6-12 Teacher--University Faculty Partnerships to Improve Science Education

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Abstract — A new graduate course for in-service teachers, *Science Research in the Classroom*, was piloted at Kansas State University in Summer 2005. The purpose of this course was to create strong partnerships between middle- or high-school science teachers and university faculty members in science, technology, engineering or mathematics (STEM). Together, the teacher/STEM faculty member partners developed instructional modules based on current scientific research. These modules were delivered at an established summer outreach workshop for middle-school girls. Feedback collected at the end of the course indicated that in general, the teachers were very happy with their participation and felt that the expectations that they had for the course were met. They were very positive about their interactions with their faculty partners and pleased with their experience in taking part in the outreach workshop. Early results provide some insight into the issues involved with integrating on-going science/engineering research with standards-based 6-12 science instruction.

Introduction

While the United States has long prided itself on the excellence of its educational system, particularly its leadership in science, technology, engineering, and mathematics (STEM) disciplines, trends at the end of the twentieth century cast doubt on the continuation of this pre-eminence (National Commission on Excellence in Education, 1983) as well as on the capacity of schools to promote both excellence and equity in STEM instruction (American Association for the Advancement of Science, 1993; National Research Council, 1995). A variety of high-level commissions have made recommendations for the improvement of STEM education in K-12 and undergraduate institutions (Advisory Committee to the National Science Foundation, 1996; Committee on Mathematics and Science Teacher Preparation, 2001).

A common theme in these recommendations is the need for closer linkages among the components of STEM education: K-12, community colleges, undergraduate institutions, and research institutions (Committee on Mathematics and Science Teacher Preparation, 2001). Some of the issues that have been identified are (1) that many teachers, especially those who teach middle school science and mathematics, do not have specialist background in these disciplines; (2) that there is little or no awareness among the research communities in science and mathematics of the issues involved in K-12 education in these disciplines; and (3) that some faculty members in schools or colleges of education, especially those who are engaged with graduate programs, may have had little or no recent direct contact with teachers in classroom environments (Committee on Mathematics and Science Teacher Preparation, 2001).

To address these issues, federal funding agencies including the National Science Foundation (NSF) and the Department of Education, as well as a number of private foundations, have created programs to foster creative solutions, some of which encourage collaborative approaches to teaching and teacher education. For example, collaborations that link STEM faculty with College of Education faculty have led to a better alignment of the content presented in discipline-specific courses to the science standards that pre-service teachers (teacher education students) will be expected to teach. These collaborations also have helped STEM faculty members diversify the teaching methods they use, enabling them to model the use of a variety of instructional approaches to the pre-service teachers (Committee on Mathematics and Science Teacher Preparation, 2001). The 2001 National Research Council report on STEM teacher education points out that "neither the higher education nor the K-12 communities can successfully improve teacher education as effectively in isolation as they can by working closely together" and recommends that "many more scientists, mathematicians, and engineers must become well informed enough to become involved with local and national efforts to provide the appropriate content knowledge and pedagogy of their disciplines to current and future teachers". (Committee on Science and Mathematics Teacher Preparation, 2001, p. 8)

These types of collaboration will become increasingly important as changes made in K-12 education begin to impact higher education. For example, the extent to which special needs students are now integrated into the regular classroom has resulted in an increase in the number who continue into higher education. Increasingly, college faculty members are being expected to make accommodations to the special needs that these students bring. Similar issues arise with increasing access to STEM undergraduate education by women and minority populations (NSF, 2006). Mechanisms must be put in place to expose college faculty to the techniques and effective practices that have been developed at the K-12 level.

The Local Situation.

Kansas State University (K-State) has had a variety of successful and productive interactions with K-12 districts and teachers in Kansas. A number of summer workshops and on-line courses have been developed by college STEM faculty for the purpose of introducing classroom teachers to effective laboratory procedures. For example, the GENE Project introduced biology teachers to the use of yeast as an effective organism for teaching genetics (The GENE Project, 2006). Visual Quantum Mechanics (VQM) works with high school physics teachers to make mathematically sophisticated concepts in quantum mechanics accessible to high school students through computer simulations (KSU Physics Education Group, 2006). Faculty members in the College of Education routinely provide workshops on effective curricular materials, such as FOSS or Project Wet, as well as the use of professional learning communities through efforts such as the Advancing Content Understanding in Mathematics through Effective Networks (ACUMEN) Project funded by the Kansas Department of Education.

The K-State College of Education uses a professional development school model for teacher preparation. Collaborations with surrounding school districts include the use of K-12 classroom teachers to provide some of the instruction in pre-service methods courses as well as the use of college faculty to respond to targeted professional development needs of the school districts. Two extramurally funded projects ("Equity and Access" funded by the U.S. Department of Education and "STEMP: Mathematics Teacher Preparation Partnership" funded by NSF) link

Kansas State University with school districts and community colleges serving a growing Hispanic population in the southwestern part of the state for the purpose of increasing the number of Hispanic youth who are prepared to become teachers.

