Utilizing Science and Engineering Professionals in the Classroom: How Your Workforce Can Positively Impact STEM and Your Company’s Bottom Line

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Abstract – With the growing need to inspire young minds in STEM areas, Science and Engineering professionals along with their employers are working to identify the best possible method to accomplish just this. Currently, many approaches are being utilized, such as summer camp programs, in school visits, large STEM events and student mentoring programs. This paper takes a focused look at how placing Science and Engineering professionals in the classroom may be the most robust and cost effective approach for STEM outreach. This paper outlines methods, approaches, benefits found, results and lessons learned from in-school pilot programs related to this approach. Overall, this paper is intended to aid educators, Science and Engineering Professionals and their employers to broaden STEM and STEaM education.

Index Terms – Classroom, Education, Employee Satisfaction, Engineer, Mentor, Science, STEM, STEaM, Outreach, Picatinny Arsenal, Volunteering.

INTRODUCTION

In today’s economic climate, it is very difficult for companies to justify sending their Science and Engineering (S&E) professionals out into the community to promote Science, Technology, Engineering and Math (STEM) areas. However, based on the findings presented in this paper, it may be detrimental for companies and organizations if they do not provide engineers to their local community for this purpose. Part of this is due to the proven effect on employees moral and work ethic when linked to volunteering [1]. This can be linked to another benefit of establishing volunteer programs, which is a reduction in employee turnover. [2] [3] Further, over the last 10 years interest in STEM careers for graduating high school seniors has decreased by 20%. [4] This could prove to be devastating to many companies as they try to stay technologically competitive.

This paper is based on the STEM outreach programs provided by the Armaments Research, Development and Engineering Center (ARDEC), located at Picatinny Arsenal in New Jersey. The specific findings and information presented is based on detailed surveys and past experience. Part I of this paper will provide a review of different methods and approaches for bringing S&E professionals into the classroom. Part II will provide a review of each of the stakeholders involved and how they are impacted, along with survey results for the S&E stakeholder in Part III. Finally Part IV will discuss the cost implication for companies and organizations related to providing S&E professionals for STEM outreach.

PART I: METHODS & APPROACHES

The following sections will review methods and approaches that have been found to be effective in bringing engineers and scientists into the classroom.

1. Meeting Teachers Needs

Before outlining different methods of bringing S&E professionals into the classroom, the authors feel it is important to layout some interaction methods with teachers to aid in the process. Teaching professionals have more time constraints and outside pressure than ever before. With new common core curricula, the need to increase cooperative learning methods, and the growing number of students per class, it can be overwhelming and difficult to find time bring S&E professionals into the classroom.

FIGURE 1
ENGINEERING PROFESSIONAL VISITING A CLASSROOM
The authors have found it is critical to have the teacher lead the discussion for determining what support is desired. Pushing a set curriculum or method on a school or teacher does not work, as the teachers need to have the outreach program integrate with their unique schedules, resources, and students’ needs.

The authors have found it most useful to present possible assistance options, with a caveat that they can be tailored and modified to suit the teacher’s needs. Another fundamental approach is to ask the teachers what their needs are and develop custom programs to match. For example, a teacher who is not comfortable teaching electrical circuits may find it helpful to have an electrical engineer in the classroom to answer questions.

II. Lectures & Assemblies

One of the most common methods to bring S&E professionals into the classroom is via lectures and speaking engagements. This method has the ability to reach large numbers of students, in individual single classrooms or large auditoriums. A lecture event or series can be very effective in reaching students. This is evident in the programs implemented by some schools, which incorporate S&E speakers visiting once a month to present and discuss different topic areas. These S&E professionals are identified by the faculty and scheduled to correlate with the subjects being taught.

Another method to support large assemblies is to offer S&E professionals as added content to an existing or planned event. Thus, the infrastructure and planning is already part of the school’s agenda. For example, the authors were able to provide S&E speakers to a school that had planned an assembly around a NASA program where the students spoke directly to astronauts located onboard the space station. Their addition brought local S&E’s to a school wide event, increasing the link between local community and national level speakers.

III. Focused Workshops

As mentioned before, the authors have found it very important to match what the teachers’ needs are in the classroom rather than serving them with a pre-packaged STEM program. Developing focused workshops may be the best way to provide support to schools and teachers. These custom focused workshops allow for the S&Es and teachers to match interests and resources.

