AC 2012-4549: EARLY ENGINEERING THROUGH SERVICE-LEARNING: ADAPTING A UNIVERSITY MODEL TO HIGH SCHOOL

Dr. William C. Oakes, Purdue University, West Lafayette

William Oakes is the Director of the EPICS Program at Purdue University, one of the founding faculty members of the School of Engineering Education, and a courtesy faculty member in mechanical engineering and curriculum and instruction in the College of Education. He is a Fellow of the ASEE and NSPE. He was the first engineer to win the Campus Compact Thomas Ehrlich Faculty Award for Service-learning. He was a co-recipient of the 2005 National Academy of Engineering’s Bernard Gordon Prize for Innovation in Engineering and Technology Education for his work in EPICS.

Mrs. Pamela Dexter, Purdue University, West Lafayette

Pamela Dexter graduated from Purdue University with a bachelor’s of arts degree in education and worked as the Gifted & Talented Program Coordinator and teacher for a local school corporation. Dexter was also the Director of Marketing and Resource Development for Lafayette Neighborhood Housing Services, Inc., before joining Purdue University’s EPICS (Engineering Projects in Community Service) program. Dexter has been the EPICS High School Program Coordinator since inception of the program in 2006. Dexter is dedicated to the national dissemination of engineering service-learning design education in schools across the U.S. and abroad. These efforts blend the outreach initiatives of the EPICS program and Purdue University’s College of Engineering. Dexter institutionalizes the high school program through local, national, and international partnerships and leads efforts in curriculum development as well as teacher development and certification.

Dr. Jane Hunter, University of Arizona

Jane Hunter received her Ph.D. from the University of Arizona Center for the Study of Higher Education. She holds an M.S. degree in engineering management and a B.S. degree with distinction in mechanical engineering. She is the Associate Director of the Engineering Management Program at the University of Arizona and is a PMI-certified Project Management Professional (PMP). Her areas of interest include engineering education, teaching strategies, assessment and evaluation of program objectives and learning outcomes, student teamwork and group dynamics, business and technology management, strategic and operational planning, project management, and technical sales and marketing. Prior to joining the University, Hunter worked for several companies, including IBM and Anaquest, Inc., as an Engineer, Engineering Manager, Technical Sales Professional, and Director of Informational Technology. At the University of Arizona, she oversees the freshman engineering experience, which includes the introductory engineering course required of entry-level students. She also teaches undergraduate/graduate courses in the Engineering Management program. She is a member of Tau Beta Pi Engineering Honor Society, American Society of Engineering Education (ASEE), Project Management Institute (PMI), and American Society for Engineering Management (ASEM). She is the ASEM Southwest Regional Director. In addition, Hunter was recently named a McGuire Entrepreneurship Scholar.

Prof. James C. Baygents, University of Arizona

James C. Baygents is the Associate Dean of Academic Affairs in the College of Engineering at the University of Arizona. Baygents is a member of the Department of Chemical & Environmental Engineering (ChEE) and the Program in Applied Mathematics at the UA. Baygents joined the UA engineering faculty as an Assistant Professor in 1991, the same year he received a Ph.D. in chemical engineering from Princeton University. He also holds an M.A. (Princeton, 1981) and a B.S. (Rice, 1980) in chemical engineering. For three years prior to joining the UA, Baygents was a Visiting Scientist, then a Research Fellow, at the Space Science Laboratory of the NASA Marshall Space Flight Center in Huntsville, Ala. In 1995, he received the Arizona Mortar Board Senior Honor Society award for outstanding faculty service. In 1997, he was awarded an International Research Fellowship by the National Science Foundation for study at the University of Melbourne. In 2009, he was recognized by ChEE and the College for Excellence at the Student Interface. He is a member of Phi Beta Kappa, Tau Beta Pi, and Phi Lambda Upsilon honor societies, as well as the College of Fellows at Rice University’s Will Rice College. Baygents’s research interests include transport processes in natural and engineered systems; separations and water treatment

©American Society for Engineering Education, 2012
processes; diffusion-reaction-precipitation in aqueous electrolyte systems; electrokinetic theory, measurements, and separations; electrically driven fluid motion and transport processes, including microfluidics; pattern formation in caves associated with Karst water systems; and industrial water treatment for recycle and re-use.

