentation by two members of the Department of Education. I stood up at the microphone and said, "You know, we are not seeing any permission to teach science at the elementary level, and I am wondering when a policy decision is going to be made at the federal government level to promote science." I was told by the two members of the Department of Education that it was a market issue, that it had nothing to do with federal policy, that it had to do with market demand. I'm wondering if you know whether that sentiment is still prevalent?

Andrés Henríquez:

I don't know about the Department, but with this administration there has been a huge interest and using of the bully pulpit to really promote science and innovation, and there have been many more resources committed to science and STEM in general. What hasn't been a big priority for this administration, unfortunately, is language and language development and ELLs. Some people may have a different view of that, but I am afraid that if we can't get it done with this administration, with what administration will we get it done? But on the STEM side we are clear. And people are not seeing the same thing, they are seeing STEM, but they are not seeing language development in the same way.

WHERE AND HOW TO PUSH*Andrés Henríquez:*

One of the areas of leverage is from the paper that comes out of this meeting. It's not a problem to go to different folks who are on the HELP committee and present this paper to the HELP committee and communicate what you all think is really necessary. That is easy to do.

You can make those appointments and make sure you have some face time. And it should be done rather quickly because the writing of this is happening as we speak.

Kris Gutiérrez:

There are staffers who are really involved in this. Bob Wise's office in D.C. and the Alliance are very much in conversation.

Andrés Henríquez:

And the Alliance is where the meetings take place every Tuesday.

from thinking about literacy like getting an inoculation in fourth grade and it lasts you forever, and instead think of literacy across the lifespan. So we came up with a model that would require federal policy around birth to adults in which English language learning was central, the things we have been talking about today, those kinds of practices.

Andrés Henríquez:

I don't know if it made it to the last part. You might want to use your leverage again and see if you can get it in.

Helen Quinn:

My question is, do we call our local representatives, do we write to some organization in Washington? Where are the leverage points where one can push the system around this issue? I don't know any place, even if I were to try to push, where I would have any impact.

SUPPORT FOR LEADING TEACHERS*Peter Dow, Chair, Firsthand Learning, Inc.:*

I have a question for Mark. I was taken with that notion of leading teachers as I think many of us are. Could we push you just a little further to comment on the kind of structure that would support that?

Mark St. John:

There are two groups that do that already. One is the National Writing Project, which supports leading teachers, not teacher leaders.

They call them "teacher consultants," but they are collegial, peer-based, self-initiated, self-directed leaders. The Knowles Science Teaching Fellows (KSTF) program is another, and actually we are writing a paper about leading teachers now to promote this idea that teachers are not only necessary but have to be the primary agents of change. They are the approvers, not the approvees.

So I think there are structures that are largely independent of the system that bring teachers together in empowered ways to learn from each other, to work on projects and so forth. But it is very hard within the system to have that kind of support for things. I think they are kind of orthogonal to the system structures. I probably have to rethink that a bit, but there are these structures that say we do value this idea that teachers can do research, generate knowledge, solve problems, be innovative, and that is a teacher-owned, teacher-directed and teacher-driven set of activities.

We are working with the Paul G. Allen Foundation and they have a program called the Allen Distinguished Educators, just a small group but very powerful people doing amazing, innovative things. It is teachers who are not pushing somebody else's ideas but pushing their own ideas.

Emily Miller, ESL/BRT Elementary Teacher, Madison Metropolitan School District, University of Wisconsin, Madison.:

I want to add something. I think that a lot of

times administrations like the teachers who don't question them and don't come to them, as opposed to the rabble rousers. Many times those are the teachers who actually would be more creative leaders than the ones who follow the status quo. I think they are often looking for teacher leaders not always in the right place.

Mark St. John:

But I think there are leading administrators too. There are people who are looking for the mavericks and the rogues and will support them. We saw examples of those today. That is really important also. The other thing is that you have to be smart. You have to, as someone was saying, "feed the gorilla." You can't completely buck the system or you're going to be in trouble. You have to say, "We're doing this, but we're doing it in a different way." You have to be smart and say, "We are

meeting your goals, but we are doing it in a different way, we are bringing in innovation and so forth."

Peter Dow:

One thing that is weird is that the system is almost designed to prevent people from talking to each other. If you've got innovation going on in one classroom, it can't spill over into another classroom because the system is designed in such a way that there is no time for those teachers to interact with each other. If teachers are teaching the same subject, say life sciences, at the same grade level and are allowed to talk to each other, already you have a context for innovation. And the same thing vertically. If life sciences are taught within the school vertically at the same time, teachers suddenly discover that somebody is doing something very innovative at a different level that could have an analog to their own level.

TEACHER RESEARCHERS, ADVOCATES AND SPOKESPEOPLE

Barbara Merino, Professor Emerita, University of California, Davis:

There is also taking initiative at the individual level on teams, and participating in national teacher research initiatives, and there is a teacher research journal. Within each organization, and NSTA is a good example, there is a lot of active teacher dialog, and it is amazing how supportive teachers are of each other in that organization. You shoot out a question and you get help from all over. So I think there are vehicles where the message about language and science could be featured.

Mark St. John:

Some of our best spokespeople will be the people doing the work, the people in this room who are actually doing the work who can share the way they shared with us. It's very compelling. When we lobbied for the National Writing Project, it was teachers going to their congressmen, and there is nothing more compelling. You can send researchers all day long, no offense to researchers, but teachers making a case based on their grounded work and articulate arguments are very powerful spokespeople.



Developing a Research and Practice Agenda

What experiences do teachers need to have to help them shift their practice? How can we design and implement these professional learning experiences?

- What ingredients are essential to think about for teachers' involvement in professional learning experiences?
- What challenges need to be addressed in order to support teachers in productive participation in professional learning experiences?

Please make at least four recommendations

If we are going to make the claim that science is a good context for acquiring language, what evidence do we need to make that claim?

- What do we need to know about how language develops through science?
- What kind of tasks, activities, professional learning experiences, etc. will ensure that language affordances are provided that will lead to engagement with and communication of science ideas?

Please make at least four recommendations for research questions and/or other aspects of research agendas.

CONTEXT FOR WORKING GROUP SESSION

Paula Hooper
Senior Science Educator/Learning Research
Scientist, Institute for Inquiry, Exploratorium

The discussion we heard after the previous session raised the types of comments we want to capture and refine into recommendations to convince others to do something about professional learning for science and language development. This is what we promised NSF we would do, give them a set of recommendations for a research and practice agenda around professional learning that supports science as a context for English language development or acquisition. Now we have gone through this whole experience with all of your wonderful sharing about why science is a good context for English development and different approaches that we have tried, exploring classroom cases and the deep work that we do with children, and then the issues of district and national policy. Those are the pieces of the pie we thought we would need to engage in the work we are going to do in the next hour and a half.

These are two sets of questions that we hope will frame your thinking as you work in small groups to come up with some pretty specific recommendations. We are going to separate

you into groups organized so that you are in a group with others who do similar types of work. There is a practice-focused set of questions: What do teachers need to have to help them shift their practice? How can we design and implement these professional learning experiences? Over the last couple of days we have dug into that in lots of different ways, and there are additional sub-questions to help you think about that [see sidebar].

There is also a research-focused set of questions. We have been making this claim that science is a good context for acquiring language from the beginning, and some of our wise advisors who are researchers said to us, "We actually don't know for sure if this is true." It makes so much sense, but we need to do some work to figure that out. So what evidence do we need to make that claim that science is a good context for acquiring language? And again there are sub-questions to guide us in making recommendations about that. Here again we are asking you to come up with four recommendations. Four is not a magic number, it is simply a goal. If you think three is best for your group, if you think ten is best for your group, that is perfectly fine.

When you get in your groups we want you to decide whether you want to start from a

practice focus and stay there, or you want to start from a research focus and stay there, or you want to do both. We asked for volunteer facilitators and found six people who graciously offered to do this, and we are asking them to help the group have the conversations needed to figure out what those recommendations will be.

You will also need to figure out a way to present your recommendations. There is chart paper and pens, you can put something on a computer and project it, or you can write in a notebook, and we have a document camera. This is real work, and we want you to feel like you've come up with a good set of recommendations.

GROUP REPORT-OUTS

Group Three

Rebecca Smith
Co-Director, Science & Health Education
Partnership (SEP), University of California,
San Francisco

We focused on the question about professional development or professional learning experiences for teachers. Our recommendations really take into account a lot of the challenges that we identified, so I am just going to go over the recommendations.

One piece that emerged from the discussion we have had over the past two days was promoting teaching as inquiry, and teachers as

learners and as agents of change. We are trying to integrate that claim into the professional development and professional learning opportunities that we have for teachers so they learn how to do that or have support in doing that in their classrooms.

Jumping down to our last recommendation (because I am nonlinear), we talked a lot about principals and administrators. They themselves need PD to encourage innovation, to encourage teachers who are involved in these inquiries to think about their work and allow them the time and space to revise it. Administrators require the patience to not demand results right away and the understanding that innovation and change takes time. Part of this area of the PD would be helping teachers identify what data they need to collect and what evidence they can collect, so they can say to their principal, "Well right now I can tell you my students are more engaged than they've ever been. I can't tell you what the outcome of that is going to be yet, but I think it's going to be good. This is

- Promote teaching as inquiry (teachers and learners & agents of change)
- Find evidence that science supports learning in all areas.
- Teachers need protection, support to take risks (e.g., time, space)
- Principals/administrators need PD to encourage innovation/revision/patience

Group Three



Group Three



Group One



the evidence I'm collecting. Talk to me again in six weeks."

