The Power of Partnerships

A GUIDE FROM THE NSF GRADUATE STEM FELLOWS IN K-12 EDUCATION (GK-12) PROGRAM

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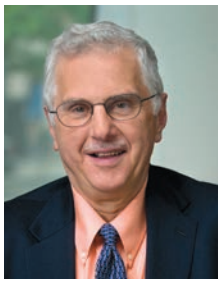
FOREWORD



Bruce Alberts

Rita Colwell

OUR NATION REQUIRES a strong science, technology, engineering, and mathematics (STEM) workforce to deliver the innovations that are so critical for economic competitiveness.[1] A healthy STEM education system—from kindergarten through graduate training—is required to meet these workforce needs. While many people refer to the STEM education system as a linear pipeline, the National Science Foundation Graduate STEM Fellows In K-12 Education Program (GK-12) bends that pipeline to create a full circle of engagement from kindergarteners through graduate students. By connecting the graduate researchers directly with K-12 teachers and students, the NSF GK-12 Program provides hands-on, inquiry-based STEM content to classrooms in the U.S. and Puerto Rico.

This "full circle" GK-12 approach provides benefits for K-12 students, teachers, and the Fellows themselves. GK-12 Fellows bring a love of discovery and inquiry into the classroom as well as up-to-date STEM content to K-12 teachers. They provide role models for younger students to pursue careers in science and engineering. The impact on students to "know" a scientist who is both accessible and enthusiastic about the discovery of science cannot be understated, not to mention the students' increased science comprehension as a result of the enriched GK-12 experience. In return, the Fellows hone their communication skills and learn pedagogy from experienced K-12 teachers. The GK-12 Fellows comprise a cadre of scientists capable of returning to K-12 classrooms as science teachers themselves, or as better teaching assistants and professors in the university setting. In an age where scientists must learn broad skills to succeed, the abilities that graduate students acquire through the GK-12 experience are critical for their success in a variety of careers. GK-12 Fellows are part of a new generation of renaissance scientists and engineers who can do much more than research—they give back to society through their teaching, public engagement, and rich communication skills. What better way to populate needed science teaching positions than with scientists trained in pedagogy and communication?

GK-12 has provided a model of STEM teaching based on curiosity-driven lesson plans, and hands-on experience in science and engineering for students and teachers that connects every stage of the STEM pipeline. The GK-12 approach of partnerships between universities and K-12 schools provides an exciting way

1 *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* National Academies Press, 2007, http://www.nap.edu/catalog/11463.html

to meet the Next Generation Science Standards[2]—learning the process of science directly from scientists and engineers. At the same time, the GK-12 approach fulfills the NSF's broader impacts criteria by creating meaningful engagement between researchers and the community. Such a model should be emulated across the country to ensure that the next generation of scientists and engineers develop a love for discovery and are ready to contribute to our nation's strong STEM-based innovation system. Beyond our shores, the GK-12 approach offers great value in connecting K-12 students with young scientists and engineers, and is under consideration for adoption in several countries around the world.

We encourage the adoption and wide expansion of the GK-12 approach to foster strong partnerships and complete the STEM "circle" so critical to ensuring the well-being of the STEM enterprise and America's innovation ecosystem. We hope that faculty, graduate students, and K-12 teachers will use this publication as a beacon for creating their own university K-12 school partnerships to transform lives and strengthen communities.

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2 http://www.nextgenscience.org/next-generation-science-standards

PREFACE

Sonia Ortega

To bring you the multiple experiences, lessons learned, practices and activities developed through the 12 years of the life of the Graduate STEM Fellows in K-12 Education (GK–12) Program would be an impossible task. Nevertheless, there is much to be shared. This guide emerged as a result of initial conversations between the National Science Foundation (NSF) GK-12 program team and the American Association for the Advancement of Science (AAAS) to determine how best to capture the legacy of GK-12. A call went out to the GK-12 community to take on this challenge. Thirty four participants from the GK-12 program were invited to Washington, D.C. to brainstorm just how best to convey the richness of the program to others. This team represented Principal Investigators, Teachers, Evaluators, Program Coordinators and Fellows who worked tirelessly discussing, assembling, organizing and reviewing multiple iterations of the manuscript to produce this final product. While preparing this guide it became clear to all that there is no single GK-12 model but multiple models. This has been the beauty of the GK-12 program. It also became clear to all that GK-12 was a program of ***Powers***:

First of all, there is the essential ***Power of Partnerships*** between institutions of higher education and K-12 schools, as well as partnerships between Fellows and Teachers. These were true and successful partnerships that brought multiple benefits to all. The Power of Partnership was also exemplified in the longstanding collaboration between the GK-12 program staff and AAAS staff and the multiple activities and products that resulted from this collaboration including the production of this guide. Of course, no partnership is possible without the spirit and energy of its people.

