AC 2012-4202: ENGINEERS SERVING EDUCATION: BRINGING MATH AND SCIENCE TO LIFE IN THE K-8 CLASSROOM

Stephen Rippon, Arizona State University

Steve Rippon is the Assistant Dean of Student Services in the Ira A. Fulton Schools of Engineering at Arizona State University. In this capacity, he oversees the engineering schools' K-12 outreach, undergraduate student recruitment, undergraduate engagement programs, and the Engineering Career Center.

Dr. James Collofello, Arizona State University

Engineers Serving Education: Bringing Math and Science to Life in the K-8 Classroom

Abstract

Many sources note the rapid erosion in the United States' competitiveness in science, technology, and engineering. They caution that the U.S. position as a global leader may be abruptly lost without a greatly expanded commitment to achieving success in advanced education in science, technology, engineering, and mathematics (STEM). The 2007 seminal report regarding STEM education and careers, "Rising Above the Gathering Storm"[1], makes numerous recommendations in long-term approaches to remedying this quandary. Primary to these recommendations is the need to increase America's talent pool by vastly improving PreK-12 STEM education.

The Mary Lou Fulton Teachers College and the Ira A. Fulton Schools of Engineering at Arizona State University are developing a sustainable long-term partnership to reinvigorate STEM education in Arizona's K-8 schools and to engage and excite youth in preparing for futures in STEM-related careers. By combining the technical expertise and resources of the Fulton Engineering Schools with the educational expertise and resources of the Teachers College, the "Engineers Serving Education" initiative is currently training approximately 250 teacher candidates (formerly known as student teachers) in the principles of STEM education with the prospect of doubling that number during the 2012-13 academic year.

The Mary Lou Fulton Teachers College recently reformed its undergraduate teacher preparation programs. A full year, full-time student teaching experience is a signature component of this new teacher preparation program called iTeach. Beginning July 2011, 500 teacher candidates began their full-year apprenticeship under the guidance of university faculty and mentor teachers in 18 local school districts.

In its commitment to this collaboration, the Fulton Schools of Engineering is working with colleagues in the Teachers College to train the teacher candidates and their mentor teachers in the engineering design process and in the preparation and delivery of integrated STEM units that bring to life the mathematics and science lessons that they deliver to their students. Faculty in the engineering school and the teachers college are meeting with teacher candidates each month throughout the school year to introduce engineering concepts and to model instructional strategies necessary to implement project-based learning and integrated STEM education in the elementary school classroom. Each of the 250 teacher candidates, under the direction of their mentor teachers, is delivering 8 STEM units, impacting nearly 7,000 students overall during the 2011-2012 school year. Trained engineering students are assisting the teacher candidates and mentor teachers with delivering the STEM units and are serving as role models for the K-8 students.

This paper inspects the collaboration and reviews the mechanics behind delivering such an innovative and far-reaching initiative. It will also take a close look at the collaborative roles played by elementary education faculty, engineering outreach staff, engineering education faculty, and elementary school teachers. The paper will also delineate the tools used to assess not only the impact on teacher candidates and the teacher mentors, but also those used to measure K-8 students' change in perception and value of STEM-related activities and studies, the increase in math and science aptitude, and the impact on students' long-term progress toward STEM-related studies and careers.

The Mechanics of the Collaboration

In essence, the Engineers Serving Education initiative infuses engineering design activities into local K-8 classrooms as a means to reinforce the students' math and science learning. By developing activities and utilizing preexisting activities that complement the state math and science standards, the ASU's Ira A. Fulton Schools of Engineering is impacting K-8 student learning through training teacher candidates (student teachers) how to incorporate these activities in the classrooms to which they are assigned. As may be obvious, the mechanics involved in delivering such an innovative and far-reaching initiative as this involves many individual, yet interactive pieces. While planning for the collaboration, there were seven major areas of consideration.