We need a research plan and we need our research folks to help us find evidence that science supports learning in all areas. That is certainly around language learning, but we think it is even broader than just in language learning.

Teachers also need protection and support to take risks, allowing that innovation to happen and allowing them to see their teaching as an experiment. I loved it when Emily said that in her talk earlier, but that's hard and you need support and to know that folks have got your back when you're doing that.

Those were our four recommendations.

Group One

Lauren Shea
 Director of Education, Outreach, and Diversity,
 University of California, Irvine

Developing Research and Practice Agendas

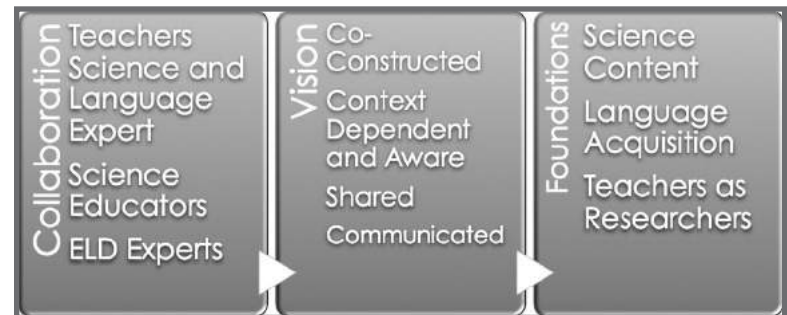
Just like probably every group here, we had an amazing discussion and a great synthesis of everything that has come up over the last two days. As we worked and talked, we were really lucky to have Angie putting this

together in a presentation so that it looks very organized and I hope it is.

We came up with a plan, a little more than recommendations. In the beginning of this type of work we need collaborations. We need to start with leading teachers, as we've been talking about, but also teachers from the ground up. We need science and language experts, science educators, and ELD experts to come together and start this process.

Then we need a vision. What is this vision going to be? It has to be co-constructed, and it needs all of the collaborators involved to help co-construct a vision of what science and language might look like in a school that is context-dependent. All players are aware of this context and how it might inform leader decisions. It is a shared vision and is well communicated to everybody throughout, so there is this idea and it is continuously communicated: This is our vision and this is where we are going.

Then, because of the uneven playing field, we talked a lot about the individualization and differentiation of professional development



and how individualized it does need to be. You need to know your learners. We decided a foundation level might be a place to start. There would be a science content area where teachers get content knowledge, such as higher level physics or chemistry. Then there is a language acquisition piece, and a piece that talks about how teachers can be researchers because later on we'd love to see action research happening in the classroom. The ingredients for this professional learning would include action research where teachers are involved in experiences, then try them, come back and share them, talk about them, go back to their collaborators and get some feedback, and keep this conversation going so that the learning is continuous.

The structure where this all takes place is a safe, free place where teachers can have this ongoing and sustained learning. Relationships are developed in which the teachers feel valued and secure and able to go to these collaborators and ask for help, or go to a mentor or a peer, a colleague, and ask for this sort of guidance.

Then we talked about essential elements of the experience. The professional development would be personalized, it would help make students' thinking visible in different modalities—we talked about reading, writing, how to get language in there. An essential element would be knowing how to reflect on student work to make sure that instructional decisions can be made, and we talked about

noticing what is there, which relates to what Emily said earlier about starting with student models and looking at where students already are. How can teachers use information about their students to start the language and science piece?

Then there is helping them to gain content knowledge, engaging teachers as science learners. This last piece was about having teachers engage in an experience of learning science, acting as learners as if they were their own students, and going through an experience of learning science content knowledge. Part of that would be not just to learn the content knowledge but to have teachers start to gain an identity as a science learner. We talked about how many of us weren't going to be scientists. We were elementary teachers and didn't have that science identity, so how can we get our teachers to start to gain a science identity? It is going through these types of experiences that would help them to get there.

Then of course we talked about challenges in each of these areas. There are policy issues, the need to make science demands and language learning richer, which will involve a growth curve. And then there is how much PD teachers already go to. How do we make this synergistic and not just another thing they need to do?

Experiences and Ingredients for Professional Learning

Structure

- Safe space for ongoing, sustained learning
- Collaboration to develop relationships
- Action Research that is being shared

Essential Elements of the Experience

- Differentiated and personalized
- Make each and every students' thinking visible via several modalities
- Know how to reflect on student work to make instructional decisions and noticing what is there
- Help gain content knowledge, engage teachers as science learners and gain a science identity

Challenges

- Policy issue in teacher preparation program
- Making science demands and language learning richer
- Competing PD's - needs to be coordinated

Group One



Elements of Leading Teachers

- Learning/action research/reflection
- Learning of children (development of kids)
- Science & ELL knowledge (content): What
- Pedagogy: How (build learning experiences for groups)
- Collaboration
- Depth through integration: develop skills and knowledge required through units/themes
- Learning frame for science and language integration

Group Two

Karen Worth
Chair, Elementary Education Department,
Wheelock College

These notes reflect our conversation, which went in many different, really fascinating directions, and an attempt to pull it back together. One of the things we did was try to identify elements that we saw in these leading teachers that were important. These are in no particular order, but clearly there is this notion of teacher as learner, action researcher, reflective practitioner.

There is the learning of children, understanding the development of kids. There is science knowledge and ELL. What is the actual fundamental knowledge about science and about language acquisition that people need? There is the pedagogy. How do you build learning experiences for groups? What are the pedagogical strategies that teachers need to move in this direction? We need to have collaboration, but what are some of the skills of collaboration? There are skills in that as well.

Group Two

We really used our leading teachers from this morning to ask what it is that these people bring to their work that has made them leading teachers that is common across them. There is this notion of depth and of integration, the knowledge that those teachers and other

leading teachers have that they bring to bear on the kind of studies and the kind of projects that we saw this morning. Then there is that deep understanding of what that learning frame is for the integration of inquiry-based science and language acquisition. There may be others, but these are some of the ones that we surfaced out of what we have been hearing.

Then we said okay, what are some of the professional development strategies we should be thinking about? What is the model? Well, we don't know what the model is yet, but overall we ended up saying that in some sense what we are looking at and need to think about is building a foundation of skills, knowledge,

PD Instructional Strategies/Model:

(Suite of experiences built on a foundation)

Foundational

- Direct experience in both science and English language acquisition as a starting point
- Foundational knowledge (inquiry, language acquisition)
- Shared understanding learning frame of science and ELL
- Provision of resources - curriculum
- Development of basic learning technologies
- Development of learning communities

Advanced

- Understanding of the research and practice
- Assessment and looking at student work
- Looking at children's expression of understanding
- Forums for working with others across disciplines and hierarchies

and so on, and then move beyond that to thinking about what else. What happens once you have the basics? So it is a kind of suite of experiences built on a foundation of knowledge, with the understanding that you need some knowledge and some understanding of what's going on before you begin to start to make choices for yourself: I need more of this, I need to go in this direction, I want to do more action research.

This is sketched out and these could be argued, but it is a challenge to provoke us to think more about this. These foundational strategies felt like they would happen earlier on: having those direct experiences in both science learning and English language acquisition and using those direct experiences to develop the foundational knowledge; a shared understanding of the learning frame, whether it is one developed within a group or one that is presented; some basic, foundational curriculum; development of some basic learning technologies, using Mark's definition of learning technologies; and development of learning communities, or whatever you want to call those. These feel like things we should be building in as experiences people need. That list could get much, much longer.

Under advanced strategies, we have deeper and deeper understanding of the research and practice; assessment and looking at student work; looking at children's expression of understanding, something Emily mentioned this morning; and forums for working with others

across disciplines, across hierarchies. And this list could also go on, we didn't get too far with it.

The idea is that this may be a trajectory that we are talking about, a trajectory that has stages as people move into understanding, and this trajectory idea should inform the model that we don't yet have.

We looked at some of the design elements that we thought were absolutely critical. First, that there be a priority at the district level, whether you want to call it a priority or be not so nice and call it mandate, but something that says, "This is what we do in this district." That there be a transparency of values at the district level so that we are all in the same boat in terms of outcomes. That there are partnerships within, across and outside of the school and district community, so partnerships within the district, across schools, and also with other institutions. That there be some sense of career development, this movement forward, so that people have other choices and new choices as they become more expert. Then there is opening the classroom doors, whether it be peer coaching, whether it be interacting with other people within your own building, whether it be instructional rounds, whatever it is. And finally, a focus on capacity building.

