The STARS GK-12 Program at the University of South Florida

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Abstract: This paper documents the development and implementation of STARS (Students, Teachers, And Resources in the Sciences) a unique graduate Fellowship program at the University of South Florida that targets the K-5 school environment. Sponsored by NSF's GK-12 program, the USF implementation has resulted in the development of innovative outreach and educational tools and modules in cutting edge technology areas such as nanotechnology, simulation, genetic engineering, electric circuits, and biosensors. The project is now in its third year, and serves as an exemplary model for the emerging trends in engineering education at the elementary school level. Both the challenges and opportunities associated with implementing this project at the elementary school level are explored and discussed. A documentary style video that chronicles the history and impact of the program will also be presented.

Introduction: Recent reports of the performance of America's children and youth from both the Third International Mathematics and Science Study (TIMSS)[1] and the National Assessment of Educational Progress (NAEP)[2] echo a dismal message of lackluster performance. This finding is supported by the school performance report from the School District of Hillsborough County (SDHC)[3], which shows that 30% of the schools are below C grade and 45% are below B grade. Now three decades old; it is time that the nation heeded it - before it is too late." A recent study among K-5 teachers in the Hillsborough County, Florida (location of the STARS project) showed that 64% of the teachers did not feel prepared in science content and 49% did not feel prepared in mathematics. We firmly believe that enough warning has been provided and it is now time for action, that is, to provide professional development and content materials to the teachers in order for them to enrich the learning opportunities for K-5 students in science and mathematics. The NSF GK-12 program[4] offers a unique opportunity to address this need.

Project STARS[5] focuses on who we believe are the most neglected group of children, namely the K-5 students. In fact a great deal of the motivation for this project is driven by the lackluster experiences relative to science and mathematics education received by the children of the PI and various co-PI's when they were

going through the K-5 system in the Hillsborough County. The objective of project STARS is to engage graduate students in the challenge of infusing engineering and science principles in cutting edge areas such as nanotechnology, biosensors, genetic engineering, electrical circuits, and simulation into the elementary school environment. It is our strong belief that it is possible to translate basic concepts in these areas effectively into the K-5 classroom.

The project has put together a strong partnership with five area elementary schools, three of which predominantly serve minorities, typically underrepresented in sciences and engineering. Over the last two years, the PI and co-PIs have had continuous interactions with the principals and the science/math coordinators of the partnering schools to explore areas where project STARS would have the greatest impact. A significant result of this interaction is that the coordinator of elementary science education from the SDHC joined the project as one of the co-PIs. She has pledged to provide significant resources to procure science activity kits developed by the National Science Resource Center (NSRC) and the National Council for Teachers of Mathematics (NCTM) for the participating schools. The school district's commitment also includes supplying the consumables for the activity kits beyond the NSF support years. This commitment, along with the resources committed by the Dean of engineering at USF, the funding from NSF and private sources for the Research Experience for Teachers (RET) program, forms a strong foundation for the development and long-term sustainability of project STARS.

The STARS project includes underrepresented minorities among the cadre of Fellows for the project. It provides training for the Fellows on pedagogy and communication skills. We work closely with the district science and mathematics coordinators, and the school principals in developing a plan for effectively utilizing the Fellows as resources for the teachers. The Fellows assist the teachers by preparing and presenting engineering, math, and science principles in the school classrooms. Also our budget plan includes provisions for adequate stipends for the participating teachers.

We strongly feel that project STARS has the potential to not only achieve the objectives of the GK-12 charter but to also serve as the foundation for additional synergistic activities that will allow USF to become a nationally recognized leader in K-12 engineering education. The diverse faculty in engineering, education, information technology that have come together for this project and are sincerely committed to providing graduate Fellows and elementary teachers with exciting opportunities that will ultimately serve significant numbers of K-5 students, many of whom are from ethnic minority and low-income backgrounds.

Ongoing Project Activities: The STARS project, after its inception in August 2002, has achieved many milestones in building the University – School partnership. Some of the project highlights are presented in this section.