This is illustrated in the following example. A local charter school was working through a curriculum designed to teach students how to measure nature, such as tracking temperature, barometric pressure and so forth. The teacher and engineer worked together to develop a focused workshop related to sensors that S&E’s use to measure their surroundings during testing. The resulting workshop introduced the students to numerous sensors that measured variables including pressure, temperature, orientation and sound.

“...my eldest daughter...will be starting the engineering program at a Technical School next year - mostly because of the influence of your workshops. She attended every one of your workshops that she was able to, and loved them so much that she decided that engineering was a good fit for her...” (Parent Feedback)

One of the side benefits of this approach is that these workshops, once developed, can be modified and utilized for other teachers and groups. Examples of these workshops include workshops on 3D printers, machine dissection, electrical circuits, inventing and visualization. [5]

IV. Meet an Engineer & Classroom Visits

One of the simplest methods that has been used to introduce students to different careers is bringing a professional into the classroom. This method transcends age groupings and professions as seen through the frequent visits from fire fighters, police officers and doctors in classrooms. Unfortunately, the frequency of S&E professionals making these visits has been low. Visits can introduce what S&E professionals do, why they enjoy doing it and answer questions about their careers. S&E visits provide support for the teacher when they cover new topics. This has been found to be especially effective in the lower grades where teachers are often covering material that is outside the scope of their past teaching education.

Classroom visits do not need to be limited to a company’s core competency areas. Across any employer’s workforce a wide verity of S&E professionals can be found. Many S&E professionals have expertise outside of their current job descriptions.
The authors have also found that providing multiple visits to the same school over a period of time accelerates momentum and continuity. Having continued exposure in the same classroom or school increases effectiveness, this has also been found to draw in students who at first were reluctant to participate, but then decided to participate based off of observations and/or peer feedback.

V. Advisor and Mentor Roles

Providing S&E professionals to serve as an advisor or mentor has shown the authors to be critical in educating students and teachers on what S&E careers truly involve. This method has been found most effective with individual students who have specific, focused interests and require a level of support above the teacher’s knowledge base. Also, mentors and advisors have been helpful with support to school programs or teams, such as FIRST Robotics. To ensure this mentor link, ARDEC has gone as far as to only sponsor a FIRST team if they have an S&E professional as part of their team of advisors.

The advisors’ and mentors’ roles in this type of environment are not to function as coaches or as primary leads. Their positions entail utilizing and imparting their learned project management and risk management skills to help the students. Suggestions are to: first, establish a realistic time line of tasks that need to be completed; second, help establish a functional attack strategy that takes into account the strengths and weaknesses of the students; third, to help students see past their predetermined mental and physical limitations. At this point, students can start exploring novel ways of amplifying their innate talents and curiosity while better understanding what S&E professionals do for a living.

PART II: IMPACT ON STAKEHOLDERS

Providing S&E professionals in the classroom has many impacts on the stakeholders involved. These stakeholders include: students, teachers, parents, local community, STEM professionals and the companies where they work.

The stakeholders in any STEM education effort can be divided into two basic groups. One group would be those who are primarily recipients of the benefits and the other group those who are primary providers. It is acknowledged that there are members of each group who cross the boundary line and receive many of the same benefits primarily associated with the other.

I. Recipients

The first group examined will be the recipients because without them there would be no need for STEM outreach programs. While schools are usually considered the primary targets of outreach programs, there are several others capable of providing a good return on investment. Examples of these organizations are libraries; social service activities (YMCA’s/YWCA’s, rehabilitation centers, religious groups, etc.); scouting; and 4H to name a few.

While the term “school” will be used when discussing recipient organizations, any group assembled for the purposes of education, job training, or increased individual self-sufficiency could be the focus.

School populations are composed of students, parents, teachers, and administrators. Students are the ones most commonly used to assess the value of educational programs. Unfortunately, student testing is often the only method employed and the only criteria used to paint a picture of the entire school organization. There are several other potential benefits which should be considered, but rarely are. Seeking answers to the following questions should provide a much more accurate and holistic assessment.

1. Did the students merely learn facts or did they also develop problem solving skills, creative thinking habits, the desire to question and explore, and a belief that they can have a positive impact on the world?
2. Did the parents notice a positive change in their children’s interest in school and learning?
3. Did the teachers acquire new teaching skills, up to date knowledge of their subject area, practical examples of how their subject impacts other disciplines, and new colleagues for support of their own professional development?
4. Did the school’s administration discover a new readily available opportunity to provide low cost teacher professional development, a free source of up to date technical information to be used when making decisions on expensive equipment purchases, and a source of information for determining what will be the most in-demand future career options for today’s students?
5. Is the school organization preparing the students for the future and providing meaningful future oriented teacher training for the instructional staff?