We also noted a few challenges. We talked about time as everybody probably did. How does one find the time for busy teachers? Maria talks about the idea of looking at how we

Context/Design

- Priority at District level (mandate), but multiple pathways (choice)
- Transparency of values at District level
- Partnerships within and outside of school/district community
- A career development trajectory of stages: at expert model
- Open the classroom doors
- Focus on capacity building

Challenges

- Finding the communal time during school
- Teachers are often done to as opposed to having their voice heard
- Principals need to learn to provide feedback that is focused on instruction
- Curriculum

Group Four



allocate time now, and that there is time in there some place, it is more about the use of time in schools and districts rather than simply not having it. We want to move away from the traditional model of PD in the minds of many, that teachers are “done to” as opposed to having their own voices heard. We were thinking about what it means for principals, and I would suggest also superintendents and everybody all the way up. They need to understand as well as learn to be supporters of teachers moving in that direction. And finally, there is finding that good curriculum that allows this to happen and move forward. Are these recommendations? I don’t know.

Group Four

Judit Moschkovich
Professor, University of California, Santa Cruz

We went all over the place and got organized at the end. If I had a three-dimensional matrix, that is where I would say we went. We actually answered both questions, which is a good thing because we think that practice and research are related, and you will see how that shows up in the recommendations we are making.

One of the dimensions, requested by somebody who was interested in policy, is that we think about what we can do now in the next two years, and what can we do later in about ten years. That dimension will cut across four recommendations that I’m using to summarize all of this.

The first recommendation, which we can do now in the short term, is to produce a review of relevant research literature. I will give you some examples of how, why, and what it could do. One example might be that it could include a meta-analysis of qualitative research. We talked about and heard examples of some things that we know (though it depends on who the “we” is). Some people, for example, know things about whether correction works better than recast for oral versus written language, and that needs to be collected together and connected to other things that we know about

Recommendations

Design Based Implementation Research

- More design-based implementation research (DBIR) - scale from classroom to district
- Assessments that include science (3D) and language
- Development of rich assessments

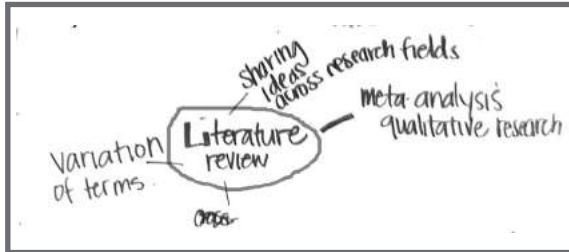
Now:

- Thoughtful review of relevant literature (What do we know?)
- Clarification on terms for use in practice
- Examine useful sources of evidence schools are using to determine strengths and weaknesses of these sources (DBIR)
- Case study on implementation and process at class level, district level, site level

Long-term:

- Effect of language and science teaching (and quality of inquiry experience) on UR groups entrance and persistence in STEM fields? (DBIR)

discourse in science classrooms. So the big question for a really good literature review is what do we already know that we don't need to reinvent, which is something we tend to do.



Another distinction that comes from the research is that between exploratory talk and representational talk. Again, that is just to give you a taste of what things could be included in the review of the literature.

Then there is connecting to the issues of engagement, interest, and motivation, which typically are concepts from informal science learning and connecting across spaces—home, school, after school—which also comes from informal.

An important piece of a good literature review would be to clarify the terms we use, and that, for practitioners especially, there is debate about the meaning of many terms. What do we mean by “scaffolding”? Does it mean nothing, something, everything, or something in-between? How is it useful? “Academic language”—what is it, what isn't it? Those debates aren't going to get settled, but we can at least acknowledge that there are debates around those terms, what they

mean, and how they work in practice. What do practitioners need to know about these terms and debates in order to be able to work with each other and talk to each other? That was another recommendation.

Another recommendation is to do more design-based implementation research (DBIR). These studies may take a little longer, but the spectrum and scale of the studies can go all the way from one classroom to the district level. One example would be documenting a case study of the district level work in Oakland, which has already been done. Even though it's not DBIR it is still important to document that.

Questions that one might ask within a design-based implementation research study, and again that is a cycle, could be: What is the role of science knowledge in implementing this kind of instruction? We have here other examples of the kinds of questions that could be asked. As you can see, these are kind of sub-questions within the big umbrella of design-based implementation research.

A third recommendation is to explore how to cast a broader net for documenting outcomes and process because they are related. We talked about sources of evidence that either teachers, schools, classrooms or districts are using to determine the strengths and the weaknesses of those sources, from not just

Questions/Points

- Is there a difference in the effectiveness of strategies in classrooms with native speakers and ones with only ELLs?
- Acquiring language = all students
- What is the role of dominant language speakers on quiet students' development in the classroom?
- Is “academic language” the best term? Is it appropriate?
- What kinds of scaffolds/supports should be used?
- What is the role of natural language in inquiry?
- What is the role of teacher science knowledge in implementing this type of instruction (important component)?

Group Four



Group Five



Revised Research Questions

If we are going to claim that science can be taught in such a way that makes it a powerful context for language development, what evidence do we need?

- Language sufficient for the demands of the context
- Language appropriate for the task
- Things that center student experience and student communication

using assessments that are already out there but more local-based formative assessment instruments, to also documenting engagement, motivation and interest.

The last recommendation is about longitudinal studies, and again it is a recommendation that is a fourth umbrella to organize and capture research that will inform practice and addresses both questions. For example, the effect and impact of this kind of instruction on students' persistence in STEM fields.

Group Five

Helen Quinn

Professor Emerita of Physics, Committee Chair for Conceptual Framework for New K-12 Science Education Standards, Stanford University

Group five started off with a general discussion, so we knew who we were in the room, and issues arose there. We decided to focus mostly on the second set of questions, and then we immediately changed the question because the claim that science “can be taught

in such a way that,” rather than that “science does” is the claim we want to make. It’s not necessarily true that under all conditions in all science classrooms language affordances are going to be offered.

The fact is we have three

case studies that we have seen, we believe that there are more out there. For example, the Seeds of Science/Roots of Reading people have documentation, etc., and there are other studies at other grade levels that “science can.”

Recommendations

- More case studies of Leading Teachers and the impact on student learning: science, disposition, language
- Identification of common features in Leading Teachers' classrooms (in science)
- Under what conditions does the linguistic diversity in the classroom influence the richness of classroom discourse and interaction?

So then all of the questions become: Under what conditions? What is it that is common across case studies that helps us try to tease out what features facilitate this happening? What we care about is student learning in science, student learning in language, and student disposition towards learning in general and towards science learning.

Those kinds of things are going to have to be separately looked at in trying to identify across multiple studies what we can say. If you do these five things, then it happens? Or is it these twenty things? We don't know. Then there are some other, more detailed questions. For example, under what conditions does the language diversity in the classroom enrich or influence the richness of classroom discourse

and interaction for all students? So it is thinking about not just whether students learn language, but what is the impact of having this diverse classroom and attention to the voices of all on the learning of all? Those were the big questions we came up with, and one could immediately make many more “under what conditions” questions, and those are the kinds of things that come up in critically designed studies.

We then very quickly looked at what we thought was common about professional development [see sidebar]. What this outlines is characteristics of professional development and characteristics of classroom practices that, in our hypothesis, are part of the “under what conditions.” Professional development needs to be differentiated and responsive to the teacher. It is different for high school or second grade, different for a new teacher or an experienced teacher. It’s different for a teacher with a strong science background or one with a strong language background. There are different needs, so we need to recognize that those needs are different.

It needs to be extended over time. It needs to involve teams of colleagues in reflective practice. Teachers need to experience and analyze the types of experiences that you want for the students. You need to develop strategies, not lessons. This is not about if you just do this lesson that will be it, but about strategies that will go across multiple lessons.

You need to build teacher confidence in doing these new things through multiple trial and error, and redesign experiences in the classroom. You need partnerships between the teachers and “experts.” I put “experts” in quotes because the teachers are expert about something too, but I mean the outside experts who come in to support teacher learning. They need to be working as a team, as we saw in the examples that we had.

And you need inquiry into teaching. You need a posture towards teaching that it is something you can analyze and think about and learn to do better. And you need an attitude to teaching that teaching is facilitating learning, not that teaching is telling. So this whole



Professional Development

- Differentiated/responsive to teachers’ needs and experience
- Extended over time
- Teams of colleagues/reflective practice
- Experience and analyze the types of experiences that you want for kids
- Develop strategies not lessons
- Build confidence through multiple trial and error; redesign experiences in own classroom
- Partnership of teachers and “experts”
- Inquiry into teaching
- Teaching is facilitating learning

Classroom Practices

- Engage students in conversation using “science” = real world experience and observation
- Pay attention to individual and group dynamics and manage processes to ensure equity and engagement of all
- Not “one right way”
- Be explicit about what the important learning goals are

agreement about what it means to teach has to be part of what underlies the whole professional development community.

Then in terms of the classroom you need to engage students in conversation using science, which means real-world experience and observation to have the language impact. So it is not just that you need to be learning science, you need to be talking science.

And you need to pay attention to individual and group dynamics (I think Emily brought this out very well in her talk), and manage the process to ensure equity and opportunity for all students in the classroom. It's not going to happen automatically just because you're doing science.

There is no one right way and you need to accept that there are multiple strategies. The job of the teacher, the art of teaching, is deciding which strategy to use when, often on the fly in the classroom.

Group Six

Finally, you need to be explicit about identifying the most important learning goals and then build around those so that your focus is always on the big, rich learning goals, not the outcome that happens to be easy to measure. So that was a very quick answer to the first set of questions.

Group Six

Sarah Capitelli
Assistant Professor
University of San Francisco

Okhee made a comment to me at the end of our group session and said, "You didn't know you were going to facilitate a science talk did you?"