Second, there is the ***Power of Discovery,*** discovery experienced by Fellows through their scientific research, discovery experienced by Teachers while working with Fellows in bringing their research to the classrooms, and discovery experienced through the "Aha" moments of children when they understood a new scientific concept or when they were marveled by the wonders of science.

Third, GK-12 brought the ***Power of Teaching and Learning*** through inquiry to hundreds of classrooms in rural and urban areas, to small schools and large ones in the U.S., and to some far corners of the world. It is the Power of Teaching and Learning that will produce generations of life-long learners.

And finally, GK-12 is about the ***Power of Community,*** a community bonded by common goals and the love and commitment of making a difference. I have been proud and privileged to have served the GK-12 community for these many years and believe that the legacy of the program will live on. It is my hope that this guide will inspire others to try the GK-12 approach so that they will experience and harness the Powers that this program has brought to others.

Sonia Ortega

Sonia Ortega
Program Director
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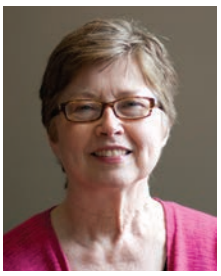
Daryl E. Chubin


Betty Calinger

This guide marks a number of "firsts" and "lasts." For most of the life of GK-12 as a program and a community, AAAS has collaborated with NSF to create opportunities for learning, achievement, and celebration.

Together, AAAS and NSF have honored Fellows, their mentors, peer teachers, students, and evaluators. We have fostered exchanges, partnerships, and the development of skills that scientists today and tomorrow will apply. With a website (http://www.gk12.org/) that continues, AAAS will feed multi-media communications to various publics, reminding all that science literacy and numeracy are tools for the ages.

For all these firsts, AAAS is grateful to the principal investigators and teams supported by the NSF Program on Graduate STEM Fellows in K-12 Education (GK–12). They are the expertise and energy that gave more than a "taste of science" to scores of children across the United States (and in a few cases, beyond our borders).

To these accomplishments, a "seeding of the next generation," we now add a final first—a guide to assist those who wish to try their hand at instituting innovative teaching and learning that stretches from graduate training to the precollege classroom. To do all this as part of a single program is stunning. To do it for more than a decade is a testament to hundreds of participants, now emissaries, displaying the power of partnership and federal investments in local education practice. To codify it in the pages that follow is to offer "extra credit."

To Sonia Ortega and her dedicated revolving band of program directors, we are forever grateful. This includes our privilege in working with additions to the "regular" NSF staff, exemplary K-12 teachers known as Albert Einstein Fellows, who were assigned to the GK-12 program, bringing their insights and practical experience to the effort. We could not hope for better colleagues in every sense of the word "collegiality."

As for the "lasts," we fondly recall conferences that brought fellowship through both affinity and dissimilarity. Alas, there will be no more under the GK-12 banner. Our annual months-long preparation for the conference was the annual renewal of this community and an ongoing re-shaping of the "GK-12 model." As this volume attests, the model is more accurately a collection of experiments borne of university settings, extended into elementary, middle, and high schools, then connected with real communities, their leaders, parents, and supporters.

All recognized the power of science education to enrich, inform, and transform. That now must continue with a myriad of patrons, venues, and designs. We welcome those manifestations. It is what GK-12 spawned. It is the program's legacy. It is what we, and those who gamely follow, shall continue to celebrate.

Our gratitude abounds to NSF for making this so much more than a gleam in the eye. AAAS was privileged to facilitate the life of a program needed then and still needed now.

For the work of science educators is never done. This guide, the product of experiences gone right (and wrong), is a beacon to the future. We urge readers to behold it, but moreover, use it, embellish it, and record in the margins your deeds alongside ours.

