OSU GK-12 Fellowships to Enhance Science and Engineering Education in Oregon Schools

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Abstract

The goal of the NSF funded OSU GK-12 project is to facilitate the development of active science learning and to enhance the delivery of science education (defined here as education in science, technology, engineering, and mathematics or STEM) in Oregon schools. Graduate students pursuing degrees in engineering and science disciplines serve as Fellows (14 per year) in one of nine schools in three school districts: Portland (a large city setting); Corvallis (a University town setting); and Lincoln County (a dispersed rural district). The multidisciplinary approach includes five graduate programs (Molecular and Cellular Biology, Mathematics, Physics, Bioengineering, and Chemical Engineering). Fellows receive formal education training in the summer, spend 6 months (15 hrs per week) in schools as "adopted scientists" in grades K-6 or "teaching assistants" in grades 7-12, and then finish their year in extended outreach activities throughout Oregon. The benefits to the schools are the participation of motivated, knowledgeable, and trained Fellows to work with teachers to develop new and exciting programs in areas of current research interest to enhance STEM education in K-12 schools. The GK-12 project improves and solidifies the connection between higher education and the public schools, establishes a "pipeline" to schools with populations of students underrepresented in the University, and develops a cadre of experienced Fellows with a lifelong commitment to science and engineering education outreach

Introduction: Goals and Objectives

The overall goal of the OSU GK-12 outreach project is to facilitate the development of active science learning in public schools. The program is just completing its third year of funding through a grant from the NSF Division of Undergraduate Education (DUE 9979507; Arp, PI). NSF Fellows (14 graduate fellows per year) supported through this program play a critical role in reaching our goal. They join Departmental Liaisons, Outreach Coordinators and GK-12 Teachers (one for each Fellow) in a project designed to enhance the delivery of science education (defined here as education in science, technology, engineering, and mathematics or STEM) in the public schools. Our efforts focus on eleven target schools (K-12) in three school districts in Oregon.

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Science education in Oregon, as in other states, has undergone a dramatic reform movement over the past few years. Science and mathematics standards were adopted at the district and state levels and state-administered tests track 3rd, 5th, 8th, and 10th graders' progress towards meeting the state standards. The standards are closely aligned with both Benchmarks of Project 2061 (American Association for the Advancement of Science) and those recommended by the National Academy of Sciences. There is a strong emphasis on a "hands on" or inquiry-based approach to science education. However, many teachers lack the training to appropriately implement these teaching goals. Resource materials in many schools are inadequate and often not aligned with the standards. Resources that are available (either from within the school or from outside sources) are often poorly used because of lack of familiarity with the underlying concepts or insufficient time to become familiar with the material. Several organizations have risen to the challenge to help facilitate this reform in science education. For example, Oregon State University (OSU) and the Oregon Museum of Science and Industry (OMSI) each have ongoing school outreach efforts and additional programs that enhance the education students receive in the schools. Our objective with this GK-12 Outreach Project was to reach further into the public schools to facilitate education reform and assist in the delivery of science education aligned with accepted standards and benchmarks. The Fellows commit 15 hours each week to this project, so they play a key role in the delivery of science education that is well outside what can be expected of faculty or community volunteers. As an example, Oregon has mandated a *CIM* (Certificate of Initial Mastery) and *CAM* (Certificate of Advanced Mastery) system which will become a necessary component for high school graduation in the near future. There are various requirements for each CAM, but the main component is a "professional work experience" for each student. A GK-12 Fellow has worked with North Eugene High School to develop the CAM Engineering program, by helping to develop Introduction to Engineering courses, engineering modules, and for a limited number of students, a research experience at the University. This program could be put "on-line" and made available to an extended community of schools in Oregon and beyond. It is hoped that Fellows, because of these types of experiences, will enter into their professional lives better prepared to contribute to science education whether in university, government or industrial settings.