The project initially started with four graduate Fellows and has now expanded to ten Fellows, which includes three undergraduates. Soon after its inception the Fellows were engaged in shadowing the schools to learn more about the teaching methods, teacher knowledge content, class participation levels, student enthusiasm in learning science and mathematic, and in general, to get an overall grasp of the elementary school education system and build the foundation for the Fellow-Teacher-Student partnership. The Fellows rotated between the five participating

schools and familiarized themselves with the diversity at each school, until each of them were assigned a school.

The kick off meeting for the launch of the pilot project was conducted in December 2002 at USF. All participating teachers, Fellows, coordinators, and PIs charted the pilot project plan which outlined the enrichment of the science and math content of the modules based on the Sunshine State Standard (SSS). Classroom implementation of these modules happened during spring 2003. The enriched modules included extensive background material on the topic's experiments so that students could better understand science. It also provided advanced technical knowledge content on the lessons of these modules for the teachers. Subsequently, with inputs and feedback from teachers these modules were further improved and were then implemented in the classrooms. The implementation process consisted of teacher training workshops and the hands-on delivery of these modules in the classroom. Models, raw materials for the experiment, and set-up procedures were prepared by the Fellows and teachers. Thus, the pilot project served as a framework for understanding the elements of the NSF GK-12 project. Theses included the goals of the project, professional development of Fellows, module enrichment and its professional presentation, building the Fellow-Teacher-Student partnership, and in increasing teacher knowledge content in science and math. The enriched modules became a part of the regular school year curriculum in Fall 2003.

The first year of the project was concluded with the STARS Summer Science Experience (S3E) which was held from June 16th-27th 2003 at USF. This two week summer camp comprised of teacher training workshops, science lessons for the 3rd, 4th and 5th grade children, games, lab tours, science Olympiad, and a field trip to MOSI (Museum Of Science and Industry). Each week a group of 60 kids participated in this summer camp from all the 5 participating schools. A total of 15 teachers underwent advanced training in science and math on topics pertaining to physics, chemistry, biology and engineering. On the Olympiad day, the kids were asked to build a car. There was an initial brain-storming session to design the car, which was followed by actual construction and testing. The summer camp had invoked enthusiasm and high expectations from both children and the teachers, and turned out to be a fun-filled successful event.

The second year of the STARS project began with a teachers meeting early in Fall 2003. After learning from the previous year's experiences, the project was headed for the development and implementation of more advanced modules in science and engineering. These included modules from nanotechnology, simulation, genetic engineering, electric circuits, and biosensors. Similar to the pilot stage, the teachers were involved in the development of these advanced modules right from the beginning. All the schools participated in the development of the advanced modules. However, the level and depth of implementation varied among the different schools. The modules were completely hands on, which invoked a lot of interest among teachers and students as well.

The first phase of implementation was completed in Spring 2004. The second year came to an end with an exhilarating water splash summer science camp that lasted for 2 weeks. The camp was themed around water, and included hands-on lessons/activities in water matter, atomic structure of water, water properties (density, volume, mass), water monitoring (mineral contents, pH content), water cycle, water electrolysis, geology (cave formation, stalactites and

stalagmites), the reverse osmosis process, water filtration, hydropower, steam engines, and sailboat simulation. The culminating experience for the students was a science Olympiad during which teams of students designed and built a water treatment plant, which was tested for the water properties and the efficiency of the treatment process.

During the year, the Fellows and PIs participated in several extra curricular science activities. In one instance, the Fellows actually conducted a science day at the school. In another instance, the Fellows started a science discovery club. An after school tutoring and science enrichment program at two of the lower performance elementary schools was started by the Fellows. Other significant events during this period included the judging of the science projects at the Regional Science Fair of the SDHC. The STARS project also brought children from 3 of the 5 schools to tour the regional science fair, which generated a lot of enthusiasm for future presentations and broadened the scope of science experimentation.

In addition to the above, STARS Fellows have attended training workshops on teaching enhancement conducted at USF, and by the SDHC in collaboration with NASA. The Fellows experienced six different workshops conducted by consultants/experts from the College of Education to enrich the Fellows understanding of pedagogy and instruction styles. These workshops expounded on learners with diverse need and backgrounds, multicultural education, curriculum development, collaborating with teachers and students, and math education. The projects' experiences have been disseminated at the NSF GK-12 annual meeting, and in many conference proceedings[6, 7, 8].