Mr. Michael Gerard Thompson

Michael Thompson is a Ph.D. student in chemical education with a focus on engineering education at Purdue University (West Lafayette, Ind.), conducting research on the impact of STEM service-learning on college and high school students. For three years, Thompson served as the developer of research and evaluation strategies for the EPICS High program. He holds a B.S. in biology/chemistry and a M.S. in biochemistry from Purdue University. Thompson’s email: mthompson@purdue.edu.
Early Engineering through Service-Learning: 
Adapting a University Model to High School

Abstract

The challenges of this next century require a new generation of engineering talent. In the United States, interest in engineering has remained flat and many groups within remain underrepresented relative to the overall population, specifically women and ethnic minorities. Attracting the next generation of diverse engineers requires a diverse set of pre-college experiences to connect diverse pathways leading to an engineering degree. One exciting approach is the use of service-learning to expose students to design and engineering. Service-learning has been well established in many disciplines with positive impacts on interest, motivation, student satisfaction, personal success, desire, and retention of students who participated in service-learning projects. Service-learning is pedagogically consistent with literature on the recruitment and retention of women and other underrepresented groups in science and engineering. These benefits have been studied at the higher education level and show promise for pre-college as well. Service-learning connected to engineering also has an enormous potential for capitalizing on the wave of interest in community engagement among teenagers nationally. Connecting service to our community with engineering aligns perfectly with the National Academy’s Changing the Conversation. This paper describes the adaptation of a successful university model to high school having been disseminated to more than 50 schools in 10 states. This paper highlights high school programs that have been integrated into the school day and are supported by a large Midwestern university and two large Southwestern universities. Example projects are described as well as the academic structure and teacher training processes. Demographic data shows that the model is attracting more female students and students from groups traditionally underrepresented in engineering. Data also shows that students are becoming more interested in engineering as a result of their experience in the service-learning programs.

INTRODUCTION

The National Academy of Engineering called for engineers with sound fundamental skills along with the broad set of skills to develop solutions in a global environment. There has been a significant effort aimed at increasing the number of practicing engineers as well as attracting the kind of students called for by the NAE report. Despite the large effort, interest in engineering has remained relatively flat. Minority students and female students continue to be underrepresented compared to their representation in the overall population.

Attracting the next generation of engineers requires a diverse set of pre-college experiences to connect diverse pathways leading to an engineering degree. The report from the National Academy of Engineering, *Changing the Conversation*, called for rethinking how engineering is portrayed to young people and our society at large. Many engineering programs that have been developed over the last decade do not fit this model and still reflect a more traditional view of engineering. Meeting the challenges cited by the NAE report requires multiple and diverse pathways for students to come to engineering, including new and innovative alternatives to compliment the more traditional programs.

One pathway that fits the characteristics described in the report from the National Academy is service-learning. Service-learning connects learning STEM content with meeting community
needs on a local or even a global scale. Service-learning is viewed as experimental learning through the integration of traditional classroom teaching with structured service experiences and reflections that connect the service to the academic learning and allows students to learn more about themselves and the larger societal contexts. Service-learning has been well established in many disciplines with positive impacts on interest, motivation, student satisfaction, personal success, desire, faculty-student interaction, and retention of students who participated in service-learning projects. Service-learning is also pedagogically consistent with literature on the recruitment and retention of women and other underrepresented groups in science and engineering.

**EPICS Model for Engineering-Centered, Service-Learning Design**

One successful model of service-learning is the Engineering Projects in Community Service (EPICS) Program founded at Purdue University and recognized by the NAE, ASEE, Campus Compact and NSF as an exemplary approach to engineering education. EPICS is a series of courses where students learn design by participating in design teams that develop solutions to meet the needs of the local or global community. The design teams are broadly multidisciplinary with students from more than 70 majors at Purdue University during the academic year. The designs are engineering-centered, applying technology to meet the needs identified with the community partners. It addresses a broad range of needs including data management for human services, assistive devices, interactive educational displays and energy efficient, sustainable home designs for low income families. EPICS develops long-term partnerships with the community organizations that work with the student teams to identify needs and then develop, deploy and ultimately service designs to meet those needs. Their partnerships add capacity to the community partners.

