Utilizing K-12 Science Education Partnerships to Develop Better Scientists: 
*Integrating Pedagogy and Partnership Experiences into Graduate Science Training*

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SEPAL: The Science Education Partnership and Assessment Laboratory  
San Francisco State University (SFSU)
Partnership Benefits Have Been Assumed For Students And Teachers, But Less So For Participating Scientists

<table>
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<tr>
<th>Participant Group</th>
<th>Participants assumed to gain…</th>
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| K-12 Students     | • Role models in science  
                    • Hands-on science experiences |
| K-12 Teachers     | • Increased science content knowledge  
                    • Insight into experimentation and inquiry  
                    • Opportunities for intellectual collaborations |
| Scientists        | Few proposed  
                    • Advocacy for research?  
                    • *Scientifically literate citizenry*?  
                    • Outcomes for scientists themselves? as future faculty? |
SEPAL Aims to Create a New Kind of Scientist!

- Founded in 2004 through an NSF GK-12 Track 2 Institutionalization grant
- SEPAL promotes collaborations among local K-12 teachers and SFSU scientists and scientific trainees
- SEPAL offers formal pedagogical training for SFSU science grads and undergrads
- Mission is to support high quality science education for all students from Kindergarten through College and contribute to the emerging discipline of partnership through research
- SFSU is a diverse, urban campus serving more than 28,000, including ~6,000 Master’s-level graduate students
Research Context:
SFSU SEPAL Partnership Programs

**SEPAL Partnership Programs**

**Partnership Component**
- Establish one-on-one partnership with middle or high school teacher for an academic year
- Co-plan and co-teach one hands-on, inquiry-based science lesson each week
- Participate in SEPAL monthly community gatherings
- Present poster at SFSU Spring Science Showcase

**Pedagogy Course Component**
- Weekly, 2-hour *Explorations in Science Education, Pedagogy, and Partnership* course for 2 semesters, concurrent with field work
- Receive formal training in topics of inquiry, equity, assessment, scientific teaching, etc.
- Develop “research lesson”
- Present and facilitate case study dilemmas
- Submit weekly reflective journals
Research Questions

• What do Master’s-level scientific trainees themselves identify as key learnings from partnership and pedagogy experiences?

• To what extent do reported outcomes vary among individuals within and across cohorts?

• In what ways do partnership and pedagogy experiences influence scientific trainees as future research science professionals?
Research Data for Analysis

Final Written Reflections from Three Cohorts of SEPAL Scientists (n=31)

What did you learn from your SEPAL Partnership experiences that you will use in the future?

- all Master’s level SFSU graduate students
- from range of science disciplines including biology, geoscience, physics, marine science

Likert Scale-Essay Combination (n=14)

I feel like this course made me a better scientist.

1 2 3 4 5

(1=strongly agree, 3=neutral, 5=strongly disagree)

Please explain the number you chose.
Research Data for Analysis: Final Written Reflections from Three Cohorts of SEPAL Scientists (n=31)

What did you learn from your SEPAL Partnership experiences that you will use in the future?
Methods for Analysis…

- SEPAL Scientists responded to open-ended prompt
- Analyzed these qualitative data sets to identify emergent themes, each of which encompassed multiple sub-themes or categories
- Assigned text from each individual to categories
- Determined the pervasiveness of reported themes and categories across individuals through post-hoc quantitation
- Re-scored data multiple times against the emergent themes with multiple observers.
Systematic Analysis of Qualitative Data Reveals Five Themes of Outcomes for SEPAL Scientists

Scientists benefit as...

- Communication Skills
  - On communicating research
  - On valuing communication skills

- K-12 Education Insights
  - On the K-12 system and schools
  - On teachers
  - On young students

- Partnership Insights
  - On being an effective partner
  - On the value of collaboration

- Pedagogical Skills
  - On assessment
  - On equity
  - On inquiry
  - On lesson planning

- Professional Identity Shifts
  - On the role of scientists in K-12 science education
  - On their future teaching practice
  - On their future research science careers
  - On their expanded definition of data collection/research
Findings on Professional Identity Shifts

On the Role of Scientists in K-12 Education

**Scientist I**

“The contribution I have made as a result of being part of the this program has given me tangible proof that as a scientist I can make a difference in our educational system and it has greatly influenced my desire to do so.”

**Scientist X**

“The contribution I have made as a result of being part of this program has enabled me to discover how much I know about science, I have realized how much I have to contribute to a science classroom. I have learned this through my journal entries which have caused me to reflect on what I have to give as well as what I have to learn.”

