Scientists Becoming Teachers:

Lesson Learned from Teacher Partnerships

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Abstract: This paper will describe the lessons learned from a research project sponsored by NSF that involves graduate teaching fellows in K-12 education programs. Themes emerging from our sites will be shared that includes the role of collaborations and community building along with the integration of technology in the curriculum. Across these sites inquiry- and problem-based learning are being uniquely implemented. Data is indicating that the greater the communication, the more supported a teachers feels in his/her classroom, and the more collaborative the fellow-teacher team, the more likely inquiry- and/or problem-based learning is employed. In short, this paper will present a set of factors that best support inquiry-based learning in science and mathematics education.

The National Science Foundation's Graduate Teaching Fellows in K-12 Education (GK-12) Program supports teaching fellowships for graduate students in the sciences, mathematics, engineering, and technology (SMET) disciplines (Award #0086455). The GK-12 Program is a collaboration of three campuses: University of Illinois at Urbana-Champaign (which is the lead institution), University of Alabama at Birmingham (UAB), and University of Alabama at Huntsville (UAH) (http://gk12.ncsa.uiuc.edu). The graduate students collaborate with SMET and Education faculty and participating K-12 teachers to integrate the use of computer-based modeling and scientific visualization in science and mathematics education. Responsibilities of these graduate students include visiting classrooms to observe, offering assistance to the collaborating teachers, and co-teaching courses with these teachers. Responsibilities of the faculty include mentoring the graduate students and the participating teachers.

The goals of this GK-12 program include (Jakobsson & Braatz, 2000):

- Develop sustainable partnerships among SMET faculty, education faculty, and school districts through the participation of graduate students with math and science domain expertise.
- Provide professional development opportunities for participating teachers and education faculty related to computer-based modeling, scientific visualization, and informatics.
- Provide professional growth opportunities for aspiring scientists, mathematicians, and engineers, especially encouraging them to concern themselves with education at all levels.
- Integrate computer-based modeling, scientific visualization, and informatics in K-12 classrooms.

The GK-12 program in the first year (2001-2002) at the University of Illinois involved three public high schools and one vocational education school in four geographically distributed cities in Illinois. Six GK-12 teams were placed in six classrooms within these four settings. Each GK-12 team comprised of a graduate fellow, a teacher, a university mentor, and an evaluator. The graduate fellows who are scientists-in-training and their collaborating teachers, however, make the core of each GK-12 program team.
The graduate fellows in the first year at Illinois included a computer scientist teaching calculus in a high school classroom, a mathematician teaching calculus in a vocational classroom, a molecular biologists teaching bioinformatics in an advanced placement high school biology classroom, another molecular biology teaching bioinformatics in a freshman high school honors biology classroom, a chemist teaching molecular visualization in high school biology and chemistry classrooms, and an information scientist with a mechanical engineering background teaching heating, ventilation, air conditioning and repair in a vocational classroom.

The GK-12 programs in Alabama at UAB and UAH involved two Fellows at each site during Year 1.GK-12 Fellows in the Alabama sites were from the departments of mathematics and computer information science. These Fellows provided assistance to K-12 educators in two high schools in Birmingham and five schools in Huntsville. Each Fellow worked with a Mentor Teacher as well as a university Faculty Mentor. Fellows participated in specific training in educational pedagogy to prepare them for their experiences in K-12 education.

The computer science Fellow actually assumed full responsibility for teaching a computer science class in C++ at one of the high schools. The teacher assigned to the class had not had previous training in this computer language, resulting in this Fellow teaching computer science to the teacher as teachers and students in the areas of mathematics modeling, visualization, and computer programming. The emphasis in these settings was on using modeling and visualization to solve real world problems. Teaching methods developed by the Alabama Supercomputing Program to Inspire Computational Research in Education (ASPIRE) http://aspire.cs.uah.edu. were used by these Fellows.

Objective of the Paper
The objective of this paper is to present the lessons learned by different GK-12 programs. Views will be shared from the principal investigator, a graduate fellow and participating teacher, a mentor, education faculty, and the evaluation and research team that have been studying the impact of the program in each classroom.

