

# CHAPTER 4

## PROJECT IMPLEMENTATION: PREPARING GK–12 TEAMS FOR SUCCESS

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Fellows and Teachers from the Emory GK–12 project test out a lesson on molecular modeling.

### CHAPTER HIGHLIGHTS

- ▶ Successful partnership projects have a plan for coordinating project elements and people.
- ▶ Research advisors should play an active role in the partnership project.
- ▶ Project activities should be linked to local and national science standards.
- ▶ Carefully planned and well-implemented training sessions can help build rapport within and between teams and can be used to develop effective teaching materials and approaches.
- ▶ Assessment and evaluation provide crucial information for tracking successful projects.

### SUCCESSFUL IMPLEMENTATION OF SCIENTIST–EDUCATOR PARTNERSHIPS REQUIRES A GOOD PLAN,

clear expectations for participants, infrastructure to support the teams, a strategy for communicating successes, leadership to make sure that the Fellow–Teacher teams are working effectively together, and the tools to succeed (Appendix 4.1). In addition, it is important to identify benchmarks for the success of the project, both to make the project better over time and to report on its successes and achievements. This chapter focuses on developing the skills for participants so that they will be successful in their work. In particular, the chapter looks at project management and logistics; the possibility of offering training workshops, institutes, and courses; and introductory ideas to plan for project assessment.

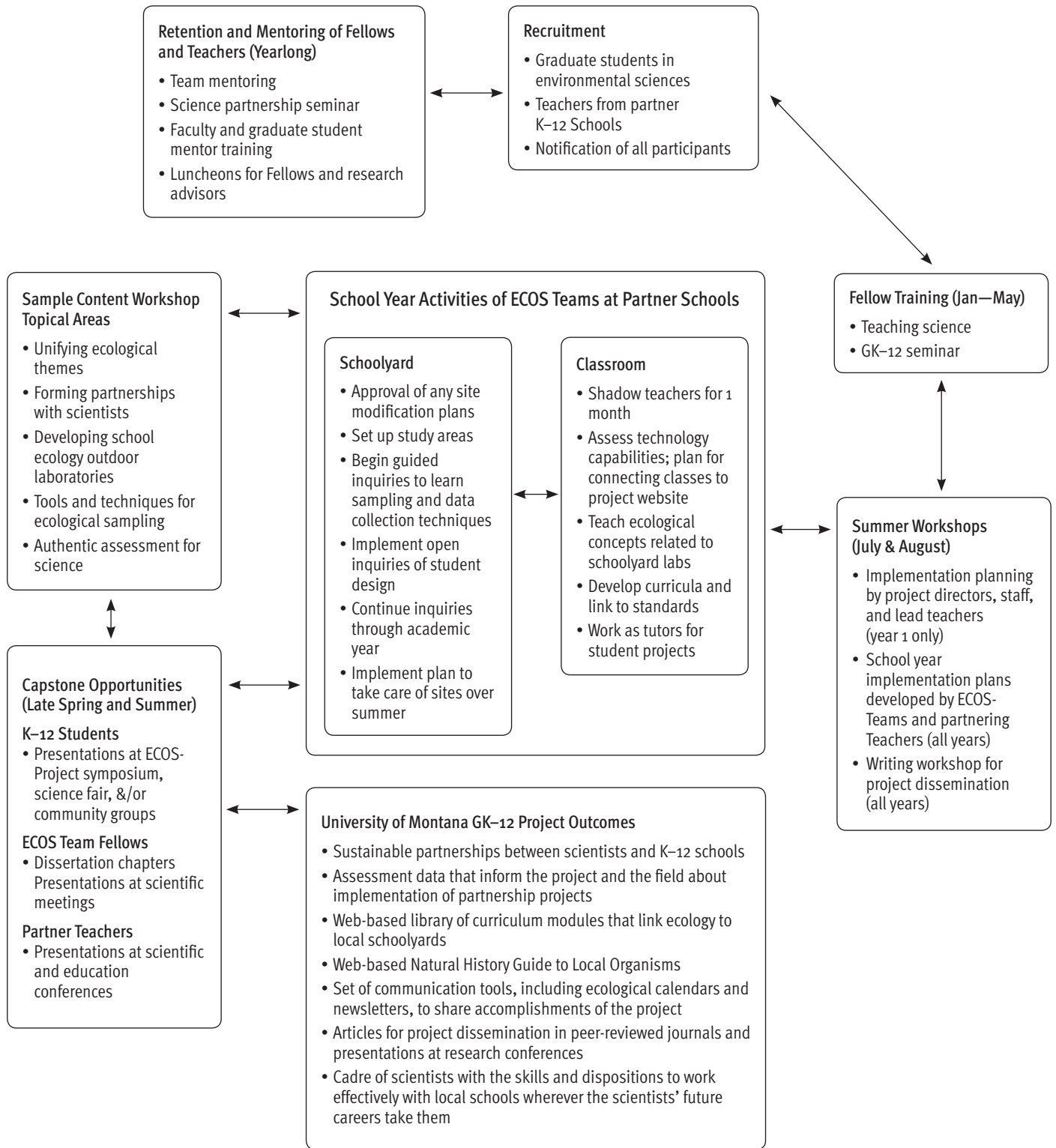
### MANAGEMENT AND LOGISTICS

#### Project Coordination

Successful partnership projects have a plan for managing project elements and people—including one or more staff members at the university employed as a project coordinator—and the appropriate infrastructure and means to manage the project. A useful tool for visualizing how all the project elements in the plan fit together, and for aiding communication about how a GK–12 project works, is a project flow diagram (Figure 4.1). Typical elements include recruiting, mentoring, school year activities, training meetings, and assessment. Such a diagram helps the implementation team focus on project core elements and how they are linked to desired project outcomes.