Daryl Chubin
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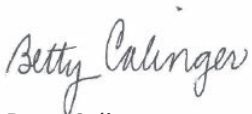

Betty Calinger
Project Director
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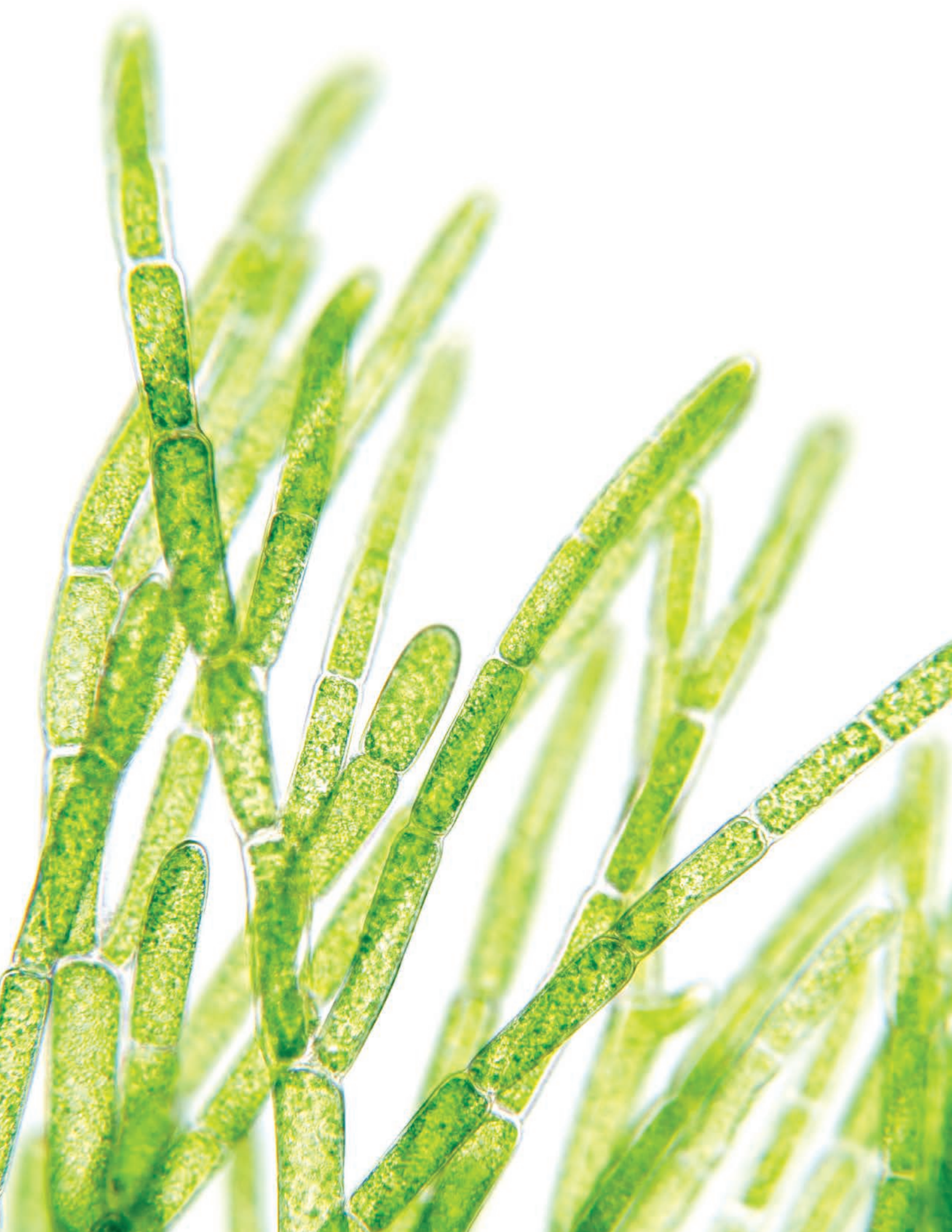
High school students learn science through a hands-on field experience in the GK–12 Program.



INTRODUCTION

Richard Boone, Donna Llewellyn, and Ana-Rita Mayol

High school students perform a chemistry experiment, supervised by a GK-12 Fellow from the University of Puerto Rico.

THIS GUIDE PROVIDES EFFECTIVE PRACTICES for anyone—university faculty member, K–12 teacher, or administrator—who wants to create a project that partners science, technology, engineering, and mathematics (STEM) graduate students (Fellows) with K–12 teachers on a sustained basis. These recommendations come from the community of faculty members, graduate students, K–12 teachers, program managers, and evaluators who participated in the U.S. National Science Foundation (NSF) Graduate STEM Fellows in K–12 Education (GK–12) Program from its start in 1999 through 2012. The guide was written to capture the knowledge and experiences of the GK–12 alumni community, which now includes more than 10,000 graduate students, 1,000 principal investigators (university faculty), 300 project evaluators, and 12,000 K–12 teachers. It is our hope that the GK–12 approach will be implemented broadly and that this guide will provide clear details for how to create a successful GK–12 type of project anywhere. Starting a GK–12 project is a serious undertaking, but it is one that provides tremendous professional and personal rewards for all participants. For many, it has been a seminal career experience.

