AC 2011-2032: SERVICE-LEARNING PARTNERSHIPS: IMPROVING EDUCATION AND ADDRESSING COMMUNITY NEEDS

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Service-Learning Partnerships:

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Introduction

Over the last 20+ years, a great deal of time, effort and money have gone into increasing interest in engineering among pre-college students. Despite these investments, interest in engineering has declined with participation of women and minority students continuing to be significantly lower than their percentage of the overall population. New approaches are being sought to attract and retain more students in engineering, especially populations who are currently underrepresented. *Changing the Conversation*, published by the National Academy of Engineering talked about the need to change how engineering is discussed and perceived by the public and potential future engineers[1].

While interest in engineering has been flat or declining, civic engagement has skyrocketed among young people. Service-learning in high schools is expanding rapidly but it is rarely connected to science, technology engineering or mathematics (STEM) fields. A growing body of literature suggests that connecting the STEM topics to people and their communities can increase interest in the STEM fields, especially among young women and underrepresented minorities[2-5]. Evidence from university service-learning experiences support this hypothesis in programs such as EPICS (www.purdue.edu/epics) and chapters of Engineers Without Borders, which are attracting higher percentages of women than the overall engineering population.

Further evidence comes from the *Changing the Conversation* study which is finding that the way engineers talk about engineering with the emphasis on the technology does not connect well with young people. What resonates much better is when connections are made between the technology and the impact on people and communities. If students who want to make a difference in their communities see the technology as a tool to accomplish their goals, they become more interested. This creates a tremendous opportunity for engineering-related service-learning in middle and high schools to increase interest in engineering or STEM fields.

The opportunity is to actually engage young people in actual engineering design that addresses needs in their communities. Some call engineering-related work in middle and high schools as pre-engineering. Service-learning has the opportunity to be *early* engineering. High school students have demonstrated that they can do real engineering as they create real solutions to community needs through service-learning[6]. Service-learning offers the kinds of open ended problems involving real people and real needs and constraints that are rich for developing the skills of engineers.

In addition, engineering service-learning has the opportunity to make a significant impact in local and global communities. Current technologies offer many opportunities to enhance services and operation of not-for-profits and address needs within the community. Computers can add efficiencies in the operation of human services. Devices, program and systems can be designed and built to improve learning and increase access for people with disabilities. Energy efficiencies and environmental impacts can be addressed in creative ways through modern technology. The challenge is that access to these technologies, products and expertise can be expensive, making them inaccessible to many in our society. Service-learning can help fill this gap by leveraging the time and energy of students and their professors, teachers and mentors.

Participants in *early* engineering-related service-learning experiences do not have to be limited just engineers nor those who think of themselves as future engineers. In the university programs, multidisciplinary teams are required and the same goes for high schools. For example the EPICS program at Purdue University draws from 60 majors, across engineering and outside. These kinds of projects need students who think of the people first and can react and evaluate as a user who is not as familiar with technology. While high school students don't have majors, many have interest or perceived interest and these kinds of learning experiences allow all students to learn about their community and be exposed to modern technologies. Many people are calling for a base technology literacy in the United States and engineering-based service-learning could be a powerful track to accomplish this.

Industry partnerships are critical to making this kind of approach work. Situating education environments within a service-learning design context opens up many aspects of design that university faculty and high school teachers are often not equipped to handle. Practicing engineers handle such challenges daily and can be a vital resource for the educators and students. A network of partnerships to provide support, guide and consult could enable a national scale effort that could have a significant impact on the engineering pool for the future. This paper highlights one model for such a partnership.

This paper describes a model approach for engineering service-learning that has been adopted both in the university and high school settings. Models at both the university and high schools are discussed. The important role of corporate partnerships is discussed along with the perspectives of industry partners who are actively engaged in the programs. Data from student and corporate participants is also presented.

Industry Engagement

Today's economic conditions create an imperative to do more with less, this includes engaging and educating the next generation of engineering leaders. Companies are also being asked to help address the expanding needs in our communities as budget cuts impact governments and not-for-profits. One corporate model is to encourage their employees to be engaged in the community as well as K-12 and university education. Often, these are separate initiatives supported by separate groups of employees as shown graphically in Figure 1. Each aspect is important. As resources are continually squeezed, we should ask how can we provide more impact with fewer resources.

An efficiency opportunity is the idea of a multiplier and service-learning could be just such a multiplier. The alternative approach is illustrated in Figure 2. At the university level, mentors can guide service-learning teams that draw other resources from the university and community to meet needs in the community. Employees may be mentoring a team of 15 students and can multiply her or his impact by 15 through the service-learning mentoring, impact both education and community needs. As they do this, they provide visibility for their company on campus and in the community in relation to the designs that are being developed. Many service-learning programs are multi-disciplinary which can also add efficiency as organizations look to make inroads into several majors on campus.