The Girls Researching Our World (GROW) Project at K-State has existed since 1999 with the primary goal of fostering the interests and increasing the participation of girls and women in science, technology, engineering, and mathematics (STEM) (Franks et al., 2002, Spears et al., 2004). A 2001 dissemination project grant from the National Science Foundation included linkages with school districts. One purpose of these linkages was to have the schools help project directors to track girls who took part in GROW programs and measure impacts on their academic successes (Spears et al., 2005). The grant also supported the tuition of teachers from these districts for enrollment in a graduate course on gender-equitable methods in science and math instruction taught by one of the authors of this paper (J. D. S.). A third element of the linkage was the creation of partnerships between middle- and high-school teachers and University faculty members to build on the teachers' expertise in pitching our project activities at a suitable level to engage our middle-school audience. Since the start of the GROW Project, 16 teachers have worked with project leaders and K-State faculty members on developing and delivering activities during the annual GROW Summer Workshops.

The Howard Hughes Medical Institute (HHMI) provides support for K-12 science education through its Pre-college Science Education Program and through the pre-college components of its Undergraduate Science Education Program. Some of the activities funded by HHMI are innovative classroom, laboratory, and field activities for pre-K to 12th-grade students, programs that provide teachers with opportunities for professional development, and outreach activities that reinforce the important role that parents and communities play in science education. The HHMI 2002 Undergraduate Science Education Program award to K-State included a pre-college program that expanded upon the university faculty member/grade 6-12 science teacher partnership concept initiated on our campus for activities conducted by the GROW Project. The intent was to offer a more in-depth experience for the teacher and the university faculty member by encouraging a longer duration interaction and creation of a classroom activity based on aspects of research ongoing at K-State.

Structure of the Course

A course called *Science Research in the Classroom* was created and offered during the summer 2005 session as a graduate-level secondary education course. The course was advertised at statewide science and gifted student teachers' conferences. The following description of the course with information about its objectives was provided:

> "By completing this course, in-service teachers will 1) get a closer look at the scientific research process through interaction with a K-State faculty member; 2) develop an activity to be used at the middle or high school level; 3) deliver this activity for the GROW Summer Workshop (June 15-17, 2005); and 4) be videotaped delivering the activity for the other students in the class and have it critiqued by peers and education professionals."

To apply for participation in the course, the teachers submitted a professional resume, information on the grade levels and courses that they taught, and a description of the area in which they wished to develop an activity. The participants would receive a $1500 stipend, a small laboratory supply budget for their classes, tuition, and room and board on campus. Four teachers applied for the course.

One of the authors (B. A. M.) arranged pairings of teachers with K-State faculty members conducting research in the general area of interest of the teacher. Two of the teachers worked with junior faculty members, one in Biology, and one in Physics, who were developing their first activities for the GROW Workshop. Another teacher was partnered with a Biology faculty member who had participated several times in the GROW Workshop. A faculty member to work directly with the fourth teacher could not be identified but a postdoctoral fellow and two graduate students in Biology acted as consultants to assist her. Interestingly, all the teachers, university faculty, and university students and staff who took part in the 2005 course are women.

The teachers and their university scientist partners were put in email contact and charged with discussing their common interests and initiating the collaboration. These activities were to be completed by two weeks prior to the workshop. The on-campus portion of the course was conducted over three weeks. The GROW Workshop occurred during the second week of the workshop. In the first week, teachers met the course organizers, their university partners, and one another. They developed the activities to be conducted at the workshop. Another activity of the first week was a tour of the facilities of the K-State Regents Educational Communications Center (ECC), at which the taping of their activities was to be conducted. By the end of the first week, the teachers developed an instructional outline for their activity. The outline included a title, an instructional overview and timeline, the purpose of the activity, the grade level of the intended audience, student learning outcomes, references to pertinent sections of the science standards, a plan for implementation, a plan for assessment, and a list of print and website resources for the unit.

During Monday and Tuesday of the second week, final preparations for the activity were made. The GROW Workshop took place on Wednesday through Friday of the second week. The four teachers were responsible for their individual sessions and then free to attend the remainder of the workshop.