ESTABLISHING A COMMON LANGUAGE

Throughout this guide, the different aspects of a GK–12 project will be discussed, from design through implementation and sustainability. Although the term "GK–12" has historically been defined specifically as the program that was sponsored by the NSF, this guide will use GK–12 Project to refer to any project that is modeled on this foundation.

All projects described in the pages that follow involve graduate students from STEM fields; these students are called GK–12 Fellows. The K–12 teachers who are involved in the projects will be referred to as GK–12 Teachers when they have a leadership or coordinating role. Unless otherwise noted, the term student will refer to a K–12 student. The term project director will be used to denote the lead university person in the project; this is usually, but not always, the principal investigator, or PI, of the grant.

WHY SHOULD ONE INVEST IN A GK–12 PROJECT?

The GK–12 community is a passionate one because it has experienced the transformative power of the GK–12 approach to K–12 and STEM graduate education; the GK–12 approach brings research and inquiry education to the K–12 classroom via a sustained partnership between scientists (STEM graduate students) and K–12 teachers. Quantifiable benefits, summarized in Chapter 12, have been reported in the peer-reviewed literature (e.g., Beghetto 2009, McBride et al. 2011, Raju and Clayson 2011, Stamp and O'Brien 2005, Trautmann and Krasny 2006) and in an evaluation of the GK–12 program by the consulting firm Abt Associates (2010). They include the improvement of K–12 students' and teachers' science literacy, enhancement of GK–12 Fellows' communication and research skills, and promotion of K–12 students' and teachers' understanding of the process of science. In addition, GK–12 Fellows are positive role models: K–12 students have developed relationships with the Fellows, and some K–12 students have been inspired to pursue a STEM career. Equally valuable, the Fellows have come to embrace the importance of being role models: They understand why their professions depend on it and have come to welcome the importance of that role in their own professional lives. Individual GK–12 projects have documented benefits for their Fellows, for K–12 students, and for teachers; many of these benefits are captured in the book *The NSF GK–12 Program: A Decade of Innovation in Graduate STEM Training and K–12 Learning* (AAAS 2011). Communicating directly with GK–12 alumni, including Fellows, Teachers, PIs, and evaluators (see http://www.gk12.org/alumni-center for names and contact information) is another way to learn about the program's value.

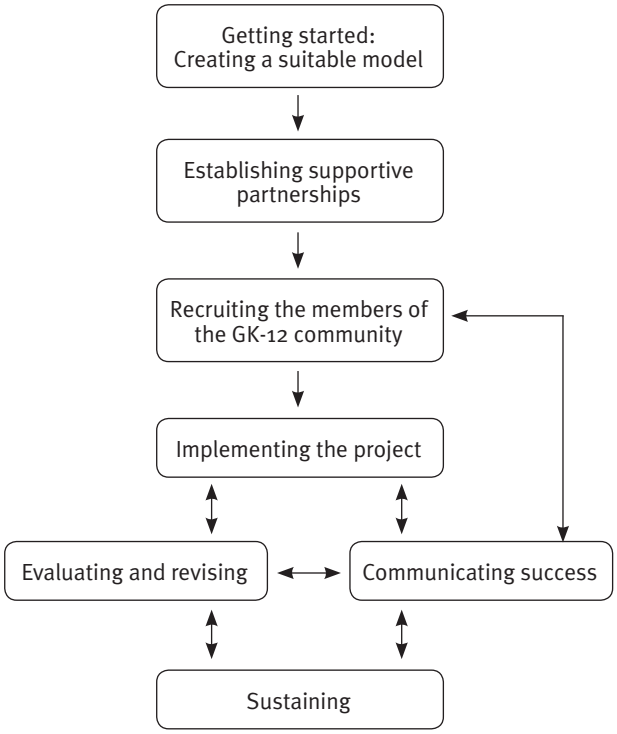
OVERVIEW

Figure 0.1 illustrates the main steps in designing, implementing, evaluating, and sustaining a GK–12 project. The remainder of this introduction will discuss the basics of getting started, with some questions highlighted that you should ask as you initiate your planning. The rest of the guide will take you through the other steps in this figure.