Many GK–12 projects have utilized a project coordinator as a liaison among participants and to ensure smooth and timely operation of all elements. On a large number of the GK–12 projects, the project director has also served as the project coordinator. Other projects have hired a staff person to play this role. Depending on the size of a partnership project, a coordinator might be a full-time staff person or a part-time graduate student assistant. The kinds of duties typically assigned to a coordinator include assisting with graduate student and Teacher recruitment, organizing training for all project participants, keeping a project calendar, organizing special events, assisting with project assessment, developing newsletters and other communications, and coordinating project records. Project

Figure 4.1 - Project Plan from the University of Montana ECOS GK–12 Project Illustrating Linkages Among Project Elements



coordinators also are available to answer questions and point graduate students and Teachers to resources to help them be successful in the classroom.

Having a dedicated project coordinator helps to ensure timely communication, accurate dissemination of information, insight into how the teams are functioning in the partner schools, and accountability with respect to project goals and objectives.

The number and kinds of schools that are part of a partnership project influence management strategies and project logistics. A project may, for example, select one focal school or choose to work with all of the elementary schools in a district or region. Some projects may work with schools across the K–12 spectrum. Working with a Teacher who is already recognized as a leader in STEM education among his or her peers and the education community can help GK–12 project leaders navigate the different cultures in elementary, middle, and high school settings. A lead Teacher also can help project leaders identify key STEM needs in a given school and facilitate communication with school leaders, Teachers, and staff.

### Project Steering Committees/Advisory Boards

Depending on the size and scope of a project, it may be useful to create a steering committee and/or an advisory board. A steering committee is usually composed of “local” members representing the key constituents of a project. In the case of a GK–12 project, the committee might include project directors or codirectors, representative administrators from the university or college and the participating schools (e.g., department chair, principal), a representative from a school or college of education, Teachers from the target grade bands, and/or graduate students. The typical role of a steering committee is to define policies, administer the student internship and scholarship

“It is an unfortunate shortcoming of graduate education that we provide our students so little real training in teaching. These Fellow–Teacher partnerships are a great way to fill that huge void, and at the same time provide new energy to graduate students to pursue academic careers”

—Ecology Professor, University of Montana



GK-12 Reach for the Stars Project Director Michelle Paulsen leads discussion between teachers and Fellows during a summer training program at Northwestern University.

projects, select partnering schools and Teachers, and ensure timely implementation of the project. Steering committees also are very much involved in oversight of the day-to-day operations of the project and meet regularly to plan activities, review project assessment data, accomplishments, and challenges, and communicate about the project.

Some projects engage an advisory board instead of a steering committee. An advisory board is often composed of individuals with a more global view of implementing STEM partnership projects and may include senior-level administrators from the university and school district (e.g., a dean and the superintendent), individuals who have successfully implemented similar partnership projects, a local community leader or donor, and other individuals with relevant experience. Advisory boards typically meet with project leaders once or twice a year to review the implementation of the project and to provide advice and insights on how to best meet the goals and objectives. Sometimes advisory boards are tasked by funding agencies to provide independent oversight reports on project successes, challenges, and accomplishments.

### Communicating Expectations and Responsibilities with Project Participants

The expectations and responsibilities of all individuals in a GK–12 project are dependent on the GK–12 model used. However, a strong project has well-structured roles and responsibilities for the various stakeholders. The project should establish

open communication between all members of the community, and the critical areas of the project should be evaluated regularly so that the project can be improved with time. The roles and responsibilities of Fellows, Teachers, their respective mentors, and education consultants are summarized as follows:

**1. Fellows'** responsibilities may include (a) devoting as many as 15 hours per week toward education activities, such as offering workshops, laboratory visits, field trips, and Teacher training, depending on the GK–12 model used; (b) preparing educational lessons related to their research and/or the discipline of the project; (c) attending summer and semester-long trainings and meetings; (d) working on a team with one or more Teachers at one or more assigned schools; and (e) submitting reports and any other documentation required by the project. It is important to note that Master's and PhD students should maintain their research activities throughout the Fellowship experience. An Abt Associates evaluation (2010) of the GK–12 Program found that Fellows were able to maintain their research activities and experienced no delays in the time it took them to complete their degrees.

**2. Teachers'** responsibilities may include (a) working with one or more assigned Fellows in the development and implementation of lessons; (b) working on a team with one or more Fellows; (c) attending summer and semester-long training activities and meetings; (d) submitting reports and any other documentation required by the project; and (e) completing a laboratory or field experience at a Fellow's research site.

**3. Research advisors'** responsibilities may include (a) assisting Fellows in the preparation of educational materials by providing feedback on scientific content and relevance; (b) mentoring Fellows in the development of scientific writing skills; (c) contributing to Fellow–Teacher team training (with scientific talks, role modeling, and/or school visits); and (d) attending key meetings of the Fellow–Teacher team training project.

**4. The educational consultant** is a person experienced in education and/or a retired teacher who monitors the progress of Fellows and Teachers in the implementation of lessons. Consultants meet with Fellows and Teachers regularly, provide feedback on educational activities, and make visits to the classroom. In the event that the project coordinator has the necessary expertise, he or she may also serve as the education consultant.