In the third week, rehearsal and taping of the session at the ECC took place. One of the activities that had taken place on the Konza Prairie Biological Station had to be extensively modified to fit the time and indoor venue of the taping session. The other three activities required only minor modifications to fit the taping session. The teachers were asked to deliver the activity in as close a fashion as possible to the approach that they would use in their classroom. Each taping session lasted approximately one hour. During the taping, which was done in an electronic classroom, the teachers made use of PowerPoint presentations, live demonstrations with scientific equipment, hands-on interactions with the audience, a whiteboard, and previously shot still pictures illustrating various concepts. The audience for the taping session consisted of the four teachers, the course organizer (B. A. M.), and one of the partner scientists. Feedback forms critiquing each presentation were completed by the audience members. Each teacher was provided with a tape of her session and a summary of the critique of her presentation. Following

the taping, the four teachers completed a course evaluation that was sent to the K-State Office of Educational Innovation and Evaluation, who compiled the information.

Examples of Teacher-Scientist Collaborations

A brief description of each teacher's activity illustrates the variety of ways in which teachers and university scientists collaborated. One of the teachers, who is currently teaching 5th grade gifted and talented students, worked with a Biology faculty member who offers a genetics activity called "Meet the Beetles". The teacher helped the faculty member refine the activity to make it more effective for younger students and developed it further for use in her own classes.

Another teacher, who is certified to teach biology, chemistry, general science, and earth science in grades 7-12, developed an activity in conjunction with a Biology faculty member. This session was titled "The War on Germs" and featured hands-on activities on microbe transfer between people. The K-State scientist is an immunologist who helped the teacher with information about the immune response to infections. The teacher helped the scientist provide information at a level the middle-school students could understand.

A third participant, who teaches life, earth, and physical science in grades 5-8, helped a Physics faculty member adapt college-level demonstrations on the properties of light for use with middle-class students. Entitled "Why is the Sky Blue?" this activity made use of a variety of instruments to demonstrate the properties of light.

The fourth participant, who taught 9th grade biology, worked with graduate students in Biology to expand a classroom activity on biodiversity to incorporate the use of the Konza Prairie Biological Station. The teacher gained insight into how to use field sites to augment classroom instruction as well as ways of integrating artifacts from field sites into classroom teaching. During the GROW Workshop, the activity "Estimating Plant Species Diversity" was conducted on the Konza Prairie Biological Station, but the lesson developed was versatile enough to be done in a classroom.

Evaluation Results

The course evaluation/feedback form that was used to assess the initial offering of *Science Research in the Classroom* asked the participants to describe 1) what expectations they had for the course, 2) whether their expectations were met, 3) how the course components compared in terms of their effectiveness, and 4) any suggestions to improve the course.

In general, the teachers were very happy with their participation in the course. They noted a few challenges such as problems coordinating with the faculty partner and issues in dealing with the University library. Most frequently mentioned were concerns with the taping of the sessions at the ECC. This engendered a high level of anxiety, in part because they were forced to make decisions for videotaping and to adjust for differences between the taping environment and the typical classroom environment. Other suggestions for improvement included introducing more structure into the program and providing necessary equipment earlier in the course.

Despite these concerns, the teachers found the experience to meet or exceed their expectations, enjoyed working with the course instructor, other program staff, and the GROW workshop, and appreciated the opportunity to collaborate with other science teachers during the course.

Course participants indicated that they will include the lessons they prepared this summer in their science classes this year. They benefited from the interactions with other teachers, and some plan to share recordings of their lesson with other teachers. In addition, the participants felt that their students will benefit from their experiences because they feel they have improved their teaching skills and because students will learn the knowledge they gained.

Discussion

The authors believe that this model offers benefits for both 6-12 teachers and university faculty members. Teachers gain knowledge of active research at the University. K-State faculty members gain assistance in contextualizing their research in a way that is appropriate for the middle- or high-school classroom. Tomanek (2005) points out that successful partnerships between university and 6-12 teachers must be two-way; they must be initiated by the teachers who identify the areas in which their current curricula are deficient; and university faculty must become involved partly to enhance the education of their own students. Moreno (2005) identifies a number of pitfalls in creating partnerships and offers recommendations for productive ones. Among the latter are that teacher participation should be voluntary, that the school-university partnerships should be long-lasting, and that change takes time.

Furthermore, the inclusion of science research into 6-12 classrooms should foster the interests of all students in participation in STEM (Dolan & Tanner, 2005). It also is the authors' hope that involvement in an outreach program specifically targeting female students and students from under-represented groups will have benefits in terms of the teachers becoming more aware of the need to include such students and encourage them to consider higher education in STEM fields.

Acknowledgment

This project is supported by the Howard Hughes Medical Institute under its 2002 Undergraduate Science Education Program award to Kansas State University. We thank Doris Merrill for her excellent assistance in arranging the Summer 2005 offering of *Science Research in the Classroom* and Susan Arnold Christian for overall coordination of the GROW Summer Workshop. We thank the K-State Office of Educational Innovation and Evaluation for their work on the evaluation of the course.

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