Make the World a Better Place: An Association-Industry-Academia Partnership

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***Abstract* – This paper presents details of a program initiated by the IEEE Central Texas Section Education Society Chapter to stimulate passion among high school students for careers in Science, Technology, Engineering and Math and to increase the participation of girls in STEM fields. The program includes participants from professional associations, industry, and academia. We describe the elements of this program (including the use of a fabrication lab or makerspace, mentoring, outreach events, curriculum design, metrics, and a replication handbook), the benefits to and contributions of each of the participants (the IEEE Central Texas Section, Tech Shop, Dripping Springs High School, and Texas State University), and the near-term and long-term objectives.**

Index Terms – Association-Industry-Academia Partnerships, Engineering Education, Experiential learning, Makerspace, STEM Education

BACKGROUND

In this paper we describe a collaborative model to build a pipeline of engaged and productive scientists and engineering professionals. This approach brings together multiple interested parties with substantive and tangible benefits to all the stakeholders and to society as a whole.

I. Motivation

Members of the IEEE Central Texas Section Education Society Chapter decided to embark upon a project that would both build engagement within the Chapter and create some positive value in the local community.

Different volunteers within the Chapter had different concerns: one (TL) was concerned that young people should have the opportunity to gain hands-on experience with making things in order to engender real enthusiasm for the work they might do in the future. Another (DS) was concerned with the efficacy of engineering education approaches. And a third (LM) was concerned that the pipeline of scientists and engineers is inadequate to meet the future needs of society. After several discussions among the members of the Chapter, their plans began to take shape: they would facilitate a pilot program to allow high school students from Dripping Springs Independent School District to use the services and equipment of Tech Shop, Inc., to gain real-world laboratory experience. And they would collaborate with Texas State University in San Marcos, Texas, to align the curricula of high school and university engineering and science departments.

The pilot program is intentionally constrained and limited to a manageable-sized population. The goals behind the creation of this program are far larger, however, namely, to

- provide transformative experiences through experiential learning
- increase the pool of students who choose STEM majors and careers
- measure the success of the program by tracking college enrollment, student achievement and employment
- create a scalable program that can be implemented by other local communities
- inspire student entrepreneurs
- expand the population of talented scientists and engineers, and
- revive American manufacturing through education and infrastructure for manufacturing startups.

Underpinning this program is the desire to improve the alignment of high school and university engineering and science, including computer science curricula; and to promote public-private partnerships that will increase students' passion and enthusiasm for knowledge of and careers in science, technology, engineering and mathematics.

II. Participants

The program, "Make the World a Better Place," is a collaboration among

- a professional association (The IEEE Central Texas Section Education Society Chapter),
- industry (Tech Shop, Inc., a company that provides access to tools, software and space where people can prototype and fabricate their designs, a makerspace), and
- academia (Texas State University and Dripping Springs High School).

ELEMENTS OF THE PROGRAM: "MAKE THE WORLD A BETTER PLACE"

I. Students Use Fabrication Lab for Keystone Project

In the core of the program, groups of high school students utilize the facilities of the Tech Shop labs, and receive safety training and training in how to use the equipment. Students work in the classroom on a Keystone Project, and complete

fabrication of their ideas at the Tech Shop facilities. Students receive membership at Tech Shop and guidance on their projects.

Over the longer term, students will have nationwide access to engineering facilities and expertise through Tech Shop's network of locations.

II. Outreach Events

IEEE volunteers conduct an outreach event to introduce high school students to ideas about science and engineering, and the process of taking an idea from conception to design and finally to fabrication.

The initial outreach event features female college engineering students and successful women engineers, and is intended to enhance interest, especially among female high school students.

Among the event presenters are four recent Westwood High School graduates who won the 2nd Place Award in the Toshiba ExploraVision 2012 competition, for their LANAPT (Ligand Attached Nanoshells Assisting Photothermal Therapy) Project [1], which integrates nanotechnology, photothermal therapy, and biomolecular recognition in pancreatic cancer therapy. It reduces the use of chemotherapy, radiation and surgery, thereby decreasing the incidence of the negative side effects associated with those therapies.