Significance
During the first year of this project, a key focus has been understanding the learning and teaching context in each of the classrooms served by Fellows. In the Illinois sites, a mixed-methods approach in data collection, such as classroom observation, unstructured interviews, and online surveys of all participants was used. In addition, educational projects and products developed by the Fellows provided archival evidence of the effectiveness of the project. At the Alabama sites, a mixed methods approach was also used, however, the methods for collection of data varied slightly from those used in the Illinois sites. Use of a case study approach provided rich, thick data about the experiences of the Fellows in the sites. The GK-12 program in Alabama was, itself, the unit of analysis, with the experiences of the fellows providing the rich, thick descriptions of the interactions of the Fellows with the teachers and the learners.

One story emerging from each classroom site has been the shift in response of high school and vocational students to the new visitors in their classrooms – the graduate fellows. In the beginning a typical response from a student to the fellow would be “show me” relating to visualization and modeling of a concept being taught by the fellow-teacher partnership in the class. Towards the end of the first year, however, the response from such student is: “Now let me show you”. This shift in response has inspired scientific inquiry in classrooms (Comstock, Bruce, Harnisch, & Mehra, 2002). In parallel, another shift has been within the fellow-teacher partnerships as both have emerged as “learners” in different situations. Thus, this symposium intends to focus on the lessons learned (or emerging themes) that have arisen from the classrooms in Illinois and Alabama.
Based upon first-year data, we are seeing certain themes emerge across research sites: (1) commitment to excellence, (2) role of collaborations, (3) community building, (4) meaningful technology integration, and (5) facilitation of inquiry- and problem-based learning.

The concept of “excellence” or the desire to excel became evident in the Fellows’ individual approaches to challenges within the K-12 settings as well as teacher and administration commitment to professional growth. In an example of the former, one Fellow met significant teacher resistance to the introduction of certain applets that could help the students grasp basic arithmetic and more advanced physics concepts. The Fellow adapted new strategies to overcome initial reluctance and—ultimately—was able to use these with the students. A student’s response to one of these applets was, “Wow, this really helped me visualize it!” Interestingly, the Fellow had never used the word “visualize” with these introductory students; the term was wholly his own. This student, encouraged, “played with” the applet even outside of class time, which was a breakthrough moment in creating understanding at this particular site.

The commitment to professional excellence was evident in the levels of dedication teachers demonstrated by their willingness to grow and learn. For instance, these teachers demonstrated openness to reversing the “teacher-learner” role with both the Fellow and with his/her students in the classroom; communicated with the Fellow, students, administration, and other educators; and sought to mentor other educators both locally and at the national level (presenting at conferences, online resources, etc.). Administrative excellence was evident by districts’ strategic goal-setting and support of its teachers by offering periods off for planning; creating open and clearly defined avenues for communication between faculty and administration; financially supporting workshop and training opportunities; and actively seeking new funding to support these endeavors (Comstock, Harnisch, Bruce & Mehra, 2002).

The role of collaborations and community building are becoming uniquely evident across sites in the relationships developing between Fellows and teachers, Fellows and students, teachers and administration, teachers and other educators/community at large, and Fellows and mentors, as well as the within the larger GK-12 Project Team. A single example is how teacher-Fellow teams create roles for themselves in the class room environment. Of particular note in these emerging roles is how a collaborative model of teaching appears to be the most successful (Comstock, Bruce, Harnisch, & Mehra, 2002). This is one in which both teacher and Fellow mutually defer to each others' areas of expertise and both adopt a reversal of roles with the students, allowing for the students to become the "experts" as opportunities arise.

The meaningful integration of technology is key at each of the sites, and differs in each K-12 environment. As noted above, one learning environment was resistant to the integration of visualization tools. Trust needed to be developed over the course of the entire year in order to implement some of these technologies. On the other end of the spectrum, another site utilized an advanced scientific tool for molecular biologists (Biology Workbench) to such an extent that the students actually assisted the Fellow in identifying specific genes for mutation in his/her own doctoral research. The students' understanding of bioinformatics—the sophisticated use of technology and information in service to science—was directly relevant to the curriculum, and took them beyond it into the realms of "real" science.

Finally, across these sites inquiry- and problem-based learning are being uniquely implemented or abandoned, based on the afore-mentioned themes. Data is initially indicating that the greater the communication, the more supported a teacher feels in his/her classroom, and the more collaborative the Fellow-teacher team, the more likely inquiry- and/or problem-based learning is employed. According to the Center for Science, Mathematics, and Engineering Education at the National Research Council, inquiry-based learning provides a framework in which both abilities and understandings in the sciences can be achieved (from "Inquiry and the National Science Education Standards: A Guide for Teaching and Learning"). Therefore, the identification of what factors best support inquiry-based learning are quite relevant to today's science education community.