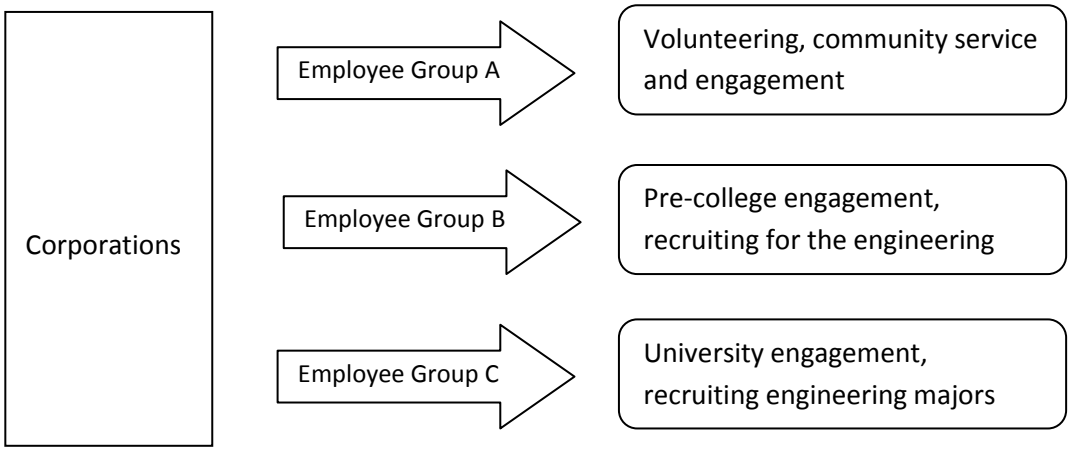

Figure 1: Corporate Engagement Models

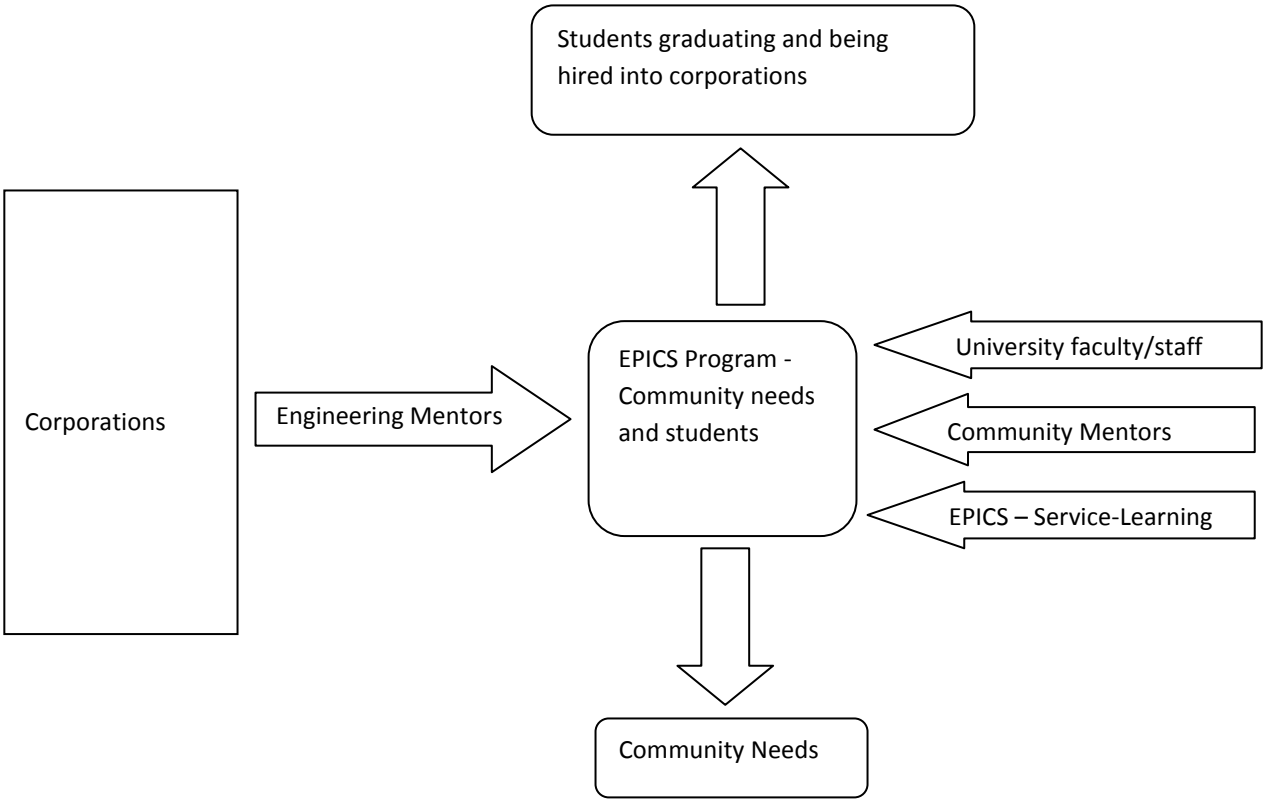

Figure2: University Model for Corporate Engagement through Service-Learning

A nationally recognized model for engineering service-learning is the EPICS Program. EPICS was initiated in the School of Electrical and Computer Engineering at Purdue University in Fall 1995 by Profs. Edward Coyle and Leah Jamieson[7-9]. The program has grown steadily in both size and breadth to where it is recognized as its own academic program under the College of Engineering. It has dedicated laboratories in the Armstrong Hall of Engineering. In the 2010-2011 academic year, almost 700 students participated on 90 projects , addressing needs ranging from data management for human services to creating energy efficient, sustainable home designs for low income families and from designing learning centers for local museums to developing custom play environments for children with disabilities. EPICS spans all engineering disciplines at Purdue and includes students from over 60 majors across the university.

Each project involves a team of eight to twenty undergraduates, a not-for-profit community partner – for example, a community service agency, a museum or school, or a government agency and a faculty, staff or industry advisor. A pool of graduate teaching assistants from seven departments provides technical guidance and administrative assistance.

Each EPICS team is vertically-integrated, consisting of a mix of first-year students, sophomores, juniors, and seniors and are multidisciplinary drawing from across engineering and the entire campus. Last year, over 60 majors participated. Teams operate for several years, from initial project definition through final deployment and support. Once the initial project(s) is completed and deployed, new projects are identified by the team and its project partner, thus allowing the team to continue to work with the same community partner for many years. Each undergraduate student may earn academic credit for several semesters, registering for the course for 1 or 2 credits each semester. The credit structure is designed to encourage long-term participation, and allows multi-year projects of significant scope and impact to be undertaken by the teams.

While one or sometimes several of the above attributes of EPICS can be found in other design programs, EPICS is unique in combining all of them. The unique structure and operation enables solutions of significant benefit to the community to be delivered. Example of projects are shown in Table 1.

Table 1. Sample EPICS teams at Purdue

Community Partner	Tasks	Disciplines
Greater Lafayette Children's Services	Develop computer-controlled toys for children with physical disabilities. Develop an artificial sensory environment to provide multi-sensory stimulation and a sense of control to children with physical disabilities. Provide ways for physically disabled children to control their motion and to play with	CmpE, EE, MatE, ME, CS, Nursing, Child Development