The four young women on this winning team are now each studying engineering at the University of Texas at Austin. Their project exemplifies the core concept of "Make the World a Better Place."

III. Curriculum Design

Texas State University Ingram School of Engineering and professionals from IEEE assist with the high school science curriculum design and lesson plans for use in the high school Keystone Project. Tech Shop's Computer Numerical Control (CNC) systems and engineering facilities augment available resources for the science curriculum.

IV. Measuring Outcomes

Professionals from IEEE, the authors of this paper, will design instruments to investigate the impact of the program on students' attitudes toward STEM fields. We will also assess the long-term impact of experiential learning in a longitudinal study that will track students through their education and early employment.

The program will be measured and evaluated by the students, staff, volunteer parents, and employers who participate in the interview and survey administered by IEEE volunteers.

V. Mentoring

IEEE volunteers provide mentoring to students and faculty. Texas State University faculty provide mentoring to Dripping Springs High School faculty.

VI. Replication Handbook

IEEE volunteers will create a replication handbook in order to disseminate the knowledge gained in this program. In order for us to judge this program as successful, it must be scalable to a broader community.

The potential for this pilot to be extended to many of other school districts in the United States is compelling. The program brings together a powerful team consisting a major university, an entrepreneurial private enterprise, high schools and a professional engineering society. Together they will improve the education of our student engineers, men and women from all walks of life, increase opportunities for innovation, and build an ecosystem for creating entrepreneurial manufacturing businesses in the United States again.

VII. Funding

IEEE volunteers will solicit funding to extend the scale and depth of the program, upon completion and evaluation of the initial phase.

This produces creative, passionate and entrepreneurial engineers through the collaboration of Texas State University Ingram School of Engineering [2], the IEEE Central Texas Section [3], Dripping Springs ISD [4] (and, eventually, other central Texas high schools) and the industrial tools, equipment and facilities of Tech Shop [5].

CONTRIBUTIONS AND BENEFITS: PROFESSIONAL ASSOCIATION

I. Contributions

The IEEE Central Texas Section Education Society Chapter participates and contributes to this program in several ways:

II. Facilitation, Coordination

The Education Society Chapter makes introductions across the various entities and facilitates cross-organizational collaboration. Each of the individual participating units coordinates its own activities, and IEEE volunteers provide the overall coordination.

III. Outreach Events

The Education Society Chapter is organizing and conducting events introducing high school students to the many ways they can turn their ideas into actual creations, using the tools available from the industry participant, Tech Shop. The initial outreach event is targeted to female high school students.

IV. Mentoring

IEEE volunteers meet with and mentor students and faculty.

V. Benefits

The IEEE Central Texas Section Education Society Chapter benefits in both tangible short-term ways and intangible, longer-term ways. In the short term, the Chapter has an exciting program underway, which gives life to the Chapter and attracts new members and volunteers.

Over the longer term, the Chapter derives benefits from the success of the program with a better ability to recruit and develop members. Individual volunteers within IEEE gain benefits through a greater network of professionals, the knowledge of how to coordinate a program such as this, and professional recognition through publications. Both IEEE and The Education Society derive reputation benefits from the success of a high visibility program.

CONTRIBUTIONS AND BENEFITS: INDUSTRY

I. Contributions

Tech Shop, a fabrication and prototyping studio, provides space, training and equipment including CNC and traditional high quality machine tools, and CAD/CAM tools used to program and operate the tools. The equipment includes laser cutters, plastics and electronics labs, a machine shop, a wood shop, a metal working shop, a textiles department, welding stations and a waterjet cutter. Students have access to design software, featuring the Autodesk Design Suite. Tech Shop provides huge project areas with large work tables for completing projects and collaborating with others.

Tech Shop provides equipment for enabling many engineering and other creative businesses and projects. The equipment includes

- Various vinyl, glass, wood and metal cutters
- Multimeters, oscilloscopes, signal generators and other electronics tools
- Sewing, serger and embroidery machines
- Digital calipers and micrometers, 3D printers, scanners, cutters and other prototyping tools
- Sheet metal, abrasives, welding and plasma cutting tools
- Wood, metal and stone machine tools
- Plastic injection and forming tools as well as surface finishing tools.