I said, "No, I didn't realize I was going to facilitate a science talk." We had a really wonderful discussion with six people who had been experiencing the same phenomenon over the last two days, but of course they



experienced it with their own background knowledge and their own set of ideas and experiences. I posed the questions at the beginning of the session and everyone had a different take on them, and it went into all of these wonderful and different directions. At some point we went off-script and did our own things, but we definitely have a few recommendations. It is interesting to think about all of these different people coming together trying to answer one question after experiencing the last day and a half differently.

I am not going to repeat the challenges that got raised because they were similar to the challenges that many of the groups already raised. However, one challenge we talked about that I didn't hear is the challenge or the question around subject knowledge, around content knowledge and the development of content knowledge. How much is enough? What does it mean in relationship to these new science standards? Is it knowing a particular content area deeply, or is it enough to know the 3D model deeply, and what is the relationship between those two?

We actually spent quite a long time talking about that and grappling with it. We didn't come to any answers, but it was interesting because I think it has an impact on both professional development and on research. How much do you actually have to know about these particular areas in science to be able to teach them? Or is it more about the

understanding of practices and the ways they are connected? We were stumped in thinking about that and were wondering where to go with all of that.

In terms of our recommendations for practice, what we all really came together on was that we had the opportunity over the last day and a half to see really wonderful examples of practices in a number of different ways: the classroom, the district, professional development practices, and thinking about national policy. We recognized just how powerful and stimulating cases are, that the stories are really, really helpful and they really matter.

So one of our recommendations for practice involves supporting teachers in creating cases of their own teaching practice. We already know that is happening and there were examples of it today, but there are roles that all of us can play in different ways in helping teachers create these cases in order to highlight promising practices for other teachers, but also for districts and on a national level. We want others to actually get to see it in action and how powerful that is for change.

The other recommendation involves thinking about creating some sort of network or space, either in-person or online, that supports teachers to improve and share their practice. You have these cases, but how are those cases used? Those cases got shared here in this space, but how do we bring teachers together to share cases amongst themselves? Tina

Practice

- Involve and support teachers in creating cases of their own teaching practice
- Create a network (on-line?) that supports teachers (isolated) to improve and share their practice

helped us also think about the many teachers who are isolated. We think about teachers who are isolated rurally, but there are also teachers who are isolated in urban districts, who might be in a school in the Mission District in San Francisco and they are doing their own thing in their classroom. What are ways that we can connect with teachers in thinking about some sort of network?

There were people in the group who had experiences as classroom teachers who were in networks, and those were really powerful learning experiences for them. I shared some experiences, Okhee talked about some experiences that Emily had and how that helps teachers to lead.

Then we were running out of time, but we really wanted to get to the research part also. Jerome said, “Hello! We’ve got to talk about assessment. We haven’t been talking about assessment over the last couple of days.” So we really tried to think about assessment. Our first research question is: What does the NGSS 3D assessment based on 3D learning look like, and what do they tell us about language development? So this is trying to understand these assessment that people are developing. What are they going to tell us about science learning and science development, but also what are they going to tell us about language learning? And do they tell us anything? We don’t know that yet, so we are trying to understand that.

Then there is this idea: Is there an assessment, or what does an assessment look, like that actually blends science learning and language development together? Jerome was reminding us of all the visuals that were shared of overlapping science and language, moving from a little bit of overlapping to a lot. That was really a model of instruction or of learning. What does that look like if we thought about it in terms of assessment?

The last piece was the notion of “language learning progressions,” (I was running out of time and didn’t come up with another term). This involves thinking about a more longitudinal study that looks at language at particular times and how that is related to science learning at those same times. I put in parentheses, “acknowledging and allowing for developmental variability.” That is how I got away from the “progressions” notion. It would be some sort of research study agenda that says: Let’s take examples, moments of language over a course of time. What do we see happening with language, and then what do we see happening with language in relation to science learning as well?

Research

- What does NGSS 3-D assessment based on 3-D learning look like? What do they tell us about language development?
- What does assessment look like that blends science learning and language development?
- The need for language learning progressions and how do they relate to science learning progressions (acknowledging and allowing for developmental variability)

SYNTHESIS AND REFLECTIONS

Some Musings Under Construction

Kris Gutiérrez
Professor, University of California, Berkeley

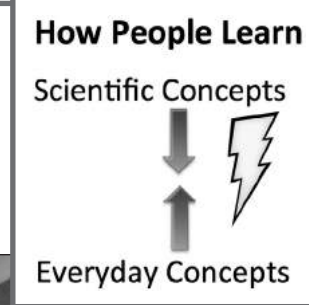
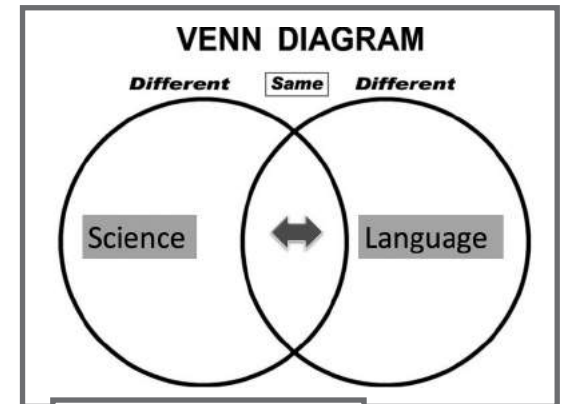
This is an interesting journey because I got to be part of an event early on in this process when they took me to Sonoma into the school and we had a wonderful opportunity to think together with the teachers. It is remarkable to see the trajectory since that time and how much work has been done.

I am not sure we are really going to synthesize because people have done such a wonderful job as a group, and I have called my PowerPoint not really a synthesis but “some musings under construction” because I am still thinking aloud. In addition to listening to my colleagues, I could have listened to the practitioners and the educators all day long and want to thank you. I learned so much from you.

One of the highlights or big ideas that I heard starting with Helen and then Guadalupe and throughout the discussion, was how language and science fit together. You can see the Venn diagram on my slide [sidebar]. We kept hearing that we want to bring language into science or science into language. I think it’s much more than bringing one to the other, it’s really understanding their inextricable relationship, their mutual constitution.

As a learning scientist I could not help but put in an idea for you to think about, how people learn. This is something that is really important for our conversation, how people learn. We know, at least from one particular view of learning, that everyday and scientific knowledge (not “scientific” in the science sense, but in the formal sense) grow into one another, that learning is a reorganization of those things, not simply bringing one to the other. I think that is really important because if we start to think about kids’ everyday language, kids’ everyday experiences, etc., not just as bridge, not just as a way to engage them, which is also important, but how everyday practices and everyday knowledge are essential for deep and consequential learning. That is a fundamental shift we have to make—you have to do them together to have consequential forms of learning.

Next are the big ideas that I heard [sidebar page 150]. One of them has to do with what I just said about everyday and scientific. I think there is something Helen really helped us understand about the three domains, and something Okhee really helped us with when she did the policy analysis. That is, we have focused a lot on what are called vertical forms of learning, which is when you go more deeply and are learning more in the domain. Usually that has been about facts and not about deep learning. The 3D model pushes us, forces us to look at horizontal forms of learning. That means border-crossing, moving across spaces, and interdisciplinarity, and how important that



Kris Gutiérrez



How Science/Language Fit Together? Big Ideas

- 3 Domains: Necessarily require vertical and horizontal forms of learning
- Focus on consequential learning: engaging in robust practices
- Language is the tool of tools
- Standards/NGSS are tools not object/end point
- Language Socialization (TO and THROUGH)
 - Discourse practices (Talking Science)
- Intent Participation
 - Shift from student-centered to community centered (dynamic/distributed/
 - Light Pedagogical Touch- (challenge scaffold)

is to new kinds of learning. There is real focus in that model on consequential learning and robust practices. NGSS is about practices, it is not about skills. It is about things in use, which I think is really important.

She reminded us that language is the tool of tools. It is the most powerful tool that we have. Also, I don't know if Helen said this directly, but it was implicit: Standards are tools, they are not the object. It reminds me of years ago when I studied standards-based instruction in California, I would see the standards all over the walls and the kids would stand up and say, "Standard 1.d2 is..." That is when the standard became the object and not the tool, which I think is critical.

Guadalupe and Sarah really helped us understand the importance of language socialization models, that students are socialized to and through the very practices in which they participate about the importance of kinds of discourse practices. A lot of the case studies helped us understand about the importance of different kinds of discourse practices. Having opportunities to elaborate and for students to repair their own understandings over time is fundamental.

We talked about intent participation, and I just wanted to highlight a couple of things that I think are critical. Intent participation pushes us to move from student-centered to a community-centered kind of model. That is important because the teacher has some expertise, and you want to have a really

important role for the teacher, so it pushes us to really question those old models and to have more dynamic and distributed models.

It also forces us to challenge notions of scaffolding. I feel like I'm committing heresy at times when I challenge scaffolds, but scaffolding is just one kind of assistance. It is one that is adult-defined; the end point has already been decided by the adult. I will give you an example. When my son was a little kid and I wanted to teach him to cross the street using the lights, I didn't do trial and error. It had to be a very carefully scaffolded kind of event so that I wouldn't lose him in the process. Scaffolding is only one kind of assistance, but it has become generic and it has become the way we end up thinking about the role of the more expert "other."

