AC 2008-596: PARTNERSHIPS FOR BUILDING THE NATION’S STEM EDUCATIONAL ENTERPRISE: A NSF GK-12 FELLOWS PROJECT

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Partnerships for Building the Nation's STEM Educational Enterprise: A NSF GK-12 Fellows Project

Introduction:

Several reports indicate lack of proficient performance of America's children in science and mathematics. The reports also indicated the need to give teachers the tools they need to enrich the learning opportunities for K-12 students in science and mathematics. Particularly, these tools include the professional development and training on content materials to the teachers. Below, we first summarize a few of the findings from these reports which motivate our educational research. Further, we provide details of our research and observations.

"Recent reports of the performance of America's children and youth from both the Third International Mathematics and Science Study (TIMSS, 1999[1] and 2004[2]) and the National Assessment of Educational Progress (NAEP, 2000[3]) echo a dismal message of lackluster performance"[4]. For example, TIMSS (2004 [2]) report "suggests that the performance of U.S. fourth-graders in both mathematics and science was lower in 2003 than in 1995 relative to the 14 other countries that also participated in both studies". According to the National Commission on Mathematics and Science Teaching for the 21st Century, the learning shortfalls are due in part to a shortage of qualified science and math teachers (Sterling, 2004[5]). Another report by the National Science Board notes that in the period 1990-2003, most students in grades 4, 8 and 12 did not reach proficient performance levels in both mathematics and science (NSF 2006[6]). Furthermore, under the No Child Left Behind (NCLB) act of 2002, policy makers have relegated science to the backburner by directing a majority of the resources to reading and mathematics-the first areas to be assessed and reported with adequate yearly progress (AYP) (Slutskin, 2005[7]). Science is slated for testing only in 2007-2008, and only a few school divisions have started monitoring their competency in science. In the State of Virginia, only 48% of school divisions met the AYP requirement for 2004-05[8].

A recent report by the BHEF[9] (Business-Higher Education Forum 2007) states "…chronic low student interest and achievement in mathematics and science poses an acute challenge to American economic competitiveness." The BHEF membership is made up of members from business and academia.

"Now three decades old; it is time that the nation heeded it - *before it is too late*"[4]. A National Research Council panel (Brunkhorst and Lewis, 2000[10]) issued a report that urged increased cooperation between universities and GK-12 schools in teacher education and professional development for teachers of science and mathematics. The NSF GK-12 program offers a unique opportunity to address this need.

This paper documents the development, implementation efforts, and preliminary results of SUNRISE (Schools, University 'N' (and) Resources In the Sciences and Engineering-A NSF GK-12 Fellows Project), a unique graduate Fellowship program that targets graduate students working in the grade 4-6 school environment. SUNRISE is a new GK-12 project, initiated in July 2007 that is aimed at partnering STEM (Science, Technology, Engineering, and Mathematics) graduate students (Fellows) with school teachers from three different school divisions in Northern Virginia. The conceptual focus of the SUNRISE project is to improve outcomes for elementary and middle school students in STEM subjects as identified and driven by the science needs at the schools in the participating school divisions. The objective of this project is to build a unique model of collaboration among elementary and middle schools, school division administration, and the University to foster systemic efforts in implementing Information Technology (IT) rich STEM content-knowledge into grades 4-6 education by graduate Fellows, with the potential to enhance the delivery of science instruction and provide long term professional development for teachers. This is achieved by constructing a framework that provides training, exchange of information, and integration of scientific research from diverse disciplines with teaching to make science exciting for students. Sponsored by National Science Foundation's GK-12 program, the implementation of this project serves as an exemplary model for the emerging trends in STEM education at the elementary and middle school level.

The paper is organized as follows. We begin with a very brief summary of the SUNRISE project’s unique feature, implementation, ongoing activities, and evaluation plans. Next, we present our preliminary observations, and conclude by stating some of the challenges of SUNRISE.

A Unique Feature of SUNRISE Project:

In this Section we highlight a unique feature of SUNRISE that makes this project different from other GK-12 projects in the nation. This is one of the very few GK-12 projects that are steered by engineering faculty. The project is housed in the School of Information Technology and Engineering which is unique in the nation unlike the traditional College of Engineering. The project is focused on infusing Information Technology (IT) rich STEM concepts into K-12 education. Sample IT rich STEM topics include infrared imaging, global positioning systems, oceanography, computer models of weather, acoustics and how sound is used for temperature measurements and navigation in animals. Every effort is made to show computer models and graphics to allow students to discover the science and engineering concepts. The projects IT theme serves multiple purposes. It motivates teachers to use more technology in the classroom, improves perception of concepts via simulation and graphics, excites students interest in STEM topics who are growing up with more gadgets than ever, and the IT theme is inline with the employment demography of Northern Virginia which has a high percentage of IT jobs in both industry and the federal government.

