Chapter 15
Out of the Tower and into the Classroom: Marine Science Graduate Students as K-12 Classroom Contributors

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Abstract For more than 12 years, the National Science Foundation's (NSF) Graduate Fellows in K-12 Education (GK-12) Program embedded graduate students in school classrooms to serve as content contributors and role models. Marine or environmental science was represented among the science, technology, engineering, and math (STEM) projects nationwide. The Virginia Institute of Marine Science (VIMS) conducted a GK-12 project with a distinctly marine science focus from 2009–2015. Through partnerships with local secondary schools, VIMS matched graduate students (Fellows) with mentoring Partner Teachers. The project sought to build the graduate students' communication and teaching skills, while enriching teachers' familiarity with current ocean science research and practices. The GK-12 model proved to be very successful at VIMS, as it was elsewhere. Positive outcomes included greater graduate student skill and confidence in communication, enriched teacher understanding of marine science content and research practices, and improved student performance and perceptions of science. The partnership also generated a collection of marine science lesson plans. While effective, the GK-12 immersive design was costly and many institutions are now

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seeking alternative means to facilitate graduate student contributions to STEM classrooms. VIMS is testing two models. One model is a continuation of GK-12 on a smaller scale. The other model challenges graduate students to develop a lesson plan based on their research, but has project teachers conduct classroom testing. The following chapter provides an overview of these programs and offers an example of project structure, timing, outcomes, and lessons learned that can serve in planning similar endeavors.

Keywords NSF graduate K-12 · University–school partnerships
Science communication · Outreach · Broader impacts

15.1 Seeking a Model for Converging Needs: K-12 Science Education that Reflects Current Research and Marine Scientists Who Can Communicate

Growing trends within marine science education are aligning and the outcome can be positive for teachers and students, as well as young scientists. Over several decades, there have been repeated calls for scientists to contribute directly to science education. But, there is widespread recognition that most scientists have not received much training in communication skills or educational methods (Leshner 2007; Thiry et al. 2008) and that a communications gap exists between scientists, and the broader public (e.g., Olson 2009; Hines et al. 2013).

The National Science Foundation (NSF) embarked on several initiatives aimed at improving both STEM (science, technology, engineering and math) education and the preparation of scientists as communicators. In 1999, NSF established Graduate STEM Fellows in K-12 Education (GK-12). The program was to serve as a model for communicating disciplines ranging from math and engineering to earth and life science using collaborations between university scientists, schools, teachers, and their students. As described by GK-12 visionary, Dr. Rita Colwell, the approach was to engender a STEM pipeline that creates a "full circle of engagement." The aim was to bring early career researchers into partnership with K-12 teachers and their students, providing inquiry-based content and skills that accurately reflect the practices of scientists (American Association for the Advancement of Science [AAAS] 2013). During its more than 12-year tenure, GK-12's diverse projects placed young scientists (graduate students and some undergraduates) in direct contact with classroom teachers and their students. GK-12's role in promoting the broader impacts of ocean sciences is cited by Peach and Scowcroft (2016). Of the program's more than 300 projects, approximately 17% were centered on marine, environmental or related disciplines.

While NSF funding for GK-12 and other programs promoting marine science education has ended, endorsements of the model have followed (Ufnar et al. 2012). Fortunately, other forces appear to be converging that can help extend the successes that emerged from earlier efforts. One is NSF's Broader Impacts requirement for federally funded scientists to engage in outreach efforts (Holbrook and Frodeman 2012). Another is the Next Generation Science Standards (NGSS) which advocate teaching more authentic practices of science (Next Generation Science Standards Lead States [NGSS] 2013; National Science Teachers Association [NSTA] 2013). And, a third is the active discussion within the academic community about how best to prepare marine science graduate students for two careers: research scientist and science communicator (Peach and Scowcroft 2016; Marcus 2016; Hopper Brill 2016).