Project Description

I. Learning Themes and Overview

To meet our goal to develop active science and mathematics learning, five activity themes were designed. These themes are developed in our Fellow training program and implemented in the schools:

•Theme 1: Inquiry-based learning. We encourage and enhance the development of inquiry-based approaches to learning science and mathematics. Science kits form the basis for much of this effort at grades K-5 while laboratory exercises are used at grades 6-12. Teachers learn the science underlying each kit or exercise and the benchmarks and standards it addresses with assistance from their Fellows. Fellows provide enhancements to some kits and develop some new activities.

•Theme 2: Communication of content. Fellows play an important role in communicating science, mathematics, and engineering content—the theories, concepts, and ideas—to teachers and students. Fellows are excellent resources to provide teachers with the content knowledge they need to assist their students in reaching the benchmarks. Fellows also participate directly in the transfer of knowledge to students in the classroom.

•Theme 3: Use of appropriate learning styles. The science content and classroom activities are appropriate to the particular setting and grade level. Fellows adapt their activities to the diverse cultural backgrounds and various learning styles they encounter.
•Theme 4: Use of technology. Fellows enhance the use of appropriate technology in the classrooms. In many, though not all cases, Fellows enhance the ability of teachers and students to use computers and the Internet as educational tools and as resources.

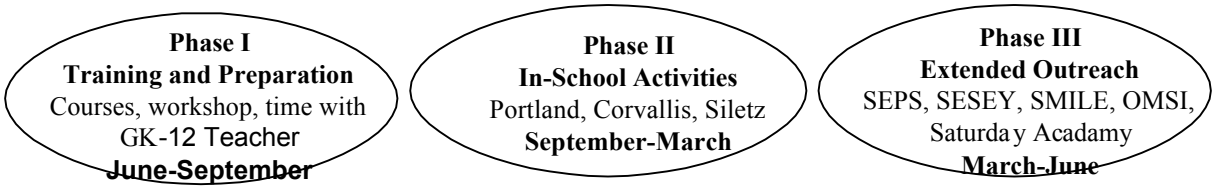
•Theme 5: The research paradigm. Fellows are a unique resource for the public schools in that they are engaged in the research enterprise. Fellows incorporate the research paradigm into their activities—formulating questions, designing experiments, analyzing data, and drawing conclusions. Students and teachers learn that the same paradigm used in research universities can be adapted to all aspects of learning in the classroom and, additionally, to questions in their daily lives. In the figure below, a GK-12 Fellow is describing her research with bees to students at Siletz school, a predominantly Native American rural K-8 school.

OSU has engaged the participation of seven departments to ensure a multidisciplinary approach to our activities. Each of the Departments already participates in ongoing outreach activities to children and the schools. A Departmental Liaison to this project was identified from each program. Their responsibility was to serve as advisors to the Fellows from their graduate programs, be resources with regard to disciplinary content, provide educational resources, and provide networking contacts for the Fellows. The graduate programs are: Molecular and Cellular Biology (an interdisciplinary graduate program with 65 faculty in 5 colleges), Chemistry, Physics, Mathematics, Chemical Engineering, Bioengineering, Environmental Engineering, and Geosciences. In addition to the disciplinary departments, the Science and Mathematics Education Department (SMED) provides pedagogical and practical training of the Fellows in preparation for their classroom activities. The unique contribution of the SMED faculty is their familiarity with teachers' knowledge and skills and familiarity with school situations.

II. Scope and Plan

The project is designed to engage Fellows in the delivery of science and mathematics education to broad audiences of children and teachers. Fellows are appointed for a period of one year.