First Steps

Before launching a project based on the GK–12 approach, we recommend (1) being able to clearly articulate how and why GK–12 projects have been successful (see Chapter 12), and (2) determining how the GK–12 model selected can have value in your particular setting.

Figure 0.1 Main Steps In Designing and Sustaining a GK–12 Project



How can one determine whether a GK–12 project will have value for the local university, K–12 teachers, and students? Optimally, a formal and comprehensive needs assessment will answer this question. However, there are effective ways to evaluate the need and potential value of the project without completing a formal needs assessment. Most importantly, does the university already have a program that partners STEM graduate students with teachers in K–12 classrooms on a sustained basis? If not, then this kind of project likely will provide value. There are some key ingredients of successful GK–12 projects. If some of these elements already exist, then it will be easier to set up a project; however, if these elements do not yet exist, then that alone might indicate an even greater need for this kind of project. Some of the issues to consider in your assessment are (1) whether the university has a high-quality professional development program that provides science communication and/or pedagogical training for STEM graduate students, (2) whether K–12 teachers generally teach STEM subjects with high proficiency, and (3) whether any professional development opportunities are offered through the university for STEM K–12 teachers.

Investigate the university's STEM outreach efforts: What is their history and performance? Programs may be offered at all levels (department, college, university-wide) and may be funded through STEM education and outreach programs of federal agencies (e.g., NSF, the U.S. Department of Agriculture, and the National Aeronautics and Space Administration). The people who lead these programs can often give insight into developing and running a successful project and forming positive connections with K–12 schools. Teachers and K–12 administrators who have been involved in university science outreach projects can provide equally valuable insights and become future partners, given the opportunity. As with any partnership, the ultimate goal is to ensure all parties that their opinions and experiences are valued and their needs met.

A GK-12 Fellow from Columbia University demonstrates the structure of molecules to students.

Sharing and vetting ideas with others

We recommend vetting ideas for projects that follow the GK–12 approach with people who have experience with this type of project before developing a full plan or proposal. Vetting is especially important with STEM research scientists, who often have little experience with K–12 outreach. Members of the GK–12 alumni community, directors of museum outreach and community outreach programs, and school district staff or teachers responsible for the district-wide science and mathematics curriculum can all provide good feedback. Many are enthusiastic supporters of new projects that follow the GK–12 approach and will readily provide advice and perspective if contacted; a list of GK–12 projects and their websites is available at http://www.gk12.org.

Sustainability

Keep project sustainability in mind as you develop your ideas. A successful project depends upon institutional commitment that goes beyond a small number of people who develop and lead the effort. Because the project is a partnership most commonly between a university and a school or school district, it is essential that university and K–12 administrators make institutional commitments to an agreed-upon time frame for the project. If you decide to begin a GK–12 project, you should consider whether you and the possible partner institutions are committed to the project's sustainability if it proves successful. A project can't be sustained if it depends on only a few committed individuals, although a few champions are necessary to get a project started.

> "So I want to persuade you [scientists] to spend time in the classroom, talking and showing young people what it is that your work can mean, and what it means to you. I want us all to think about new and creative ways to engage young people in science and engineering..."
>
> —President Barack Obama
> April 2009, National Academy of Sciences

Costs

If a university values the GK–12 approach and chooses to start a GK–12 project, it must designate resources (time and money)—potentially supported partially or wholly with external funds—for the project. If faculty or staff workloads are flexible enough, then adjusting them is one way of providing faculty and staff time for instruction and coordination. Always, however, there is some time and monetary cost to running a GK–12 type of project. Major costs are time and, perhaps, compensation for a coordinator and the participating STEM graduate students.

Compensation mechanisms for the GK–12 Fellows—financial support and/or academic credit of some kind, perhaps for a certificate—will be necessary to ensure that the STEM graduate students engage in a K–12 partnership that lasts long enough to be useful. Teaching certificate programs for STEM graduate students are growing in popularity nationally and may offer a cost-effective way to support and sustain a GK–12 project.

GK–12 of the Future

Even as the NSF GK–12 program ends, the GK–12 approach in various forms will continue. The chapters that follow provide detailed guidance on the major elements of the GK–12 projects identified in the preceding text, including case studies, pitfalls, and solutions. The chapters describe highly effective practices developed by the national GK–12 community over a decade. It is our hope that those who set out to create their own GK–12 project will find this publication a useful guide.

FOR MORE INFORMATION

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