Challenges: Although a lot of thought and planning went into writing the proposal that convinced the NSF GK-12 program directors to fund this project, the actual execution was beset by a significant number of new challenges that were not foreseen. In what follows we discuss some of the key issues that needed to be addressed to get the project started.

I. Initiation of Partnerships: Even though we had secured the consent of several participating schools as well as the school district during the proposal stage (this was part of the proposal requirement), the development of the details of the partnership framework, the specifics of the modes of operations and the nature as well as the level of participation among the partner schools and the SDHC posed significant challenges. Although the issue of collaboration was somewhat addressed and assured during the proposal stage, it became clear that the partnership with some of our schools needed to be revisited and further strengthened. The schools were selected based on several important factors, including ethnic diversity and economic status, academic rigor for the purpose of benchmarking, desire and enthusiasm as shown by the school administration and teachers, and proximity to the university. Several meetings and presentations took place at different schools. The school district science coordinator assisted us in this regard. The presence of this school district official as a member of the project team did much to allay the fears of the schools and the school district. Based on our sense of the level of interest and commitment, we ended up with five schools. There is notable diversity among the schools, namely, a prestigious private school, 2 suburban public schools that are performing well academically, and 2 schools that have had considerable challenges with respect to the Sunshine State standards, specifically the high stakes Florida Comprehensive Assessment Test (FCAT) in the State of Florida. The partnership with the County and their firm commitment had to be reestablished due to a change

in the personnel. During the kick off meeting for the project school and County personnel were invited and this laid a strong foundation for the project.

II. Selection of Fellows: Perhaps the most crucial task of the project was the selection of Fellows. The Fellows of this project play the significant role of physically building the university-school partnership by directly interacting with the students and teachers in the participating schools on a day-to-day basis. Some of these interactions include assisting teachers with lessons in the classroom, jointly preparing new lessons, and participating in various school related activities. Applications were sought through 1) a nationally disseminated call for student Fellowships, 2) dissemination among the student organizations of underrepresented students in science and mathematics, 3) Deans and department heads in the University of South Florida (USF), and 4) personal contacts of the PI's. After a thorough review, the final applicants were selected based on their academic ability, involvement in teaching, enthusiasm to teach at the elementary school level, personal interest in working with kids, commitment level in terms of time and motivation expressed at the time of interview, and approval by major professors. It was made clear to the applicants that periodic assessment of their contributions to the STARS project and their ability to maintain good academic standing while involved in STARS would be considered in determining their continuance in the project. The above stringent procedure had resulted in a strong team of graduates and undergraduate Fellows from engineering, chemistry, biology, and life sciences.

III. Realization of Objectives and Goals: Unlike traditional school with a set time line of activities, this project is driven by the realization the education needs and taking self-motivated proactive measures. Thus the challenge is to understand the gravity of the project's goals. The reports of the performance of America's children and youth from both the Third International Mathematics and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP) served as initial indicators, which emphasized the need for such a project. Time and effort was spent via regular meetings to bring about the thought process needed to appreciate the true impact of such a project. Over time, this regular contact and work with the K-5 students and teachers facilitated the realization of the need that exists. Emotional involvement of the Fellows with their students and moving from the mode of "tell me what to do" to being proactive in finding out what can be done to address the education needs, served as indicators of the realization process. Teacher's commitment to the project, strong partnership with Fellows, and their quest to learn and teach their students better, proved their extent of realization of the objectives of the project.