In addition to adhering to the theoretical underpinnings of service-learning, EPICS has a set of core values that allows it to explicitly connect students’ interest in community engagement with science, technology, engineering, and mathematics (STEM) disciplines, while connecting content learning with the skills called for in the ABET 2000 and Educating the Engineer 2020 criteria. It can be argued that the structured combination of service-learning and engineering content that EPICS creates accounts for the program’s rapid expansion within Purdue and to 20 other campuses and explains why EPICS’ pedagogical strategy attracts a diverse population of students. The demographic trends in the EPICS programs at Purdue and other institutions have consistently shown that both women and underrepresented groups are attracted to the EPICS curriculum.

**EPICS in High School**

These data suggest that similar results may be achieved by leveraging the model as a pre-university approach. Two Purdue EPICS alums saw this potential and piloted an approach for a high school class in Bedford, Indiana supported by Prof. Ed Coyle (co-founder of EPICS) and Crane Naval Surface Warfare Weapons Center. The EPICS High School team produced a design for an assistive technology device that received a provisional patent and placed second in a national entrepreneurship competition. The class attracted a high percentage of women with enrollment of females exceeding males most semesters. The success of the pilot EPICS High School motivated an expansion into five states supported by a grant from Learn and Serve America.

The program has continued to grow and this paper will provide a description of EPICS and how it is implemented at the high school level. The high school program spans urban, rural, and suburban as well as in-school and after-school programs. Initial assessment data obtained using
both quantitative and qualitative methods will be summarized that show changes in both students’ perceptions of engineering and increased interests in engineering specifically from underrepresented ethnic groups and women. This paper will also provide discussions of recommendations for those interested in implementing STEM service-learning, lessons learned, and future assessment needed.

EPICS High Teacher Preparation

The goals of the EPICS High Program start with equipping teachers to create learning environments that engage students in hands-on design experiences that address the needs of their local communities. A four day training session has been developed that introduces teachers to service-learning, human-centered design, project management and other topics that enable them to manage and coach design teams. The training is designed to allow new teachers as well as experienced teachers to participate with parallel sessions and active learning that capitalizes on discussions involving experienced teachers. A sample of the topics and schedule is shown in Table 1. The workshop is designed to introduce teachers to the skills and topics needed to manage real design topics.

A curriculum was created to provide a tangible, classroom-ready approach to meeting the goals of the EPICS High program and the lessons plans are used during teacher training to provide teachers with experience with the curriculum. The curriculum was developed for use in varying socioeconomic and cultural contexts in high-school curricula across the country with the goal of giving students a sense of empowerment and involvement in their own communities, as well as a sense of engagement with a global community. It is designed to be flexible, written in sections that can be taught as stand-alone lessons, with or without homework assignments, or combined into a series. It is organized around five modules: Human-Centered Design, Service-Learning, Cultural Context and Ethics, Teamwork, and Communication. Each module includes 45 thematically organized nine-week lesson plans with content handouts and materials to assist educators in tailoring lessons to the needs of their specific classrooms and educational contexts.
The EPICS model follows the characteristics of high quality service-learning, including providing youth voice. Students are empowered to be drivers of the project and start with needs assessments that identify the community needs and initial projects. This empowers students and results in greater interest in and ownership of the projects. It was hypothesized that this method could draw students to the EPICS classes that were not necessarily interested in engineering but were motivated by the project. Data from as early as the first classes at Bedford, Indiana have shown this to be true.