	peers.	
M.D. Steer Speech-Language and Audiology Center	Automate calculation of speech rate for clinical sessions. Design specialized speech recognition systems. Design directional microphone system for hearing aids.	EE, CmpE, CS, Audiology and Speech
Affiliate of Habitat for Humanity	Design systems, structures, and floor plans to minimize home construction and energy costs. Investigate new construction techniques and materials. Design data management systems for local, regional and national operations.	Civil-E, EE, ME, CmpE, IE, Mgmt, CS
Happy Hollow Elementary School	Develop technology-based interfaces to improve the usability of school science, computing, and media facilities, including a weather station and a TV studio. Develop an interactive science center in the school.	EE, ME, CmpE, CS, Education
Imagination Station (local, interactive science and space museum)	Develop hands-on exhibits that demonstrate science and engineering principles for the Imagination Station Interactive Science and Space Museum.	EE, IE, ME, CmpE, CE, ChmE, Art and Design, Liberal Arts, Education
Purdue's Office of the Dean of Students Adaptive Programs	Design classroom furniture for physically handicapped college students; develop closed-captioning systems for deaf and hard-of-hearing college students.	EE, ME, CS, CmpE, Liberal Arts
Lafayette Adult Resource Academy	Develop computer hardware and software to help non-native English speaking adults become acquainted with the community and gain job-related English skills; develop a uniform computer interface to allow LARA staff to use a wide range of computer programs with their clients; develop software to facilitate record-keeping and reporting.	EE, ME, CmpE, CS, Liberal Arts, Education
Wabash Center Greenbush	Develop aids to assist workers with disabilities as	EE, ME, IE, CmpE,

Industries	they perform simple manufacturing tasks.	Mgmt
Lafayette Columbian Park Zoo	Design a multimedia learning center, including exhibits, kiosks, interactive computer programs, and sound systems for the zoo.	CmpE, CS, EE, Civil-E, ME, Visual Design, Education

Corporate Partnerships

Corporate partnership are critical to the success of the EPICS Program. One form of the partnership is through weekly mentors or advisors. At Purdue, eight professionals from local companies serve as advisors for teams. Advisor is the term EPICS uses for instructor and is more appropriate for the role. Advisors act more as a coach than a traditional teacher as the students develop the designs for their community partners. These advisors supervise a division which typically has 3-4 projects active per community partner. The advisors mentor the students and assign grades. They work with the teams on a weekly basis.