Their activities in that year are divided into three phases (see figure below): I) Training and Preparation, II) In-school Engagement, and III) Extended Outreach. The details of each phase are described below. This plan was designed with the participation of GK-12 Teachers, Outreach Coordinators, and Departmental Liaisons and reflects three years of experience with the current project. Each Fellow was paired with a GK12 Teacher from their school. This teacher accepts the responsibility to assist the Fellow in preparing for the in-school activities, offer guidance throughout the year, and provide some assessment of the Fellows. The GK-12 Teacher is also expected to be the primary beneficiary of the assistance afforded by the Fellow. The Departmental Liaisons assist in all three phases by providing disciplinary support and serving as a contact for the GK-12 Teachers, Fellows, and Outreach Coordinators. The Outreach liaisons coordinate the activities of the Fellows in Phase III. While the activities of Phase II and Phase III are conceptually distinct, the activities need not be temporally distinct. Therefore, Fellows are given the opportunity to follow the timeline shown below, or to combine the timelines while keeping the ratio of effort devoted to each at about 1:2:1.



Phase I: Training activities for fellows.

Fellows are selected in January, matched to schools and Teacher Facilitators in February, and begin their appointments on July 1. In June, the Fellows attend a two-day workshop organized with the objective of bringing Fellows, Teacher Facilitators, Outreach Coordinators and Departmental Liaisons involved in the project together. In July, Fellows enroll in three Summer Session classes offered by the Science and Mathematics Education Department (SMED) at OSU. SMED, organized within the College of Science, offers graduate degrees in science and mathematics education. The programs are designed to prepare teachers and meet licensure requirements. Faculty members of SMED have participated formally and informally over the past few years in state and national discussions of benchmarks and standards for science and mathematics education. The formal courses emphasize science and mathematics reform and include coverage of the current suggested science and mathematics standards and efforts to implement and assess progress towards these standards. They also provide the pedagogical underpinnings and practical experiences for the development of active learners of science and mathematics in a variety of settings. The first two themes (1. Inquiry-based learning and 2. Communication of content) are emphasized in the methods course. The remaining themes (3. Use of appropriate learning styles, 4. Use of technology, and 5. The research paradigm) are emphasized in the advanced strategies course. This formal instruction takes place as an intensive four-week summer session in the month of July.

Once in-class activities begin in September, Fellows attend a biweekly seminar organized by the

Project Coordinator. The seminar goal provides continued mentoring of the fellows throughout the school year, follow-up to the training activities of the summer and an informal forum for discussing problems and sharing ideas. This provides an opportunity for Fellows to build a sense of community among themselves. We want fellows to benefit from each other's experiences and recognize that they are a part of a unique group. Fellows are linked electronically on an email listserve. The Project Coordinator periodically observes the in-class activities of each Fellow and provides feedback on performance and effectiveness. GK-12 Teachers help monitor the performance of Fellows and communicate directly with the Leadership Team (Arp, Rochefort, Haak).

Phase II: In-school activities

Fellows spend 10 hours each week in classroom activities and an additional 5 hours each week in preparation. They use one of two models (described below) of classroom participation. In grades K-5, our model is most easily described as a "scientist-in-residence" for a school. In grades 6-12, the model is best described as providing a "teaching assistant" for one or two science or mathematics teachers. With these two models we are able to reach a large number of students and teachers (see Table 1) while still maintaining a high quality of interactions. Activities incorporate the five learning themes described above . Each Fellow and GK-12 Teacher pair develop the implementation plan for their school. To provide coherence, in-school activities at all grade levels are connected to the organized curriculum so the activities do not appear to the children or their teacher as isolated incidents. The students get to know the Fellows personally, not just as scientists, and thereby shatter some of the stereotypes about what kinds of people become scientists. .

In the *"scientist-in-residence"* model for grades K-5, a Fellow will work with all the classrooms in a particular school. At first blush, it might seem that we are "spreading the Fellow too thin" by expecting them to interact with up to 12 teachers and 275 students. However, this model has worked very well for 10 different Fellows in 5 schools in 3 districts. One key to success is coordinating the effort such that an activity used for one grade (two classes) can be adapted for other grades. The Fellows spend nearly one hour in each classroom each week. That's a substantial proportion of the 2 hours typically spent on science each week. Our assumptions with the "scientist-in-residence" model are 1) science occupies only a portion of a weekly curriculum (10-20%), 2) Fellows will usually have a more extensive science background than their GK-12 Teacher, 3) Fellows will have the content knowledge to assist in all aspects of science delivery at these levels, and 4) Fellows will be most effective if they can get to know their students in their classrooms and build a foundation of trust and understanding. The Fellow and GK-12 Teacher coordinate activities with other teachers and classrooms and adapt this model to suit the needs of their host school. Past GK12 Teachers and Fellows have commented on the importance of this flexibility.