Table 1: EPICS Teacher Development Workshop

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plenary Welcome and Introductions</td>
<td>Suburban/Urban/Rural Small Groups</td>
<td>Labview 1</td>
<td>In-school and After school Small Groups</td>
</tr>
<tr>
<td>Introduction of Web Tools</td>
<td></td>
<td>Solidworks 1</td>
<td>Teaching Communication Skills</td>
</tr>
<tr>
<td>Ethics, Social Context &amp; Culture</td>
<td>Managing EPICS Projects</td>
<td>Teaching Design</td>
<td>Cultivating Leadership</td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td>Funding and Sustaining</td>
<td>Presentations of Plans and Discussion</td>
</tr>
<tr>
<td>Intro to Service Learning and the EPICS Model</td>
<td>Engr. Careers &amp; College Prep</td>
<td>Assessing Teams and Individual</td>
<td></td>
</tr>
<tr>
<td>Intro to Design - The EPICS Design Process</td>
<td>Design Tools 1</td>
<td>Labview Advanced</td>
<td></td>
</tr>
<tr>
<td>Intro to EPICS Curriculum and Assessment</td>
<td>Assessing Teams &amp; Individual</td>
<td>Solidworks Advanced</td>
<td></td>
</tr>
<tr>
<td>Intro to Reflection</td>
<td>Managing EPICS Projects</td>
<td>Human Centered Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design Tools 2</td>
<td>Teaching Project Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sustainability</td>
<td></td>
<td>Closure</td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>Reflection</td>
<td></td>
</tr>
</tbody>
</table>
Another principle of service-learning is reciprocal partnerships with the community. Models are discussed to identify, cultivate and manage partnerships with community members. Reciprocal partnerships seek mutual benefits and empowerment. A hallmark of the EPICS model is the establishment of long-term partnerships with community members. After projects are delivered, the partnerships continue, through new projects or service of fielded projects. Another key type of partnership in the model is with engineers.

While teachers are introduced to engineering concepts and design, it is not the intention or belief that the training can equip them to be engineers. The concept of EPICS is to build partnerships and practicing engineers are needed as a key partner in the process. Experienced engineers mentor the student teams, provide reviews for the designs and assist teachers in the design process. The experienced engineers can come from industry, retired community members, university faculty or students. The EPICS High staff assists teachers in making connections with engineers in their own community.

**EPICS High Models**

The high school program models include in-school and after school models. The University model for EPICS is a curricular model that is part of the university curriculum. Adapting to the high school environment required more flexibility. EPICS High was designed to allow flexibility in program structure while still maintaining the core goals and pedagogy of the original program. Three models have evolved: embedded within the school-day curriculum, after-school programs, and combination in-school/after-school programs.

EPICS High programs embedded within the school day can offer separate classes dedicated to their projects that include engineering design classes (especially in states with engineering standards); technology education classes; and environmental science and career exploration courses. The projects can also be integrated into existing math, science, career education, or social science classes. Projects that are integrated into existing courses are used primarily as curricular connections between STEM courses and social studies, communication, art or English.

After-school programs leverage the interests students have in service and connect that interest with a STEM-service project that requires them to learn new material or reinforces previously learned material from STEM disciplines. Schools that have service requirements for academic diplomas can utilize EPICS High as a way to fulfill those requirements while teaching students about design and careers in engineering, technology and computing fields.

The combination in-school/after-school programs have been implemented to accommodate the diverse needs and interests of students and to allow more students to participate. Some students have difficulty accommodating both required courses and EPICS High courses in which they want to participate. Other students may be able to participate in class, but are too busy after school to attend meetings at that time. This two-pronged approach gives schools and students more flexibility while managing the kinds of diverse projects that are addressed by EPICS High programs that occur outside of school hours.

EPICS High projects are categorized by four main areas of impact: Access and Abilities; Human Services; Education and Outreach; and the Environment. Examples are shown in Table 2.

Table 2: Example EPICS High Partners and Projects
<table>
<thead>
<tr>
<th>Area of Impact</th>
<th>Community Partners</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access and Abilities</td>
<td>Muscular Dystrophy Association, Lions Club, Leader Dogs for the Blind, Special Needs Classrooms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wheel chair swing, accessibility ramp and railing, Tactile map, learning experiences for</td>
</tr>
<tr>
<td>Human Services</td>
<td>Food banks, Habitat for Humanity, Homeless shelters, Parks and Recreation</td>
<td>Software for data, volunteer and client management, play structures for children, sustainability analyses, playground designs</td>
</tr>
<tr>
<td>Education and Outreach</td>
<td>Their own school systems, Environmental agencies, local museums</td>
<td>Hands-on and lab equipment for middle and elementary classrooms, models for community education, mobile science centers</td>
</tr>
<tr>
<td>Environmental</td>
<td>Governmental environmental agencies, planning commissions, School systems, local universities</td>
<td>Recycling processes, Energy audits, sustainability analyses, rain gardens, green roofs</td>
</tr>
</tbody>
</table>