We want to move into thinking much more robustly about forms of assistance than just that adult-defined scaffolding. I can say a lot more about that at another time. Instead we want to move toward what we are calling a "light pedagogical touch." A light pedagogical touch gives the learner just enough information so that they can engage fully in the activity. We have to keep telling our teachers over and over about that light pedagogical touch.

One thing I don't think we talked very much about is equity, but I think Sarah and Guadalupe did because they are expanding Barbara's model of intent participation. In Barbara's model there are experts already

in the practices and they highlighted the importance of modeling as not just a learning thing but an equity issue, which I think is really important.

Big Ideas

- Equity- modeling- access to valued practices
 - Monitoring as full participants; distributed expertise
- Mistakes to Mis-takes (testing out, tinkering with, playing around with ideas, assumptions)
 - Developmental Dialogue
 - Move from Deficit to leveraging students' history of involvement in science and linguistic repertoires
 - Ecologically Valid Practices and forms of Assessment; heterogeneity of language learners

Lots of people focused on this notion of “mis-takes” and I loved that notion of “mis-takes,” not mistakes—the importance of testing, teasing, tinkering and playing around with ideas. There is a need for a kind of developmental dialogue in classrooms and moving from deficit views. What I loved about this morning’s case studies was they were really ecologically valid practices. They really tried to find out the repertoires that youth had and leverage them in ways that led to more consequential learning.

In terms of the future-oriented, our notion of learning is learning as becoming, designing for possible futures. I think that is true for

teachers and students.

New forms of research are really needed. I focus on DBIR because it is iterative, it is collaborative, it is open-ended, and you have to have a high tolerance for ambiguity, but it also reorganizes the participation structures between people in schools and the researchers. So I think it is an important new way of thinking about it.

Let’s not forget the informal. We have learned so much from the Exploratorium about the playful imagination, etc., etc. Play is the richest zone of learning. Let’s not forget that.

And there is re-imagining teacher learning. We still think of the old continuum. It is not a linear process. It depends. That should be our operating phrase, “it depends,” and I think it calls for a very different way of thinking that the working groups have already summarized.

Four Issues

Guadalupe Valdés
Bonnie Katz Tenenbaum Professor of Education,
Stanford University

I am not going to try to synthesize, I am rather going to talk about what are four outstanding issues for me as I listened over time. This has been such a wonderful experience and I want to thank Paula and Lynn for including me and Sarah. It has been an incredibly transformative experience for me in which every time I turned around I thought, how wonderful, how marvelous! I talked to a lot of teachers

Future Oriented

- Learning as becoming/designing for possible futures
- New Forms of Research: Designed Based Implementation Research
- Leveraging the informal (connected forms of learning; play and the playful imagination)
- Leveraging new tools or repurposing tools (new media)
- Re-imagining Teacher Learning

Four Issues

- Discourse practices
- Literacy
- Role of first language
- Population

Guadalupe Valdés



and said, “You do such wonderful, wonderful things,” and I truly feel that.

There are a number of outstanding issues that I think we need to talk about together. Those four things include discourse practices and what Kris just talked about, the discourse that we are depending on for language to develop. I want to talk about literacy because we didn’t talk a lot about literacy. I want to talk about first language and the role of first language. And then I want to talk about our population and what about those long-term kids.

First of all, in terms of the discourse and making certain that we have the discourse in science classrooms that promotes language acquisition, we know from Helen that it really matters what the task is, and she tells us that what science problems will prompt rich discourse will matter. So it is not neutral what you talk about, there are going to be some things that promote rich discourse and other things that will not.

We have heard a lot about the importance of getting children to engage, and the importance of the local, something that involves the children in something they know about and care about and feel good about and really want to know more about. We also learned about the problems of status and the status-based conversations, and we know that people have worried about how to do status enhancement, and we probably have to think about doing some status enhancement in some of these conversations.

We know that talking together is hard work. We need to go back and talk to those folks who have told us that conversation is mere conversation. I could talk about a lot of theorists in second language acquisition who have said that conversation is really meaningless, we really don’t need it, and have to move to the rich, higher level of academic language. If you enter the language acquisition field, that is where you are entering, the people who have said that basic interpersonal communicative skills are pointless and we need to move into cognitive academic language proficiency. It is a discounting of the interactional as being “mere,” when in fact, science teachers are seeing very clearly that is where that understanding begins.

We heard a lot about the importance of noticing, the importance of moving children to express ideas more precisely. We still have the challenge we heard wonderfully from the working groups, especially Helen’s group, that actually told us what we need to know. If we are saying that science can be taught that way, what are the things that we have to document, and what does that growth look like?

We might say, when do we first begin to see a child defend an opinion or contradict a peer? Notice the verbs I am using: “argues,” “contradicts,” “defends.” To me that is what doing with language is, it is speech act theory pure and simple, that you do things with language. You might know some language to be able to do something, but it really doesn’t

depend on a particular structure. I can argue and contradict you with very flawed English, and I can make my point by using my drawing. We need to understand a lot about these discourse communities. These are moving things, we are just creating them, so we bring people into these communities in the intent participation and they are shifting and moving. It is not like working in a community of tailors, for example, where you can come in and say, “Here’s what the practice looks like.”

Let me move to literacy because literacy is very important, and I am going to distinguish between reading and writing.

In terms of the writing, we heard quite a bit about writing. Students were doing reports, students were doing journals, children were doing other things. Writing is one of those places where language stands still. We know a lot about trying to correct children’s oral language, and most of the research tells us it doesn’t work. Recasts are probably better, but even those aren’t really well thought about.

But when the language is written, notice that everything you write has a different purpose and it has a different audience. If you are writing for yourself your notes don’t look like something you would give to someone else. So it’s a little bit confusing to me what those little notebooks were. Is it for me? Is it my notes? Is it about my thinking? Or is it to share with the world? If I’m sharing with the world I’ve got to dress it up in its Sunday best, and that’s where conventions come in, but also what comes in

is models. In the same way that I model oral language, I’ve got to model written language. Don’t ask me to write something I’ve never seen because I don’t know how to write that, but if you show me something, and this is the convention that you want to show me, then the next thing you probably want to say is, “And I want you to notice how language works in this kind of genre, in this kind of text.”

I have a lot of English language learners, and one thing I notice is that the past tense doesn’t seem to be there. If you care a lot about the past tense, wonderful. Make language stand still and then, in whatever it is they are going to write, circle and say,

Literacy: Reading and Accessing Resources

We saw in what Jessie and Naomi presented today a connection to literacy that was much more obvious than the others. We saw those rich books that were there. For me, reading is very important if you’re going to have children who say, “I am really interested in this and want to know more.” What you saw in Jessie and Naomi’s presentation is the wonderful way they made those books accessible. A child can’t read yet, so I can record it for them and they can go and learn more about the penguins. A lot of trade books are accessible to children, but unfortunately a lot of them are not. If we are concerned with literacy and we want kids to really get engaged with this, it is not the science textbook. It is going to be, “I want to find out about...”

I happen to have had a kid who, at ten years old,

wanted to make glass, so he decided he needed to find out about a carbon arc furnace. I had to go to my chemistry colleagues and ask if it was safe. But it is this goal to read in the library at levels beyond, and we know from the research that children read about things they want to know about, whether it is Pokemon or basketball statistics, as Jabari Mahiri has found. Kids read about very complex things that we as reading teachers would say they could never do. But they do in the real world.

So for me the challenge, if you are going to light into science, is to say, “And you can learn more by going out there.” How do we urge you, or how do we make accessible to you in different ways those wonderful places that will make you a reader for a lifetime?

“Notice, and notice, and notice. Let me circle all of the ways in which we do past tense in English. There is ‘ed’ here, but there are irregulars—thought, ran—those don’t have ‘ed.’ Did you ever notice that? Isn’t that interesting? Now let me show you another model of this.”

That is how you attend to language. I can call out a feature of it, then I can say, “You’ve now done this first draft of your report. When you do your second draft...” We are dressing it up in its Sunday best. When the ideas are right, then you edit it. Writing is about ideas, and I always say you can hire yourself a good editor, and as you know, many of you hire yourselves good editors. But writing is about ideas, so you let the children understand that when they are ready to edit is when conventions come in, not before then, because if the conventions come in too early the child freezes and doesn’t write anything at all.

I think we want to think about that writing and how it is going to work in science. It has a very important place, but if you don’t do it right you can actually not get to where you want to go.

The next thing I want to talk about is what is the role of first language? The role of first language is really quite complicated because you can think about it in a variety of ways. Is it for support? Do I want to use first language for support or access to meaning? We cannot do anything in science, or in any topic at all, if I don’t have access to meaning. If the kid doesn’t know what phenomena you want to focus on because they don’t understand English yet because they’re newcomers, how do you make that apparent? Emily told me, “The way we make it apparent is we go out and we walk around and pick up the soil,” so that is one of the ways that we do that. We need access to meaning. In what ways do we have a possibility of using an L1, and are we trying to get that access to meaning? Awareness of the fact that there must be access to meaning is very important.