The Virginia Institute of Marine Science (VIMS) conducted a NSF GK-12 project focused on marine science from 2009–2015. The VIMS project serves here as a case study for marine education best practices targeting graduate students in ocean sciences, as well as K-12 educators and their students. The experience at VIMS serves as a reasonable proxy for NSF's GK-12 model. For example, diverse NSF projects nationwide targeted students of different educational levels in schools representing different demographics and economic profiles. Schools included in the VIMS GK-12 project mirrored some of this diversity. In light of national initiatives aimed at sustaining aspects of the model (Ufnar et al. 2012), this chapter also shares some alternative program structures that may convey some of the benefits of GK-12 program designs without their intensive level of investment.

15.2 The VIMS Experience: Lessons Learned and Recommended Practices

Objectives of the VIMS' NSF GK-12 project tracked those common to the basic GK-12 model (AAAS 2013), with benefits intended for three key audiences. Our project, like many others, contained elements designed to:

- improve graduate Fellows' communication and teaching skills;
- enrich STEM content and skills for secondary science teachers;
- bring real-world practices of scientists to the classroom, stimulating student interest in STEM careers.

The VIMS project supported eight to eleven Fellows each year from 2009–2014, forty-one Fellows in all. In sum, Fellows invested more than 13,000 h, worked with 16 different Partner Teachers from six different schools (three middle schools and three high schools), and interacted substantively with close to 5500 students. It is important to note that the chief objective of this project was not to transform marine science graduate students into classroom teachers, but to help them develop the communication skills and confidence that would serve them with any audience.

15.2.1 Phase 1, Establishing the Partnership

Building administrative support is key to any institution-wide project. Nationally, administration of GK-12 projects varied widely (AAAS 2013). Managers came from science departments, schools of education, outreach offices or science centres.

Establishing Institutional Support and Project Management The VIMS management team included science faculty and the Associate Dean of Academic Studies. For a project that involves graduate students and their advisors, support from an administrator at the Dean's level was essential. Once the management team was established, continuity from year to year was very important in ensuring smooth project operations. Two Project Managers, both marine educators, worked directly with the graduate students, teachers and schools for a total of 50% FTE (full-time equivalent position). The evaluation plan was designed and directed by an external evaluator.

Selecting K-12 Partner Schools and Teachers VIMS project Principal Investigators selected school districts and schools for both logistical and demographic reasons. Schools had to be within reasonable commuting distance from VIMS campus. Demographically, schools from urban, suburban, and rural communities were sought. Included were schools with representative and underserved ethnic groups, and some with specific focus on marine sciences. Partnership agreements started with the School Superintendent, then progressed to the Principals of selected schools. VIMS conducted presentations to familiarize administrators and interested teachers with the project, its objectives, expectations for teacher investment, and anticipated rewards for students and teachers. Principals nominated interested teachers and teachers submitted an application.

Partnerships with project schools were refreshed each year. While some other GK-12 projects recruited a new cohort of teachers every year (AAAS 2013), the VIMS model allowed veteran Partner Teachers to reapply. There were advantages in cultivating relationships with teachers who had come to know the project. They developed understanding of the graduate students' abilities and mentoring needs. And, they were more experienced in helping Fellows connect their diverse research disciplines with the required Science Standards of Learning (SOL) that drive curricula in Virginia's public schools.

Recruiting Graduate Students and Making a Match At VIMS, potential candidates and their faculty advisors attended an informational project seminar. To assure that the faculty supported their student's participation, applications had to be advanced via the advisor.

The match between scientist and teacher was viewed as a partnership of reciprocal expertise. Graduate students bring authentic first-hand experience and cutting edge science. Teachers are expert communicators who can guide the translation of the science into something that has impact for classroom students. Matching graduate students with teachers was done largely based on subject area. Since marine science is so multidisciplinary, not all matches were perfect topical alignments. But, all Fellows were able to use their research experience to help teachers address standards of learning regarding the "Nature of Science" that exist for all STEM subjects in Virginia's public middle and high schools.

The First Meeting—Setting Expectations At the first meeting for each year's partner cohort, we encouraged school administrators and faculty advisors to attend. The Project Management Team revisited GK-12 objectives, shared evaluation data and successes from prior years, reviewed the annual timeline, and outlined the specific expectations for Fellows, Partner Teachers and major advisors. After Fellows gave brief research summaries, the Fellow–Teacher matches were announced, and bonding began. Holding this start-up meeting no later than mid-April allowed lead time for scheduling a preview classroom visit before the end of the year, planning activities for the summer and building rapport.