The answers to all of the above questions can be found when using S&E professionals in the schools. These scientists and engineers are perhaps the greatest providers of support and motivation to students, parents, teachers, and administrators available and, in most cases, available without additional cost to the school.

Students: The impact on students by providing outreach is clear: the more that students become aware of STEM career options and, more importantly, better understand what it means to be a Scientist or Engineer the greater chance they will choose to pursue these careers in the future. This in classroom interaction also aids in eliminating or re-educating the students about common stereotypes related to S&E Professionals that can harm or deter students from choosing these career paths. [6] Beyond understanding S&E careers, having professionals in the classroom allows for the student to attain real world answers to why what they are learning is important to them and our society. The student’s one main desire when learning any new material is answering the age old questions “Why is this important?”
and “How will I ever use this?” This is the most important information the S&E professional can provide.

**Teachers:** Beyond helping the teachers convey difficult material and justify that what they are teaching is important, having S&E professionals in the classroom also ensures that the teachers are familiar with the latest technologies and innovations. By having S&E professionals visit non-STEM classes, teachers can begin to branch STEM into STEaM, which integrate the arts into the STEM fields. This gives students the opportunity to learn the material through interdisciplinary means, providing them with a more complete understanding. Further, having S&E professionals in their back pocket, so to speak, gives teachers the confidence to dig deeper into material knowing they have an expert on call for aid or additional information. This increase in confidence alone has the potential to increase the effectiveness of teaching in the classroom.

**Parents & Extended Family:** Parents are a key stakeholder for many reasons. They have significant contact time with their children. Further, parents make many decisions regarding education, particularly in the younger grades. If parents are not made aware of possible education options and careers for their children, they will not be able to make an informed decision regarding their child’s education. Additionally, as mentioned in the previous section, the roles that S&E professionals assume and the technologies they utilize change over time, making it even more important to reach parents and ensure that they understand the current options for their children.

**Local Community:** When S&E professionals visit classrooms, there is a prominent and profound impact on the community. This affords students the opportunity to view a snapshot of how the local businesses use science and technology. This not only offers students a tangible understanding of the applications and practicality of a STEM related career, but also unites the local commerce and educational systems. This cooperation is the foundation for a strong sense of community. A strong sense of community may later prove mutually beneficial to companies and students by helping students find a STEM related internship or job. Additionally, the collaboration between the schools and businesses gives parents an opportunity to become more connected and aware of local STEM opportunities. Ultimately, the community begins to take on a larger role in the education of its youth. This increase in participation should strengthen the overall community.

**II. Providers**

The second group of stakeholders in STEM education outreach to be examined is the providers. The providers primarily supply funding, support and guidance.

**Government:** The best known provider is government. Taxes are used to fund education at all levels of government from Federal through State to local/municipal governmental bodies. One of the primary responsibilities is to provide the safety and security its citizens need to live productive lives. One way this is accomplished is by having the people focus on creating a continuously improving quality of life. An effective future oriented educational system is essential in accomplishing this goal. The government’s principal ally in educational support is private industry, ranging from huge international corporations to local businesses.

**Company and Organizations:** While government is not required to show a financial gain or profit, private industry is. Most industrial partners do not manufacture or market educational supplies. Still, they must concentrate their activities in areas that will positively impact their profits. Suggesting that private industry provides additional support to education does not seem on the surface to be advantageous to most businesses. Yet, large and small companies alike regularly support educational programs in communities across the nation. The increased visibility within the community will also be a benefit to the company providing the S&E professional. A corporation or organization will see benefits to their employees.

**Science & Engineer Professionals:** S&E professionals assume a role in which they provide an understanding to the recipient stakeholders of the importance of STEM careers. The S&E professional has direct contact with students and represents what a “true” S&E professional thinks and how he or she operates. This can be a powerful tool to use while addressing negative stereotypes.

**PART III: PROFESSIONAL SURVEY FINDINGS**

To expand understanding of how visiting schools impact the S&E workforce, a survey was conducted throughout the population of S&E professionals who have had involvement with ARDEC’s STEM outreach program. The survey was submitted to a approximately 150 S&E professionals who have supported the program over the last ten or more years. Approximately 1/3 of the surveys were completed. Figure 3 shows the distribution of completed surveys based on the number of years of STEM outreach support.