Different GK–12 models might require different

**“The trouble with scientists is that they teach science. What we need to do is to teach students.”**

—Ellis Bell, University of Richmond, AAAS Annual Meeting, Washington, D.C., February 2011.

responsibilities. It is important that the leadership, in collaboration with the committee, clearly establish the specific roles and responsibilities of Fellows, Teachers, and research mentors and provide training and mentoring for Fellows and Teachers, in order for the project to be successful. In addition, it is important for Fellows, Teachers, and research advisors to be adequately compensated for their involvement. In the case of the Fellow and Teacher, the compensation could be in the form of monetary support and/or graduate credits.

Table 4.1 shows the most common activities that Fellows engage in during their Fellowship experience. The table includes data from the Evaluation of the National Science Foundation's GK–12 Project (Abt Associates, Inc. 2010). A total of 1,456 Fellows responded to the survey.

### Engaging Research Advisors

Because STEM graduate students are a key component of GK–12 partnership projects, it is important to engage their research advisors in order for projects to be successful. Advisors need reassurance that participation in a GK–12 partnership project will not have a negative impact on the ability of the graduate students they advise to meet departmental and university requirements



GK-12 Fellows from Southern Illinois University and K-12 Teachers develop lessons on 3-D imaging for the upcoming academic year.



for timely progress toward the completion of their degrees. Communication with research advisors about the expectations for GK–12 Fellows should begin during the recruitment and application processes. For example, the GK–12 project at the University of Montana required a Fellow, her or his research advisor, and members of the Fellow’s graduate committee to collectively read and sign a contract that outlined expectations for the Fellow regarding participation in the GK–12 project (Appendix 4.2).

GK–12 projects have found many innovative ways to engage research advisors. Hosting a luncheon for Fellows and their advisors and asking Fellows to make presentations is one effective mechanism for keeping advisors apprised of the work of their students in local schools. Some projects have hosted field trips to the Fellow’s lab to meet the research advisor and the lab staff and learn more about what it means to be a scientist and to do science. Other projects have invited research advisors and lab colleagues to community service days at their local schools to work with Teachers and students or to help improve the school infrastructure for teaching science. Ultimately, it is important to seek feedback from research advisors to better understand how the GK–12 experience is affecting their student and to address issues as they arise. (A sample questionnaire for advisor feedback is shown in Appendix 4.3.) Advisors should be asked to play an active role in the partnership, both in supporting the work of their graduate students and in creating opportunities to further enhance university–school partnerships through the GK–12 project.

### Engaging Community Partners

It is likely that there are many excellent resources in every community that can be included in partnerships to enhance STEM education. Beyond the graduate students and the labs they represent, most universities and colleges have a rich array of resources and individuals that may play a role. Examples of these resources are museums; centers for teaching and learning; schools and colleges of education; and other STEM undergraduate and graduate students, staff, and faculty. In many communities, individuals from government agencies with a science mission can offer access to resources and exciting field trip opportunities. Agencies that have complemented the work of GK–12 teams in schools include the Forest Service, Park Service, Agricultural Extension Offices, Fish and Game

**Table 4.1. Description of GK–12 Activities Performed by Fellows**

Description	Percent of Fellows Performing Activity (%)
Presented lessons/lectures to K–12 students	92
Designed new inquiry-based lessons, activities, or modules for use with K–12 students	89
Led small-group activities/discussions with K–12 students	83
Modified existing lessons, activities, or modules for use with K–12 students	81
Planned, coordinated, and/or facilitated inquiry-based learning activities for K–12 students	77
Demonstrated scientific procedures, tools, and techniques in a K–12 classroom	77
Developed educational resources (e.g., lab equipment, software, books, websites)	62
Helped K–12 Teachers understand and use technology (e.g., computer software)	52
Planned, coordinated, and/or led student field trips or excursions for K–12 students	44
Developed and provided professional development to Teachers	39
Other	46

SOURCE: ABT ASSOCIATES 2010. NOTE: PERCENTAGES DO NOT SUM TO 100 BECAUSE RESPONSE CATEGORIES ARE NOT MUTUALLY EXCLUSIVE AND RESPONDENTS COULD CHECK MULTIPLE RESPONSES.

Agencies, NASA, and the National Oceanic and Atmospheric Administration (including the National Weather Service). Many GK–12 projects also have engaged local individuals and businesses. For example, the University of Montana ECOS project worked with local construction businesses and parents to construct nature trails and outdoor classrooms on the grounds of several partner schools. Many local businesses donated materials and labor to help build these facilities.

### PREPARING TEAMS TO WORK TOGETHER THROUGH WORKSHOPS, COURSES, AND REFLECTIVE PRACTICE

Successful Fellow–Teacher partnerships can be challenging to achieve, so it is important to provide varied opportunities for team members to build rapport and to develop a common vision for collaboration (Caton et al. 2000). Many GK–12 projects have brought team members together in workshops and courses to develop highly effective partnerships. Creating workshop and course environments that stress equal status for Teachers and research

scientists (as recommended by Feazel and Aram 1990) and promote the two-way exchange of ideas and expertise is key to building successful partnerships and collaborations between scientists and K–12 Teachers. Moreover, working together on engaging inquiries and investigations which use low-tech materials that are easily available to Teachers can help all team members overcome their reserve and establish a personal basis for collaboration. During these meetings, participants learn strategies for collaborating in the classroom and beyond. They also work together to explore discipline-specific sampling methods, data collection protocols, data analysis, pedagogies, and curricula that are informed by the National Science Education Standards (Table 4.2, NRC 1996), the Standards for Mathematical Practice, and the National Educational Technology Standards. Note that at the time of this publication the Next Generation Science Standards (NGSS) were in the process of being developed and should be available in the spring of 2013. Once completed, the NGSS should be used as a guide.