On their Future Teaching Practice

**Scientist R**

“A big change for me was learning to spend less time lecturing, which gives lessons more time for personal/group discovery. This way I can better craft life-long learners, not test takers, and get more of the class involved in lessons.”

**Scientist O**

“Another broad teaching technique is the process of converting closed-ended questions to open-ended questions. This is a skill I will continue to use as an educator, learner, scientist and professional. Understanding and knowing how to implement nuances to invite individuals to share as much information as possible is quite a useful skill that I can apply in every element of my life.”
Findings on Professional Identity Shifts

On their Future Research Science Careers

“Another thing that I have learned from my SEPAL experiences is to become a better scientist... it keeps occurring to me that the science process goals that I try to teach to my students are also for me to learn as a young scientist... I remember telling them about how important it is in science to persist through confusion and to be resistant to failure. A few hours after that, I found out in my lab that my 3-month experiment failed to give results. It hit me at that moment that I was also still learning what I just taught my students. The fact that I just taught my students the “skill” of persisting through failure helped me in my research to not give up and to keep trying. I believe on that day, I became a better scientist.”

Scientist F

On their Expanded Def. of Research

“Having only been trained in the life sciences I really did not have a good understanding of qualitative research. I’ve come to realize that qualitative types of research are vital to assessing classrooms as I have noticed that often times it is less about percentages, methodologies, and statistically significant numbers; but about the students themselves. I am reminded of that fact - that my study subjects are people with many different facets to their lives. There are many ways to view the “data” we collect from them.”

Scientist C

“The idea of collecting data to help you analyze and better teach your classroom I think is a great idea. Sure it’s a bit of work involved, but I think that if you really want to know how your classroom functions, it’s a good approach to take. I really enjoyed the variety of questions and techniques that my colleagues used in their classroom.”

Scientist U
SEPAL Scientist Outcomes from Partnership and Pedagogy Experiences are Robust

Scientists benefit as…

Communication Skills
• On communicating research
• On valuing communication skills

K-12 Education Insights
• On the K-12 system and schools
• On teachers
• On young students

Partnership Insights
• On being an effective partner
• On the value of collaboration

Pedagogical Skills
• On assessment
• On equity
• On inquiry
• On lesson planning

Professional Identity Shifts
• On the role of scientists in K-12 sci. ed.
• On their future teaching practice
• On their future research science careers
• On their expanded def. of research

% reporting outcome (n=31)

- Communication Skills: 35%
- K-12 Education Insights: 42%
- Partnership Insights: 48%
- Pedagogical Skills: 56%
- Professional Identity Shifts: 77%
Individual Scientists Report Benefits Across Multiple Categories: Sample High Responders

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<th>PROFESSIONAL IDENTITY SHIFTS</th>
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88% 75% 75% 75% 63% 63% 63% 63% 75% 38% 100% 50% 38%

1 comment ● 2 comments ● 3 or more comments ●
Individual Scientists Report Benefits Across Multiple Categories: Sample Low Responders

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1 comment • 2 comments • 3 or more comments •
Research Data for Analysis: Likert Scale-Essay Combination (n=14)

I feel like this course made me a better scientist.

1  2  3  4  5

(1=strongly agree, 3=neutral, 5=strongly disagree)

Please explain the number you chose.
Methods for Analysis...

• SEPAL Scientists responded to Likert scale probe
• Quantitative score determined by averaging all responses
• Analyzed qualitative data sets (comments) to identify emergent themes
• Determined the pervasiveness of reported themes within cohort through post-hoc quantitation
Scientists Report that their Pedagogy Experiences Have Made Them Better Scientists

Emergent Categories

**IMPROVED SCIENTIFIC PRACTICE**
50% of cohort
“I have learned more about being a scientist in this course than in any other science course I have ever taken.”

**IMPROVED COMMUNICATION SKILLS**
43% of cohort
“I feel more capable in communicating my ideas in science to scientific colleagues and non-scientists.”

**REJUVENATED/REINFORCED SCIENTIST IDENTITY**
36% of cohort
“This course brought me back to my roots. I remembered why I liked science! I remembered what it was like to ask questions and wonder.”

**BROADENED PERSPECTIVE ON SCIENCE/SCIENTISTS**
29% of cohort
“I feel that this course has changed my perspective of what kind of scientist I want to be. Before taking this course I never really thought of a scientist as an educator. So, if being a better scientist means combining passions for research & teaching than yes! It made me a better scientist.”