Table 1. Summary of Fellows, Classes, and Students							
School	Grades	Num. of Fellows	Num. of Classes	Num. of Students*	Num. of Fellows	Num. of Classes	Num. of Students*
Year 1: 2000-2001					Year 2: 2001-2002		
Siletz	K-8	2	9	232	2	9	236
Portland	K-5	1	7	182	1	8	184
	6-8	1	4	110	1	8	132
	9-12	1	4	150	1	5	185
Corvallis	K-5	2	26	660	3	35	944
	6-8	4	15	480	3	12	375
	9-12	3	8	227	3	12	369
Totals	**K-12**	**14**	**73**	**2041**	**14**	**89**	**2425**
*Num. of students Fellows interacted with directly, in classrooms, for at least six months.							

Fellows assigned to elementary schools participate in the delivery of science to children in keeping with the thematic elements described above. Classroom activities are primarily inquiry-based (Theme 1) and involve personal interaction with the students. Activities involve commercially available science kits (e.g. FOSS), activities developed from a variety of resources, and activities developed entirely by the Fellow. Fellows serve an important role in content communication (Theme 2) and serve as content resources for teachers. As one teacher commented, "There were moments of Aha! for me and they added so much more depth of understanding and more ways to explain concepts to kids." (Fellows use their weekly preparation time to organize materials for the classroom, pilot new units, test software, and research new resources. This use of Fellow time has proven very valuable to teachers. Evaluation and adoption of appropriate Internet resources enhances the use of technology in the elementary grades (Theme 3). As one example, an entomologist Fellow, took her own experimental bees to her 5th grade class to demonstrate life cycles and animal communities.

In the *"teaching assistant"* model for grades 6-12, Fellows will participate in classroom activities with one or two teachers in disciplines related to their majors. Our assumptions in this model are 1) a science or mathematics teacher will spend most or all of their time teaching science and mathematics courses, 2) the disciplinary or content knowledge of teachers and Fellows will be similar (although Fellows are more likely to be "specialists", e.g. ecologists, while teachers are "generalists", e.g. biologists), 3) Fellows will have the content knowledge to assist in specific disciplines, but not necessarily all science or mathematics disciplines offered at the high school level, 4) Fellows will be most effective if they work with just one or two teachers. Again, this model has proved very effective in the first two years of the project. Most participating high schools have gone to 90-minute blocks for courses and each Fellow will assist in 5-7 such blocks during a week in two or three separate courses. In a typical implementation, a Fellow assists the GK-12 Teacher with AP Biology and Introductory Biology and also helps another teacher with Marine Biology. As with the K-6 model, details of the plan are left to the Fellow and GK-12

Teacher and are tailored to the needs of the individual schools and teachers.

Fellows who serve as "teaching assistants" focus their efforts on laboratory exercises where active "hands-on" learning is emphasized (Theme 1). Fellows can and have assisted with curriculum development related to their field of specialization and served as content resources (Theme 2). Fellows can assist the teachers in updating their disciplinary knowledge. A Fellow brings to the curriculum information that is state of the art. Weekly preparation time is used in the schools preparing class materials, and outside the classroom researching resources for teaching a particular unit. In one example of this model, the Fellow provided enhancements to all the lab exercises used in AP Biology. The lab manual was revised and remains in use in the classroom. One of the notable enhancements was the development of the "Mitosis Square-dance" where students represent chromosomes in the "dance" that takes place during cell division.

