Project

A scientist-science teacher partnership that supports meaningful learning

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G.R.O.W.

We know that bringing scientific research into the classroom is often a goal of science teachers, and that it is not a new idea (Brown, Bokor, Crippen, and Koroly 2014; Hanson and Burakowski 2015). The notion of having students engaged in authentic practices of science underlies the *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013) and is foundational to the *Framework for K-12 Science Education* (National Research Council 2021).

The overarching goal of scientist–teacher collaborations is the improvement of PK–16 science education; the specific goal of this project was to have students engaged in meaningful, "real" science as a way to learn about ecological principles. The mechanics of having that happen, however, required careful planning and a strong partnership.

This article describes a successful effort by a college biology professor, college science education professor, and high school science teacher to bring science into the high school classroom. We discuss the steps in assembling a meaningful and productive long-term partnership that can transform the experience of science for high school students, make "real" science more accessible for teachers, and provide meaningful outreach for college professors. At the end, we share a link to data and classroom materials developed by the collaboration.

For the purposes of this article, our definition of a "scientist doing real science" is a faculty member in a university, academic setting that conducts data-based and question-driven research in the lab or field. However, scientists involved in these types of partnerships could include STEM professionals and affiliates in non-academic settings. Scientist–teacher collaborations can have varied goals and organizational structure, but a partnership which enables the students to perform hands-on investigations, as opposed to the teacher or scientist delivering the science is our focus.

Initial steps include finding a partner, choosing a topic, and integrating the material with school goals and standards. Finding a partner with whom to collaborate can be a challenge. As a high school teacher you want to find someone with whom you can build a true partnership, where you both contribute and both gain. Sometimes collaborations develop organically. As a student in college or graduate school, you interacted with lots of science faculty, perhaps even working in a research lab. This might result in a natural pairing as you understand the research and you have an existing relationship. (That's the basis of the partnership in this project.) You might meet STEM professionals through professional development/professional learning, conferences, or workshops that lead to future partnerships. Your district may be partnered with scientists in colleges or industry.

If you do not have a personal connection to STEM faculty, you will have to make an effort to make some; Figure 1 shares some strategies to make these connections. With technology, you do not need to be geographically close to carry on a partnership, although there are advantages to being nearby.

Next, it is crucial to focus on a particular area or investigation topic. Successful collaborations between scientists and teachers come from a shared passion, goal, or need. From the scientists' perspective, there may be a need to distribute findings or provide educational outreach as part of their professional obligations. The scientist may be passionate about their field and see a partnership with high school teachers and students as a possible pipeline for recruiting students into the field. The teacher may have had research experiences which ignited their love for science and want to pass that along to their students. For a collaboration to work well and be positioned to overcome challenges, both the scientist and the teacher need to have a reason for participating and a benefit from that participation.

Finally, the collaborative project must align with school/district goals and grade level standards. In this current environment, having real science in the classroom will inherently align with aspects of *NGSS* standards, making this type of project appealing to administrators. The integration of research-based data within the classroom is one way to help students achieve mastery in the Science and Engineering Practices (SEP) as well as apply real world application of the Disciplinary Core Ideas (DCI) being taught and the connection to the interdisciplinary Crosscutting Concepts (CCC). It's important, however, that the content and the DCI content, align with the course. We will be sharing how to create and nurture the scientist–teacher collaboration, but at the end of the article we will also be sharing specific project resources so you can replicate this unit in your own setting.

Finding a partner and topic: creating an authentic collaboration

Our scientist–teacher collaboration evolved from a student–faculty experience in graduate school at California State University, Long Beach. While Wendy Hagan was attending CSULB to obtain her master's degree, she took several of Dr. Christine Whitcraft's classes including conservation biology, plant ecology, and wetlands ecology. Christine, an associate professor in the Biology department and head of the Wetlands Ecology Lab at the time, had a teaching style that was hands-on and inquiry-based. She integrated case studies, critical thinking, service-learning projects, and real data into her classes in a way that communicated her enthusiasm and passion for science, research, and wetlands.

FIGURE 1

Strategies to connect with STEM faculty.

- Get connected to faculty at your local college campus.
  - ◊ Make appointments to meet with the appropriate department chair(s) at your local college.
  - ◊ Visit faculty webpages to learn what research might be scalable to your setting.
  - ◊ Attend department research seminars.
  - ◊ Talk with the science teacher credential faculty at university (e.g. your alma mater) and ask for suggestions and introductions.
- Apply to participate in a virtual forum with scientists (e.g. Skype-a-Scientist).
- Get involved with professional development opportunities and institutions, like NSTA, your state science teacher organization, and regional professional development programs.
- Talk to your CTE colleagues to see what STEM industry partners are in the area who already work with your district/site.
- Attend regional or state science teacher conferences and network with scientists presenting there.
- Attend professional science meetings where teacher discounts exist for registration or when K-12 days or events are scheduled.

FIGURE 2

Key steps in Project G.R.O.W.