An important lesson learned in these kind of partnerships is that that we need to establish the partnership between the corporate management and the EPICS administration. Early in the program, relationships were established based on individuals. That model broke when the people were promoted and moved in the middle of the semester, leaving a class without an instructor and the EPICS Program scrambling to fill that slot. By developing the partnership with the company's management and the EPICS Program, we are able to work together to replace employees as they move through their careers and maintain the academic support during the school year.

Some corporate volunteers cannot commit to a weekly meeting and they serve as design reviewers. Twice each semester, every EPICS team conducts a design review, at the midpoint and end of the semester. Corporate representatives serve as the design reviewers for the teams and provide valuable feedback to the students. Each design reviewer is given training and standardized forms to provide feedback and the teams are scheduled so that a reviewer can attend four lab divisions in a day.

Corporate representative also participate in the lectures and workshops that are part of the EPICS course. Topics cover design, project management, communication, ethics, customer relations and community involvement.

Finally, corporate partners also provide financial assistance for the materials needed for the designs. EPICS does not charge the not-for-profits for their products and corporate funding allows this tradition to continue and add needed value to the community.

Corporate Perspectives

Four of the corporate advisors, each spending weekly time with the Purdue students as they develop their designs, provided their perspectives to a series of questions. These provide some insights into their experiences being engaged in the service-learning program.

1) Why do you participate in EPICS?

My brother is disabled and benefits from the services WCGI provides. EPICS is a way for me to give back to those who give him a sheltered, safe place to work and interact.

I like to be a part of the educational experience for students, and it's fun to see students gel as a team and accomplish some meaningful objectives. It's also fulfilling to serve our community partners by providing advice and guidance to our team members.

a. EPICS is an application class where the student is "required" or encouraged to use his or her knowledge learned from other sources to solve a problem or complete a project in the community. The application of previous knowledge (or skills) are not stressed [in college] and is a necessary need for most employment opportunities.
b. Many recent graduates from college are not properly prepared to solve real problem that are complex and where the problem approaches are not defined for them. Therefore, this class should be and is a real learning opportunity for many students.
c. By completing the EPICS class, the student is able to obtain free advice on their problem solving skill levels. They also can gain valuable feedback from industry advisors before they enter the work force. Therefore, this class should be a positive learning experience and time commitment for the students.
d. EPICS also stresses documentation, communication skills in groups and presentations skills as well as the problem solving skills. For most students, these skills are learned skills (not taught skills) thru practice.

Because I regard it as important to reach out from industry to the academic world and share, what in my personal case, has been more than thirty five years of experience in a diverse range of leading edge engineering positions within key and strategic industries. This gives an opportunity to help groom an upcoming generation of engineers and other professionals and offer some payback for the wealth of learning experience provided by all those years of personal contribution to wealth creation.

2) What do you think your participation adds to the student experience?

I believe my participation adds a real world outlook and expertise. It makes the experience more real for the students.

My participation helps students grasp the significance of their work, both in terms of community impact and also in terms of their professional development. I can relate the skills they're learning to jobs in information technology. This helps them understand the

relevance of what they're learning and also frames their entire experience: part of the reason they participate is to prepare for a career in software development.

a. For the interested student, my past experiences and problem solving efforts can be used to help guide the students with their project efforts. This is particularly true with the student's presentation efforts and evaluations of problem solving options which is a general weakness of the students.
b. I think that I can give the students more confidence that their efforts and approaches to obtain solutions to issues are valid and help them to present and justify their ideas and solutions.

Hopefully; it provides some real exposure to a seasoned engineering professional with the ability to answer questions about that world of working in industrial settings and to also be able to provide guidance on the importance of budgeting, project planning, project execution, teamwork and interaction with customers.

3) What value does your participation in EPICS add to you and/or your company?

It provides a connection to both the community and the university. They can use this to give back to the community, but also to draw from for future talent.
EPICS helps me think about team dynamics and effective ways to organize software development teams. I also have a better idea of the type of team member I'm looking for when interviewing potential new hires

a. I enjoy giving back to the community the knowledge what I have gained thru my 40+ years of working within industries. I value and enjoy my time with the students.
b. This is a positive outreach program for industries to help industries and universities to graduate and/or hire better prepared students. This experience should also give the graduating student a step above other less fortunate students during their first year of employment. From a company point of view, it should allow the new hires to earn their pay checks (company point of view) earlier than other recent hires.
c. It also provides industries with insight to top notch students for candidates for employment.

Working with EPICS provides my company with an opportunity for good corporate citizenship within both the local community and higher education establishments. It provides me with a further measure of personal growth in that it further develops my own skills in the conveyance of knowledge and experience not to mention working in a cross generational environment. It has also taught me the immense value of EPICS as a tool to early professional development and that hiring managers are likely to show a high preference for potential recruits who present participation in EPICS on a resume.

