Implementing STEM Programs that Capture and Nurture Imaginations and Talents

Background

While the need for more experts and innovators in STEM fields is critical to the success of our nation and is increasing (National Science Board, 2012), the number of students pursuing and completing degrees in these fields is decreasing (National Academies of Science, 2011; National Science Board, 2012). Implementation of programs that will transform education and enhance the pipeline from grade school to university to the workforce is imperative (National Research Council, 2011). The Prime the Pipeline Project (P^3): Putting Knowledge to Work proposed a solution to this problem by designing, implementing, and evaluating the *scientific village* strategy for (1) increasing student interest in and success with the study of mathematics and science through engagement with teachers (as learners and collaborators) in the solution of challenging problems that mirror those faced by STEM professionals and that use workplace technologies, and (2) updating teachers in STEM fields.

Scientific Villages are communities of high school students and secondary school STEM teachers as learners; scientists from the university, business, or industry who design and lead the villages; and undergraduate STEM majors who serve as assistants to the scientists, mentors to the villagers, and role models for the students. Villagers (24 per village) work collaboratively on long-term projects/problems for a semester (9 sessions, 2 ¼ hours per session) and summer (10 sessions, 4 hours per session) in the labs at Arizona State University. The projects are of high interest, are similar to those faced by STEM professionals, and require application of STEM concepts and skills for their solutions. The approach during project engagement reverses the lecture-and-then-apply method of instruction. Rather, villagers bring to bear what they already know and gain information and direction at point of need. Four different villages were held each semester/summer. During the final session of each semester and summer program, villagers showcase their work for the community.

Connections Courses for Teachers, held daily in tandem with summer villages (an additional 2 hours per day, Monday through Thursday) and led by project staff, village leaders, and visiting scientists, provide teachers with (1) greater insight into big ideas in their content areas of expertise and sister fields, (2) experience with various types of assessment strategies, (3) methods for counseling students through the STEM pipeline, and (4) techniques for developing proposals to fund materials and supplies for implementing integrated content and project-driven learning in their classrooms.

The website for P^3 served as a communication portal for project activities and provided valuable information for participants, including access to technology support; links to STEM conferences, programs, and events in the Phoenix metropolitan area; and links to potential funders and grant development information. All village materials and products are available on the website.

Products include the *MATHgazines* and *MATHgazine Juniors* that continue to be produced every month with opportunities for students, teachers and families to solve and send in problem solutions to compete for STEMatician awards. The *Pipeline Story Book*, detailing village goals and projects, student and teacher recruitment and evaluation, and interviews with participants, is in production now. It will be available in print and uploaded as an e-book to the website. The project is also documented in the P^3 film, made by students under the direction of an Emmy-award winning filmmaker.

Documented Results

Evaluations showed that P^3 students completed significantly more STEM courses in high school, completed significantly more advanced courses in those fields, and had significantly higher GPAs than

their controls. P^3 students were more likely to go to college and choose STEM or business majors—a significant increase over self-declared interest during their junior year in high school. Perseverance in majors in college is significantly higher for P^3 students than their controls. In interviews during and after P^3, students identified not only the great academic experiences, but also the confidence they gained from collaborating with new peers, teachers, and scientists, and working in the labs and other facilities of a large university campus. More than one-third of teachers stated that as a result of the P^3 experience, they are using long-term projects and investigations to enhance learning and exploration of new concepts with their students; 30% indicated higher expectations for their students' engagement and performance based on their collaborative work with P^3 students in scientific villages; 28% described their increased use of activities to develop students' critical-thinking and problem-solving talents; 28% identified an increased awareness of what interests and motivates students; and 21% cited several methods they had employed to foster collaborations among students. Teachers also gained skills in grant writing, with 40% attaining financial or technology support for implementation of project-driven programs in their classrooms. Awards ranged from $250 to $40,000.

Potential Applications

Based on the success of P^3, the Helios Education Foundation supported STEM in the Middle (SIM), targeting students in grades 5–8 and middle school teachers of mathematics, science, or technology (2010 –2013). This is a Saturday morning program for both teachers (four Saturdays, 4 hours per session each semester) and students (Club STEM, seven Saturdays, 3 hours per session each semester) during the academic year, with an additional week in the summer for teachers. Students work on long-term, content-integrated projects. Like participants in P^3, Club STEM students are mentored by trained high school students and undergraduate STEM majors. The program for teachers focuses on the big ideas of mathematics and science developed in the middle grades and projects that facilitate student acquisition of those big ideas. In addition it focuses on the design, conduct, and analysis of assessment strategies; the development and offering of professional development programs with staff mentorship; and the production of proposals to fund needed resources. We are currently working on a program to engage elementary school students and their teachers in STEM explorations.

References

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For More Information

P^3, see http://primevillages.asu.edu/
SIM, see http://prime.asu.edu/ClubSTEM