Project Steps	Description
1. Students were provided with scaffolding for this culminating project using real data.	• Several activities, investigations, and discussions centered around the nature of science, reading, writing, asking questions, planning investigations, constructing and/or evaluating ecological models, organizing data and constructing graphs, graphical analysis and interpretation, constructing explanations, arguing from evidence, and communicating ideas through oral presentations and Socratic discussions.
2. Background about coastal wetlands, ecological field site, and conservation and restoration (Engage, Explore)	• Students observed patterns in changes to coastal wetlands over time. • Students used models demonstrating the ecological functions of and services provided by wetlands. • Students discussed, read, and watched videos about the characteristics, abiotic and biotic parameters, and overall dynamics and nature of coastal wetlands. • Students took a field trip to the ecological field site, Local Wetlands (LW), to observe the different plant and epifauna biodiversity and zonation of the wetlands, participate in data collection methodologies (both abiotic and biotic parameters) and take action in actively restoring the upland area of a coastal wetland. • Students met with scientists (professors and graduate students in the field), a science education professor, and a naturalist for the LW Nature Conservancy) to ask questions and gather information on the LW.
3. Constructing a Research Question and Planning an Investigation about the abiotic and/or biotic parameters within the zonation areas of the HBW for a 4-year period (Explore)	• Students worked in collaborative teams and constructed their own research questions which included an independent and dependent variable. • Students planned and designed a field ecology investigation that was appropriate to investigate their research question using the methodologies and techniques learned at the LW. • Students discussed their research question with Teacher and Bio Prof (via Skype) and the appropriate raw data set they would need in order to investigate their research question.
4. Organizing, Analyzing, and Interpreting Data (Explain)	• Students parsed out the appropriate data needed for their research question. • Students processed their data by finding the means, standard deviation, and correlation (via scatterplots). • Students discussed their processed data with Teacher and Bio Prof (via Skype) and any outliers or anomalies to be considered.
5. Constructing Explanations (Explain & Elaborate)	• Students constructed explanations based on their processed data and evaluated the overall connections to coastal wetlands and restoration, and the effectiveness and limitations of their research study.
6. Organizing and Communicating their Research Paper into a Final Report and Presentation (Evaluate)	• Students communicated their findings in a formal scientific paper and a PowerPoint presentation. • Students presented their findings to Teacher, Bio Prof, and a science education professor. • Students, Teacher, Bio Prof and Sci Ed Prof asked the students questions after their presentations which required students to engage in argumentation and justify their reasoning for their evaluation of the data.

While enrolled in a master's in Science Education program at the university, Wendy was able to work in Christine's lab learning new research methodologies, sampling techniques in the field, and ways to analyze and interpret data. These experiences in the classroom, lab, and field inspired Wendy to construct a similar learning environment within her classroom by integrating environmental education and the *NGSS*, especially the skills associated with the SEPs (in particular asking questions, analyzing and interpreting data, engaging in arguement from evidence, and obtaining, evaluation and communicating information) and the Nature of Science.

Both Wendy and Christine are interested and enthusiastic about wetlands, restoration and conservation, and science education and research. Wendy wanted to integrate scientific research and methodologies into her classroom, and Christine wanted to understand more about how students learn in a K–12

FIGURE 3

Benefits and challenges of scientist-teacher collaborations.

	Potential Benefits of Collaboration	Possible Challenges of Collaboration
Teachers	• Helps craft meaningful 3-D learning sequences for students. • Increases teacher's science knowledge and expertise. • Brings an understanding of what scientists do and the culture of science. • Brings a level of recognition and support from administration and community for partnering with scientists. • May result in future partnerships and opportunities.	• Finding the right partner—there needs to be trust, respect and a willingness for both partners to commit to the effort. • Time—it is always more time to work together and coordinate efforts than to work alone (you get a better end product, but more time required to get there). • Career timing: not when you the scientist is an early faculty member who needs to get a lab up and running, not when professor is going for tenure and needs research publications, etc.; not when the teacher is new (going through induction program, getting classes up and running, and untenured). • Scientists' effort may not count for their career advancement at their institution. • Communication—how and when will you work together? If geographically close, do you meet in person? Who does the traveling? If geographically far how does the scientist visit the classroom? • K-12 logistical issues and concerns of field trips (to field site, university, etc.). From scientists' perspective, field trips include minors at a research site, potential problems if accidents or misbehavior.
Scientists	• Provides an outreach opportunity and broader impact of research. • Enhances understanding of how K-12 education works. • Helps recruit future students. • Provides a meaningful service activity that is linked to scholarly work.	
Students	• Empowers them to answer their own questions (not someone else's). • Engages students in all three dimensions of *NGSS*. • Enhances understanding of how science is conducted, communicated, and presented within the scientific community. • Enhances student understanding of the value of collaboration and communication.	• This will be a challenging project for some students, so teachers need to scaffold the experience.

environment and to interest younger students in wetland ecology. This was the genesis of Project G.R.O.W.—Guided Research On Wetlands—a semester-long series of lessons that led to a culminating project which had high school students asking and answering questions about wetlands using Christine's data.