Implementation:

The implementation started with the recruitment of Fellows and Teachers in 2007. The program supports 8 Fellows from STEM disciplines who are paired one-on-one with 8 teachers, one pair per school. Of the eight fellows, four are in engineering disciplines with the rest in physics (two), mathematics, and biochemistry. 50% of the Fellows are women graduate students. One of the eight spoke a language other than English at home. The fellows were given a two month long training program by the project co-PI from the College of Education and Human Development. The training included an understanding of the Virginia State Science Standards of Learning (SOL) [11], preparing and delivering of sample lessons, and discussing general topics on pedagogy particular to elementary school teaching. The Fellows worked out a schedule with the teacher at the Fellow-Teacher meeting just before school reopening in September 2007. The Fellows began their visits to classroom, identified the science needs with the teacher and began contributing to the enrichment of the lessons and discussing the science behind the lessons. The Fellows were introduced to the children as Scientist, Researcher, or an Engineer. Thus, a strong foundation was laid for a long-lasting partnership between the school and the university.

Ongoing Activities:

One of the key activities of the Fellows is the enrichment of existing curriculum and leading the discussion of the science behind the experiments. The Fellow and the teacher plan the activities a week ahead so that there is sufficient time to enrich and test the lesson before they are presented to the classroom. Another activity consists of bringing lessons from their engineering and science research, and graduate education into K-12 environment. These new lessons are tied to the SOL and the IT theme is emphasized where applicable. Fellows also act as guest lecturers in other science classes who are not participating directly in the SUNRISE project. The Fellows help with field trips, judge science projects, and answer general science questions that are dropped in a question box.

Examples of lessons that were enhanced with a deeper understanding of the science behind it include waveforms, light's electromagnetic spectrum, alternative fuel energy, earth science and so on. Some highlights of the advanced engineering and science lessons that are not part of the textbook include experiments to understand decision theory, infrared properties, RADAR, and protein bonding. At one school, a weather bulletin board was created by the Fellow with different instruments purchased with project funds. Students regularly take readings from these instruments and also perform simple statistical calculations. Infusing more IT rich STEM topics are planned for the second half of the first year of the project between February and June 2008.

Impact Indicators:

We measure the impact of the project on Fellows, teachers, K-12 students, school, and GMU using certain indicators as described below and in the extensive evaluation plan, which is described in the next section. The following impact indicators are monitored.

Fellows: Number and quality of applicants; satisfaction level with the program; opinions of teachers, principals, research advisors and Fellows, Fellow's; communication and teaching skills; and their progress in their research projects and towards their degree. Much of this information is currently being collected in the form of surveys, and discussion with school principals and research advisors.

University: Increased interest in participation by faculty and graduate students; adaptation of GK-12 like activities as an option within graduate education for all students.

K-12 Students: Test grades if available; knowledge of what a scientist (mathematician, engineer) does; understanding of and ability to use the scientific method in solving problems; attitude toward science; interest in STEM careers; attitude toward the Fellow. The Fellows conduct pre and post test for every lesson that is being implemented and teachers monitor their student's overall performance in weekly and quarterly tests.

Teachers: Number and quality of applicants; comfort with STEM and using inquiry methods in STEM classes; time in class spent on STEM; knowledge of STEM; increase in professional activities such as publications, and attendance at professional meetings.

K-12 Schools: Evidence for the use of GK-12 developed teaching methods and materials by others in the schools, and number of schools and teachers asking to be included in GK-12.

Information on the above indicators is collected via observations, surveys and regular interviews. Both teachers and Fellows are aware that the project staff would contact them for participation in post-project evaluation efforts to track long-term effects of the project. An effort to track K-12 students is being initiated with the help of the school administration.

Project Evaluation:

Since the project's inception in July 2007, a baseline survey and a few visits to the participating schools have been completed by the project evaluator. We present our evaluation plan below and report on the some of the findings in the next section.