- The Teachers' College iTeach Program
- The development and/or adaptation of engineering design activities
- Teacher candidate training
- The role of the teacher mentor
- Engineering undergraduate students as co-facilitators
- Funding
- Assessment and evaluation

<u>The iTeach initiative</u>

In the spring of 2010 the teachers college reformed its undergraduate teacher preparation program in order to create a more robust and impactful experience for its student teachers. Rather than the traditional one semester placement in a local K8 classroom, the iTeach initiative matches these "Teacher Candidates" with one K8 teacher mentor for the entirety of an academic school year. The teacher candidates serve in the mentor teacher's classroom assisting, facilitating, and leading curriculum components four days of the week. On the off day of the

week, they meet at the "hub"—a school within the teacher candidate's school district—with all of the teacher candidates placed in that school district and attend their senior year education methods classes. Beginning July 2011, 500 teacher candidates began their full-year "apprenticeship" under the guidance of university faculty and mentor teachers in 18 local school districts.

Engineering design activities

The Ira A. Fulton Schools of Engineering assigned one of its K12 outreach staff to take on the task of creating and/or adapting preexisting, age appropriate engineering design projects that effectively demonstrate and reinforce the state math and science standards and concepts being taught in our local elementary and middle schools.

The first order of business, then, for the newly appointed Engineers Serving Education coordinator was to research the state standards and discuss with classroom teachers how these standards are being met. Then, in collaboration with the Fulton Engineering Education faculty, the coordinator began researching existing engineering design projects through such entities as ASEE and the Boston Museum of Science, modifying some of those activities for his purposes, and created new activities on which to base curriculum that he could train the teacher candidates to facilitate in their own classrooms. The goal was to develop eight activities so he could train the teacher candidates to facilitate one activity per month throughout the school year.

After choosing the activities, the coordinator then set out to develop the curriculum for teaching the activities to the teacher candidates keeping in mind that the activity must support the math and science standards, demonstrate the engineering design process, and provide a fun learning environment for the teacher candidates that reflected the fun that they could have with their own students. The curriculum had also to take into account that that the teacher candidates had to, in turn, modify the activity in order for it to be appropriate for any one of first through eighth grade.

Teacher candidate training

The iTeach "hub" approach to delivering the teacher candidate education methods classes proved to be an ideal setting for also delivering the Engineers Serving Education (ESE) curriculum. The ESE coordinator meets at each of the hubs once a month to train the teacher candidates in presenting the activity. He has the class of teacher candidates for an hour during which time he lays the groundwork for the activity and discusses the engineering design process as it relates to that month's activity. He then breaks out the materials for the activity and leads the 20-30 teacher candidates in actually performing the activity.

While doing the activity, the coordinator and the teacher candidates discuss approaches to facilitating the activity in the K8 classroom and how to modify the activity and desired outcome to be appropriate for the different grade levels.

The role of the teacher mentor

The teacher mentor is critical to the success of the Engineers Serving Education effort, because, without their support, the teacher candidates do not have the opportunity to conduct the activities in the classroom. This has proved to be a challenge for the initiative. Although nearly all of the teacher candidates have had the opportunity to present an activity in their teacher mentor's classroom, none of them has had the opportunity to conduct them all. The teacher candidates have reported that their mentors find it difficult to find time within their own curriculum to allow the candidates to facilitate the activity. We are currently inspecting ways to educate the teacher mentors regarding the benefits of making time in their curriculum for their students to engage in the activities and to, perhaps, provide them with exterior motivators to encourage them to build the engineering design activities into their lesson plans once a month.

Engineering undergraduate students as co-facilitators

One of the goals for this semester is to incorporate the assistance of the Ira A. Fulton Schools of Engineering undergraduate students in joining the teacher candidates and assisting in facilitating the activities in the K8 classroom. We believe that the synergy created by these undergraduate peers in education and engineering will greatly empower the two by sharing their individual, respective expertise in teaching methods and in the engineering design process. We also believe that the Fulton Engineering student will greatly benefit by engaging in and practicing a great number of those "soft skills" that they will need to succeed as future engineers.

Funding

An initiative of this scope requires significant funding to implement. The Mary Lou Fulton Teachers' College has funding from a number of sources to conduct the iTeach initiative but none to assist with the implementation of the Engineers Serving Education efforts, nor does the Fulton Engineering Schools have the internal resources to fund the effort other than to supply the staff member to coordinate the initiative. Fortunately, a local defense industry partner has seen the value of our efforts and the impact that ESE will have on our state's education and the STEM pipeline and has contributed a sum large enough to implement the program through the first year while we garner the evaluation and assessment to present to other industry partners and alumni for future support.