Likert Scale Average Value: 1.28
(1=strongly agree, 5=strongly disagree)
Partnership and Pedagogy Research: What We Have Learned And Future Directions

What have we learned?

- Partnership experiences impact scientists’ professional identities, especially ideas about future teaching practice.
- SEPAL Scientists report learning skills and gaining insights in specific ways that can impact their careers as research scientists.
- Analysis suggests that integration of partnership and pedagogy experiences into graduate training is a promising mechanism of K-16+ science education reform.

Future Directions & Questions

- **To what extent do these outcomes for scientific trainees endure** for 2, 5, or 10 years after their partnership experiences?
- **To what extent can a pedagogy course alone promote these same kind of shifts** for graduate teaching assistants teaching at the college level?
- **As a research community,**
  - how can we get smarter about the nuances of how to teach scientists how to teach?
  - how can we build assessment tools that will support robust cross-programmatic research?
  - how can we build the discipline of partnership through research?
Acknowledgments: Many thanks to all of the educators and scientists who cross professional boundaries every day to build strong science education partnerships.
Reference Slides
Findings on Communication Skills

**On Communicating Their Research**

“I think a big skill I have gained and come to appreciate is the use of appropriate language to explain my research to others outside my field of biology and outside the realm of science… This awareness of the people outside of my research and the need to create a common understanding with them is one of the most precious things I think I have gained this year.” - Scientist L

**On the Value of Communication Skills**

“I feel I have learned the importance and value of clear communication and been provided numerous opportunities to improve my verbal, written and physical communication skills. I know I am better at writing than I am at speaking. Yet, teaching and explaining ideas to others in a classroom setting has improved my confidence communicating in front of others. I now feel I am better prepared to communicate ideas to more scholarly audiences.” - Scientist A
Findings on K-12 Insights

On the K-12 System and Schools

“Our secondary education system, while certainly having room for improvement, at this time *is what it is* and produces students with a certain level of ability on average. The most logical way to teach college [science] then, if it is indeed our intention to *teach* it, is to begin at this level, not to demand anything more and scare off all but the high-end outliers from the norm. But this is exactly what is done. There is a great deal of weeding out that goes on in competitive scientific fields.”

**Scientist B**

On Teachers

“In the coming years, I will remember that teaching is intensive. Anyone who says teaching is easy either hasn't been in a classroom as a regular teacher or put minimal effort as the instructor. I wasn't aware of the number of issues a teacher must deal with until my experience in GK-12. This program re-shaped my ideas of a science educator.”

**Scientist E**
“I have been bothered for a long time by many students’ apparent apathy towards learning, but they are usually told the answers to things, so it is logical that that is how they would expect everything to be, and there would be little need for them to figure it out. But by asking students to figure things out for themselves, they own the answers they find. On the same note, I learned that it is very important to question the students about their own answers and conclusions, and probe them on how they came to them. This allows them to discuss their work with someone and you can make sure that they are really understanding what they are doing and they are not faking it.”

*Scientist T*
Findings on Partnership Insights

On Being an Effective Partner

“I think the one thing that every partnership requires is a sense of respect and flexibility on the part of both the scientist and the teacher. If both partners make a point to overtly express their respect and willingness to be flexible, the partnership will naturally progress toward its optimum…. As I continue to grow as a scientist, I hope to identify more ways to use partnerships to expand students’ understanding of scientific concepts. I think the partnership challenges from the GK-12 program have provided me with the tools I need to navigate future partnerships between scientists and other professionals. This will continue to benefit me as a scientist and educator for many years to come.”

Scientist G

On the Value of Collaboration

“Scientist H

“I am very appreciative that my [teacher partner] is such a willing and capable collaborator. The year would not have been half as good with a teacher unable to share the responsibility of creating hands-on, inquiry-based, [science] lesson plans…We also spent a great deal of time evaluating and assessing student learning and participation…Working with [my partner] this year has been highly educational and rewarding.”

Scientist L

“Scientist G

“I soon realized that teaching really is a team effort and that most successful teachers work as a team or in a group environment. It had made a lasting impression on me to watch all the teachers working together. It is a reminder of the power of collaboration, and I will take it into my own scientific work.”
Findings on Pedagogy Skills

On Assessment

“It seems logical that it would be more difficult to learn something differently from how you have known it to be then to learn from scratch. Often times these misconceptions are never addressed, so a more complex understanding of things is on a faulty foundation… Learning how to use assessment tools to identify misconceptions, as well as just to see where students are starting from, has been incredible. They can be useful in enabling teachers to see where students are before embarking on a chapter or to see whether or not students are learning what you think you are teaching them.”