**EPICS High Project Examples**

**Fredrick Douglas Academy**

**New York**

Fredrick Douglas Academy (FDA) is located in New York in the Harlem district. When FDA first joined the EPICS High program they looked at projects that would include older students mentoring students at the feeder middle schools. Their program has since grown to involve several teachers with projects in various subjects.

In researching needs in their local community the poor air quality in a Senior Center located near the school was identified. Harlem is an area of extremely polluted air with a greater number of breathing-related health issues. Students and teachers already had some experience in growing plants in a greenhouse located on the roof of their school, and they made the decision to build on those learning experiences. The EPICS High project began with an extensive period of training in advanced chemistry; quantifying concentrations of various physical-chemical parameters, engineering; building water re-circulating systems, and ecology; studying the theory behind the Earth’s natural cycles. Students then focused on the process of building a self-sustaining ecosystem in the senior center. The system in the senior center is designed to beautify the center, but more importantly to generate fresh oxygen.

Other FDA EPICS projects are focused on Genetic and Environmental Engineering. FDA teacher Mauricio Gonzalez stated, “My best EPICS High success story is having seniors that have gone through this program get accepted to MIT and Vanderbilt with full scholarships, and reach the finals in the regional science and engineering fair. I have been able to give my kids the opportunity to become active contributors to the improvement of their neighborhood through their EPICS service learning design projects. They have a better sense of empowerment and citizenry than they previously did. Our students have made an exemplary impression on local...
community partners, and our work has been acknowledged by different organizations and has
been written about”.

**McCutcheon High School**
**Tippecanoe County, Indiana**

EPICS High emphasizes the importance of multidisciplinary teamwork. During Purdue’s initial summer teacher-training course, a team from McCutcheon High School included instructors of English, science, and special education, along with an education technology specialist. Their first in-school project had students designing, building and/or modifying equipment for their schools special needs classrooms. Then a senior, Monica Del Real began another McCutcheon project creating interactive PowerPoint lessons to teach phonics to early readers. These lessons will eventually be made available to urban schools across the country via Say Yes America. The project, said Del Real, “made things more real” than regular classes. “Just the idea that people are actually going to use it is exciting.”

McCutcheon also chose to partner within their school on initial projects, filling needs on their high school campus. One of the projects the students engaged in was for the school’s Guidance Department. Students tackled an issue the school was facing due to the dramatic increase of Hispanic students into the district. Many times the parents spoke little to no English, making the process of registering their students for school a frustrating one. Students worked with the English as a Second Language (ESL) assistant software computers creating software to give a welcome message and collect information in Spanish allowing parents and students to complete the registration process in Spanish. Forms then reverted to English for counselors to input for school use. A fairly simple solution to an issue that had surfaced in their school district made the registration process much more efficient for the school.
Columbus Area Career Connection (C4) has been a part of the EPICS High Family since the 2007 school year. They currently have 25 – 35 students working on projects. Their initial project upon joining the program was a community holiday light display, which students continue to work on and improve each year. C4 has been very successful in building long term partnerships and completing projects for established local organizations.

This past school year, Columbus students completed an Eagle pen and now have final plans to build the flight pen at Utopia Wildlife Rehabilitation which will be constructed during the summer with volunteer student workers from the Building Trades classes. The project was designed through the Architecture class.

Other projects included students in 3D Visualization and Animation classes. Students partnered with the Columbus Visitor’s Center in developing 3D models of Columbus’s architecturally
significant building. The project gave the Columbus Visitor’s Center more visibility on the internet. Thirty-two of the students’ models are now available on Google Earth 3D Warehouse web site along with information about the building.