“One of the most beneficial experiences I had as a Fellow was the opportunity to meet with other GK–12 Fellows on a regular basis to share what we were doing in our different schools, and ask questions. We learned so much from each other during these meetings and we grew as a team.”

—GK–12 Fellow, Washington State University  
Global Change in a Local Context Project

Participants’ meetings can last for just a few hours or an entire semester, depending on the needs of the project and the aptitudes to be developed. An effective approach for training is to offer one or two weeks of workshop training in the summer, followed by daylong workshops several times during the academic year. The template for the work of the teams is developed during the summer sessions. The meetings during the academic year provide opportunities to develop new skills and knowledge, share the experiences of teams in the schools, and make changes as needed or desired.

### Summer Planning Workshops

An ideal time to bring Teachers and Fellows together is during the summer before they will work together in a classroom. Many GK–12 projects around the

## ELEMENTS FOR A SUCCESSFUL PLANNING WORKSHOP

- Enthusiastic, knowledgeable, respectful, flexible, friendly leaders.
- Clear objectives, excellent examples, and a detailed agenda (that is followed).
- Concrete ideas that can be used immediately.
- Research that supports applications.
- Lots of interaction and a variety of activities.
- Demonstrations of ideas and strategies, with relevant classroom examples.
- Time for participants to share their relevant experiences and insights.
- Time for participants to develop an implementation plan for the coming year, including an activity timeline, necessary resources, and a resource acquisition plan.
- A comfortable and appropriate meeting room and breaks (with food and beverages).
- Excellent visual and written materials, including a workshop packet with agenda, informational materials, forms, a reading list, examples, etc.

SOURCE: SHARP 1993.

country have brought Teachers and Fellows together for one to two weeks (in one or two sessions). Summer workshops provide an ideal opportunity to share information on the goals and objectives of the partnership project, clarify expectations for all participants, explain policies and project requirements, and plan the activities of the teams for the coming academic year.

Summer meetings are also the best time for all of the participants to get to know each other and to build relationships that will allow them to work together successfully in the classroom setting. GK–12 projects have used a variety of strategies to get their summer workshops off the ground. Some projects

**Table 4.2. Examples of How GK–12 Partnership Project Activities Can Align with the National Science Education Standards**

Teachers of science...	GK–12 Project Alignment with Standards for Teaching
A) ... plan inquiry-based science project for their students	Teachers work with graduate student partners to develop inquiry-based research projects for their students.
B) ... guide and facilitate learning.	Teachers and graduate student partners provide opportunities for students to ask and research their own questions, with an emphasis on mentoring and advising.
C) ... engage in ongoing assessment of their teaching and of student learning.	Teachers and graduate student partners work together to develop and use diverse methods of assessing student understanding appropriate for the research projects.
D) ... provide students with the time, space, and resources needed to learn science.	Schoolyards and other local areas are explored as research sites to allow yearlong investigations by students using field and equipment and materials.
E) ... develop communities of science learners that reflect intellectual rigor of scientific inquiry, and attitudes and social values conducive to science learning.	Student-centered research projects reflect the variety of skills, interests, and ideas of all students. The Teacher–scientist partnership project models scientific collaboration and the science process skills essential to inquiry.
Professional development requires...	GK–12 Project Alignment with Standards for Professional Development
A) ... learning essential science content through the perspectives and methods of inquiry.	Teachers are mentored by scientists with strong science backgrounds, in the context of inquiry-based investigations. Teachers learn about the latest advancements in the science and technology fields, to better represent the scientific community to their students.
B) ... integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching.	Through the development of inquiry-based research projects mentored by scientist team members, Teachers concurrently are exposed to scientific content and processes, as well as enhancing their skills in facilitating learning through the use of inquiry. Teachers apply that knowledge directly as projects advance.
C) ... building understanding and ability for lifelong learning.	A GK–12-like model provides intensive, yearlong participation in professional development activities and exposure to science culture, and opportunities for acquiring knowledge and experience.
D) ...projects that are coherent and integrated.	A GK–12-like project can provide coordinated professional development opportunities with a common goal of enhancing inquiry-based science opportunities for all students. Collaboration throughout the districts will build a vital network of innovative science Teachers.

SOURCE: NATIONAL RESEARCH COUNCIL 1996.

have engaged Fellow–Teacher teams in daylong open scientific investigations during which the team comes up with a researchable question, collects and summarizes data, and makes a presentation to the workshop group. Other projects have built trust and camaraderie through participation in an “adventure ropes course.” The key is to design an engaging introductory activity that focuses the participants’ attention and builds trust and rapport among team members and between the teams and project leaders.

Projects have also used a variety of approaches in matching Teachers with Fellows. This is an important component that should not be overlooked. The partnership between the Teacher and Fellow is key to success. Speed dating is one way projects have identified successful Teacher–Fellow matches. As

part of the speed-dating process, each participating graduate student designs an activity around his or her research topic. Over a day or two, Teachers rotate through the graduate students, engaging in each of the activities with each graduate student. Alternatively, the situation could be reversed, with the graduate students rotating through the Teachers and the Teachers developing the activities. Either way, the process provides an opportunity for Teachers and Fellows to get to know each other, including their personalities and work habits. At the conclusion of the speed-dating exercise, each Teacher is asked to privately identify the three Fellows they would work best with and the Fellows are asked to do the same. The project management team then uses these rankings to pair the Fellows

with Teachers. Other projects have used in-depth, one-on-one interviews of Teachers and Fellows to pair them properly. Regardless of the method used, it is important that sufficient attention be paid to the matching process and that the matches be made as early as possible. The sooner the Fellow and Teacher begin working together, the sooner potential issues can be resolved.