15.2.2 Phase 2: Fellow and Teacher Preparation

This was a central phase in all GK-12 projects, though the intensity and focus of training varied depending upon objectives. Some GK-12 projects involved both Fellows and teachers in a multi-week summer course during which they studied pedagogical models and developed activities, followed by additional class sessions during the academic year (AAAS 2013). The VIMS approach was less intensive, using multiple, shorter activities to prepare Fellows and Partner Teachers.

Fellows' Science Education Methods Short Course Project Managers developed and delivered a one-credit course for the Fellows only. The aim was to provide them with basics in educational theory and practice, plus familiarity with state Standards of Learning for science. This helped Fellows communicate with their Partner Teachers about lesson design and teaching methods, and provided some awareness of how their research could fit into the context of classroom reality. The syllabus was refined after Year 1, based on feedback after the Fellows' classroom experiences. They identified lesson plan design as the most important topic. The 5E learning cycle, inquiry-based learning, learning styles, Bloom's taxonomy and Standards of Learning were singled out as particularly valuable. This parallels the larger body of GK-12 practice (AAAS 2013).

As a final product for the short course, Fellows generated a lesson or activity, preferably based on their research. A lesson plan template was used that integrated standard features of modern lesson plans and reflected the elements covered in class. Fellows presented this "pilot" and used feedback from peers and instructors to make revisions before presenting an improved version to all cohort teachers at the end of the summer.

Summer Research Collaboration Professional development for Partner Teachers centered on an introduction to their Fellows' research expertise, methods and tools. After the brief sketch presented at the introductory meeting, Fellows provided their teacher with a more in-depth and personal experience. This allowed the partners to begin discussing how the research might enrich the curriculum in the coming school year. Due to busy teacher schedules, the two-week course offered the first year was not repeated. Instead, 20 h of "summer collaboration" was scheduled between Fellow and teacher at their mutual convenience. This typically included Fellows' preview visits to the classroom in late spring, teacher visits to the Fellows' laboratory and/or field sites, and planning sessions. Some teachers became involved in their Fellows' investigations, learning how to use sampling equipment and assisting with data collection. Teachers cited these experiences as very valuable in introducing them to current research, and in helping to identify concepts, content, and skills applicable to the classroom.

Fellow–Teacher Workshop Bringing all Fellows and Partner Teachers back together at the end of the summer reinforced cohort identity and facilitated sharing between Fellow–Teachers pairs. Starting with a focus on lesson plan design and feasibility, Fellows delivered their revised pilot lesson to the entire teacher cohort so that they received feedback from educators with experience in different subjects and grade levels.

The second element of the workshop put Fellow research in the spotlight and provided another opportunity to expose the teachers to diverse marine science topics and methods. Fellows were challenged with creating concise field or laboratory experiences that were interactive and allowed participation by all teachers.

The final workshop activity involved planning for the classroom experience. This included a discussion about school culture, professional practices, and what to expect from students of different ages and abilities. Then, Fellows and teachers buckled down to scheduling, looking at the scope and sequence of the curriculum, as well as state Science Standards of Learning, to map out where the Fellows' contributions would be most timely.

15.2.3 Phase 3: Graduate Students as Classroom Contributors

Within the classroom, the NSF GK-12 Fellows were referred to as "visiting scientists," to make it clear they were present as special contributors. Fellows were expected to: use ocean topics to advance general science concepts; use their marine research to foster science process skills (experimental design, data analysis, technology, etc.); provide examples of how science helps investigate and address current issues; and show scientists as "real people" and role models, illustrating science as an accessible career.