Developing and implementing the project

The scientist–teacher collaboration initially led to the development of a semester-long, cumulative research-based project for each high school student in ninth grade honors biology. Over a single semester, students generated research questions, collected appropriate data in the field, analyzed and interpreted data, created and explained graphs, and communicated their findings in a formal presentation to their peers and mentors (Figure 2). While the projects were individual, students worked in collaborative teams to discuss the design, evaluation, and overall presentation of their research. In order to build the necessary skills required for the completion of this project, a sequence of lessons and activities were specifically designed to the high school students' strengths and weaknesses. The project has subsequently been repeated in various forms in college-prep, honors, International Baccalaureate, and Advanced Placement level courses. The project has been successful at all levels.

Christine shared her data with Wendy for use by the students via numerous Skype visits, readings, and a field trip to Christine's research site. This helped students understand the habitat and potential interactions between biotic and abiotic features of the habitat, making them better able to develop researchable questions. Christine had to share a manageable data set which required time on her part. It is worth noting that this effort doesn't fall neatly into the typical expectations for tenure and promotion, which is why it is important that there be some added value to the scientist for their participation.

Beyond learning about wetland and scientific practices, many students also felt empowered and inspired to pursue a career in science. One student commented that "science was hard and the research itself was intense and rigorous." She is now pursuing a degree in environmental science.

Challenges and benefits of scientist–teacher collaborations

As with any partnership or collaboration, there will be challenges and benefits. Figure 3 lists some of these. None of the challenges are insurmountable, and we believe the benefits far outweigh the effort required to overcome them.

The reason to work through the challenges is the enhanced learning experience for students. This project provided an authentic, science-learning experience that was truly representative of how science is done (Nature of Science). Students in Wendy's classes realized that science does not always "find the answer," and that "science doesn't always have neat results," while discovering the collaborative aspect of scientific inquiry. Almost all of the students mentioned that they felt this project was challenging but they also thought it was a valuable learning experience.

Beyond learning about wetland and scientific practices, many students also felt empowered and inspired to pursue a career in science. One student commented that "science was hard and the research itself was intense and rigorous." She is now pursuing a degree in environmental science. Another student wanted to become a biologist, just like Christine, and is pursuing her biology degree at a four-year institution. These are two instances of how interaction with a scientist in formative years affected college and career choices. We have not tracked the students to know how many others have made similar decisions.

While not an intentional choice at the outset, the three people involved in this project were all women. Many students noticed that and commented on how that expanded their view of science and their own sense of identity as a scientist. Most students mentioned how they really enjoyed working with a scientist, using authentic data and going out in the field to explore the wetlands. Overall, students appreciated the opportunity to act, write, and communicate like a scientist.

Benefits to the teacher collaborator

Through the scientist-teacher collaboration, Wendy was not only able to integrate real data collected from a local ecosystem and the SEPs into her classroom, but she also grew as a teacher and gained more experience as a research scientist/field biologist. Working with Christine provided the necessary support and guidance needed to make the classroom and this project content-rich and SEP/skill-rich specific to current scientific research and methodologies.

While there are data sets available on the internet, many of these can be hard for teachers to find, navigate, and interpret. This also makes it difficult for students to use and segregate the data. Through the partnership, Christine made the raw data easier to access in terms of organization and graphical interpretation. Moving forward, the work done on the dataset with Christine means that Wendy can continue to use these data for this project and to modify them for future purposes and audiences. While you can't expect Christine to come visit your classroom, you can access her data and Wendy's lesons at *https://drive.google.com/drive/folders/1h0cckpbblxCLMVRUS5kbFfB0sRQTiVHo?usp=sharing*.

Conclusion

This particular collaboration has been successful and resilient, lasting through many iterations of Project G.R.O.W. Wendy has implemented it in her classroom six times, and students have gained better understanding of the nature of science, greater interest in science, a sense of pride and accomplishment, and a greater understanding of ecology in the real world (Hagan 2014).

Both Wendy and Christine have benefited professionally from the partnership as well. This initial partnership focused on integrating SEPs and the Nature of Science into a high school classroom. Since Project G.R.O.W.'s development, Wendy and Christine have designed other curriculum and learning sequences centered on the three dimensions of the *NGSS* for middle and high school classrooms and informal institutions. They are continuing the collaboration and fostering professional development for science educators across the state. This project and the collaboration are sustainable—the hard work of creating a dataset appropriate for high school students, structuring the assignment, and supplemental learning experiences has already been done. The effort will continue to help develop scientific literacy in the next generation and years to come. Although finding the right person with whom to partner can be challenging, it is possible and well worth the effort!

Note to readers

While it is important that your scientist–teacher partnership model science as science is done, we know that the content must to be aligned with standards and the appropriate content for the class. This article focuses on the development and care of the scientist–teacher partnership as opposed to the ecosystem and habitat content of *Project G.R.O.W.* (the content of our partnership). Because we know readers will be interested in the specific science resources developed for the unit (assignments, rubrics, and scaffolding to help students to successfully work with the data and develop written and oral presentations, raw data, etc.) we have included a link to resources developed during this collaboration. The shared folder includes the datasets, lessons in the unit (with links to *NGSS*), benchmarks, rubrics, reflections, and samples of student work so that you can replicate this project in your own classroom: *https://tinyurl.com/ydb9s5r3*. ■

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