![Figure 3: Distribution of Outreach Experience](image)

Figure 3, shows a focused concentration around the 3 year point. Further, Figure 5 shows the distribution of S&E Professionals based on how often they support the outreach program.
As can be seen, a pretty even distribution for the level of outreach support is found throughout the workforce. Related to the frequency of support, Figure 5 breaks down the demographics of the recipients of the outreach provided by the S&E professionals.

These findings show a strong concentration in the 4-8 and 9th-12th grade levels. Based on ARDEC’s outreach experience, the authors have concluded that a strong presence in the 4th-8th grade is critical to ensure students understand the value and options of STEM careers. This correlates well with the studies identifying K-8th as critical years in students developing interest in STEM fields. The next focus area, 9-12 is to ensure the inspired students continue on a STEM path. This directly relates to ARDEC’s STEM program focusing in areas related to Robotics Teams and in classroom outreach. It gives the students a strong STEM option within the school structure. The last three categories represent a growing area to expand outside the traditional classroom setting. This includes homeschool groups, which are becoming more organized and structured, thus making it possible for an S&E professional to reach reasonably sized groups of students cost effective. Traditionally homeschool outreach was limited to 1 or 2 families and was difficult to justify.

Doing outreach acts as a re-charge for me, a chance to step away from the daily grind. (S&E comment taken from survey)

Relating to the category “public events and locations”, ARDEC ran a pilot program in local libraries to broaden its audience. The pilot consisted of workshops and presentations in 7 different library locations with a focus on introducing new technologies and what S&E professionals do. It was found that these programs not only reached K-12 students but also parents, extended family, and the community at large. Reaching this adult population has the potential to be a STEM outreach multiplier for students due to amount of quality time parents, grandparents, and family members have with their children. It should be noted that the category “other” included consulting support for school administration.

Of the surveyed professionals, over 98% indicated they feel an increase in job satisfaction and they would like to continue to provide outreach support.

This result speaks for itself as a strong indicator why employers should take a good look at developing outreach programs. It was also found that 64% felt providing outreach increased their interest in their chosen field (Figure 6). Followed by 70% indicating they felt an increase in work motivation or drive (Figure 7).

Although very difficult to quantify, 30% of the professionals indicated they felt providing STEM outreach has aided in advancing their careers (Figure 8).
would like to continue to provide outreach. This is a strong indicator that the employees feel a benefit from providing outreach.

**PART IV: IMPACT TO BOTTOM LINE**

As most commercial companies have stock holders and a focus on profits, it can be difficult to justify community outreach and volunteering. But, this thinking has become more and more outdated and overcome by proven leadership models and public opinion of companies. [9] In a recent study conducted by CONE communication, it was found that more than 90% of consumers are loyal and trust companies that are socially responsible. [10] The authors would like to state the case that providing S&E professionals in classrooms may be the most cost effective method to support STEM outreach.

I. Large STEM Investments vs. Engineer Hours

Many corporations struggle with how they can increase STEM interest in the career fields needed for their future work force. Many companies choose to put on large multi day STEM events. These events are typically child focused experiences like summer camp programs, engineering challenges, and similar events. The planning and cost of this type of event can be large, ranging from $5,000 to $30,000 or higher depending on the number of students, facilities required and the number of staff needed to support the event. Based on past large event programs conducted by ARDEC [11], a cost of $10,000 to $25,000 is reasonable when reaching ~50 students and having 4 dedicated trained teachers on staff. These types of events have increased the student’s awareness of and excitement for STEM.

A second option considered by corporations is a one-time large sum donation of funds given to schools or other organizations. This type of donation can play a critical role in bringing up-to-date technologies and infrastructure to a school. This level of funding can range from as little as $1,000 to millions of dollars, such as the $120 million recently donated by the Zuckerberg family. [12]

The question then arises is this the most cost effective approach for companies to invest in STEM outreach? To make this comparison, the authors will utilize the value of $100/hour as a base burdened labor rate for sending an S&E professional into the classroom. This rate is only to allow for comparisons and could range significantly based on region, discipline, corporation size, and career status. As described in Part I, S&E outreach in the classroom can take many different forms. Reviewing conducted outreach activities, such as meet-an-engineer, classroom workshops and lectures the average run time is easily 2 hours of time, including, travel and setup. Depending on the activity, additional coordination and preparation time may be required. For comparison, an average in classroom event is established at a cost of $300 (2 hours conducting and 1 hour for coordination) and reaches an average of 25 students, 1 teacher and 1 school administrator.

