A STEM Outreach Program Model: Case Study of a US Army Based STEM Program

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Abstract

Not enough students are selecting STEM careers to meet the needs of an increasingly technological society. There is concern that the anticipated needs for the future research and development workforce will not be met. Coupled with the increase of technical resources for potential adversaries, the lack of students interested in STEM generates national security issues. A strong STEM outreach model may be the most powerful defensive weapon that the United States will have to confront the challenges of the 21st century. Picatinny Arsenal's STEM Education Office was created at the U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey in 2006. Its outreach mission has grown into a robust program in which hundreds of Picatinny STEM professionals assist in classrooms, support field trips, aid hundreds of teachers, and mentor thousands of students ranging from pre-kindergarten through graduate school. The geographical location of Picatinny Arsenal supports urban, suburban, and rural communities, and allows direct contact with a full range of ethnic, economic, racial, and cultural populations. The purpose of this paper is to document the Picatinny STEM outreach program, lessons learned over the preceding decade, and propose a STEM outreach model as means to circumvent the growing risk. It is the hope of the authors that the program model will aid other organizations in establishing successful outreach programs.

Keywords

Army, Education, Outreach, STEM, Systems

Introduction

To advance innovation and secure global leadership, the 21st century workforce needs Science, Technology, Engineering and Mathematics (STEM) disciplines. The best educated, most creative, future-oriented, adaptable, and productive employees are needed. To achieve this, education and re-training are necessary throughout an individual's career, as indicated by Buckminster Fuller's predictions about the increasing rate of human knowledge, which doubles approximately every 12 months.[1] Without these efforts, foreign adversaries will economically and militarily threaten our nation's safety and stability. One of the key ways to establish this security is through the U.S. Department of Defense (DoD) which needs a properly trained workforce that is educated by first class educational institutions. Utilizing its research and development laboratories, the DoD will produce the innovative weapons systems needed for physical security. It will also offer many advancements that will directly benefit the civilian

population, such as GPS navigation, the computer, new materials, robots and sensors.[2] As a result, the DoD plays a key role in the education of the nation's youth and future workforce. This paper is provided by the authors based on the last 10+ years of experience operating within the Picatinny STEM program.

STEM for the Army and the Army for STEM

Currently, China graduates eight STEM students for each American student.[3] Thus, when not enough American students selected courses in STEM fields, alarms began to sound. This problem was compounded by the nation's military laboratories because they could only hire U.S. citizens and relied upon technology to support the warfighter.

Picatinny Arsenal's Science, Technology, Engineering, and Mathematics (STEM) Education Office was created at the U.S. Army Armament Research, Development and Engineering Center (ARDEC) in Picatinny Arsenal, New Jersey in 2006. Its mission was to develop a program that would allow high-tech resources to augment the STEM educational programs in area schools. Picatinny had a large civilian workforce containing approximately 2,000 professional scientists and engineers working in the arsenal's 64 state-of- the-art laboratories. Its geographic location in northwestern New Jersey also provided opportunity to reach nearly one million New Jersey children in grades Pre-K to 12th grade living within a 35-mile radius.

In addition, there are several universities, colleges, and junior colleges with close proximity to Picatinny. If one considers the range of outreach potential equal to the commuting distance of the arsenal's workforce, the number of reachable students includes communities from urban areas such as New York City, the New Jersey suburbs, and the rural farmlands of western New Jersey and eastern Pennsylvania. Having a diverse supply of STEM mentors offers living examples of success to students from under-represented populations. In many cases, these mentors return to the schools they themselves attended.

It was immediately clear to Picatinny's leadership that application of their resources had significant potential to impact the STEM crisis. This was the catalyst to formally establish a STEM office. This led to a search for arsenal employees, both government and contractor, who had knowledge of the customer, an understanding of the military, as well as research and development (R&D) expertise. The result was a three-person team that involved a high-ranking military officer with R&D knowledge and experience in the public school system as a science teacher and administrator; an outgoing, patent-holding engineer with excellent communication skills; and a bilingual computer technician who provided expertise on internet communication, programming, social media and recognition in underrepresented communities. These three individuals continue to occupy the three full-time positions in the STEM Office but have been augmented with several hundred government volunteer scientists and engineers providing support and mentoring for students and teachers on a variable part-time basis.

Picatinny Launches Operational System

With the STEM Office Team in place, the next task was to overcome new and unexpected problems. For example, schools can provide resources, but Picatinny cannot give money to schools due to government regulations. However, working with the National Defense Education Program and awarding competitive grants to non-profit organizations opened the pathway to provide educational support and maintain control over how the resources were used. This was important when needing to demonstrate non-political equal opportunity support.

Another challenge was handling requests for support when the requests outnumbered the resources. To resolve this problem, the STEM Office focused on working with selected schools, and then gradually shifting resources to other schools when the original recipients displayed competency in their programs. Additionally, Picatinny's STEM Office established a few fundamentals as guiding principles, which remain in effect.

"The students of today will be the workforce of tomorrow and must be taught accordingly."

"The TEACHER is the most important link in the educational chain."

"Win the teachers, win the war. Lose the teachers, lose the war."

Many previous outreach programs lacked vision, coordination, and knowledge of the customer, which are often students and teachers in elementary and secondary schools. Many career fairs and special events also lacked sustained impact and motivation to pursue STEM careers. In many cases, teachers were not involved in the process. Inspiring teachers to become STEM advocates will increase return on investment. It appears that middle schoolers are the most receptive to being motivated toward STEM, but that interest may be lost if not supported through high school.[4] If resources permit, outreach from Pre-K through graduate school should be considered.