High School Model: Early Engineering through Service-Learning

High school students can also be multipliers to address community needs. As illustrated in Figure 3, K-12 service-learning could also add efficiency to the way companies engage the K-12 education system and the local community. The EPICS Program has shown the ability to do this at the university level and the potential benefits to the community and student participants motivated the expansion of the model to the high school level.

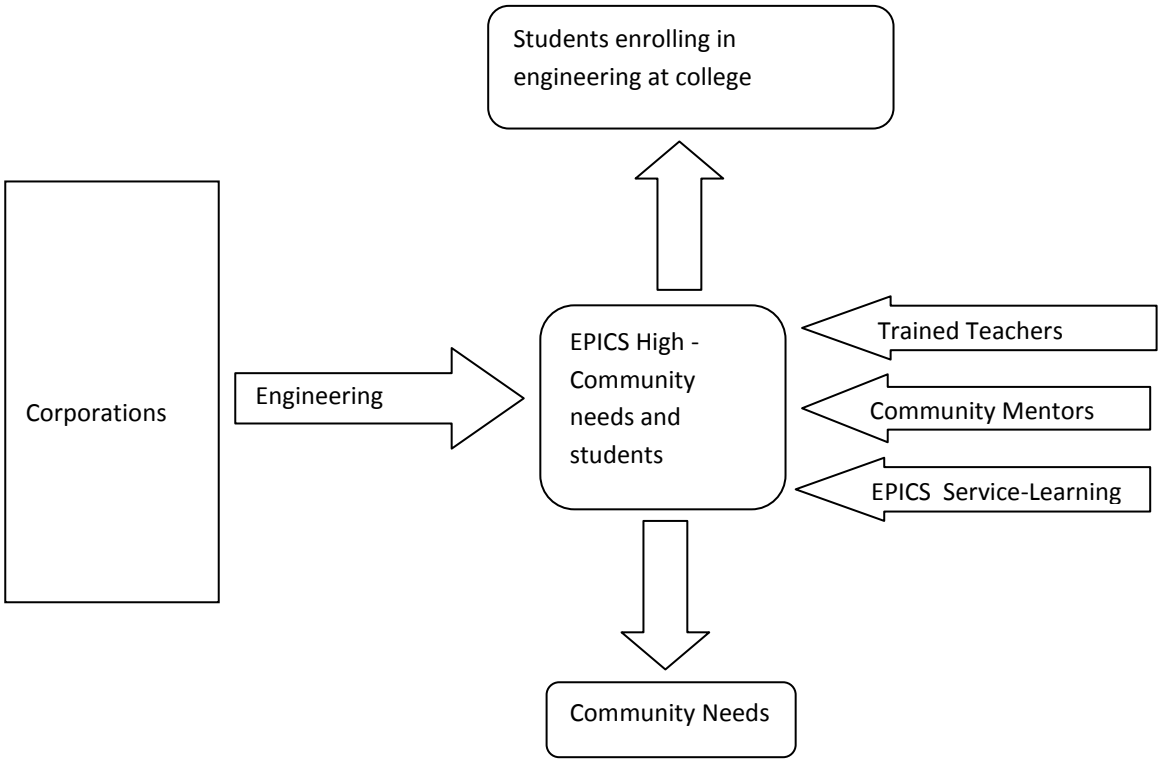

Figure 3: Model for Corporate Engagement

Transferring the college-level model to a high school environment required restructuring to provide the engineering background and technical skills required by the individual project(s) and to acknowledge pedagogical needs of younger adolescents. This approach teaches design in an engineering-centered but multidisciplinary approach. Student design teams work to define, design, develop and deliver projects in their local community over a semester or even several years for large and complex projects. The EPICS model forms partnerships that last several years with local not for profit organizations, educational institutions and governmental agencies to meet needs in the local community. The long-term partnerships provide real value to the community in that projects that are fielded are supported after deployment, existing projects can be upgraded and relationships are built that improves the understanding of the partners and the projects that are produced.

This model is being adapted and implemented in high schools in seven states (epicshigh.ecn.purdue.edu). The summer teacher development sessions were created to equip teachers to manage student design teams. A model of the design process is taught to teachers. This model, shown in Figure 4. The same model is used at the university and high school level.