In the third year of the current project, we have partnered with North Eugene High School (NEHS) to help develop an Engineering program. NEHS secured $50,000 in state funding to develop this program, and the collaboration with the OSU College of Engineering (Rochefort) was a key component in securing this funding. One Fellow will work with teachers at NEHS to develop a 9-week *Introduction to Engineering* course, with subsequent 9- or 18-week engineering projects. The goal is to develop a program that is "exportable" to high schools throughout Oregon. This GK-12 activity is being "leveraged" through the recent award to the OSU College of Engineering of a grant from the *William and Flora Hewlett Foundation* of $1.1 million (2003 – 2006) for, *"An Integrated Learning Platform To Improve Engineering Recruitment and Retention".* Approximately one-quarter of the Hewlett Foundation grant ($250,000/3yr) has been specifically allocated for *K-12 Engineering Outreach*. The focus of the activities will be to bring expertise in engineering education down to the high school and middle school levels, with the Community Colleges of Oregon as the natural local conduit to the high schools.

For all in-school activities, we are especially interested in development of activities that can be continued even after the Fellow leaves the school. In many cases, tangible "products" were developed that can continue to be used by the teachers and also shared with teachers in other schools and districts. Examples of some of these products are 1) a series of manuals for Physics of Roller Coasters based on the experiences of an after-school club, 2) a vacant classroom at Siletz school was developed into a fully stocked science room for all grade levels, 3) an AP biology laboratory manual was revised by inclusion of enhancement activities developed by the Fellow, 4) a fellow purchased software, textbooks, and reference books, and began establishing a Math Learning Center in a rural, low achieving school district.

Phase III: Extended outreach activities.

Extended outreach activities are an integral component of the GK-12 project, due in large part to the extensive network of outreach activities currently available both at OSU and in the State of Oregon (see Table 2 below). The reasons to include this type of activity are: 1) to give the Fellows an opportunity to leverage their experiences to a larger number of students or teachers or

both, 2) to give the Fellows direct experience with the kinds of outreach activities in which increasing numbers of professional scientists, mathematicians and engineers find themselves engaged, and 3) to gain exposure to additional types of education and skills.

TABLE 2. Examples of Outreach Programs involving GK-12 Fellows

K-8 (OSU based programs)
- Saturday Academy (Corvallis and Portland)
- SMILE - Science Math Investigative Learning Experiences (rural communities)
- Hydroville Project (SMILE associated program)
- Science Education PartnershipS (SEPS – Corvallis)
- Adventures in Learning and Explorations (summer programs)
- KidSpirit (sports/arts/science summer camps)

HIGH SCHOOL (OSU based programs)
- Saturday Academy ASE - Apprenticeships in Science and Engineering (statewide)
- SESEY - Summer Experience in Science and Engineering for Youth (nationwide)
- Certificate of Advanced Mastery (CAM) – CAM Engineering for Oregon High Schools
- Science Connections (Portland)
- Association for Women in Science

COMMUNITY – K-12 and Public Outreach (Lifelong Learning)
- OMSI – Oregon Museum of Science and Industry (Portland based with statewide connections)
- MESA – Mathematics, Engineering, and Science Achievement (Portland State University)
- 4-H of Oregon (statewide)
- Girl Scouts and Boy Scouts of Oregon (and associated programs)
- da Vinci Days (Corvallis celebration of the arts and sciences)

As described above, extended outreach (approximately 180 hrs of total time) can and does occur during any portion of the Fellowship year. This flexibility is a change from the original proposal that was driven by feedback from the first cadre of GK-12 Fellows, and we have found that it has been extremely beneficial and rewarding for both the Fellows and the programs involved. In addition, the extended outreach is a wonderful tool for training Fellows (point 3 above), prior to their entering the traditional classroom environment. One example is Adventures in Learning (AIL), a two-week science and math summer program (July) for middle school children on the OSU campus. Fellows can participate in developing their own two-week course or afternoon workshop activities, or assist in the delivery of such activities. Fellows have developed courses in such diverse areas as Astronomy, Wetland Ecology, Marine Science, Geographic Information Systems (GIS), and Math as Art which have been extremely popular with students, while providing valuable "student exposure" for the Fellows and an increased diversity of offerings for the AIL program.