A two-pronged evaluation design is employed to assess the success of the project in meeting its goals and objectives, focusing respectively on: a) *formative evaluation* of training and implementation processes during the first year, with the goal of making refinements and adjustments to procedures in subsequent years of the project; and b) *summative evaluation* of the impact of the project on: i) the University's higher education program and in the development of teaching Fellows; ii) K-12 institutions served in enhancing student performance; and iii) the long-term professional growth of participating Fellows and teachers, beginning in the second year of implementation. The anticipated outcomes of the project, as given in the NSF Request For Proposals, were used as the guiding framework to formulate the specific goals and objectives of SUNRISE against which project outcomes are continuously being evaluated. The evaluation focuses on the benefit of the project to the Fellows' education and development of professional skills, the teachers' growth in content knowledge, the K-12 students' problem solving expertise and attitude toward science, and cultural changes that this project has on the schools and the university. The evaluation also considers the role played by the Fellows' research advisors in the program, and the long-term effects of participation in the program for teachers and Fellows.

Sample questions that are being answered by the evaluation are: 1) How does the project benefit the education and professional growth of the Fellows? 2) What do the Fellow's research advisors know about GK-12, SUNRISE, and their advisee's role in the program? 3) What is the effect on the participating teacher's science content knowledge? 4) How is the project supporting teachers in their implementation of inquiry-based science? 5) What are student outcomes in science content knowledge, problem solving ability, and attitude toward/interest in science? 6) What are the lasting effects of participation in the project on the Fellows and teachers? and, 7) How are project results being disseminated? The following qualitative and quantitative data is collected and delivered to the evaluator to answer the above questions: information from the impact indicators, baseline surveys of teachers and Fellows in their first month of participation in the project; classroom observations by project staff and the external evaluator; interviews and surveys of teachers, principals, and Fellows; journals kept by the Fellows; surveys of the Fellow's research advisors; interviews with school and district administrators; interviews with project staff; and assessments collected at teacher and Fellow training sessions. The Fellows' academic progress and the benefits to them from participating in the project are evaluated by their research faculty. They evaluate the Fellows' academic progress, growth in skills such as communication, teaching, and team building, and any potential long-term effects on the Fellows. Beginning in the second year, data will be collected from alumni teachers and Fellows to determine the long-term effects of participating in the program.

Preliminary Results:

In this section we present the results from a few baseline survey questions conducted in September 2007 a month after the inception of the project.

a) Teacher Survey Question: "What are your expectations for working with the fellows this year?"

Understanding the expectations of the project was the major challenge faced at the beginning of the project. Some of the common mistakes include the perception of the Fellow as another intern and not knowing completely the role of the Fellow in the classroom. In the initial weeks of the project, the project staff had to hold one-on-one meetings with some teachers to explain the expectation and the role of the Fellow as a resource in their classroom.

Overall, the teachers had modest expectations for their work with the fellows and did not refer at all to the project theme which is the implementation of information technology (IT) rich STEM content. Teachers by and large saw that the fellows could help with existing projects such as weather stations or work with the National Geographic JASON project. For one teacher dress and professionalism were important, another said that "I expect to have the opportunity to enhance my students' understanding of key science & math concepts with the help of my fellow and her expertise in the subject matter" Only one teacher mentioned help in raising test scores. Another said "Some of the expectations I have for working with a fellow this year include generating a sense of excitement about learning science and math with my students, planning labs with the regular education teacher, aiding the regular education teacher in planning field trips." One teacher said that "I expect that the teachers will deepen their understanding of the science we teach." A number of teachers cautiously expressed a desire for collegiality, perhaps the joint preparation of a paper.

b) Teacher Survey Questions: "What three elements make for a good science lesson for your kids? "What types of science lessons appealed to you in school and university?"

Most teachers saw inquiry and hands on activities as a sign of a good science lesson although all seemed to focus more on the structure of the lesson and the resulting transfer of content than on the actual doing of science. Many teachers saw the need to link to real world applications, "they need to make connections to things they already know and understand." The ability to work independently was seen as a value by one teacher who said "An increase in the output from students as the input from the teacher decreases." Another saw hands on as being important but also saw the value of repetition for a good science lesson saying "Hands on activities, repetition of ideas/vocabulary via variety of media, well planned lessons with connective ideas." While closure and structure were important to these teachers, none mentioned provoking student questions or making or testing hypothesis. Yet when these teachers were asked in another question about what types of science lessons appealed to them when they studied in high school and university, they all mentioned hands on activities.

Yet when these teachers were asked about what types of science lessons appealed to them in school and university they all mentioned hands on. One said in response "Labs were my favorite, especially ones that involved making predictions and then testing those predictions." Another teacher expressed her excitement about her own science learning saying, "The most appealing lessons for me were with biology and animals. I really had a great time in high school dissecting and learning about animal functions and I also learned a tremendous amount in college during a lesson with owl pellets. I had a wonderful time working with students and my daughter on dissecting the pellets. These things appealed to me because they were new and allowed me to work on my own discoveries."