During the summer workshop, project staff also work with Teachers and Fellows to identify STEM content themes that link to the curriculum standards the Teacher must meet in a given academic year (especially with regard to benchmarks and learner competencies), as well as to the National Science Education Standards (NRC 1996, Table 4.2). The teams typically choose a set of inquiry-based learning experiences and then plan how they will coordinate instruction for the upcoming academic year. Graduate students are challenged to develop elements of the school year activities that relate to their scientific research background and knowledge. It can be helpful to include experts in curriculum development and pedagogical innovations from on and off campus to assist project participants with planning. Typically, teams also develop strategies for effective age-appropriate instruction (e.g., AISES 1995, NRC 1997) and plans for appropriate assessment, including examples of rubrics and alternative formats for assessing student performance. In addition, they may plan to use technology to support student learning.

Because these training sessions involve significant learning, many GK–12 projects offer academic credit for Teacher participation. Credit can be in the form of university or college credit hours and/or professional training hours for Teacher recertification purposes. A university extended education office can usually



A Fellow and Teachers from the Worcester Polytechnic GK–12 project discuss plans for using formative assessments.

provide advice and administrative assistance for offering both kinds of credit.

### Curriculum Development

A key effort, both during summer workshops and over the course of an academic year, may be developing and adapting STEM curricular materials to use in the classroom. There is no shortage of materials or approaches that a project might use to get started. Sample resources are listed in Appendix 4.1. A good starting place is to review the National Science Standards (NRC 1996) and the accompanying materials on achieving science literacy (NRC 1998). Also, the special feature “Learning to Read and Reading to Learn” (Science, April 23, 2010) provides an excellent collection of articles reviewing literacy in science.

The most effective STEM instruction takes a “learner-centered” approach, to make sure that we focus on students while we are teaching science. Once a team has decided on a topical area, what is involved in developing an effective unit for a K–12 classroom? First, it is important to decide what a student in a particular grade should know and be able to do by the end of the instructional unit. Second, it is important to determine what proficiency, or mastery, looks like for a student in the targeted grade. Third, teams should decide what evidence they will accept which indicate that the student has actually mastered the content and skills in the unit.

Regardless of the level of instruction, a very useful model for developing curricula is the “backward design” described by Wiggins and McTighe (2005). This model works equally well for the K–12 classroom or the university course. The design of student-centered units begins with defining clear and



University of Alaska Fairbanks Teachers and Fellows in the field during their summer training program.



measurable learning goals. Next, assessment tools are devised that are appropriate for evaluating the extent to which the learning goals were met. The third step is to plan the instructional strategies that will best help students meet the learning goals. In the K–12 setting, it is important to minimize lecturing to students and to create as many opportunities as possible for students to engage in active learning. The curricular materials developed by Fellow–Teacher teams can become a valuable resource for the broader educational community. Having GK–12 teams use a standardized format for the curricular materials they develop will make it easy for other Teachers to use them and for a GK–12 project to disseminate them widely. A sample unit format is shown in Appendix 4.4.

### PLANNING FOR CULTURAL DIVERSITY

- Identify local and regional organizations that support underrepresented minorities, and seek their input when selecting Fellows and Teachers.
- Identify community elders (e.g., Native American tribal elders, prominent ministers, leaders in larger community organizations, etc.) who are respected and who know the community’s history, and seek their input on how best to engage Fellows and Teachers with the community.
- Provide opportunities early on for Teachers and Fellows to share their cultural background with each other and explore similarities and differences.
- Identify authentic STEM research projects that can directly address local community and cultural issues. Such projects provide a central theme around which Fellows, Teachers, K–12 students, and community members can build a strong relationship.
- Keep in mind that all communities are different and evolving. Engaging members of the community early on and keeping them informed and involved throughout implementation of the GK–12 project is important for its success.

### Culture and Diversity

Culture and diversity are also important things to consider in preparing for team success. Many dimensions of diversity, inclusion, and cultural competence are relevant to establishing and sustaining GK–12 projects and the Fellow–Teacher team. For the purposes of this guide, diversity refers to acceptance and respect toward individual differences, regardless of race, gender, socioeconomic status, age, physical ability, religious belief, cultural background, sexual orientation, or political perspective. In implementing various phases of the GK–12 collaboration, whether between the K–12 schools and the university, the schools and the community, or the Fellow and the Teacher, an essential first step should be to assess the demographics of the K–12 student and Teacher population, as well as the student and faculty population at the university.

The GK–12 project is an ideal vehicle for enhancing diversity across institutions. A number of institutions used their projects to increase the diversity of their pool of graduate students through recruitment efforts. In addition, many colleges and universities implementing a GK–12 model chose to target K–12 schools that serve primarily underrepresented or economically disadvantaged children. Placing Fellows who are typically much closer in age and cultural background to K–12 students can bring about positive results. The students then find themselves looking at graduate students as academic role models and begin feeling that they, too, can one day break stereotypes and become a graduate student pursuing a STEM degree. According to Abt Associates (2010), 94% of K–12 students participating in the GK–12 project experienced an increase in interest and excitement about learning mathematics and science at school.