In most cases for extended outreach, the Fellows are integrated into existing outreach programs, even though they often create new activities for these programs, which take advantage of their individual expertise in STEM content. Fellows have the opportunity to select the extended outreach activity that most suits their interests and talents. Many times in the first two years of the program, individual Fellows "found" or "created" their own outreach activities (such as science programs for Girl Scouts or the HS Salmon Quiz Bowl) and recruited other Fellows to participate. Margie Haak, the Project Coordinator, facilitates the contacts with the extended

outreach activities. Once the contact is made between the Fellows and the outreach programs, the Outreach Coordinators direct the participation of Fellows in their outreach activities. Regardless of the specific outreach activity, the training and experience of the Fellows place them in a position to be able to make valuable contributions to the ongoing activities of each outreach effort. The response from the outreach programs in which the fellows have participated in the first two years has been an overwhelming "we want more". In many cases, the Fellows have allowed these programs to expand offerings or create programs that would not have existed without the "volunteer efforts" of the Fellow. Of particular note is that in many cases, the Fellows from the first year that are still in the area have continued to participate in and recruit for their "favorite" outreach programs. Descriptions of some of the established outreach organizations, and some examples of their ongoing outreach activities, and how Fellows have and might participate in these activities follows.

III. Outreach Programs for GK-12 Fellows

Oregon Museum of Science and Industry (OMSI). OMSI permanent facilities are located in Portland, OR. OMSI also runs an extensive Outreach Division. While OMSI was a partner in the initial grant, the reality has been that there has been less than anticipated interaction by the Fellows with this outstanding science facility. With the decision to remove the Fellows from the Portland School District, we have made a commitment for increased participation in the wide variety of activities available through OMSI. Opportunities include: after school programs at Portland area Boys and Girls clubs; summer science classes where Fellows could develop curriculum for weekly sessions; weekend science "camp-ins" at the OMSI facility for middle school students; "road shows" to Eastern Oregon to deliver science programs directly to school assemblies; Outdoor School at any of the five OMSI supported camps throughout the state; and participation in the Jason Project, for which OMSI is one of about 30 "primary sites" in the nation. Marilyn Johnson, Director of Science Education, will coordinate the interactions with Fellows. OMSI programs are aligned with the Oregon Education Act for the 21st century. Many activities are directed at teachers and enhancing their content knowledge while providing hands-on experience with resource materials.

Science Education PartnershipS (SEPS) and Science Connections. The Science Education PartnershipS (SEPS) program (Arp, 6-12 Chair) is committed to using community scientists to help teachers provide a quality science education for all students. SEPS activities are directed primarily at the Corvallis School District and surrounding communities. SEPS maintains a database of scientists, currently about 150 volunteers, who give presentations, arrange field trips, mentor individual students, and help teachers with classroom science activities. Responding to a desire to enhance science education, teachers from the Corvallis School District and scientists from OSU and Hewlett-Packard developed SEPS in 1993. SEPS currently operates with funds ($100,000/yr) from the Howard Hughes Medical Institute Foundation.

Science and Math Investigative Learning Experiences (SMILE) . The Science and Math Investigative Learning Experiences (SMILE) Program (Davis-Butts, Director) is a partnership between Oregon State University and eleven Oregon school districts, mostly rural, to provide

science and math enrichment for minority and disadvantaged students in grades 4-12. SMILE's mission is to increase the number of minority and disadvantaged students who graduate from high school qualified to go on to higher education and pursue careers in STEM professions. The program functions as a "pipeline", taking students from 4th to 12th grades and ultimately into post-secondary education. SMILE conducts a year-round schedule of activities designed to provide hands-on science experience, strengthen students' knowledge, and raise students' academic and career aspirations. SMILE began in 1988 and now serves more than 700 elementary, middle, and high school students, along with 70 teachers, in 39 schools. SMILE schools are located in areas with significant numbers of Native American and Hispanic students. The areas served are economically depressed, largely rural, and educationally under-served; levels of per capita income and educational achievement (rate of high school graduation, percent with college degrees) are below state averages.