Per NSF GK-12 guidelines (AAAS 2013), Fellows were committed to ten hours per week in the classroom or learning environment during the academic year, a total of 280 h in our case. This did not include lesson preparation time, an expected minimum of five hours per week. Most VIMS Fellows began their classroom experience by observing their teacher, building familiarity with their teacher's style and the students' abilities. Next, many Fellows presented a well-tested activity of their choice or the teacher's. They gradually took more responsibility for design and instruction of demos or mini-laboratories, followed by leading a major laboratory or data analysis activity. By the end of their assignment, Fellows had to assume complete responsibility for designing and leading a full lesson or unit.

Partner Teachers provided mentoring and advised their Fellows on lesson feasibility, structure, and flow. Fellows often reported that they craved more guidance from their mentors. The Project Managers observed Fellows early and again late in their classroom experience and provided feedback using a rubric. The Fellow's major advisors were also expected to visit the classroom for at least one observation.

Fellows found ways to use marine science examples for teaching basic concepts, content, skills, and learning standards. By interpreting their own research projects, they modeled the science process and the authentic practices of scientists. Many lessons were interactive, with hands-on or inquiry components including re-enactments and simulations, games, and role-playing. Lessons frequently drew connections between research and practical applications, showing how science is used to solve problems. Some lessons introduced additional technology into the classroom. And, several represented science and science careers as rewarding and attainable for students of all backgrounds. Years later, former Partner Teachers are still using some of these lessons. As one project teacher put it, "These incredibly energetic and creative scientists generated an amazing number of lessons—tailored fit to our curriculum—that were engaging and yet stretched the students beyond that benchmark."

15.3 Outcomes—Evidence for the GK-12 Model as an Effective Tool in Marine Science Education

Positive outcomes of the GK-12 model for STEM education are summarized in NSF's program summary report, *The Power of Partnerships* (AAAS 2013), and related publications. The VIMS project sought to examine the benefits of this model in communicating marine science, and to evaluate its impacts on graduate Fellows, Partner Teachers, and classroom students.

15.3.1 Program Evaluation: Refining Project Operations and Tracking Impacts Using Diverse Instruments

The VIMS NSF GK-12 project tracked outcomes on several levels and used multiple instruments (Day–Miller 2014). In designing evaluation plans, project developers and managers need to be attentive to requirements for university and school system advance review. Communicate early with the university Internal Review Board or Protection of Human Subjects Committee. Similarly, having completed the university review, permission is required from the school system to conduct research on their students. Carefully consider project objectives and evaluation design. It is advisable to consult with a professional evaluator.

Fellows, Partner Teachers and classroom students completed attitude surveys at the beginning and end of each year. Fellows and teachers evaluated project classes and workshops offered during the preparation phase. And, each Fellow maintained a weekly online blog that recorded reflections about their lessons and classroom experiences. Project Managers reviewed the blogs regularly and brought up successes and concerns for discussion at monthly meetings with the Fellows.

A mid-year evaluation meeting was very important for "taking the pulse" of the partnership as it progressed. Focus group interviews with Partner Teachers, Fellows, faculty advisors and the Project Management Team provided important information and guided refinements to the program timetable and partnership activities. The interviews also helped identify means for disseminating more of the Fellows' teaching products and resulted in the addition of an annual Lesson Plan Expo during the mid-year meeting. Sharing Fellows' lesson ideas excited the teachers, encouraged "cross-fertilization," and spurred sharing of Fellows between teachers and schools. The Expo also served as a recruitment tool, offering other VIMS graduate students or their advisors exposure to GK-12's impact and the creative work being done. Based on recommendations from Partner Teachers, the expo concept would grow to greater proportions in later phases of the project.

15.3.2 Outcomes for Fellows

Evidence that the GK-12 model achieved its objectives for graduate students was provided through diverse evaluation mechanisms (Tang 2014). These indicated that Fellows developed confidence in their ability to teach marine science in a way that classroom students could successfully learn it. Fellows reported that the most effective teaching strategies included small group, hands-on activities and various inquiry and questioning strategies. They favoured a variety of strategies that kept the students engaged in the lesson and facilitated learning by students with different learning styles. Partner Teachers validated positive changes in Fellow skill. They observed that, over time, Fellows became more relaxed in the classroom and explained complex concepts more effectively. Teachers reported that their Fellow "learned to talk to the kids at a level that is appropriate for them, yet still challenging," "provided creative and innovative approaches to teaching," and "learned to pique students' interests, while not getting so technical that they lose them and their interest." Further evidence of the Fellows' improved communication skills came during VIMS departmental seminars for scientific peers. Project Managers and faculty advisors saw the direct transfer of classroom presentation skills to these scientific presentations. Fellows appeared more comfortable than many of their peers, their seminars were better organized, provided clearer context and examples, and had stronger transitions and closings.