Assessment and evaluation

Since we are currently in our pilot year of Engineers Serving Education, the assessment and evaluation has not yet been conducted. The following indicates how we plan to assess the impact of the initiative at the end of the academic school year.

There are four primary outcomes that the Engineers Serving Education collaboration addresses: 1) Teachers' knowledge and implementation of engineering design principles to enhance the

relevance and retention of STEM concepts and skills in their classroom; 2) K8 students' understanding, application, and STEM learning as a result of their new experiences; 3) K8 students' excitement and motivation towards STEM learning and potential STEM careers, including Engineering; and 4) Preparing engineering students to be active members of the communities in which they live and work.

The first outcome will be addressed with common tests of engineering design administered to all candidates and their mentors. Additionally a subset of candidates will be observed using the RTOP observational protocol to assess the quality of their instruction.[2] The second outcome, students' learning and understanding, will be assessed by collecting District-administered data on mathematics and science performance on the Common Core State Standards for mathematics, and when available, science. Student motivation (outcome 3) will be assessed using the Elementary School Motivation Scale[3,4,5], and Repertory Grid Techniques[6]. Outcome 4 will be assessed through record of the spread of engagement of engineering students through the undergraduate population in our engineering school, and through teacher and mentor teacher feedback on the effectiveness of the professional development and assistance. Together, these measures of the impact of the program can be administered, analyzed and the results fed back for the improvement of the program in a timely fashion. Moreover, the results will shed light on the critical role of motivation and its interaction with teaching practice to influence student achievement in STEM subject matter.

Conclusion

The implications of this project are far reaching, providing benefit to all critical partners: Schools and children, prospective teachers, their mentors and teacher educators, and engineering undergraduates and faculty. For the 2012-13 academic year, it is our goal to double the impact of this current pilot, expanding to train more than 600 teacher candidates and impacting in excess of 15,000 PreK-8 kids throughout Arizona. These, however, are not the only benefactors of the Engineers Serving Education collaboration. The 600 teacher mentors, in whose classrooms the teacher candidates are working, will also be greatly impacted. The collaboration will provide a workshop at the beginning of the school year for the teacher mentors to help them understand the initiative and know how to best assist their teacher candidates as they engage the students in the engineering activities. Up to 600 undergraduate engineering students will also benefit for this initiative during the 2012-13 school year. In partnering with their peers in Teachers' College, these engineering students will learn and practice the communication, interpersonal, and interdisciplinary skills that are becoming more and more essential to success in engineering professions. Moreover, the collaboration between Arizona State University's Ira A. Fulton Schools of Engineering and Mary Lou Fulton Teachers College will enable each group of faculty to learn new content, skills, and teaching techniques from each other. Thus this program has far reaching impacts including those on new teachers, existing teachers, engineering students and Arizona's PreK-8 students.

References

1. "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future", The National Academies Press, 2007.

2. Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Benford, R. & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: The Reformed Teaching Observation Protocol. School Science and Mathematics, 102(6), 245-253.

3. Guay, F., Marsh, H.W., & Dowson, M. (2006). Assessing Academic Motivation among Elementary School Children:The Elementary School Motivation Scale (ESMS). Technical report. *SELF Research Centre, University of Western Sydney, Australia.*

4. Middleton, J. A. (1995). A Study of Intrinsic Motivation in the Mathematics Classroom: A Personal Constructs Approach. *Journal for Research in Mathematics Education*, *26*(3), 254-279.

5. Middleton, J. A. (1999). Curricular influences on the motivational beliefs and practice of two middle school mathematics teachers: A follow-up study. *Journal for Research in Mathematics Education*, *30*(3), 349-358.

6. Kubishta, A., & Middleton, J. A. (2011). Analysis Of The Motivation And Achievement Of Secondary Students Enrolled In A Summer Mathematics Academy In T. Lamberg & D. Wiest (Eds.), *Proceedings of North American Group for the Psychology of Mathematics Education Conference*. Reno, NV.