

Supporting Students' STEM Innovations with Industry Partners

Alka Harriger, Brad Harriger
Purdue University

Abstract

Many universities employ STEM outreach programs to spark interest in their disciplines by middle and high school students. Teaching Engineering Concepts to Harness Future Innovators and Technologists (TECHFIT) and the Nanoline Contest are two programs that are designed to give student teams an opportunity to explore STEM concepts with a final goal of innovating an automated system. This paper will discuss a partnership between an international controls company and an R1 university that makes both of these programs successful in recruiting students to computing, engineering, and technology disciplines.

Background

In 2013, the nation's 5-year strategic plan for STEM Education identified STEM as a national priority and challenged the private sector to make tangible commitments to that goal ^[1]. Not surprisingly, some students are already developing STEM innovations ^[2]. However, the demand for STEM-skilled students may be significantly higher than estimates from previous studies ^[3]. Fortunately, there are many initiatives that are designed to excite and entice more students to consider STEM fields of study and STEM careers, and two of them are described in this paper:

1. Teaching Engineering Concepts to Harness Future Innovators and Technologists (TECHFIT), NSF-DRL# 1312215 ^[4] and ^[5]
2. Phoenix Contact's Nanoline Contest ^[6], referred to as Contest in the remainder of this paper.

TECHFIT and the Contest are programs that equip students with technology, skills on using that technology, and encouragement to innovate physical, automated systems using what they learned. TECHFIT and the Contest are also two initiatives that demonstrate successful partnerships between an R1 institution and an international controls company, both of whom value and support student innovation in STEM. More information about TECHFIT can be found in ^[7], and more information about the Contest can be found in ^[8].

The authors are professors at Purdue University in West Lafayette, Indiana, an R1 institution that includes degree programs in technology-based majors. Phoenix Contact (PxC) is an international controls company with USA headquarters in Harrisburg, Pennsylvania. The partnership between PxC and the authors grew out of a professional relationship between Brad Harriger and a graduate of his program who worked for PxC. When the graduate made visits back to campus, he sought out faculty that he felt made an impact on his career. Those visits led to conversations about him, his job and his company, and eventually the visits led to the alum wanting to help give back to the university while assisting his company in better name recognition with faculty and students at the university. This alum's relationship with the authors led to equipment donations from PxC to support the Purdue program from which he graduated.

When the authors began the process of developing their TECHFIT proposal, they invited PxC (through the alum contact) to become a project partner. Shortly before TECHFIT was funded, PxC invited the authors to help them broaden the reach of their Contest by implementing a Midwest regional. They managed the Northeast regional, which included the areas where most teams originated in prior years of the Contest. The success of the Midwest regionals over two successive years led PxC to invite the authors to help add a Southeast regional just two years later. The Southeast had a couple teams that had entered the Contest before the regional approach was begun, and it was also the home of the TECHFIT partners of the authors.

TECHFIT targets middle school students who develop technology-supported fitness games known as exergames, and the Contest targets high school students who develop any automated system. Both programs use the same microcontroller: PxC's Nanoline controller. Both programs

also use competition to motivate student innovation.

Building Effective Partnerships

The Centers for Disease Control and Prevention (CDC) documented a structured approach for creating effective partnerships ^[9]. Although their recommendations apply to formal partnerships, they are equally useful to informal partnerships such as the one described in this paper. Defining each partner's role, investing in the program financially and by providing education, fostering collaboration, and marketing the program are among their recommendations.

An effective partnership should work like a cohesive team. The following tips can help yield a successful team/partnership ^{[10][11]}:

1. Each member understands the goals, and each member is committed to attaining them.
2. Each team member feels comfortable communicating openly and honestly and are respectful for each other.
3. Each member understands the value s/he is bringing to the team as well as the value her/his partners bring to the team.
4. Everyone feels valued.
5. Continuous improvement is applied to the team's processes and practices.
6. There is a common, shared vision, which allows for high quality decisions to be made together.

In the case of the informal partnership described in this paper, the roles and responsibilities for both parties have stayed fairly consistent over the past four years. For TECHFIT, the authors handle all responsibilities, but PxC provides some financial support through their donation of technology components that comprise the majority of the toolkits given to TECHFIT participants.