Regionalization

As the model of EPICS has spread to other states, additional partners have been brought in to provide support for the teachers, students and their projects. Universities that are located near the schools provide a great resources and this section will describe how the area of Phoenix is growing with the support of Arizona State University and the University of Arizona in partnership with Purdue University and EPICS.

Arizona State University

EPICS at Arizona State University (ASU) is in the third year of a partnership with Xavier College Preparatory High School (XCP), a top-ranked girl’s high school located in Phoenix. In the current 2011-12 academic year the Xavier EPICS program involves four teachers and approximately 150 girls taking EPICS classes or working on projects in other classes. Two of the Xavier teachers currently involved have attended the national training session held each summer for EPICS high school teachers at Purdue and the national high school EPICS coordinator has visited XCP and observed their program in action.

The advantages of a local EPICS High school program partnered with EPICS at ASU is that this collaboration creates a connection that will help identify and recruit motivated high school students into engineering at ASU, by way of the high school program and classes. Presenting engineering to students as a fun and interesting educational experience is a major goal of EPICS programs everywhere.

Xavier High School is a leading provider of incoming freshmen to Barrett, The Honors College at ASU, and over half of all EPICS at ASU students are also enrolled in Barrett. By creating opportunities for top ASU students to mentor their high school peers, and do so in a way that clearly makes a difference for their community and world, everyone wins as these highly capable Xavier students are recruited to attend ASU and major in engineering.
The ASU – Xavier partnership is funded and supported by the school and the university, with additional funding for the last two years provided by Intel, and in-kind support this year provided by Ballet Arizona. A half-time Undergraduate Teaching Assistant (UGTA) funded at ASU has been assigned to facilitate the relationship between student teams at ASU and XCP. Regular meetings, e-mail and phone contact between the director of EPICS at ASU and the four teachers at Xavier helps to facilitate and coordinate interaction between the two programs.

In 2011 there were a number of joint activities held between ASU and Xavier. These included:

- **Ballet EPICS projects.** Launched in August 2011, a unique collaboration between EPICS at ASU and Ballet Arizona (the state’s leading ballet company) is thought to be the first collaboration of this type in the nation. Four projects are underway, each creating a three way partnership between Ballet Arizona, ASU, and Xavier. Activities to date have included joint team meetings, visits to the Ballet offices, and in October, over 60 EPICS at ASU and XCP students attending the opening night of Ballet Arizona’s world premiere of ‘Cinderella’ at Phoenix Symphony Hall, courtesy of Ballet Arizona.

- **Project Presentation Palooza (P3).** In October 2011, this EPICS team competition awarded $6,500 to the best of teams from ASU (10 of 36 overall teams) and XCP (2 of 30). Awards were provided by Intel, Innocentive, Barrett, The Honors College at ASU, and the Ira A. Fulton Schools of Engineering. The XCP teams from Xavier competed against each other but presented alongside the ASU teams in a standing room only atmosphere along with the EPICS at ASU student teams. This event is being planned again for March 2012.

- **EPICS High School Symposium.** In April 2011 a symposium at XCP was held to showcase the work of EPICS students at XCP and Phoenix Union Bioscience High School. Six ASU students facilitated a project competition at this event, and speakers include both Richard Filley, the director of EPICS at ASU, and Jamie Casap, Education Evangelist at Google.

Nearly 40% of the students in EPICS at ASU are female, while 100% of the students in EPICS at Xavier are female. The female students at ASU are strong role models for the younger female students at Xavier. For instance, all three ASU teams winning national awards are headed by females, as are many other top ASU teams. Future plans for the ASU – Xavier partnership include:

- **Collaboration to ‘Empower Girls.’** Building on the successes of the joint EPICS projects with Ballet Arizona a number of team projects underway or planned for 2012 in the EPICS at ASU program are designed to empower girls, such as clean water projects in Bangladesh, Burundi and South Africa. An effort will be made to both include Xavier students in these projects and also to promote awareness of young women involved in EPICS helping girls across the globe.

- **EPICS Showcase Event.** Planned for April 2012, this “Girls Have It” event will showcase the partnership between ASU and Xavier and will include the participation of 500 or more high school girls. At least 20 female students representing _________ at ASU are expected to participate.