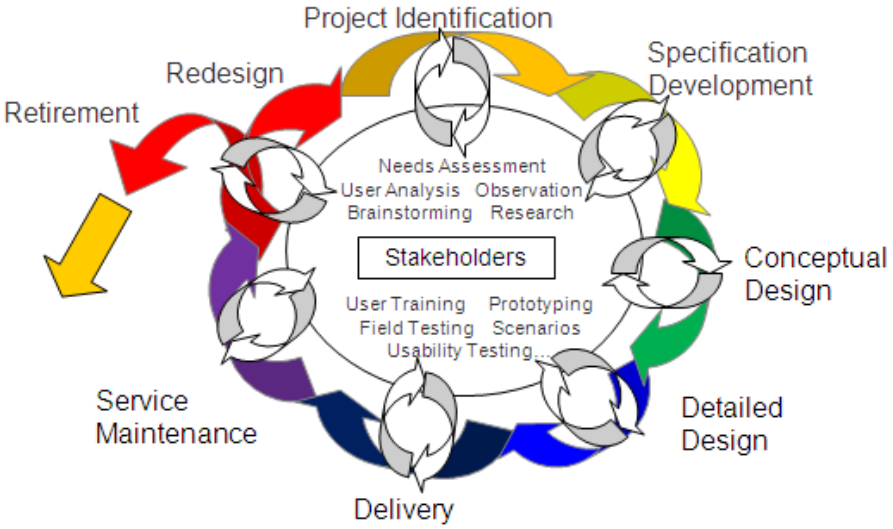

Figure 4: EPICS Human Centered Design Model

This model is a human-centered approach to design. The local community partners provide real users for students to interact with and gain insights into the needs of the community as they develop their designs. This high school concept was piloted at the first EPICS High School Program in Bedford, Indiana[6]. Engineers who worked at Crane Naval Base and had participated in EPICS as college students, partnered with science teachers to create an EPICS team that designed a swallow monitoring device for a middle school student with neurological disabilities that resulted in the student drooling. The device was a feedback device that fit around the neck and if it didn't detect a swallow in a period of time, either sent a tone to an ear piece or activated a vibrator. This team has a patent pending on the device and finished second in a university entrepreneurship competition. True early engineering!

The success of the pilot school motivated a grant from Learn and Serve America to expand the approach to five states with a diverse set of schools that include public and private as well as urban, suburban and rural schools with diverse socio-economic and ethic populations[10]. The program has grown to have schools in seven states. Example projects include:

Wastewater diversion/"green" field maintenance project - Caseville Michigan
Students are designing an irrigation system that will use the discharged water from backwashing the municipal water systems filters. Currently, this water is pumped into lagoons as waste. The water contains silt and other solids but is not contaminated. The water will be used to irrigate the community athletic fields that are adjacent to the school. In addition, water will be supplied to irrigate an organic garden and educational facility

next to the school. This garden will be used to demonstrate sustainable agricultural practices and water useage. A wireless data acquisition system is being installed to make the garden a living laboratory for the school's science classes as well.

Inventory and Case Management Software for Food Bank – Harbor Beach, Michigan

Students are designing a software system to manage inventory, exchanges in the foodbank and to track usage. The software is based on commercial software for account management and is being designed to link the food banks within the county to improve efficiency, coordination and sharing of resources to serve the families in need in their area. A web application is planned in the next phase that would allow potential donors to see what the needs and surpluses are for the food bank. As part of the project, students worked as volunteers at the foodbank.

Guidance Department ESL Assistant Software, Lafayette, Indiana

Students creates software to aid Spanish speaking families to communicate information with the school and help to enroll students. A growing Latino population and a shortage of Spanish speaking school counselors created a need for the students to fill with software engineering. A computer kiosk was installed to give a welcome message and common task menu for Spanish speakers entering the high school. The system walked the users through common options for families, such as enrollment, withdrawal and questions commonly asked. Completed computerized forms were translated to English for the school counselors/ to use

Aquaponics for Nursing Home - Harlem, New York

Harlem has the highest incidence of breathing diseases including emphysema and asthma in the New York metropolitan area. The students are developing and installing aquaponic systems at a nursing home to improve the air quality. Once the systems are installed, the students monitor the air quality to assess the impact and to identify ways to improve the system. Elementary and middle school classes are included with projects in the nursing home, contribute to the project and are exposed to the high school design project

Elementary School Science Materials - Harlem, New York

Students partner with elementary school teachers to design and build science equipment for use in their classrooms. The schools in the inner cities often lack the science infrastructure to engage students in the exciting opportunities in science let alone connecting to engineering. The connection with the high school program to the lower grades creates the opportunity for mentoring by the high school students who are doing the designs for the classes. The context of a design that will be used by elementary school children introduces user-centered design issues as well as issues of durability, safety and reliability that are real engineering constraints. The result of the project is increase capacity in the STEM classrooms within the school district.

Green Roof – Boston, Massachusetts
Students are partnering with an environmental not for profit organization to design and build a green roof on a local university library. Data will be collected from the roof on the impact on energy efficiency and environmental impact. The project is intended to be a demonstration and education project as well as reducing the environmental footprint of the university.

Energy Education and Demonstration Trailer – North Huron, Michigan
Students are converting a trailer into a portable energy demonstration learning environment. Students have built a small bio-diesel demonstration system along with solar and wind energy models. The trailer is being equipped with energy and water conservation demonstrations that will teach community membersf about ways to reduce our environmental impact. The trailer is also equipped to be the stage to make presentations for community and school groups.