Fellows also recognized their growth as science communicators, as expressed in representative quotes from the project exit survey:

> GK-12 has been an amazing experience for me. I have truly grown as a person and as a scientist during the duration of the fellowship. It has definitely made me realize how important communication is.
>
> I am more aware of what I am saying and I am better able to tell if the person I am talking to is understanding. I think that I communicate better and am better able to analyze how others are communicating. I am able to focus my message better and make sure that I am only trying to get one message across.

Project Managers have tracked the career progress of alumni Fellows using periodic communications. Within five years of their experience, former Fellows reported that GK-12 directly contributed to their success. Fellows are currently: conducting research; teaching at universities, high schools or science centres; serving in government agencies as science policy advisors or research analysts; running non-profits or working in science industry, including jobs highlighting science entrepreneurship. A longer view comes from a colleague within VIMS Marine Advisory Program, who participated in a GK-12 project at another institution ten years ago:

> Serving as a GK-12 Fellow for two consecutive years re-routed my entire career path. While shifting graduate students away from research is not the intended outcome of the program, serving in the classroom allowed me a unique perspective on my personal strengths and weaknesses and made it clear to me (and others) that I had a strong aptitude for outreach. The rigor of weekly lesson planning forced me to look at topics from unconventional angles and really engage my creative side to find fresh interpretations for young audiences. This was unexpectedly energizing and, by the time my second term was up, it became clear that my outreach skills might better serve the science community than my background in research and policy. Ten years on, I know that this decision was the correct one. I pull from my GK-12 experience daily, and the skills I developed during the program have helped frame all of my projects going forward." (C. Cackowski, personal communication, October 10, 2016).

15.3.3 Outcomes for Teachers

The majority of project Partner Teachers reported (Tang 2014) that in addition to their Fellow's research, they learned about specific marine science conducted at VIMS, the applications of this research to our local region, and a variety of new research skills and techniques. Teachers reported increased understanding of how science is conducted and felt they could provide more real-world examples of marine science research in their teaching. They reported an increase in the ways marine science content, technology and data analysis was being incorporated into the curriculum by the Fellows and by themselves. Teachers described being more enthusiastic about their teaching, and felt their students seemed more excited about and interested in science because of the Fellow. They cited many lessons developed and introduced by Fellows that they will incorporate into their curriculum and use repeatedly. The following quotes from teachers sum up some of the benefits they experienced from the partnership:

> I am now better able to demonstrate the practical/applied value of scientific research, based on the work that Fellows are doing…

> Fellows give us credibility with content, science process and provide great access to experiences at VIMS. The annual renewal/exposure to new fellows and their science elevates us!

15.3.4 Outcomes for Classroom Students

The VIMS project did not attempt to measure changes in content knowledge of classroom students as a result of GK-12 activities. However, Partner Teacher reports from surveys and focus group interviews (Tang 2014) provided indications of the Fellows' positive impact on student content mastery. For example: Due to the increased number of laboratories and activities in the classroom, and the real-world applications emphasized by my fellow, my students' assessment scores were consistently and significantly higher than previous years."

Partner Teachers and Fellows also reported many positive effects on student learning as a result of the Fellows' presence in the classroom (Tang 2014). These included: developing a deeper understanding of complex science concepts; better understanding of the scientific method and the actual applications of science. Student perceptions of science were impacted, as well. More students expressed excitement about science. Meeting female scientists improved girls' attitudes toward science. Students developed a better idea of what scientists do, more imagined themselves as scientists, and they expressed increased interest in college and science careers. This report from a Partner Teacher is representative: "… students are genuinely interested in marine science. Several of them are excited whenever we use marine examples in our lessons. That means that by including marine examples in every lesson, they learn about broader science concepts and are excited about it."