Fellows and Teachers may differ on many of these dimensions. Fellows and K–12 students may also come from very different backgrounds and other characteristics. Whether in recruiting diverse Fellows and Teachers, preparing Fellows for inclusive instruction, or considering a culturally sensitive curriculum, taking into account diversity and inclusion is essential to many projects.

### SUPPORTING TEAMS THROUGH GRADUATE COURSES AND SEMINARS

A clear benefit of participating in a GK–12 project is that Fellows are able to bring cutting-edge science to K–12 classrooms.

But many GK–12 Fellows report that they also profit substantially in terms of developing their

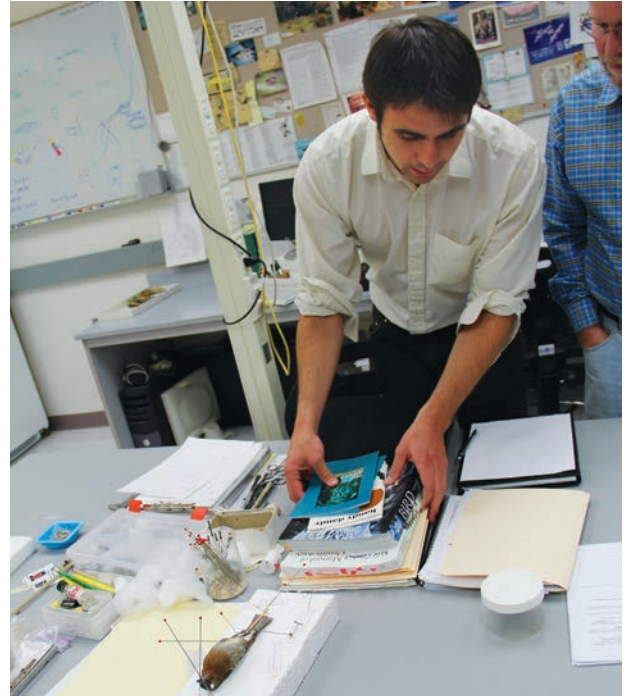
teaching skills. GK–12 projects can support the professional development of their Fellows and Teachers by offering academic courses and seminars focused on innovative instructional pedagogies, the latest educational research on teaching and learning, elements of successful partnerships and the most effective collaborations between Teachers and scientists, issues pertinent to K–12 learners, approaches to learning of students of different ages, and strategies for assessment. In these seminars and courses, participants can (1) develop effective teaching strategies for diverse students; (2) review the literature related to instructional management techniques, science education and the current reform movements, and the use of technology in the classroom; (3) develop innovative guided- and open-inquiry investigations; (4) present an innovative instructional unit in a classroom setting; and (5) use classroom-based research methods and assessment techniques to ensure that their teaching is well connected with student learning. Such courses and seminars also provide opportunities to develop practical skills and tools that will help the participants in future academic positions, including articulation of their teaching philosophy, learning and practicing time management techniques, developing communication skills, and preparing a professional curriculum vitae. Some examples of courses are listed in Appendix 4.1.

### Building Reflective Practice

To grow as educators, it is critical to reflect on what we are doing in the classroom, why we choose particular materials and methods, and whether our approach is working. Ideally, reflecting on our practice as educators is most helpful when it is approached systematically and a variety of information is used to better understand the extent to which our teaching actually is connected to learning. Of course, carefully analyzing how students perform on classroom assessments is an excellent place to start reflecting on how well our teaching materials and approaches are connected to student learning. There are many examples in the literature (see, e.g., Appendix 4.1) that provide advice on how to cultivate reflective practice. In the next few sections, several tools and approaches will be described that can be very useful for Fellows and Teachers in a GK–12 partnership.

### Teaching Logs, Blogs, and Journals

Keeping a teaching log, blog, or journal is perhaps the easiest way to reflect on one's teaching experiences.



University of Alaska Fairbanks GK-12 Fellow shows off the kit and curriculum he developed that uses bird features to demonstrate evolution principles.

In a journal, the Teacher describes how a particular teaching session or unit played out in the classroom. The Teacher can record how he or she felt during instruction. Furthermore, it is helpful to note how students reacted to and engaged in the unit, what elements worked well or did not work as planned, and what should be changed before the next class session or before the unit is used again.

Teaching logs can be kept on paper, or they can be web based (a blog). Several GK–12 projects have used digital teaching logs as a web-based project assessment tool. Teachers and Fellows sign on to a password-protected site and make entries about their experience with their curricular materials. They can be prompted as well to comment on how the team is functioning, thereby providing valuable information to project leaders about possible issues before they become real problems.

### Peer Observations

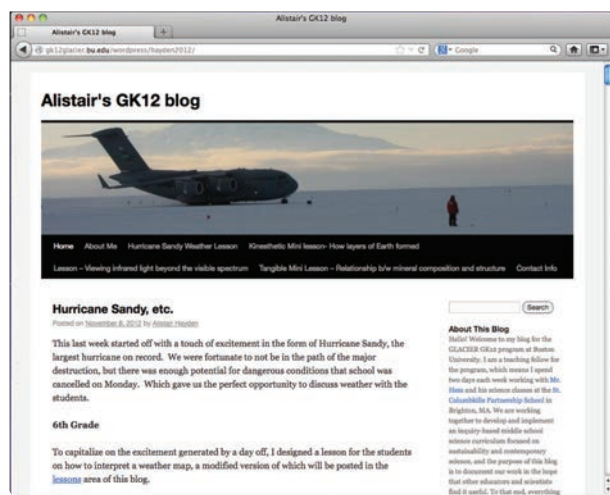
Having a trusted colleague observe the teaching team in action can be a valuable way to improve teaching. The peer observer can note what the students are doing and how they are reacting in the moment of teaching. The observer also can comment on what strategies were particularly effective. Peer observations can be made in person during a class session or by viewing a video of the class session.