Fellows have participated in several SMILE activities including "Elementary Outdoor Science Adventure", a 3-day outdoor science experience for 4th and 5th graders held at the 4-H Education Center near Salem. About 80 children attend each of two sessions in May. The Fellows planned curriculum, designed preliminary activities, trained teachers in those activities, trained camp staff, and conducted the camp. As another example, Fellows participated in "High School Challenge Weekend", a two-day event for high school students held on the campuses of Western Oregon University and OSU. The students complete a "real-world" environmental challenge problem that has occurred in the fictional town of "Hydroville". The problems are open-ended and involve both faculty and business professionals in planning and conducting the event.

Saturday Academy. Saturday Academy (Ellen Ford, Director) programs are pre-college, community-based education activities providing extracurricular enriched learning experiences using community professionals. These professionals share facilities, equipment and expertise through hands-on classes, workshops and mentorships to extend and augment the science curriculum of the school systems. Since 1983, Saturday Academy has provided instruction to more than 50,000 students and teachers in urban, suburban and rural communities in Oregon and southern Washington. Fellows have taught workshops in Astronomy, Geographic Information Systems (GIS), Chemical Engineering for high school girls, and LegoRobotics for middle school girls. In a different model involving "one-on-one" mentoring, Fellows participated in the Science Mentor and Apprentice-ships in Science and Engineering programs that encourage students to pursue STEM degrees.

Summer Experience in Science and Engineering for Youth (SESEY). The SESEY program (Rochefort, Director) was initiated in 1997 with seed funding from the Dreyfus Special Grants Program. A collaboration between Chemical Engineering and Bioengineering at OSU, the focus is on underrepresented high school students (girls and ethnic minorities) who have an interest in math and science. The students (approximately 25 per year) are brought to the Oregon State University campus for a one-week summer camp where they are paired with a faculty mentor in engineering for a mini-research project. The emphasis is on exposure to engineering and science as a viable and interesting career path. Engineering Fellows have served as project mentors,

discussion group leaders, and dorm counselors.

Evaluation and Assessment

Evaluation of the impact of this type of activity is always a challenge, and we have been working with experts in the SMET assessment area (Dr. Edith Gummer) to develop tools for informal and formal short term and longitudinal assessment. These include 1) informal and ongoing program evaluation, 2) qualitative and quantitative internal evaluation, and 3) external evaluation. All three approaches will be used to make adjustments to the program as necessary, and to determine if our goals and objectives are being met.

Informal and ongoing program evaluation: Many sources of information are constantly made available to the leadership team and used to make immediate adjustments in the program. These include diverse sources such as input from Fellows at the biweekly seminars, input from GK-12 teachers at workshops and via personal communications, conversations with parents and other teachers, the advisory board, classroom observations, and other sources. This information is constantly being taken in, considered, and used to make adjustments where necessary. As just one example, we heard from Fellows and Teachers that the summer courses, while useful, were not providing some of the practical teaching methods and classroom management skills the Fellows needed once they entered the classroom. We responded by making adjustments to the classes, and are continuing to find the right balance between pedagogy and pragmatism.

Qualitative and quantitative interna l evaluation: Prof. Gummer, an evaluation specialist in the Science and Mathematics Education Department, will conduct both a quantitative and a qualitative evaluation. She will develop a quantitative instrument that appropriately identifies and measures the effect of the fellows on student achievement. Qualitative observations and interviews will document the change process of both the GK-12 Teachers and the Fellows. In the first three years we have attempted to modify existing instruments for use with the Teachers and Fellows in the GK-12 program. However, the instruments were not designed for this application. Under the direction of Prof. Gummer, a graduate student in the Department will develop a new, specific instrument which will be used for all Fellows and GK-12 Teachers.