A third teacher remembered vividly building circuits in a high school physics class saying "There were many science lessons that appealed to me throughout my life. I love science! In my undergraduate program, my favorite was designing a circuit board in physics class. Before doing the lesson, I did not know a lot about circuits and how they worked until I actually was able to make one of my very own. In high school, my favorite science lesson was dissecting a pig. I had never seen actual intestines and other organs before doing this activity. It gave me a better understanding of how organs in an animal function and it was a lot of fun." These same teachers, however, all felt that hands on was an important component of a good science lesson but, when talking about their own students, mentioned it in a generic sort of way together with other good teaching practices.

c) Fellow Survey Questions: "What types of science lessons appealed to them when they were in High school and now when they are at the university?" "What are some of the kinds of lessons you would like to develop and present to kids? Have you thought about the approach you might take? What would it be?"

We found the same enthusiastic response for the specifics of hands on and inquiry yet, for the most part, a cautious embrace of these methods when faced with developing lessons for students for the project. Commenting on his own experience one fellow said "I always liked the shock and awe sort of labs that were usually a presentation to the class. While I believe hands-on learning is valuable, you also need to create some desire to learn the material outside of the labs. For example, when my chemistry teachers blew something up, I wanted to go read about it and find out what happened. I think this is important not for every lesson, but at least some of the time." Another fellow said "I loved any type of lab that was hands on. I realize that there are times for labs, and times for lecture, but the messier the lab was the more fun it was. It was also nice to be able to see how something worked instead of reading about how it worked."

There appears to be somewhat of a disconnect between the experience and memory of good science lessons for teachers and fellows and the somewhat cautious embrace of hands on and inquiry based learning for teaching science in schools now. Both teachers and fellows are aware of the time constraints of SOL's with one fellow saying "The teachers have to complete eight SOL units by end of the school year. Due to the time limit, they might not want to incorporate cutting-edge research and new topics to the curriculum." It appears that the teachers and fellows share some basic and important ideas about how science is best learned but are for various reasons unable to embrace these ideas fully.

The teachers and fellows clearly share some basic and important ideas about how science is best learned but are for various reasons unable to embrace these ideas fully, A fellow led summer teacher and administrator workshop on the use of specific hands on lessons being adapted and generated by the project with thumbnails of the basic science and engineering behind these lessons would be beneficial to both groups and to the operation of the project as a whole. There are eight teachers and three administrators with science curriculum responsibilities in the project. Funding for teacher and administrator attendance should be provided with appropriate professional development credit.

Conclusions and Challenges:

The paper summarized some of the preliminary results from the baseline evaluation conducted through surveys, and challenges that lay ahead for the SUNRISE GK-12 project. From what we have seen so far we make two important conclusions. 1) Our GK-12 project has already laid a strong Fellow-Teacher partnership since its inception in September 2007, which we conclude, is the key ingredient to the success of any effort such as introducing new modules, identifying the STEM needs of the schools, and delivering the assistance that will better prepare the teachers to teach STEM topics. 2) One of the important focal points of the project, which is also a challenge to implement, is to continually emphasize on the importance of the discussion behind the science in each experiment that is conducted. This was noted from the initial surveys that teachers first wanted assistance in deeper understanding of the science behind their existing lessons through more hands on modules. While there were many new experiments added to existing curriculum along with the use of technology such as power point slides and smart boards, the project did not aggressively implement the advanced and IT rich STEM content from the Fellow's research in its first few months ending in December 2007. This will be a challenge to introduce new lessons given the time constraints in an already tight school teaching schedule.

Results from the pretest and post-test conducted by Fellows in the classroom (not presented here) have indicated a substantial gain in knowledge by children particularly when the science behind the experiments is thoroughly discussed. Another major challenge that is already facing the project is working with ESL (English as a second language) children. Often times the progress in science in classrooms with ESL children is slowed by language barriers. The paper also presented our impact indicators and evaluation plan which the project will follow through and report in the coming years. As the project matures, we will continue to report on how the above challenges were met, and the impact that the project is making on the K-12 environment. We strongly believe that the SUNRISE GK-12 project serves as one source of evidence that demonstrates the importance and the process of building partnerships among university's engineering/technology departments, schools of education, and the K-12 STEM education that would strengthen the nation's educational enterprise.

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