A new thing has come into the second language acquisition field and that is “translanguaging.” That is, the use of all of the language resources that the child brings with them, and you give them permission to use their language resources and you invite them. So it is not necessarily that you are putting up a word wall with the words they are going to need, but you allow them to start talking in English

Dealing with 40 Second Languages

Another consideration is, do we want to use first language because we think that we want to make that home-school connection? What do we translate? And again, Emily and Okhee told us that home connection is very important, and you choose. You may not be able to support the 40 languages in a district, and some of us commented that the 40 languages question is sometimes very discouraging because where we go with that is saying that we are then paralyzed: “If we can’t serve all of the languages, we should

serve none of them.” My response is always, what is the largest number and the most at-risk students, and then tend to those languages. And in every school and every school district you know what those languages are, the most at-risk and most numerous. Attend to those languages, get the resources to deal with those languages. And you must because you cannot make those home-school connections without that. If you don’t do that, then you don’t have a way of supporting the children.

and then, when they run into a blank, they can use their word: “That’s a doohickey.” And you can then tell them, “That’s really called an ‘X’ or whatever,” but allow them to use another language as a resource in that way momentarily and you can move forward.

You can also have a position, regarding the role of the first language, that you want to grow both of them, that as a society we really cannot afford any longer to just say we are going to do everything in English. That’s not the way the world works. So part of what you want to do is give opportunities to enrich and grow those other languages. But then we have to think in terms of policy, in terms of what is available, in terms of resources, and all of the other considerations.

My final point is, what about the population? When we say that someone is an English language learner, we somehow use the term “learner” in very strange ways. There is a very interesting British applied linguist by the name of Vivian Cook, who has a series of books (www.homepage.ntlworld.com/vivian.c/Vivian%20Cook.htm), focusing on L1 and L2 users. He asks: How long is a learner a learner? When, in fact, people are users of the language, why do you continue to call them learners?

The long-term English language learner is a case in point. I have two battles: one against academic language and the other against the long-term English language learner. I just finished an article about that and would be happy to send it to you. It is going to *The*

Modern Language Journal. What I am arguing is that this is a bureaucratic categorization, it is not real. Those students are using English and in fact English is their dominant language. It is only accidental that because of all the bureaucratic ways in which we measure English language development, these kids are dubbed English language learners. I had two students in a class that illustrate this point.

A Portrait of Two “Long-term English Language Learners”

I had a student who was a Spanish major in my class. She spent one year in Bogota or somewhere, she said she tried to teach Spanish for a while and worked a little as a bilingual teacher, and she always spoke of herself as, “I am a Spanish speaker.” I had another child in the room who had grown up in Southern California in very poor immigrant family, ended up at Stanford as an undergraduate, was doing a coterm master’s in policy, and had written an undergraduate honors thesis based on a science study in the Yucatan. She spoke of herself as being in the same class as an English language learner.

Notice the difference. Here is a child who had never done any academic work in Spanish who spoke of herself as a Spanish speaker, and another who had done academic work her whole life, plus presented an honors thesis in English, who called herself an English language learner. So I caution you when you hear these labels. In fact, the article that we just completed is problematizing the whole notion of learner and the classification of advanced, beginning, and intermediate and all of those things that we fall into in the whole ELD community. So I want to leave you with the idea: Beware of labels, particularly labels for learners, and understand that they may not be telling you anything. Then I will feel my time here has been well spent.

Acknowledgements

- I want to publicly thank Guadalupe Valdés and Sarah Capitelli for collaborating with us and bringing the language learning community together with the science community.

And I want to thank Molly Campbell and Michael Fairchild, who have taken such great care of us. Organization and deep thinking about conceptual ideas have to go hand in hand, so our administrative staff is as important as our teaching staff in our program and I can't thank them enough for supporting us to be able to do this kind of work.

- Lynn Rankin

CLOSING REMARKS

Had there Been a Third Day...

Paula Hooper
Senior Science Educator/Learning Research Scientist,
Institute for Inquiry, Exploratorium

We have run out of time, but we now know what we would have done on a third day. We would have worked on issues of equity and culture and assessment. Maybe we will get to come back in another couple of years and talk. I hope we will definitely keep these ideas going. This has been amazing. This has been some of the hardest work I've ever done in my life, but we have planted a seed that I can tell is growing, and I am so thankful for how hard you have worked the last couple of days. It is going to benefit not just us, but the students who we work with, so thank you very much.

Next Steps

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

It is an understatement to say how inspired and excited we are about the opportunity we have had to spend these last two days with you. It is going to take our work in amazing directions, and I hope it will for you as well. The important thing for us to leave with is thinking about the next steps. There is a tremendous momentum that we feel in this room. This was a one-time conference grant, which is not going to carry us to the places we ultimately need to be. People have said we need to make a case

for this, and I said in the beginning that we need to make a lot of noise about it. One step is for us to stay in touch in some way. We are going to do a questionnaire. We will send it to you, and it is important for us to get feedback from you about ways we might stay in touch, whether through webinars or whatever you think. We will figure out a way.

The other part is how do we disseminate this? Hopefully this conference documentation will be a catalyst for reminding us and thinking about the next stages. We are committed to find ways to carry this forward, and I think it would be a mistake if we couldn't gather together again in some way and go to the next level because I think we have just scratched the surface here. There have been important ideas that have bubbled up to the surface. What do we do with those ideas? I know this work is so complex and multi-layered. We can't afford to stop here, but I don't know what that means and I would be happy if somebody else wants to host a conference or partner with us in hosting one. We are committed to finding ways, if we can, to continue the conversation.

I want to thank all of you for your participation. Whether you presented or were talking with your colleagues, every single person here contributed in a very significant way, and where else do you see that? This is a special group. It is a little sad to see you go, but please promise to stay in touch and we will as well. Let's continue the work forward.

BIOGRAPHIES

Presenters and Synthesizers

Listings below are in alphabetical order. To see all conference participant biographies go to: www.exploratorium.edu/ifi.

Jessie Auger
**Bilingual Teacher, Rafael Hernández School,
Boston Public Schools**

Jessie Auger, a bilingual teacher in Boston Public Schools, has been an elementary classroom teacher for twenty-four years. Living in El Salvador and Puerto Rico and collaborating with teachers there for more than a decade helped to form her as an educator. An experienced teacher leader, mentor, and coach in the areas of literacy, math, project-based integrated curriculum design and best practices with English Language Learners and bilingual education, Auger has provided professional development in the form of courses, workshops, and speaking engagements locally, nationally, and internationally. Her essays have appeared in the Harvard Education Review and Rethinking Elementary Education. In 2007 Auger was named Massachusetts Teacher of the Year.

Cory Buxton
Professor, University of Georgia

Cory A. Buxton is a Professor of Educational Theory and Practice at the University of Georgia and a former high school science and ESOL teacher. His research explores fostering more equitable science learning opportunities for all students and especially

for English learners. His most recent work is focused on creating spaces where students, parents and teachers can engage together as co-learners while strengthening their academic relationships, their knowledge of science and engineering practices and careers, and their ownership of the language of science. His research has been funded by the National Science Foundation, The U.S. Department of Education and by several private foundations.

Sarah Capitelli
**Assistant Professor,
University of San Francisco**

Sarah Capitelli is an Assistant Professor at the University of San Francisco in the School of Education's Teacher Education Department. Sarah works with pre-service and practicing teachers to support their developing pedagogical practices for teaching bilingual, English learner, and immigrant students. She facilitates a teacher inquiry group comprised of USF graduates and current SFUSD teachers focused on supporting teachers' systematic examination of student data to improve their teaching practices with English learners. She also coordinates the Bilingual Authorization Program at USF. Additionally, Sarah has been working with IFI at the Exploratorium since 2012 contributing a language development perspective to IFI's inquiry-based science professional development work. Previously, Sarah was a kindergarten teacher in Anaco, Venezuela for two years and a first and second grade Spanish-bilingual teacher in East Oakland for six years. She received her MA in Early Childhood Development and Bilingual

Teacher Credential from Mills College and her PhD in Educational Linguistics from Stanford University. Her research focuses on young English learners and their teachers and the role teacher inquiry can play in improving pedagogical practices for English learners.

Louann Carlomagno
**Superintendent,
Sonoma Valley Unified School District**

Louann grew up in San Francisco and moved to Sonoma in 1974. She attended Altimira Middle School and SVHS. After graduation she attended Santa Rosa Junior College and then transferred to UC Davis as a Regent Scholar. She received her Bachelor of Science in Genetics in 1985; Louann was then hired by Genencor International and worked as a researcher in the Protein Biochemistry Department for 6 years. While at Genencor, she became interested in teaching and applied for a position as a science teacher in Sonoma Valley. She was hired and taught science for 5 years at SVHS. During this time she received her teaching credential in Chemistry and Life Science. From there she moved to Sonoma Charter School and taught integrated math and science to middle school students while obtaining her Administrative Credential. She was then hired as Vice Principal at Altimira Middle School where she spent a year and was then appointed principal at El Verano Elementary School. During her six years at El Verano, Louann received her Masters Degree in Educational Leadership from Sonoma State University. She was then hired as Director of Curriculum & Instruction in 2006 and was appointed Superintendent in January 2010.