IV. Motivation for Participation: At the inception stage, after realizing the need to achieve the goals set by the project, it was necessary to motivate the participants to commit time and effort into the project. Some of the challenges that we faced were scheduling conflicts and inadequate time to dedicate to the project by teachers who were also committed to several other ongoing efforts in addition to teaching. It was observed that the schools had a rigid yearly schedule and it was quite difficult the get the school administration to modify this schedule and implement newer lessons. However, with time and effort in aligning all the involved teachers with the objective of the project, STARS proved to be a viable means to improve science and math education. The commitment from the schools also gradually improved. Another challenge was in understanding the role of Fellows in the classrooms. Initially, many teachers felt that the

Fellows were like interns and did not allow them to participate in their classes. It took some effort in establishing the role of the GK-12 Fellows as contributors to the curriculum content and teacher knowledge enhancement. In general due to a significant difference in academic preparation between the Fellows and the teachers, some of the teachers did not feel comfortable when a Fellow added or modified the technical content of a subject. However, these differences were overcome gradually when both sides realized that the Fellow-Teacher partnership is mutually beneficial. This is due to the fact that while the teachers benefited from exposure to advanced sciences and professional development, the Fellows benefited from training in expert pedagogy by the teacher. This motivated the teams to come together and focus on the educational needs of the students.

V. Developing Action Plan: The next challenging stage was the physical implementation of actions and achieving the goals of the project. As mentioned earlier, the action plan evolved over time and became increasingly challenging as the diverse needs at each school became apparent. We found that many teachers felt unprepared and it was noticed that some would skip over the lessons and many others would just touch upon the surface. This situation prompted STARS to adapt a teacher training approach. As a first step in this direction, the Fellows jointly developed some pilot modules (enriched version of current lessons) with hands-on experiments in line with the Florida Sunshine State Standards (FSSS) to teach students and better prepare the teachers. These pilot modules had extended background information for the teachers to thoroughly understand the concept behind the lessons and these were implemented in the classrooms jointly. It was also necessary to develop these pilot modules and the corresponding lessons at different content levels because of the presence of schools that were academically challenged. However, background information for teachers was not compromised. Teacher training on enriched modules was first attempted through a workshop. However, it was soon realized that this was not an effective means due to difficulties such as, differences in levels of understanding, motivation, and diverse content needs which depended on school dynamics. It was then decided to go on a one on one partnership between the Fellows and teachers, which proved to be a very effective scheme. The one-on-one partnership resulted in many advantages such as need based training, stronger partnership, and increased attention. The Fellows would also help in the preparation and delivery of classroom teaching on a daily basis. Moving from being addressed as a "part time intern" to that of a close working partnership is a significant attitudinal change and an achievement for this project.

VI. Monitoring and Assessment: An important and challenging aspect of STARS is the monitoring and assessment of the project's progress. This is indeed a difficult task given our background and lack of PI and Fellow training in this area. Use of standardized test scores from FCAT to judge the performance of the project was inappropriate at this stage since the project has been ongoing for less than 2 years. Hiring an evaluator was critical. The evaluator helped us to start real documentation and data collection, such as time sheets for Fellows, weekly journals which explain in short the experiences of the Fellows and teachers, interim and final reports with complete documentation of daily activities sheets used in schools, pretest and post test results for some modules, and surveys which document overall experiences and challenges that are being faced by Fellows and teachers. In addition to the above, the evaluator also makes a formal visit to the schools to see Fellows in action, conduct interviews with the project staff, research

advisors of Fellows, and school teachers, and thus provide valuable suggestions to maintain the progress of the project.

Successes of the STARS Project: In this Section we present some of the highlights of the STARS project's annual progress report for the year 2003-2004, which was prepared by the NSF approved evaluator. Though the project continuously receives verbal feedback from Fellows, teachers, and students, documented evidence of such feedback were collected twice a year through surveys prepared by the program evaluator. The surveys are treated confidential and some excerpts from the evaluator's final report to NSF are presented below.

- The graduate Fellows are an enthusiastic and committed group. Most of them expressed a desire to learn more about our educational system and to help students learn. They are excited and appreciative at being part of the project. They appear to be perceptive about how the classrooms in which they assist could be improved; more important, they have some specific ideas of what could be done to effect this improvement. As a group, the Fellows profess high goals for the students, in some cases higher than the goals they think their teachers have.

- The Fellows come from a wide variety of academic backgrounds, which is a positive factor both for the project and their ability to learn from one another. Their content knowledge in science is extraordinarily high, but some of the Fellows have expressed a need for some training in pedagogy.