Lessons Learned During the STEM Battle

If one were to chart the accomplishments of Picatinny STEM over the past decade it would show growth, slowly rising at first, and then increasing exponentially to its current level. Recordable data (primarily numbers of customer schools, students, and teachers trained; engineers volunteering; customer satisfaction; the variety of services offered; number of requests received; the expansion from middle and high school to the full Pre-K to graduate school spectrum; and the expansion of the customer base into public libraries, scout troops and other civic activities) have all followed the same growth pattern. Picatinny scientists and engineers have visited classrooms, supported hundreds of student field trips, assisted more than 1,000 teachers, and mentored tens of thousands of students in hundreds of schools.

Other projects implemented by Picatinny STEM include scholastic programs such as symposiums for highly advanced students, student created STEM video competitions, robotics competitions (Figure 1), summer STEM Academies, on-going research, publication of professional papers, data collection, consulting with other STEM outreach providers, a lending library of STEM equipment for employees to use with their own children, coordination with

civic organizations, student intern opportunities, and support of local library programs have yielded valuable information.

Figure 1 – Seven of Picatinny's FRC Robotics Teams gathered at the 2017 International finals in Saint Louis. All of the 70+ robotics teams the arsenal sponsors are provided engineer mentors.

Recommended actions when establishing a STEM program:

1) Assess the Area of Operations. Determine what schools are in the area, their needs, and their demographics. Then, establish and maintain credibility with the schools. Do not promise more than can be delivered and customize the outreach. Forced programs, whether government or private, will not generate the enthusiasm needed for success. Some schools may have had some bad outreach experiences and may not be receptive. The best option is to support other districts in the area and allow time for word of the success to travel back to the original targets. Avoid wasting resources on any teacher or school not willingly participating. Also, remember to contact the State Department of Education, which will help to secure local administrative support. Unless the district and building level administrators grant their approval, it will not be possible to gain school entry.

2) Provide all Assistance Free of Charge. Offer teacher-training workshops. Show teachers how to use an inquiry and design teaching method or understand the experimental learning style. Teachers that attend workshops should receive the supplies they will need in their classrooms for free. They will need assistance becoming comfortable with these methods, but it is essential in the engineering process and vital to stimulate creativity. There is no need to create the next Jeopardy Champion. The engineers who created Watson already did that.

Additionally, use only high quality trainers who will leave the workshop participants motivated and eager to try their newly learned skills. Then, continue supporting the teachers after they return to the classroom. If possible, cover your employees' salary as most school visits occur during the regular workday hours. Be certain their health benefits remain active should there be an accident or injury. Where appropriate allow acquisition of continuous learning points for employees supporting STEM outreach. The authors have shown that employees participating in STEM outreach develop greater satisfaction with their own careers and increased productivity.[6] It is also suggested that government provide tax break incentives for organizations allowing their STEM professionals to conduct outreach functions. Giving industry the ability to deduct the

salary time each employee spends in outreach should allow the organization to increase profits and perhaps lead to increased growth of the business. Compared to expensive bureaucratic government funding and regulation it will send the assistance that is actually needed directly into classrooms. Scientist and engineer volunteers are well suited to provide the guidance teachers need to stay current with changes in technology.

3) Mentor and Coach Students. Once students are interested in STEM, they will need opportunities for growth via clubs and activities. For instance, competitions will sharpen the student's skills and keep them motivated until they graduate. Scientists and engineers also make excellent mentors and coaches for school robotics and rocketry teams.

Furthermore, surveys have shown most students have no idea what an engineer does and have never knowingly spoken to one.[7] The mentor puts a face on the term "engineer" and brings it to life. However, before any inexperienced volunteers make a classroom visit, it is recommended they be given advice on school protocol and operating procedures. Two pieces of advice all volunteers should receive are: 1) Be yourself, be proud of what you do and what you have accomplished and 2) Remember you will be expected to answer one very important question: "why do I have to learn this?" Chances are that the volunteer will be the only one in the room with the answer.

In addition, field trips to working laboratories and production facilities are very popular with students and teachers. It is good to be able to speak to an engineer in a classroom, but visiting that engineer provides a lifelong memory for the student. Traditional feedback from the participating teachers, students, and parents of the students indicates field trips are "life changing experiences" (LCE). Where the opportunity exists, provide internships or summer employment for students, and make maximum use of those resources. Effective use of classroom visits by scientists and engineers, teacher training workshops, STEM activities, inquiry and design education, utilization of technology, innovation, speaking the digital language of today's students, using competitions to challenge students, and showing students the advantages of engineering careers (Figure 2) will all help the students discover the pathway to a successful future.

Figure 2 - High school students listen as a Picatinny engineer shows her project at an "Introduce a Girl to Engineering" event.

After Action Review

STEM skills are applicable to all subjects in school. STEM Professionals play a key role in the professional development of many teachers. When scientists or engineers visit the school, teachers have the opportunity to receive one-to-one information on new technologies. Simply listening to the engineer's presentations can supply the teacher with information. Plus, relationships established with teachers often provide the teacher a way to find answers to student questions. In the future, there will be high demand for outreach assistance in several key areas: robotics, 3-D printing, nanotechnology, simulation-design, video gaming, interactive technology,

remotely controlled aircraft, innovation, composites, carbon fibers, rocketry, space travel, artificial intelligence, and more.

Picatinny's STEM Office is proud of its accomplishments, but cannot fight the battle alone. Allies are needed. Support and partnerships with other government agencies, the private industrial sector, and the educational community are ideal. Outreach is a critical tool that should be utilized to inspire young minds to pursue STEM careers. As the current generation of STEM professionals disappears from the active workforce, let its greatest contribution to the world be passing the fire of creativity to the next generation using the torch of education.

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