For the Contest, there is greater division of responsibilities. The authors meet in person with PxC executives at least once each year to review results from the past year and plan for the upcoming year. The authors provide input to PxC for the Contest's schedule, such as optimal dates to disseminate Contest announcements and dates to offer complimentary training for competing teams. Since the partnership began, the authors have been leading the marketing of the Contest for the two regions that they helped initiate: Midwest and Southeast. They also develop and provide the training for the Contest teams from both of these regions. PxC handles all financial costs for the Contest, including travel support for the authors' travel to deliver the training at both regional workshops.

Effective partnerships between industry and education should automatically provide favorable opportunities and benefits for all parties involved. The following sections detail the benefits for each party.

Benefits to Non-Partners

The most important recipients of the benefits of the described partnerships are the ones for whom the partners have developed these programs: students. Both TECHFIT and the Contest provide students with opportunities to learn the engineering design process, engage in physical computing, apply creativity to the innovation of physical systems, and gain practical experience working in teams.

The TECHFIT program formalizes the instruction of the engineering design process as a way to approach innovation and document one's process of innovation from idea inception to implementation of the finished system/product. The Contest presents it more informally; however, many teacher/mentors use the Contest as an opportunity to have their students follow the engineering design process as they innovate their projects. Furthermore, students experience using industrial-quality technology and gain practical experience with tools of the manufacturing discipline.

Physical computing has been shown to support scientific inquiry ^[12], and provide tangible and creative learning opportunities to students ^[13]. President Obama's *Computer Science For All* initiative was launched in early 2016 ^[14], and it mandated that every child have the opportunity to learn computing. Both TECHFIT and the Contest provide opportunities to develop computational thinking in students.

Students of both programs individually receive basic instruction on programming, project fabrication, controls setup and wiring, manufacturing tools and processes, project implementation, testing, and improvement. Then after all students individually understand all basic steps, they are grouped into teams, each of which focuses on a subset of the overall team innovation. For example, after the team decides on their project, one group may work on the program, while another does the wiring of the physical components to the system, and another develops marketing literature to gain community support. The team-based approach allows each student to see the value of each individual's contribution to the overall project.

Teachers are another important non-partner beneficiary of both programs. They are able to offer their students a unique opportunity to learn, apply and experience advanced STEM technologies to creatively build their own innovations. They also receive direct benefits.

Teachers participating in TECHFIT receive a broad array of upgraded and practical STEM skills through their attendance in a week-long, free STEM professional development workshop hosted in the summer by the authors. Teachers serving as mentors for student teams in the Contest receive fundamental STEM skills in a half-day, no-cost workshop.

Both programs offer participating teachers free controls hardware and software donated by PxC to use in the construction of their automated systems/products. The equipment and software is also available for in-school for other classes, if desired by the teachers/schools.

Teachers involved in TECHFIT receive a small amount of financial compensation for participating in the summer professional development workshop. They can also receive educational credit that may be used to support renewal of their teaching credentials.

School administrators are another beneficiary of both programs. They are able to have better prepared STEM teachers on staff due to the free technical training provided through the two programs. This can be an important aid for schools that are in the process of gaining or maintaining STEM certification. Because their teachers are able to keep the technology toolkits from the programs, the schools benefit by having that equipment available for other appropriate uses. Finally, both programs provide opportunities for school administrators to promote school activities through local media outlets to inform the community of the stellar things that the school is doing for its students.

Benefits to PxC

There are many benefits for companies like PxC to engage in a relationship with a major R1 university like Purdue University. One of the top benefits includes the company's ability to be involved in the education process whereby company professionals serve on various advisory boards. This service allows them to guide and encourage programs in directions that will provide program graduates the best technical skills and abilities for when they enter the workforce. This type of company involvement often leads to a company donating equipment or providing equipment at deeply discounted prices to assure that the programs have the capabilities to move in the encouraged directions. Additional, longer-term benefits for the company providing the university programs with equipment include a company presence, increased visibility, and name recognition by both students and faculty. Ultimately, visibility and name recognition leads to an easier time for the company when they recruit top students from baccalaureate programs.