Peer observation works best when it is done systematically, with a checklist or a set of questions to answer during the observations (Appendix 4.5). It is important for the peer observer to meet with the GK–12 team before observing takes place, in order to understand what will happen during the class period. At the meeting, the members of the team also can alert the observer to any particular issues they anticipate during the session. After the observation period is over, the peer observer meets with the team to share what he or she has found and provide honest, constructive advice.

Like teaching logs and blogs, peer observations are a valuable assessment tool for documenting changes in the teaching approaches and skills of both GK–12 Teachers and Fellows. After meeting with the peer observer, the teaching team should reflect on how the observations align with their personal experience in the classroom and strategize on the kinds of changes that are feasible for improving the connection between their teaching and student learning.

### Scientific Teaching

One especially effective way to improve the connection between teaching and learning is to envision our teaching as an experiment designed to have a positive impact on student learning. Using “scientific teaching,” an approach that mirrors scientific research (Handelsman et al. 2007), instructors review and revise their teaching in an iterative fashion based on evidence from assessment tools. To use a scientific teaching approach, it is critical to explicitly define what students should know and be able to do at the end of an instructional period and then to collect evidence to learn



Example of a blog maintained by a Boston University GLACIER GK-12 Fellow.

### CHECKLIST OF CONSIDERATIONS REGARDING SCIENTIFIC TEACHING

- What knowledge and skills are relevant to the subject area?
- What should students know and be able to do at the end of the unit?
- What do proficiency and mastery look like in the subject area for this level in the curriculum?
- What evidence demonstrates that a student has achieved mastery and proficiency across the relevant content and skills previously identified?
- What evidence on learning would convince colleagues, parents of students, and other interested parties?

SOURCE: ADAPTED FROM HANDELSMAN 2007 IN BREWER ET AL. 2011.

the extent to which the students have met the learning objectives. Evidence is composed of both quantitative and qualitative data (e.g., problem sets, objective questions, projects, observations of students in a lab setting, etc.). The key is that the assessment tools must be valid measures of student learning, behaviors, and attitudes that are closely linked to the learning outcomes defined for the unit or topic and the data are shared with the students so they know how well they are progressing. A scientific teaching approach allows instructors to make more informed decisions about the pace of instruction as well as teaching strategies that best link instruction with learning. In some GK–12 projects, graduate students have published the classroom research data they have collected in peer-reviewed journals (e.g., Whiteley et al. 2007 Piotrowski et al. 2007, Perkins and Brewer 2010).

### PROJECT EVALUATION

Assessment, in a nutshell, is the practice of collecting data to better understand the extent to which project goals and objectives are being met. The resulting data can then be used to guide decision making about how to improve project implementation. (See Chapter 9 for guidance on conducting an evaluation of your project.) There are two kinds of programmatic assessment that may be valuable for

GK–12 projects, and these will be described next. Whichever kind is chosen, implementing it can be done internally within the project (by project staff) or externally (by an external consultant). Deciding on whether to do project assessment internally or externally will depend on the size and scope of a particular project and on the budget available for the assessment. In either case, many GK–12 projects have made examples of their assessment tools available through their websites; the examples can be excellent resources for developing an assessment plan that fits each particular project. Because educational assessment involves collecting data from human subjects, it is necessary to have the assessment plan, as well as the tools that will be used to collect data, reviewed by the Human Subjects Institutional Review Boards of both the university or college and the schools and school districts. There are likely to be special requirements for collecting assessment data from minors. It is essential that project staff and all of the graduate students and Teachers be clear about human subject data collection protocols before any assessment plan is implemented.

### Formative Assessment

Formative assessment documents and reviews project activities and provides interim information for reviewing and redirecting the project as necessary. Often, formative assessment is shared with all participants as the project develops. A formative assessment plan will examine the effectiveness of recruitment activities, document the work of Teacher–Fellow teams as they create plans and research experiences for participating students, and review mentoring support materials and strategies. Typically, participating faculty, Fellows, project leaders, and staff are interviewed about the quality and effectiveness of project activities and are requested to make recommendations regarding additional project needs. Early on in a project, it is useful to gauge the perceptions of project leaders and staff, Teachers, Fellows, and district leaders to quickly identify any emerging issues or challenges. The development and implementation of courses, workshops, seminars, and informal social gatherings, as well as the overall reaction of participants related to these project activities, are reviewed. Sometimes, formative assessment for a GK–12 project might analyze the breadth of opportunities offered to K–12 students, the number of students involved in guided and authentic research experiences, and the barriers encountered in involving all students in research.

### CHECKLIST OF ELEMENTS FOR EFFECTIVE COLLABORATION

- Bring together key partners involved in scientific research and education to develop a common vision for instruction and collaboration.
- Foster interaction between scientists and educators through experiences focused on a shared vision, inquiry-based instruction, and learning related to the science content of interest.
- Compile and develop (as needed) excellent curriculum resources that translate basic research so that it is accessible to a broad audience.
- Develop and pilot a series of “demonstration curricula” in open and guided inquiry formats.

SOURCE: CATON ET AL. 2000.

Needed improvements and project successes can be identified with a variety of tools, including surveys, questionnaires, focus-group discussions, individual interviews, and participants’ reflective logs, to name just a few.