High level support from the administration of both ASU and XCP has helped facilitate the partnership between the university and high school. Long term support and commitments are being sought to continue and enhance the ASU-XCP relationship. Support from the National EPICS high school coordinator has been very helpful and is expected to continue. The overall
Integration with First-Year Engineering Course taught in High Schools

The College of Engineering at the University of Arizona offers their Introduction to Engineering course at high schools throughout the state. The high school version of the course, henceforth referred to as ENGR 102 HS, began in AY 2008–09, subsequently grew to six high schools (AY 2009–10, 82 students), then to 14 high schools (AY 2010–11, 197 students) and currently includes 22 high schools with a total of 300 students enrolled in the course. At the high school, the course is taught by HS teachers who are appointed adjunct instructors by the College. The participating instructors typically have experience teaching AP calculus or science or, alternatively, career and technical education (CTE) engineering courses. The adjuncts receive two-weeks training from university faculty members who have offered the on-campus version of the class. Curriculum is supplied by the College and the HS instructors are given the freedom to supplement the curriculum with their own materials (most do). The HS students are admitted to the university as non-degree-seeking students and register for three units of ENGR 102—the same credit and course designation used for the on-campus engineering students. Students are recruited into the class by the HS instructor acting locally. The course is targeted toward HS seniors who have previously exhibited an interest and proficiency in math and science. Tuition is assessed, though at a greatly reduced rate (approximately 75% discount). College algebra and trigonometry are required as co-requisites for enrollment, and many of the students have had, or co-enroll in, calculus and AP science.

ENGR 102 HS is unique in several respects. Advanced placement courses are not generally available in engineering and most high school engineering schemes require that students take several years’ worth of high-school technical courses (electronics, computer programming, etc.), which doesn’t appeal to the vast majority of high-school students—including some who think they might want to be engineers. The concept for this course is to encourage students to look into engineering as a prospective college major and a profession that helps people, without asking them to take on additional commitment. Since a primary objective of the course is to portray engineering as a helping profession, EPICS High matches seamlessly with the goals of ENGR 102 HS. Due to the size of the network, which includes major school districts in the three largest metropolitan areas of the state, implementation of EPICS High in the ENGR 102 HS network has the potential for significant impact in the following ways:

- The EPICS High program will grow substantially and a model for a statewide program will evolve.
- 300+ students will develop a greater appreciation for the ways in which engineers help people and will become more committed to serving their communities.
- 22 engineering teachers will be trained in service-learning.
- 22 or more community service organizations will be helped by a group of enthusiastic and innovative students committed to solving their technical problems.

A pilot of EPICS High in six ENGR 102 HS classes is underway. In fall 2011, the College of Engineering team partnered with the National Director of EPICS to develop and conduct a workshop for the six teachers participating in the pilot program. The workshop was well-received inasmuch as all of the participating high schools elected to implement EPICS High in
their ENGR 102 HS classes. Each of the pilot schools has identified their community partners and has developed plans for their projects. At the end of the school year, students and teachers, in conjunction with their non-profit organization partners, will have the opportunity to display their work in a Showcase event intended to bring the community of schools and service organizations together in a celebration of the unique collaborations. Opportunities to include all Arizona EPICS High Schools, not just those offering ENGR 102 HS, will be pursued. The benefits of the Showcase are many. Students will have the opportunity to practice their communications skills and reinforce their sense of accomplishment. Members of the community will see real-world examples of the important roles that engineers play in helping people and may identify ways that EPICS High programs could benefit their communities. Finally, industry representatives will see the value of investing in the program and should be motivated to begin or continue to support them.

EPICS High is an ideal opportunity for the state’s three major public universities to work collaboratively to improve the quality of life in the state, while simultaneously developing the STEM pipeline. The strategy is to develop capacity on a local level to eliminate barriers that might prevent high schools from establishing a program due to travel and other expenses. A train-the-trainer model will be used. This plan is consistent with the long-term strategy for the national EPICS High Program to begin building statewide programs that include high schools, service organizations, colleges and university and industry partners all working in unison to achieve the goals of the program. Toward this goal, faculty members from the two largest universities in the state have forged a relationship in an effort to identify opportunities to collaborate. To further advance this strategy, representatives from one or more of the state programs will actively participate in the National EPICS High Workshop. By doing so, the representatives will gain knowledge by helping to conduct some of the sessions of the workshop and will bring the added knowledge to the local programs. Hopefully, the state programs will have made progress towards the goal of implementing a comprehensive statewide program strategy and will be able to provide guidance to representative from other states.