Opportunity for important collaborations with Purdue faculty and students is another benefit that comes with an effective partnership. Collaborations can range from technology implementation consultation for a course or lab to sophisticated, applied technology, proof-of-concept projects, or even K-12 engagement projects like the Nanoline Contest and TECHFIT. These types of activity often lead to publications and media outlets that report on or promote the activities and show the company as a positive contributor to the community or even an exemplar for other organizations.

Benefits to Purdue

The authors have realized many benefits to their Purdue programs from the partnership with PxC. These include:

- 1) Building and equipping state-of-the-practice laboratory facilities via equipment donations received
- 2) Supplying advisory committees with qualified technical professionals to serve on

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- committees for:
- a) Polytechnic Engineering Technology programs
 - b) Polytechnic program course projects
 - c) Research projects
- 3) Providing valuable technical support and equipment needed for projects
 - a) Traditional lab stations
 - b) Capstone projects
 - c) International competition projects
 - d) Research projects
 - 4) Increasing employment opportunities within PxC due to their enhanced experience using their technology

There have also been numerous outreach and engagement collaboration opportunities through invited participation in all of the following:

- 5) Nanoline Contest, a national high school automation competition held in Harrisburg, PA with regional competitions held at various locations around the United States.
- 6) Xplore New Automation Award, an international collegiate level automation competition held in Germany.
- 7) EduNet, an international education program created to assist university programs implement controls and automation curricula.

Project Outcomes

Previous results from TECHFIT teachers in the 2015 cohort reported, “All teachers agreed or strongly agreed that TECHFIT enhanced their understanding of how science, technology and engineering concepts can be applied to real-world problems... the afterschool program should increase their students’ interest in technology and engineering careers.”^[5] The same article reported on feedback from students in the 2014 cohort regarding the impact of TECHFIT:

1. Several students said their career goal changed and they “now want to be an engineer, programmer, and/or work with technology.”^[5]
2. Several students said they enrolled “in technology, science, and/or computing courses” because of their TECHFIT experience^[5].
3. Many students indicated that their performance in STEM courses improved as a result of their TECHFIT experience^[5].

Anecdotal feedback from teacher/mentors of students teams in the Contest reported that many of their students who may not have considered a STEM career or even going to college ended up going to college and studying computing, engineering, or technology. In fact, one of the current student TECHFIT team members happens to be a student who participated in the Contest as a senior and is now a first generation college student studying engineering technology.

Another teacher informed the authors that a student from one of his 2016 Contest teams ended up earning an internship at a manufacturing company based on the experience he developed as a member of that team. The teacher shared that this student helped the company solve an issue during his internship that other permanent employees were unable to resolve.

Conclusion

Both programs described in this paper include a competition that allows participating students to see the many inventions by their competitors in a gracious professionalism manner following the FIRST model. This positive approach to competition further strengthens innovation and provides practical lessons on the importance of teamwork.

When students are given encouragement, support, and access to technology and instructional resources to build the essential educational foundation for their innovations, universities, companies, and ultimately the nation benefit by building future, needed STEM innovators. The support of industry partners through 1) making the technology available at no cost to students, teachers, and schools, 2) inspiring interest and innovation through direct interaction with the students and teachers, and 3) demonstrating a commitment to the value of an innovative spirit is helping propel future generations of STEM leaders forward.

The programs described have been successful, but more educators are needed to broaden the impact of these programs. Readers of this paper are invited to contact the authors if they wish to become involved with TECHFIT and/or the Contest.

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ALKA HARRIGER is a Professor in the Computer and Information Technology Department (CIT) at Purdue University. She was the primary author of three NSF-funded projects totaling nearly \$5M. Her current interests include application development, outreach to K-12 to interest more students to pursue computing careers, applying IT skills to innovating fitness tools, and wearable computing.

BRAD HARRIGER has over 30 years of experience teaching automated manufacturing and has authored/coauthored several related articles. He has served in several leadership roles in several professional organizations. He led the development and maintenance of a multimillion dollar manufacturing laboratory facility. He has been a co-PI on four NSF funded grants and co-hosts PxC's Midwest regional Nanoline Contest.