- There is a wide variation in the teaching experience among the teachers participating in the project, ranging from two teachers with two or fewer years of experience to four teachers with twenty-one or more years of teaching. The teachers are generally happy to be part of the project and looking forward to a productive year of collaboration. As a group the teachers consider innovative pedagogical methods, such as using performance-based assessment and hands-on activities, to be important. They also consider themselves prepared to use these methods.

- There are both similarities and differences in the Fellows' and teachers' responses to questions on the surveys. Both the teachers and Fellows expect that the major impact the fellow will have in the classroom is to give support in the area of science content. Both Fellows and teachers also expect the fellow to bring new ideas and new ways of teaching to the classroom. In this, the Fellows have more specific ideas of what they can do, such as presenting activities, experiments, and resources other than the textbook. Teachers were more likely to use more general terms such as "new ideas" or "new techniques". This might suggest that some teachers want to change the way they teach science, but aren't sure what those changes should involve.

- Graduate Fellows were more likely than the teachers to want to change the way children view science, to make it fun and give them confidence that they can succeed in science. The teachers report that they are well-supplied with materials for science instruction, while some Fellows said that their teachers need more classroom resources. The teachers also report greater skill and frequency of hands-on and group activities than the Fellows do. Many of the

Fellows wish that their classrooms were more interactive, while almost all teachers consider themselves well-prepared to have their students participate in hands-on and inquiry-oriented activities.

- The majority of the teachers report positive relationships with their graduate Fellows and that their students looked forward to the Fellows' visits. The Fellows also thought that the students seemed happy to see them when they visited. The teachers appreciated the materials the Fellows provided them for their classrooms and some said that they did more in-class projects when the Fellows were in the classrooms.

Monitoring of the students performance before and after implementing a lesson are being recorded by the Fellows through pre and post tests. It is observed that a significant proportion of the children were able to absorb advanced curriculum material. Also answers to written tests indicated interest in the subject and increased knowledge content among students.

Emerging trends and future challenges: In what follows we discuss some of the salient features of the emerging trends in engineering education at the elementary school level that are an outcome of the STARS project. Also presented are future challenges and upcoming actions for the project.

Institutionalization of the project at the schools and County is a top priority for the project. The project is poised for expansion and it is necessary that the project maintain its influence and standard on both old and new schools. To do this, a lead teacher program has been envisioned. The program will have groups of STARS-trained teachers whose primary task will be to pass on their knowledge to other teachers in the school and also be the primary contact for the Fellows in their schools. This information exchange is being planned with the help of school administration in small workshop sessions on a regular basis. Simultaneously, meetings with the school district board are underway to help with incentive programs for the lead teachers and to also designate the University of South Florida as one of the teacher training centers.

Several steps are also underway to institutionalize the project at the university. Since the numbers of Fellowships are limited, we plan to involve more engineering and education undergraduates and graduates into the program by creating a separate course with credits in which the students will work with school teachers as part of the STARS program. We intend to elevate the teacher-training program to a much higher level of creativity and discourse by developing a "Research Experiences for Teachers" (RET) program. Information technology (IT) support to schools to enhance teaching methods and to link the schools with other sites has been planned. As the first step in this direction, laptops and projectors have been distributed to the participating schools, and videoconferencing between the schools and the university has been envisioned.

Financial sustainability is a key factor for efficiently carrying out a project of this magnitude. The STARS project being a unique opportunity for the university to partner and assist in community development, plans to seek both internal and external funding through the university's foundation are underway. Also funds from the Children's Board of Hillsborough County and the School District of Hillsborough County are being sought for the annual summer

program. Matching funds and supplementary funding for research grants earmarked for GK-12 activities are being sought from the National Science Foundation.

Conclusions: This paper highlights some of the challenges and emerging trends in engineering education at the elementary school level that the STARS project has experienced so far. We believe that sharing our experiences through this paper would benefit the community of researchers and educators who wish to develop strong University-School partnerships for enhancing K-12 mathematics and science education. We strongly feel that Project STARS has the potential to not only achieve the objectives of the GK-12 charter but to also serve as the foundation for additional activities that will allow USF to become a nationally recognized leader in K-12 engineering education.

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