Externa l evaluation: In the spring of the second year, we will assemble an evaluation team to spend a day meeting with focus groups (GK-12 Teachers, Fellows, students, Fellow advisors, Outreach and Department Liaisons, Leadership Team) and learning about the impacts of the program. Prior to the meeting, the team will be provided with information about the program including the goals and objectives, participants, and the objectives of the evaluation. The evaluation team will consist of three members, one teacher from a school district not associated with the project, one teacher from within a participating district (but not from a participating school), and one education professional from another University. Such a team met on March 13, 2002 to evaluate our current project. The team prepared a 16-page report that has been valuable to us in making immediate adjustments and in preparing for this renewal proposal. Most

importantly, however, the evaluation validated what we already believed—that the project was going very well and that with some minor adjustments, it could be even better.

Preliminary results from Internal Evaluation: Prof. Gummer and a doctoral student from SMED are currently conducting an internal evaluation. Preliminary results from a survey administered to both Fellows and GK-12 Teachers indicate that goals of the GK-12 fellowship program are being met. For example, at least 80% of the Fellows stated that being a GK-12 Fellow has changed their views on science teaching and learning, improved their confidence in talking about science with non-technical audiences, and they felt a responsibility to continue to stay involved with public schools and other outreach programs. The majority also felt they now had a better appreciation for inquiry-based teaching and a better understanding of K-12 education. Over half of the teachers surveyed felt they had increased their content knowledge as a result of having a GK-12 Fellow in their classroom. All of the teachers felt that their students had benefited from their interaction with the Fellows. They reported that many students had changed their views on what type of person can become a scientist and about what it means to be a scientist. The teachers also reported feeling more confident in planning and teaching inquiry-based lessons. More information will be available at the time of the ASEE National Meeting in June 2003.

Benefits of the GK-12 Project

As anticipated, the benefits of the current project have manifested themselves in distinct ways and we expect that these benefits will continue. For example, the *GK-12 Fellows* have gained valuable knowledge and experience in delivering science and mathematics education to diverse audiences. Their communication skills have improved, their content knowledge was enhanced, and their teaching skills have matured. Already, we are finding that this experience is advantageous to Fellows as they apply for jobs. In the long run, we expect former Fellows to become ambassadors for the importance of science and mathematics outreach in the schools and the community. Based on the continuing participation of former Fellows in outreach activities, we believe this expectation will be realized!

The *teachers* who work directly with Fellows have the benefit of a motivated, enthusiastic, and trained individual to assist in the delivery of science and mathematics education. These teachers benefit from the content knowledge of the Fellows and their involvement with research. Teachers not directly involved also benefit from the projects that are developed and the resources that are made available. The excitement generated transfers into additional classrooms and schools. Many teachers benefit from training activities in which the Fellows participate.

Students, however, are the major benefactors of this project. As shown in Table 1, if we extrapolate the two year totals to the third year, well over *6000 Oregon K-12 students* will have been impacted by the NSF project!.A much larger number benefit indirectly (e.g. through teacher education, activity development) or directly (e.g. through extended outreach activities). In addition to a better science education, students also learn that women can be engineers and scientists, scientists can be Seattle Mariners baseball fans, and that college is not an impossible dream.

Higher education also benefits from this project. The OSU faculty have become more connected with education as a continuum. A long-term benefit of the project will be increased enrollment at OSU and other universities of individuals from minority groups currently underrepresented in science and engineering. This benefit is expected as a result of our targeting schools with high populations of underrepresented individuals and the continued development of "pipelines" from these communities to OSU.

Conclusions

The GK-12 program works! The assessments will allow us to put some quantifiers to the already abundant anecdotal evidence. Sustainability of this type of a program beyond the NSF funding years is a question we are still wrestling with. The key result is that we currently have a cadre of highly motivated graduate fellows (soon to be scientists and engineers!), faculty, K-12 teachers, and public school administrators, and we need to keep that momentum going.

Acknowledgements

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