Kris Gutiérrez
Professor, University of California, Berkeley

Kris D. Gutiérrez is Professor of Language, Literacy and Culture. She was most recently a professor of Learning Sciences/Literacy and the Inaugural Provost's Chair, University of Colorado, Boulder and Professor Emerita of Social Research Methodology at GSE&IS at UCLA. Professor Gutiérrez is a national leader in education, with an emphasis in literacy, learning sciences, and interpretive and design-based approaches to inquiry. Gutiérrez is a member of the National Academy of Education and is the Past President of the American Educational Research Association and the National Conference on Research on Language and Literacy. Gutiérrez was appointed by President Obama and confirmed by the U.S. Senate as a member of the National Board for the Institute of Education Sciences where she served as Vice Chair.

Her research examines learning in designed learning environments, with attention to students from non-dominant communities and English Learners. Her work on Third Spaces examines the affordances of hybrid and syncretic approaches to literacy, new media literacies, and STEM learning and the re-mediation of functional systems of learning. Her work in social design experiments seeks to leverage students' everyday concepts and practices to ratchet up expansive forms of learning. Professor Gutiérrez's research has been published widely in premier academic journals and is a co-author of *Learning and Expanding with Activity Theory*.

Susan Gomez Zwiep
Associate Professor, Science Education,
California State University, Long Beach

Dr. Gomez Zwiep began her career as a middle school science teacher in urban Los Angeles where she spent over 12 years working with English language learners. She is currently an associate professor in the Science Education Department at CSU Long Beach where she teaches courses in the teacher preparation and Master's of Science Education programs. She serves as a Regional Director for the K-12 Alliance/WestEd involved in the "NGSS Early Implementors" grants and is a member of the current CA Science Framework committee.

She has published in both research and practitioner journals such as *Science and Children*, *Science Scope*, the *Journal of Science Teacher Education* and the *International Journal of Mathematics and Science Education*. In addition, Gomez Zwiep has contributed to book chapters such as *Integrating Inquiry into the Science Classroom: Challenges and Possibilities*; *Professional Learning Communities for Science Teaching: Lessons From Research and Practice*.

Dr. Gomez Zwiep consistently works toward establishing equitable access for all students to rigorous, inquiry-based science instruction and supporting teachers in their journey to become advocates for students, science education, and their own professional development.

She holds a BA in biology from the University of California, Berkeley and a PhD in science education from the University of Southern California.

Andrés Henríquez
Independent Professional

Andrés Henríquez formerly served as a Program Director in the Division of Research and Learning in the Education and Human Resources Directorate (EHR) of the National Science Foundation (NSF). At the NSF Henríquez's primary responsibility included recruiting and running panels for proposal reviews and working with principal investigators for grant oversight. In addition, he worked in EHR's Office of the Assistant Director and assisted in building a strategy for philanthropic partnerships and contributed to building a strategy for Hispanic Serving Institutions. Prior to joining NSF, Mr. Henríquez served as a program officer in the education division of Carnegie Corporation of New York, where he led the Corporation's work in college and career ready standards and assessments and oversaw the work of the Next Generation Science Standards. This included funding the National Research Council's *A Framework for K-12 Science Education*, funding Achieve Inc. to develop the framework-aligned *Next Generation Science Standards*, and funding the NRC to write *Developing Assessments for the Next Generation Science Standards*. Earlier at Carnegie he launched the Advancing Literacy initiative which focused on literacy for students in grades 4-12 and included a substantial body of work to support English language learners. Mr. Henríquez received his undergraduate degree from Hamilton College and Masters degree from Teachers College, Columbia University.

Paula Hooper
Senior Science Educator,
Learning Research Scientist,
Institute for Inquiry, Exploratorium

Paula holds a Ph.D. in Media Arts and Sciences with a focus on epistemology and learning with digital media. She has been an elementary classroom teacher; has worked on the design and teaching of inquiry-oriented science professional development experiences for K-8 teachers, administrators and museum educators; and worked with youth in informal settings on robotics and using digital design fabrication for their creative activism. Her research and teaching addresses uses of digital media to support STEM learning in both informal and formal learning settings from a sociocultural perspective. She is also interested in the design and facilitation of cyberlearning projects that complement STEM professional development. She is a member of the National Research Council Committee on Strengthening Science Education through a Teacher Learning Continuum. Paula has worked for TERC, the Massachusetts Institute of Technology, and the Shaker Heights public schools. She has served on advisory boards for Science Museum of Minnesota and the Technology Committee of the American Educational Research Association, and was a Warren Weaver Fellow at the Rockefeller Foundation.

Maite Iturri,
Principal, El Verano School,
Exploratorium Project Coordinator,
Sonoma Valley Unified School District

Maite was born and raised in San Francisco, in a bilingual and bicultural home. Her father was a Basque immigrant from Spain and her mother an

American from the mid-west. She attended Lowell High School, San Francisco City College, University of California Berkeley, Sonoma State, and she and is currently working on a Doctorate at the University of California, Davis. Her undergraduate work focused on Mexican American studies and Latin American history. Her master's work focused on parent participation in the Latino community in Sonoma. At present she is studying the role of a principal in promoting literacy.

Maite is principal of El Verano elementary school where she works with the families and community that surround the school and with La Luz. She is particularly proud to have created a parent leadership group which fosters home-school communication. She has worked to provide Visual Thinking Strategies (VTS) and The Exploratorium Science Project, inquiry-based programs that encourage curious observers who collaborate and investigate. In addition, she started the first preschool in Sonoma Valley Unified and the first Community School in collaboration with La Luz, Boys and Girls Club and Sonoma Valley Health Center.

She has served on the Sonoma Valley Education Foundation (SVEF), Todd Trust Team (TTT) and Coordinating Council for Youth Development in Sonoma (CCYDS). She currently serves on the Community and Local Law Enforcement Task Force (CALLE) for Sonoma County.

Okhee Lee
Professor, New York University

Okhee Lee is a professor in the Steinhardt School of Culture, Education, and Human Development at New York University. Her research areas include science education, language and culture, and teacher edu-

cation. Her current research involves the scale-up of a model of a curricular and teacher professional development intervention to promote science learning and language development of English language learners. She was a member of the writing team to develop the Next Generation Science Standards (NGSS) and leader for the NGSS Diversity and Equity Team through Achieve, Inc. She is also a member of the Steering Committee for the Understanding Language Initiative at Stanford University. She was a 2009 Fellow of the American Educational Research Association (AERA), received the Distinguished Career Award from the AERA Scholars of Color in Education in 2003, and was awarded a 1993-95 National Academy of Education Spencer Postdoctoral Fellowship.

Gennifer McDonald
Academic Coordinator,
El Verano Elementary School,
Sonoma Valley Unified School District

Hello! I am Gennifer McDonald. I am currently the Academic Coordinator for El Verano Elementary School in the beautiful town of Sonoma, California. I have been an educator for ten years, eight of which have been at El Verano. I have always worked with English Language Learners and have continued to improve my practice and knowledge in English Language Development over the course of my career. I have been fortunate to be a part of the partnership and development of the Science and ELD program between El Verano and the Exploratorium where Science is being used as the vehicle for language development and instruction. I love teaching and learn every day as an educator!

Emily Miller
ESL/BRT Elementary Teacher,
Madison Metropolitan School District,
University of Wisconsin, Madison

Emily Miller is a practicing teacher and a lead writer on the NGSS Diversity and Equity writing team. She has taught science as an ESL/bilingual resource science specialist at a Title 1 school for 17 years. Emily teaches the NGSS in her own classroom and improves and refines teaching to the standards with her students. She is consulting with the Wisconsin Center for Educational Research to develop teacher tools to promote sense making and language learning for English language learners in science. Emily authored an NGSS culturally responsive engineering grant, a school garden curriculum grant, and a culturally and linguistically responsive teacher training grant for her school district. She is pursuing a PhD at the University of Wisconsin-Madison.

Naomi Mulvihill
Teacher, Rafael Hernández School,
Boston Public Schools

Naomi Mulvihill is a bilingual educator and poet. She completed her Masters' at Harvard where she studied with Eleanor Duckworth and Courtney Cazden. For the past thirteen years, she has worked as a dual-language teacher in Boston. Prior to that, Mulvihill developed curricula and served as a consultant in public schools in the U.S. and Mexico.

Mark St. John
Director, Inverness Research

Dr. Mark St. John, founder and president of Inverness Research Inc., has a broad background in science and mathematics education at all levels. For

over 20 years he has been involved in the evaluation and study of public and private initiatives aimed at improving science and mathematics education. He also advises philanthropies about investments in educational improvement.

Dr. St. John and his colleagues at Inverness Research Inc. have been involved in many evaluations of reform initiatives in education—from the study of large scale initiatives undertaken by the National Science Foundation and the U.S. Department of Education to the evaluation of individual science museum exhibits. They have been involved in studying professional development and teacher leadership networks, curriculum design projects, informal science education efforts, multi-institutional partnerships and centers, and systemic reform initiatives at the state, district, and school levels.