Data and Results

Teacher training has attracted a large number of teachers, shown in Figure 6, through the annual summer workshop and regional mini-workshops. The number of training participants has continued to increase and the demand has motivated EPICS High to begin development of an online course to reach teachers who are not able to travel to a training location.

The results of the training evaluation are very encouraging with a 69% increase in reported knowledge of the EPICS Program in the 2010 reporting period. 100% of participants felt that they had the tools to implement at their respective schools.
Student Data

The literature on diversity suggests that pedagogies such as EPICS High should be more welcoming to diverse students. The data supports that hypothesis. With over 2200 students from 50 high schools in ten states, the demographics are much closer to the overall population than the college engineering programs with 44% female participation, shown in Figure 8. The student breakdown by ethnicity also shows diverse participation, which is in part due to the schools that have participated. However, the fact that minority serving schools have sought our EPICS High is another positive sign. Underrepresented populations within engineering are represented at higher rates than the overall population in EPICS as seen in Figure 9. The population also reports 46% eligible for free or reduced lunch programs.

The National Academy of Engineer’s report on changing the conversation talks about changing the perception of engineering. Participants were asked about their perceptions of Engineering and there is clearly an increase in these attributes, as seen in Figure 10. Students were asked if their participation in EPICS motivated them to pursue a career in STEM.
Participants were asked how interested they were in engineering when they started their project. 32% reported “not at all”. Of this group, more than half of the females (53%) changed to “A lot” after a semester on the projects. Almost half, 47%, of the males also changed.
Discussion
Service-learning offers an enormous opportunity to be added to the current pathways into engineering and more broadly STEM. The EPICS model has been shown to transfer from the university to the high school environment. Engaging students in projects that matter within their local community is being shown as a way to engage students who do not think they are interested in engineering in real design projects. Very early in the first EPICS high school class, there were two young women who reported no interest in engineering but discovered they liked it after being on the team. This continues to prove true.

For engineering to make a difference, in the areas of diversity and overall interest, there have to be new and different models to compliment the current more traditional pre-engineering. Many of the classes are gender balanced with some having more women than men. More research is needed to identify the key elements of these promising trends and how they can transfer. Studies are underway to gather more detailed data on the participants and to track graduates into college.

Teacher training has received very positive reviews but it is becoming clear that a distance learning option is needed to provide economical training and support for teachers interested in EPICS. It is a barrier to ask teachers to travel to a central site. Regionalizing the training, as being done in Arizona is a key component that will help but there is still a need for on-line components to reach schools in other areas.

Originally, model was designed to use universities to disseminate the model with the faculty and students providing the engineering support. This has worked in a few cases but it has not worked on a broad and large scale. Many schools have found partners with local companies and community members to provide the support. Many universities have already invested in outreach models of their own and do not have the resources to assist additional schools. EPICS has established other partnerships with companies and professional societies to provide support for the schools beyond university partnerships.

One of the very successful partnerships has been between EPICS and IEEE The principal outcome of the effort is to establish a relationship between the student branches in each of the participating IEEE Sections, a local high school (or schools), and charitable, communal or humanitarian organizations in each venue. The secondary outcome is to institutionalize EPICS within IEEE by drawing upon the successful Teacher in Service Program (TISP) of EAB. Specifically, local Section champions will be trained by IEEE and EPICS staff on how to setup an EPICS site in their IEEE Sections using local volunteers and resources. These Section champions, and the volunteers they train, will be empowered to disseminate the model further – locally and to other Sections. This approach has broadened the portfolio of EPICS schools to include programs in Philadelphia and Puerto Rico and globally in South Africa, Zambia, Namibia, Uruguay, Zimbabwe, Nigeria, Belgium, Uganda, Argentina, South America and India.

Bibliography