Tactile Maps – Detroit, Michigan
Students are partnered with a center that trains leader dogs and is designing a tactile map of the downtown area for people with visual disabilities. The map will be an improvement from current designs with improved detail and Braille descriptions of areas. The free standing map will be housed in the lobby of the training center, allowing visitors to learn the downtown area before taking their leader dogs out for practice.

Water Quality Testing – San Diego, California
Students are designing water quality monitoring systems and are taking data on water quality in local rivers and resevoirs. Students design the test systems and data acquisitions systems by integrating commercially technologies where appropriate. Students analyze the data from the findings and present their results to the community.

Implementing EPICS High

Three models have emerged for implementing EPICS into high schools. The first is as an after school program or club. Students meet with teachers after school or during activities periods during the school day. This model was the one that launched the pilot at Bedford, Indiana.

A second model has been to integrate an engineering-based project into an existing course. Students work on the project and relate their work to the class material. These have been science classes such as physics, mathematics, technology and agriculture classes. One school was using the projects in more than one course. The projects could count in a science class as well as the English or careers course.

A third model has teachers created a separate course around the engineering projects. This model has emerged in states with engineering or technology standards. This has been most common in states with engineering or technology education standards, such as Massachusetts.

Other places where the EPICS course has appeared is in careers exploration courses. These kinds of experiences allow students to explore different "jobs" as they rotate different roles on the teams. Appropriate reflections can build on the experience to give students a deep understanding of opportunities for careers, casting the careers in the context of needs in their own communities.

Partnerships with EPICS High

Engineering-based projects require many levels of partnerships from the community, government and private sectors. In the community, long term partnerships are needed between schools and community organizations. The EPICS Program has demonstrated the need and value of long-term community partnerships. First, in the quality of work that is being done. It is not obvious what community needs can be met with engineering and technology but once a partnership is established and begins to develop with initial projects, a host of other opportunities become apparent. Also, as the community partner learns what the students can do and the students learn what the partner's needs are, richer and more meaningful projects are developed. The relationship between the two contributes to richer and more effective projects with greater impact on the people we serve.

The second benefit from the long term partnerships is the support of the fielded projects. Most engineering-based projects result is a device, program or other artifact that that is used by the partners. These delivered projects inevitably need maintenance and/or support. Software, for example, can develop problems when operating systems are upgraded. Interactive displays for children can get broken. Parts may need replacing. Since the community members don't have technical staffs themselves, the students provide the value of service and support of the fielded projects.

Another kind of partnership that is critical to the success of the engineering projects is with practicing engineers or an entity that can provide engineers. Most high school teachers are not engineers. Many projects require technical expertise that is beyond the knowledge of the high school teachers. This expertise can be obtained with partnerships with organizations or companies that have engineers. These partnerships have been critical to the success of the initial cohort of schools. o prepare lessons for the EPICS teams, they arrive to consult in their area of expertise.

This kind of partnership provides efficiency for the corporate volunteers. There is minimal training that is needed for them to partner with EPICS-High teachers. They are asked to provide technical advice, not create curriculum or entertain pre-college students. They are being part of the technical team developing a product for the community. In addition to technical consulting, the engineers can mentor the students in the development of professional skills and career decisions. Like with the university program, there are many levels and ways to connect.

They can be a regular mentor who meets on a regular basis, come to design reviews a few times per year or provide specific consultations when needed.

Results from EPICS High

The December issue of ASEE's Prism, started an article with the following:

> *Jessica Roggenbuck is midway through freshman year at the University of Toledo. If you had told her two years ago that she would be studying chemical engineering, however, you might have gotten a puzzled response. "Engineers? I thought they were train drivers," she admits, with a laugh. But during her junior and senior years at Harbor Beach High School in Michigan, Roggenbuck developed a new appreciation for engineering when leading an after-school project to help charity food pantries track their inventories using a computer program she and other students had designed. "It helped me understand what an engineer does," says Roggenbuck. It also influenced her decision to pursue an engineering degree.*
>
> *The project Roggenbuck joined operates under the auspices of EPICS High, a national initiative based at Purdue University's college of engineering. For the past four years, it has gained momentum from the push to get more American students interested in engineering – especially young women, minorities, and students from low-income families, all of whom remain woefully underrepresented in the field. The genius of EPICS – Engineering Projects in Community Service – is that it tackles this goal by engaging students in service learning.*[11]

Jessica is not alone. EPICS is proving to attract a high percentage of young women. The most recent census shows EPICS' percent of female participants over twice the national average for engineering.