It was, however, a survey from outside the GK-12 project that provided some of our best evidence of changes in student attitudes about marine science and scientists. In 2009, 2010, and 2011, Fellows took the initiative to conduct the Draw-A-Scientist Test (Chambers 1983) with modifications they developed (Kraatz et al. 2011). Students drew and described their impression of a scientist before their Fellow joined the classroom and again at the end of the year. The differences were dramatic. Initial drawings pictured the stereotypical mad scientist wearing a laboratory coat and surrounded by chemicals, equations or explosions. After experiencing a Fellow in the classroom, student impressions shifted to include more female and minority scientists, a wider range of scientific endeavors, outdoor settings and specifically marine research.

15.3.5 The Fellow Teaching Resource Collection, Longevity & Dissemination

As a final assignment, each Fellow submitted an exemplar lesson plan that they had developed and tested in the classroom. In five years, VIMS GK-12 amassed a collection of more than 40 lesson plans and 30 additional teaching resources. An index, acknowledgements, and all resources were loaded on flash drives and shared with all Fellows and Partner Teachers involved in the project. To disseminate the lessons beyond our immediate GK-12 teacher cohort, additional avenues were tried —some proved more useful than others.

Project Website Many NSF GK-12 projects posted Fellows lesson plans on a project Web site. Unfortunately, when most of these projects ended, Web sites came down and the resources were no longer available. For a variety of reasons, the VIMS GK-12 project encountered difficulties sharing Fellow lessons via the institution website, as well.

Teacher Professional Development Opportunities at Conferences VIMS GK-12 lesson plans have been disseminated via face-to-face interactions with teachers. Project Managers and some GK-12 Partner Teachers have shared Fellow lessons in sessions or exhibits at state, regional, and national science education conferences. The concept of scientist-generated inquiry activities has generated teacher enthusiasm, but the brief conference interactions allow only cursory discussion of the lessons.

Fellows as Presenters at More Intensive Workshops or Courses More in-depth teacher professional development involving the Fellows proved to be a particularly effective means for sharing lesson plans. As an extension of the NSF project, a one-day workshop was offered for more than 50 middle and high school science teachers in 2015. Seven GK-12 Fellows served as workshop instructors and were assisted by their Partner Teachers. Fellows introduced their research and conducted their research-based classroom activity. Partner Teachers shared lessons they learned working with a "visiting scientist" and provided attendees with tips on how to incorporate authentic research into instruction. So teachers could more readily implement the lessons, they were given supplies for conducting several activities, as well as a flash drive with the collection index and all 70 activities. In the workshop evaluation, participants reported that as a result of the workshop: 71% were very likely to increase the use of ocean science topics in their instruction; and 86% were very likely to use the workshop activities in their classroom. Teacher comments about the Fellow lessons were nearly identical to those from our smaller cohort: "Learning how to incorporate real scientific work being done by real scientists into my daily lessons is priceless! Students will relate to the scientist far better than they will to textbooks!"

An additional extension program integrated the GK-12 project into an existing summer field course for teachers. During this one-week residential ocean science course, Fellows served as guest instructors. After sharing aspects of their expertise during field work, Fellows gave a presentation about their research and conducted their classroom activity with the group. Teachers found this approach to be highly valuable. One high school teacher noted, "This class really demonstrated ways to incorporate research topics in my teaching. In fact, the instructors and guest speakers presented me with many "ready-to-use" activities and lessons based on current research and data." And, because Fellows and course participants spent time interacting with one another, more in-depth professional connections resulted. In one case, when a seventh grade life science teacher from the mountains of Virginia delivered a Fellow lesson, she included the Fellow via Skype. This gave her students—many of whom have never been to the ocean—a deeper connection to the topic and the scientist. The teacher reported that the experience was extremely rewarding for herself and her students.