II. Benefits

Industry participants gain both immediate and longer-term benefits. The immediate benefits for participants such as Tech Shop include increased membership (through the membership fees associated with student participation), increased visibility in the community (word of mouth from students).

The benefit to industry in general is a larger, more energetic and self-renewing talent pool of engineers, scientists and entrepreneurs.

CONTRIBUTIONS AND BENEFITS: ACADEMIA

I. Contributions

Dripping Springs High School provides education and develops new courses. Dripping Springs High School provides funding for the pilot program fees for membership at Tech Shop, and transportation for the students to Tech Shop.

Students from the video production program will attend the Tech Shop training to create a documentary on the experience.

Texas State University provides curriculum development and mentoring of the high school teachers. Texas State University faculty mentors will provide professional development opportunities for math, science and engineering teachers as well as guidance in curriculum development, including the provocative idea of a "Keystone Project" for graduating seniors.

Texas State University will create recommended programs based upon this collaboration that can be extended to other high schools, creating a pipeline of motivated, creative and excited engineering, science and other students to feed Texas State University and other university programs.

II. Benefits

The program brings academic concepts to life for Dripping Springs High School students by ensuring that they are able to see and feel the connection between what they learn in the classroom and how the concepts are applied in real situations. The tools, technology and services help them to provide access to lab experiences, otherwise unavailable to high school students.

The crux of this transformative education opportunity, however, is the ability to align Dripping Springs High School programs with university programs like those at Texas State University and therefore enhance the relationship between the faculty at the high school and the instructors and students at the university [6]. The mentoring will assist the staff and students alike at the high school, providing more support for understanding the relevance of and creating excitement for what is being learned.

Texas State University will benefit by having a well-prepared and enthusiastic group of applicants to their science and engineering programs. It will also benefit by having a clear differential over Massive Open Online Courses (MOOCs), through having opportunities for students to engage in hands-on engineering learning.

Over the longer term, the program will create a connection between high school and college curriculums that can be monitored and measured by high schools and universities alike.

It will enable high schools to go beyond the dead-end curricula success measurements that rely only on graduation rates, SAT and AP test scores. Instead, high schools will be able to collaborate with universities to construct curricula success measures that include the performance of the students in college and the work force.

The curricula will be exciting and relevant, encouraging our next generation of engineers to start thinking and feeling the exhilaration of innovation and engineering early on in their careers.

OTHER RELEVANT STEM AND MAKER PROJECTS

Other IEEE Sections have undertaken STEM projects. Some include training for specific tools such as MATLAB or LabView; others include hosting or helping with high school science fairs. The IEEE Princeton / Central Jersey Section has been especially active; they undertook an initiative to encourage high schools to form STEM clubs, which are informally affiliated with the Section and are eligible to complete for annual funding for projects. Additionally, they have funded a proposal from their high school students to purchase some computer equipment and create a cyber-classroom for a rural village in India. And they host the annual STEM conference, the IEEE Integrated STEM Education Conference.

Another relevant effort involves TechShop and encourages the Makers' Movement in Pittsburg, PA. This effort is aimed not at high school students but rather at displaced workers and returning veterans. "Making It In America" [7] involves industry, academia, economic development agencies, several non-profit organizations, unions and government (TechShop, Carnegie Mellon University and DARPA). It aims to train displaced workers and create a talent pool of skilled manufacturing workers in order to encourage startup companies with a need for manufacturing operations to locate in the Pittsburg community.

CONCLUSIONS

In 1882 Massachusetts Institute of Technology offered the first curriculum for electrical engineering education, and the discipline was not wide-spread until the period between World War I and World War II [8]. Today's generation may see a 21st century college-level discipline using more complex components as the building blocks of the field.

New careers and jobs fitting today's technology will restart manufacturing and be portable, diverse and multiplicative. By creating the ingredients for manufacturing in the 21st century, we hope to contribute to exciting opportunities for many.

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