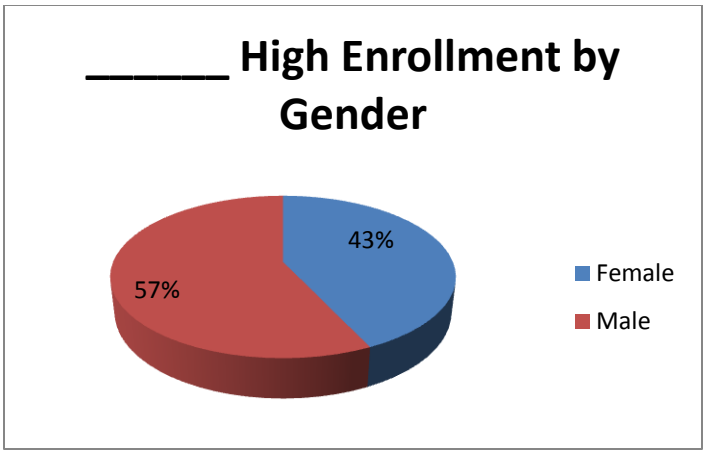

Figure 5: Enrollment by Gender

In addition to attracting a more diverse population, students are showing an increased interest in the STEM fields and in engineering. Survey data from this past year showed positive results including

70.0% Show increased interest in taking STEM classes in High School
76.2% Show increased interest in pursuing a STEM major
80.0% Show increased interest in pursuing a STEM career
65.1% Students state that EPICS influenced them to stay in school

The impact on the students is significant, but it also impacts the community. A holiday card sent this year to the EPICS Program from Caseville City Schools stated that the "EPICS Program has been a blessing to the entire community"

Conclusions

Service-Learning is a potentially powerful tool for corporate-university and corporate-high school partnerships. It is not a silver bullet for all of the challenges we face, but it can be a powerful tool in our arsenal. If we are to excite and engage a truly diverse and talented pool of future engineering leaders, we need a diverse and exciting array of opportunities along the pathways to engineering. While traditional pre-engineering curricula and competitions are engaging thousands of young people in technology, we are still missing many students.

Service-learning can help do that without having to take resources away from addressing needs in the communities. Often, these needs become barriers for students succeeding in the pathways into engineering. Service-learning can help address these challenges and provide an efficient vehicle for learning the broad set of skills needed in today's global engineering environment.

Service-learning also offers cost and resource efficiencies needed in today's challenging economic climate. Service-learning leverages existing resources with the purpose to address compelling needs in our local and global communities. Partnerships are the key concept in making this work and corporate partners integral to success. Through service-learning, we could reach more students for engineering and in the process address more needs of our citizens without more resources.

There is also an immense in the pre-college arena to expand our partnerships and leverage the national network of service-learning professionals that is in place in every state. These professionals are training in K-12 service-learning, teacher development and partnership building related to community-based projects and learning. They have not, however, been engaged in STEM education and that is an opportunity for engineering education. With corporate and university partners, this national network could be unleashed as partners to bring technology to our communities and excite the next generation of technical leaders. In the process, we will also make the world a better place.

References

1. NAE (2008). *Changing the Conversation: Messages for Improving Public Understanding of Engineering*. Washington, DC: National Academies Press.

2. Rosser, S. V. (1990). *Female-Friendly Science*. Pergamon Press, Elmsford, NY.

3. Rosser, S. V. (1995). *Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering.* Teachers College Press, New York, NY.

4. Seymour, E. & Hewitt, N. (1997). Talking About Leaving: Why Undergraduates Leave the Sciences, Boulder, CO: Westview Press.

5. Tsang, Edmund, (2000). *Projects that Matter: Concepts and Models for Service-Learning in Engineering,* American Society for Higher Education, Washington, DC.

6. Nation, Sarah, Oakes, William, Bailey, Lowell, Heinzen, Jill, "Conversion of Collegiate EPICS to a K-12 Program", *Proceedings of the Frontiers in Education Conference,* Indianapolis, IN, October 2005.

7. Coyle, Edward J., Leah H. Jamieson, and Larry S. Sommers, "EPICS: A Model for Integrating Service-Learning into the Engineering Curriculum",*Michigan Journal of Community Service-learning,* Vol. 4, Fall 1997

8. Coyle, E. J., Jamieson, L. H., & Oakes, W. C. (2005). Epics: Engineering Projects in Community Service. *International Journal of Engineering Education, 21*(1), 139-150.

9. Coyle, E. J., Jamieson, L. H., & Oakes, W. C. (2006). Integrating Engineering Education and Community Service: Themes for the Future of Engineering Education. *Journal of Engineering Education*, 7-11.

10. Thompson , Michael, Pamela Turner and William Oakes, “Teaching Engineering In High School Using Service-Learning: The Epics Model”, *Proceedings of the 2008ASEE Annual Conference*, Pittsburgh, PA, June 2000.

11. Grose, Thomas K. “A Winning Combination, EPICS draws high school students to engineering through community service”, *Prism* magazine, December 2010