15.4 Where Do We Go from Here? Developing and Testing of New Models

The popularity and efficacy of the GK-12 model in marine, as well as other STEM disciplines, recommend its continued use in university outreach and research Broader Impacts (Komoroske et al. 2015). Indeed, Handelsman et al. (2004) envisioned the broader impact mandate as a means to inspire universities to function as "incubators" contributing to science education. Ufnar et al. (2012) offered multiple designs for sustainable projects that feature GK-12's beneficial practice of placing scientists-in-training into K-12 classrooms. Lower cost options for science outreach that benefit both students and scientists have been discussed by Clark et al. (2016).

Over the course of the NSF VIMS GK-12 project, VIMS faculty and administration increasingly valued the additional skills, tools, and marketability that GK-12 offered VIMS students. When NSF funding ended, VIMS helped identify funding to continue VIMS GK-12 on a smaller scale, using private money. Currently, a variation of the initial model is being tested, with two to four graduate students per year, rather than the eight to eleven Fellows supported each year by NSF. To conserve funds and address concerns about Fellow time commitment, the classroom assignment has been reduced to a single semester. Other elements remain nearly the same.

Lessons learned in GK-12 have also been applied in developing additional lower-cost projects that disseminate marine science lessons created by graduate students. Based on the success of the one-day GK-12 workshop for teachers, we were intrigued by an emerging project in North Carolina. The Scientific Research and Education Network (SciREN) is a grassroots effort by two graduate students from the University of North Carolina's Institute of Marine Sciences. They created a project in which graduate students develop lesson plans based on their research and present them to teachers via expo settings (T. Kirby-Hathaway, personal communication, March 3, 2015). From this, a more formalized program evolved. SciREN's mission is to build the network of North Carolina scientists, teachers, and resources, furthering connections and communications around their science (E. Theuerkauf, personal communication, March 17, 2015). Per the SciREN webpage,[1] their goals are similar to those of GK-12, including: establishing a lasting network of researchers and educators; facilitating cooperation and collaboration; bringing current research and researchers into local communities and classrooms; supporting researchers in developing broader impacts; strengthening outreach efforts; and improving scientists' communication skills.

Combining the SciREN concept and partnership features of the VIMS GK-12 program, educators at VIMS Marine Advisory Program and Chesapeake Bay National Estuarine Research Reserve initiated the Virginia Scientists and Educators Alliance (VA SEA). Similar to SciREN and GK-12, graduate students receive training on lesson plan design and use their research as the theme. Drawing from the GK-12 model, graduate students receive coaching from VIMS educators, and their lesson plans are reviewed and classroom tested by local teachers. This assures that lessons generated have been reviewed, edited, and improved—all of which increases the likelihood for success in the classroom. When lesson reviews come back from the teachers, graduate students make revisions and demonstrate their polished lessons at a large-scale expo for teachers from across the state.

15.5 Summary Statement: Is the GK-12 Model Worth the Investment?

In a convergence of needs, science educators are seeking examples of authentic science practice and scientists are devising broader impacts to communicate the relevance of their research to the larger community. Diverse models for possible

[1]http://www.thesciren.org/about/.

relationships between scientists and educators have been proposed (Morrow 2000; Franks et al. 2006; Feinstein et al. 2013; Skrip 2015; among others). Why should marine educators promote a model like Graduate K-12 that focuses on partnerships between young scientists, K-12 teachers and their students?

Consider the GK-12 model in pipeline context, a "full circle of engagement" (AAAS 2013), linking key points of the educational system in a reciprocal way. By preparing graduate students as early career researchers, this model strengthens their abilities to address the broader impacts of their work and corrects some of the deficits currently seen in science communication. Including science teachers enriches their understanding of research practices and allows application of their practical pedagogical expertise. Together, Teacher-Fellow partners generate useable teaching tools for classrooms. Classroom students experience more inquiry-based learning, see the applications of science in the real world, and build new awareness of scientists and science careers.

Despite the challenges of developing and funding the partnerships needed, there is evidence that the core of the GK-12 model—young scientists as contributors to the classroom—is particularly rewarding and impactful. The authors encourage the marine science education community to seek ways to get more graduate students out of the tower and into the classroom.

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