Annemarie Sullivan Palinscar
Jean and Charles Walgreen, Jr. Professor of
Reading and Literacy, University of Michigan

Annemarie's primary research interest is in supporting students to learn how to engage in knowledge building with informational text, especially in the context of project-based scientific investigations. With her research group - and in collaboration with computer scientist, Elliot Soloway - she has designed and studied the use of a cyber-learning environment in which students collaborate as they read texts, view video, use simulations, write, and draw, while engaging in scientific inquiry. With science educator, Betsy Davis and the ELECTS team, she has recently conducted a series of studies investigating the value of educative supports for science teaching in the upper elementary grades. With linguist, Mary Schleppegrell and the Language and Meaning

research group, she has used design-based research to investigate the process and outcomes of teaching English learners the use of functional grammar analysis as a means of supporting them to interpret and learn from narrative and informational text. Annemarie is a teacher educator who prepares elementary educators and she teaches in the graduate program for the Literacy, Language, and Culture Program at the University of Michigan.

Helen Quinn
Professor Emerita of Physics,
Committee Chair for Conceptual Framework
for New K-12 Science Education Standards,
Stanford University

Helen Quinn is Professor Emerita of Particle Physics and Astrophysics at SLAC National Accelerator Laboratory. She received her PhD in physics at Stanford in 1967. She has taught physics at both Harvard and Stanford. Dr. Quinn is an internationally recognized theoretical physicist who holds the Dirac Medal (from the International Center for Theoretical Physics, Italy), the Klein Medal (from The Swedish National Academy of Sciences and Stockholm University) and the Sakurai Prize (from the American Physical Society). She is a member of the American Academy of Arts and Sciences, the National Academy of Science and the American Philosophical Society. She is a Fellow and former president of the American Physical Society. She is originally from Australia and is an Honorary Officer of the Order of Australia. Dr. Quinn has been active in science education for some years. She served as Chair of the US National Academy of Science Board on Science Education (BOSE) from 2009-2014. She served as a member of the BOSE study that developed the report "Tak-

ing Science to School” and chaired the committee for the “Framework for K-12 Science Education”, which is the basis of the Next Generation Science Standards (NGSS) that have now been adopted by multiple states in the US. She also served on the committee that developed the report “Developing Assessments for the Next Generation Science Standards”. She is a member of the steering committee of the Stanford “Understanding Language” coalition, with a focus on the intersection of science learning and language learning.

Lynn Rankin
Director, Institute for Inquiry, Exploratorium

Lynn Rankin is Director of the Exploratorium’s Institute for Inquiry, a national professional development center for K-5 leaders and practitioners of elementary science reform efforts. Lynn has decades of experience in science curricula development, teacher professional development and program design in both formal and informal learning environments. She was a co-founder and faculty member of the Association of Science and Technology Centers’ Professional Development Institutes for museum educators; she served on the faculty of the NSF funded Center for Informal Learning and Schools, a collaboration between the Exploratorium, King’s College, and the University of California at Santa Cruz. She has contributed to numerous national publications and committees, including the National Science Foundation’s, “Foundations II: Inquiry, Thoughts, Views and Strategies for the K-5 Classroom,” the National Academy of Science’s committee to develop “Inquiry and the National Science Education Standards” and National Institute for Science Education’s Committee on Professional Development. She has

served as PI on numerous National Science Foundation, U.S. Department of Education and private foundation grants. She leads the US DOE funded i3 (Investing in Innovation) project “Integrating ELD and Science: A Professional Development Approach” and the BaySci Science Champions Academy. Before joining the Exploratorium in 1975, she taught elementary school in San Francisco Unified School District.

María Santos
Director, School and District Services, WestEd,
Co-chair and Senior Advisor for Leadership,
Understanding Language, Stanford University

María Santos is the Co-chair and Senior Advisor for Leadership at Understanding Language, Stanford University and Director for School and District Services in the Comprehensive School Assistance Program at WestEd. From 2010- 2014, she served as Deputy Superintendent for Instruction, Leadership and Equity-in-Action for the Oakland Unified School District and is a 2014 *Leaders To Learn From* leader selected by Education Week. Until 2010, she was, the Senior Instructional Manager and Superintendent for the Office of English Language Learners (ELLs) at the New York City Department of Education. In that capacity, she led the Office in ensuring that Children First reforms were raising the academic rigor of ELLs through quality teaching and learning citywide. Early in these reforms, she led the restructuring of New York City’s Early Childhood, ELL, and Instructional Technology departments. Ms. Santos has designed and developed strategic initiatives and resources for several nonprofit organizations that provide state and national support, setting trends in the educational agenda nationwide. As an Education

Program Officer at Wallace-Reader’s Digest Funds, Ms. Santos designed the Leadership for Education Achievement in District (LEAD) project—a program that engaged twelve urban districts in twelve states in developing educational leadership to improve student learning. Before going to New York City, Ms. Santos spent 20 years in the San Francisco Unified School District (SFUSD). As Associate Superintendent, she supervised the development of major instructional improvement initiatives such as SFUSD’s Professional Development Initiative and gained SFUSD the recognition of an Exemplary Site by the U.S. Department of Education’s National Award for Professional Development.

Terry Shanahan
Science Academic Coordinator,
University of California, Irvine

Dr. Terry Shanahan started her 28-year science education career teaching high school Chemistry and Physics in Southern California. She has developed science curriculum for pre-K to grade 12, with a special focus on English Learner strategies since 2000. She has been a frequent presenter at numerous National Science Teacher Association (NSTA) and California Science Teacher Association (CSTA) conferences. Dr. Shanahan served with the team of science educators who wrote the California Department of Education Professional Learning Module for Common Core State Standards: Literacy in Science. For the last two years, Dr. Shanahan has written and facilitated a series of afterschool science lessons for English Learners at the Boys and Girls Club in Santa Ana. Her research interests include the effects of student talk strategies on science and math content acquisition and comprehensible science curriculum

for English Learners. With her colleague, Dr. Lauren Shea, she has published several articles about the positive effect of intentional student talk strategies in supporting English Learner achievement in science and math.

Lauren M. Shea
Director of Education, Outreach, and Diversity, University of California, Irvine

Dr. Lauren M. Shea is the director of Education, Outreach, and Diversity at Chemistry at the Space-Time Limit (CaSTL) in the University of California, Irvine. With degrees in bilingual education, E.S.L., and applied linguistics, her current research and practice centers on the integration of language development strategies in the content area of science. Before conducting research in language-based classrooms, Dr. Shea was a classroom teacher and site-coordinator in a Dual Immersion school. Along with Dr. Terry Shanahan, her relevant publications include *Using science as a context for language learning: Impact and implications from two professional development programs* (2012), *Incorporating English language teaching through science for K-2 teachers* (2012), *Student talk: Oral language development through science* (2011) and a review of *Teachers' roles in second language learning: Classroom applications of sociocultural theory* (2014).

Guadalupe Valdés
Bonnie Katz Tenenbaum
Professor of Education, Stanford University

Guadalupe Valdés is the Bonnie Katz Tenenbaum Professor of Education at Stanford University. Working in the area of applied linguistics, much of her work has focused on the English-Spanish bilingualism of

Latinos in the United States and on discovering and describing how two languages are developed, used, and maintained by individuals who become bilingual in immigrant communities. Valdés is a member of the American Academy of Education, a Fellow of the American Educational Research Association (AERA), and a member of the Board of Trustees of Educational Testing Service (ETS).

Claudio Vargas B.
Coordinator, Elementary Science,
Oakland Unified School District

Claudio Vargas B. is the Coordinator of Elementary Science at the Oakland Unified School District. He oversees and supports the implementation of the science program at the 54 district elementary schools. Before joining OUSD, Mr. Vargas served as the Director of the Bay Area Science Project (BASP) at UC Berkeley's Lawrence Hall of Science (LHS). Mr. Vargas has led numerous professional development programs throughout the Bay Area, Los Angeles, Texas, and El Salvador. He has designed and implemented K - 8 professional development programs that focus on developing teachers' science content knowledge and expanding their teaching strategies, with particular emphasis on strategies that provide English Language Learners with access to the core curriculum. Prior to joining LHS, Mr. Vargas worked for 10 years as a bilingual K-5 teacher and a science coach in the Oakland Unified School District, 11 years as a science researcher at the School of Pharmacy at the University of California, San Francisco, and 9 years at the Department of Bioengineering at the University of Minnesota.

Karen Worth
Chair, Elementary Education Department,
Wheelock College

Karen Worth has been a faculty member at Wheelock College for over 35 years, where she teaches early childhood and elementary education with a focus on science education. She works closely with the Mathematics and Science Department to enhance the mathematics and science preparation of pre-service students at the college. She also coordinates the Integrated Elementary and Special Education program at the graduate level. She is currently Chair of the Elementary Department. Ms. Worth also worked as a senior research scientist at Education Development Center, Inc. for more than 25 years leading a range of programs focused on science curriculum development, professional development, and systemic reform. She has been a consultant and advisor to a number of museums including the Boston Children's Museum and the Chicago Children's Museum. She has advised public television stations such as WGBH and PBH and community organizations across the country and internationally. She is a recipient of the Exploratorium's Outstanding Educator Award for her work in science education, the international puRkwa prize for the scientific literacy of the children of the planet, and the NSTA Distinguished Service Award. She is the author of numerous articles and book chapters and was the principal investigator in the development of *The Young Scientist Series* (Redleaf), *Worms, Shadows and Whirlpools* (Heinemann), *Insights, An Elementary Hands-On Science Curriculum* (Kendall Hunt), *Science and Literacy: A Natural Fit*, and *The Essentials of Science Literacy* (Heinemann.)