### Summative Assessment

Summative assessment focuses on the overall quality and breadth of the project’s accomplishments. Summative data include, for example, general demographic data on all participants; data on overall participation by Fellows and Teachers, and on their enthusiasm for future participation; the overall number of K–12 students participating in research experiences; information about the level of content and process mastery of students in GK–12 classrooms (e.g., results of pre- and post-tests, performance on standardized tests); and data on the degree to which Teachers’ instructional practices have changed to reflect the “learning by doing” model and the level of inquiry-based instruction in and out of the classroom. Additional summative data might include the average time taken by Fellows to earn their degrees, the number and types of higher education placements after Fellows graduate, and the percentages of underrepresented groups among higher education participants and faculty.



## EXEMPLARS

## CONNECTIONS IN THE CLASSROOM: MOLECULES TO MUSCLES

**University of Southern Mississippi GK-12 Project**

<http://www.usmgk12.org>

The goal of the “Connections in the Classroom: Molecules to Muscles” (C2M2) is to enhance Fellows’ communication and teaching skills in an interdisciplinary research and education setting. Training Fellows begins in the spring prior to the Fellowship year when graduate students meet their Teacher partners. Training continues during the summer prior to entering the classroom. The Fellows participate in two important educational training activities. The first is a required course, taught through the College of Education, to introduce the Fellows to relevant ideas about pedagogy, lesson planning, and scientific inquiry. The second is a two-week intensive summer workshop spent with their partnering Teachers to provide each Fellow with a chance to learn about the particular needs of his or her Teacher’s classroom, to work with diverse students in schools that serve minorities, to discuss classroom liability issues, and to develop trust and working relationships through personality assessments and team-building exercises.

The training for Fellows continues during the school year. All of the Fellows are enrolled in a course that meets weekly to share research updates and further develop their educational expertise. Fellows work with staff in the speaking, writing, or learning center, as appropriate, to learn a variety of communication techniques that help them to interpret their research for funding agencies, legislative staff, and the general public. One technique used is to videotape the Fellow giving a presentation and then analyze the video for areas of possible improvement. In the spring, each Fellow is asked to give a formal presentation to a general university audience about his or her research.

The results extend beyond the project and high school setting. Project leader Sarah Morgan shares a story that illustrates success in developing improved communication skills. During three years of graduate school, one of the Fellows in the project had tried to explain his project to his mother, but to no avail. Following the first semester of training in the C2M2 Fellowship, he traveled home for the semester break. Using the new communication skills he developed as part of his GK-12 training, he was able to explain his research work to his mother for the first time. This example shows that not only do the Fellows learn to communicate with students and general scientific audiences, but they also learn to communicate the complexities of their research effectively to the general public.



University of Southern Mississippi GK-12 Fellow with students during a field experience.

## ECOLOGISTS, EDUCATORS, AND SCHOOLS

**University of Montana GK-12 Project**

<http://www.BioEd.org/ECOS>

The Ecologists, Educators, and Schools (ECOS) project used the school yard and adjacent open areas nearby as outdoor laboratories for learning about science and the environment. The theme was “No Child Left Indoors.” Over the course of a year, ECOS Fellows and Teachers participated in a series of training opportunities to introduce participants to the project, teach content and methods of ecological science, develop innovative approaches to the teaching of science in K-12 classrooms, create teaching materials and resources, and develop a



Hellgate Intermediate School students, working with the ECOS project, construct a native garden at the school.

## EXEMPLARS (CONTINUED)

portfolio of tools for Fellows to take with them when they completed their graduate training.

The ECOS Fellowship year began with a reception late in the spring semester for new GK-12 Fellows, their research advisors, and GK-12 Teachers from the partner schools. The reception provided an opportunity to describe the ECOS project to new participants and for the team members to meet. In early June, Fellows were brought together to prepare them for working with their partner Teachers, to learn about national and local science standards, and to begin strategizing on how they could link their research and disciplinary backgrounds to the standards.

Over the summer, Fellows and Teachers participated in two weeklong workshops. Teams engaged in an outdoor open-inquiry investigation in a local park (e.g., Feinsinger et al. 1997). Teams devised a researchable question, collected and analyzed data, created a simple poster describing their research and results, and presented their findings to the other ECOS teams. This experience was crucial and set the stage for the rest of the partnership year. During the workshop, teams identified an ecological theme for their work in the partnering school, established a planning calendar, determined equipment needs, and learned pedagogical approaches to outdoor ecological inquiry. Teams also focused on developing guided and open-ended inquiries, collaborated on an ECOS web-based natural history guide, and solidified plans for the school year.

Once the school year began, the Fellows met on a weekly basis with their school-based team and participated in a two-credit seminar course each semester. The course was designed to help them further develop their communication and pedagogical skills. Fellows also identified an area for a dissertation chapter related to their GK-12 experience, a requirement of the University of Montana GK-12 project.

Over the academic year, the ECOS project hosted three to four Institute days to bring the ECOS teams together, report on GK-12 activities at their schools, and learn one or two new approaches to using their school yards to teach ecology.

At the end of the academic year, the ECOS project hosted an annual three- to four-day writing retreat for Fellows in an off-campus residential setting to help them progress on their teaching dissertation chapters and to prepare manuscripts and reports on the successes and lessons learned as ECOS GK-12 Fellows for subsequent publication. By the end of the ECOS project, all of the Fellows had documented their ECOS teaching scholarship as one chapter of their dissertation and many of them had successfully published manuscripts, in collaboration with their partner Teachers, in teaching journals.

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