If compared with a large event of $10,000, reaching 100 students and 4 teachers, the same investment in S&E professional labor would equal to ~33 classroom visits, reaching ~825 students, 33 teachers and 33 administrators. This represents a more than 8:1 increase in effectiveness, when looking at reached students alone. These numbers could be reduced as the outreach may go to the same student body over a long period of time, which as referenced before has been found to be very effective. Further, the effectiveness can be optimized by increasing the number of students at an event or visiting multiple classrooms in a day.

When compared to large sum donations from a large organization, as referenced before, the cost comparison is staggering. A $1,000,000 investment would be ~10,000 hours and would represent over 3,300 classroom visits, reaching over 80,000 students. This cost, distributed over many employees and over a given school year, could also reduce the financial impact on a company’s cash flow, making it possible to increase or decrease levels of outreach with changing market conditions.

II. Employee Job Satisfaction and Motivation

Employee job satisfaction and motivation are directly proportional to an employee’s innovativeness and long term value. Unfortunately, the standard monetary means by which employees are motivated has become a major sticking point. [13] Other means of bolstering moral need to be leveraged to reinvigorate the workforce by reminding them of the reason why they chose their current career path. The link to job satisfaction can be seen directly from the survey results reported in this study, with 98% indicating they feel an increase in job satisfaction. This also correlates to lower turnover rates and higher job retention.

III. Company PR, Marketing, and Community Awareness

Improved Public Relations (PR) is an additional benefit for companies and organizations that provide outreach support. Placing S&E professionals in the classroom increases a company’s visibility in the community. Although direct marketing to students is typically frowned upon, students will gain an understanding of possible future employment opportunities. Beyond students, visiting classrooms also expands awareness to teachers, administration, school boards, and parents. To take full advantage of the marketing opportunities, corporations need to be diligent in tracking and publicizing their outreach programs. This allows small in classroom visits to gain the same notoriety as large events or one-time donations. Reaching students, their parents, and extended families over a sustained period of time through word of mouth alone, [14] may have a much greater impact on brand/company recognition than one-time large feel good donations or events.

IV. Future Workforce

Current practitioners visiting classrooms allows students to better understand future careers that they may be interested
in pursuing. A student cannot major in a career if they do not know it exists. Many surveys have been conducted asking the question, “What is an Engineer or Scientist?” The findings continue to be very shallow or unrelated to engineering. [15] This is an indicator that S&E disciplines are not being exposed early enough to the nation’s youth. Bringing S&E professionals in the classroom will directly impact this statistic. Studies have shown that repeated and early exposure to STEM careers cultivates interest in those fields, which will directly relate to an increase in the future STEM workforce. [16] [17] Further, having active outreach programs will increase a company’s appeal when seeking new employees for introductory and senior positions.

V. Tax Incentives for Volunteer Hours

Unfortunately, the current federal tax code does not allow additional deductions for labor hours designated for volunteering and outreach. Although they do not fall under donations, the hours spent by employees do fall under normal business expenses for the entity providing the S&E professional in the classroom. This allows companies to track and list these hours as part of their traditional expenses to further offset profits.

Many expenses related to volunteering can be tracked and deducted by either the company or employee. These could include costs for things such as transportation or STEM supplies for conducting workshops with the students. It is important for companies and employees to take the time to track their hours and costs related to volunteering and outreach, for both tax considerations and to ensure the stockholders and employees understand the level of importance the company places on this type of work.

CONCLUSIONS

As described in this paper, having S&E professionals spend time in local classrooms has a strong impact on STEM disciplines. This falls back to the fundamental need to ensure in the early educational environment students are exposed to STEM disciplines, so students gain an understanding of how STEM relates to their everyday lives. The authors are not suggesting that providing S&E professionals in classroom settings should be a company’s sole method of STEM outreach, but rather urges companies to recognize the benefits associated with a portfolio that includes placing S&E professionals in the classroom. Most importantly, having a S&E professional in the classroom answers the most fundamental and critical student question: “Why do I need to learn this?” Further, the authors’ opinions are that employers who provide S&E professionals to their local community will see impacts relating to employee job satisfaction and motivation, which will ultimately increase their bottom line.

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