On Equity

“What we can do as teachers is to give each student an equal opportunity to participate in science class. I can make sure that each student has materials they can work with, that they are working in a situation where they can participate. I can also keep my hands in my pocket and let the student manipulate objects according to verbal instructions. I can practice waiting after I pose a question so that everyone has a chance to think of the answer. I can say things like ‘I want to hear everyone’s voice’. I can have students have pair-share where they talk to one another before answering to a group. I can also use a whip as a way to hear from everyone in the class in a brief period of time….”
Findings on Pedagogy Skills

On Inquiry

“The most fundamental thing I learned this year was how to teach science in a way that is inquiry based. I have known for a long time that students need to “discover” things, and make logical connections themselves about things in order to fully understand concepts & retain their understanding. However, this year we have learned so many strategies on how to teach in an inquiry-based way and discussed what it means to teach this way in our weekly seminar, that I have a very different picture of what inquiry looks like in a classroom.”

On Lesson Planning

“Through working with my partner teacher, I have learned how to create a lesson plan that teaches content and process goals, is engaging, and that students will enjoy. At the beginning of the year, I had no idea how to create a lesson plan. … It was great practice to move from brainstorming ideas to implementation of the lesson itself. I was able to see what worked and what didn’t work in the classroom.”
Another Explicit Professional Identity Shift: I am a scientist!

SCIENTIST I

“One of the most important things I have learned from my experiences with GK-12 this year is that I am a scientist. I have been a student for nineteen years and as such have been constantly surrounded by people who know more than me. The GK-12 program has enabled me to realize just how much I know. Instrumental in inducing these realizations has been SFSU’s practice of referring to GK-12 fellows as scientists. Being called a scientist by teachers, professors and middle school students has made me more comfortable applying the term to myself.”

“Calling myself a scientist has required that I realize just how much I know about science. Working with students in a 7th grade classroom has underscored the extent of my knowledge. More than just discovering how much I know, working with the GK-12 program has also enabled me to realize that I think like a scientist in almost every aspect of my life – even my approach to writing a shopping list is methodically scientific! This has made me more comfortable referring to myself as a scientist because I see all the ways in which I act as a scientist.”
Conceptual Rubric for Categorizing Written Reflection
Data: Communication Skills

On Communicating Their Research
• sharing research with students
• research lessons
• first translations

On the Value of Communication Skills
• public speaking
• using analogies and metaphors
• speaking in less technical terms
Conceptual Rubric for Categorizing Written Reflection
Data: K-12 Education Insights

On the K-12 System and Schools
• educational system in general
• challenges in public schools
• schools as institutions
• society-scale education issues

On Teachers
• on teaching profession in general
• observations on how teachers work together
• on pedagogy in general

On Young Students
• relating to & interacting with students
• student knowledge & learning
• student motivation & engagement
Conceptual Rubric for Categorizing Written Reflection
Data: Partnership Insights

On Being an Effective Partner
• necessity of planning time
• persevered challenges with partner
• thoughtful communication

On the Value of Collaboration
• learned from partner
• appreciate partner
• value working with other GK-12 scientists
• Partnership expands capacity for teaching science well
Conceptual Rubric for Categorizing Written Reflection Data: Pedagogy Skills

On Assessment
• crafting questions
• evaluation
• uncovering misconceptions
• getting students to understand what they have learned

On Inquiry
• promoting discovery
• guiding students to wonder about their world
• encourage curiosity and exploration

On Equity
• equal access and participation
• language and socioeconomic issues
• structured group work
Conceptual Rubric for Categorizing Written Reflection Data: Professional Identity Shifts

On the Role of Scientists in K-12 Science Education

• making a difference in K-12 system
• have much to contribute
• noticed benefit to students of scientist in classroom

On Their Future Teaching Practice

• articulated teaching philosophy
• desire to pursue science education PhD
• applying K-12 teaching strategies to university teaching
• better understanding of incoming freshman ability
Conceptual Rubric for Categorizing Written Reflection Data: Professional Identity Shifts

On Their Future Research Science Careers
- Interacting with colleagues in new ways
- Developing teamwork and communication skills useful in their profession
- Reflecting on their interests in or enthusiasm for science

On Their Expanded Definition of Data Collection and Research
- Reporting greater appreciation for the rigor of qualitative research
- Seeing the classroom at context for data collection
- Reflecting on their knowledge in a new field of science education research literature