Engineering Service-Learning : A Model for Preparing Students for Engineering Practice While Meeting Needs of the Underserved

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Abstract : *Preparing tomorrow's global engineering leaders requires a strong technical foundation as well as a broad set of professional skills. Integrating these into the undergraduate curriculum can be challenging within traditional courses. One approach that has shown success is service-learning, which engages students in meetings needs of local or global communities. An engineering exemplar of service-learning approach is the EPICS (Engineering Projects in Community Service) Program founded at Purdue University and disseminated to more than 20 other universities. This paper describes the EPICS model and how it has been disseminated and discusses data on student perception and learning.*

1. Introduction

Engineering educators in countries across the globe face daunting challenges to adapt their curricula to prepare students to succeed in today's global economy. Technology continues to advance, adding content that must be covered without compromising the fundamental knowledge needed in all engineering disciplines. In addition to the technical expertise, industry is asking that graduate possess a strong and broad set of professional skills including communication, teamwork and leadership, societal and global awareness and entrepreneurship and innovation. The U.S. National Academy of Engineering (2004, 2005) summarized the need to integrate these very broad skills with the technical in their reports describing the engineer of 2020. Industry adds to this list by asking for graduates who are ready to step into the corporate sector with minimal training.

As engineering educators, we face a significant design challenge to create curricula that can accomplish these goals. With traditional approaches, we either have to take things out of the curriculum or add time toward graduation. An alternative approach is to seek more efficient learning experiences for students that enhance learning the core content and facilitate learning of the broader set of skills needed for engineers in this century. There is significant research on educational practices that can do this (Eyler and Giles, 1999). Service-learning is one of these potentially powerful tools that is backed by educational research and has the potential to provide this kind of efficiency needed to prepare the future leaders of the 21st century (Coyle, Jamieson and Oakes, 2006). Service-learning also has the potential to address broader needs of our local and global communities. This paper describes service-learning and the EPICS (Engineering Projects in Community Service) model which is integrated into the engineering curriculum. We discuss research findings from the current EPICS Programs and offer a perspective on the potential impact for India and other developing countries.

2. Service-Learning Overview

Service-learning is the intentional integration of service experiences into academic courses in order to enhance the learning of the core content and to give students broader learning opportunities about themselves and society at large. In engineering, design offers an excellent way to fulfill the service component of service-learning. Designs done to meet needs of underserved people or groups within our society can provide a valuable service to our local or global communities. Service-learning does not simply comprise volunteer activities but rather integrated learning experiences within the curriculum. These experiences are what can create the needed curricular efficiency to meet the educational goals for the engineer of the 21st century.

In addition to curricular efficiency, service-learning leverages resources of our colleges, schools and universities as well as energy of our students in order to address broader needs of our society. This form of efficiency is vitally important in these days of tightening governmental budgets and growing social and environmental challenges. Service-learning creates opportunity for learning while addressing the needs of the underserved within our society. Moreover, service-learning has enormous potential to enhance engineering education. While there are many successful examples of service-learning within engineering (Tsang, 2000; Oakes, 2004), our field has been slower than other disciplines to integrate service-learning into our curricula on a large scale.

3. Characteristics of Service-Learning

One of the most common definitions for service-learning within higher education is a type of experiential education in which students participate in service with the community and reflect on their involvement in such a way as to gain further understanding of course content and of the discipline and its relationship to social needs and an enhanced sense of civic responsibility (Hatcher and Bringle, 1997). The pedagogy of service-learning has four key characteristics. They are: service, academic connection, reciprocal partnerships, and reflection (Lima and Oakes, 2013).

Service - A central component of the service-learning experience involves service opportunities that meet the needs of the underserved in a community and/or contribute to projects for the common good of the community. In engineering, service can take many forms, from direct contact with people through educational programs for children or the elderly to projects that are delivered to the underserved populations to address a need, such as a solar power system for a remote rural village. It can also take the form of research, data analysis and interpretation and presentation of results, such as addressing an important environmental issue. The service might address a short term need that is filled during a course or it could be part of a larger on-going project or set of projects in an area.

Academic Connection - The service students perform must provide reinforcement of and connection with the subject material of an academic course. If it is a design course, engineering design principles are being taught and the service provides an environment in which to apply what they have learned. This requires that each service-learning design project have appropriate engineering content to address the academic goals of the design course. The service provides a context for the academic material. In addition to design, there are other ways to integrate a service-learning component into an engineering course. For example, an Indian colleague integrated a service-learning component into a mechanical engineering course on internal combustion engines. Students performed a service of installing and monitoring emissions control devices in local vehicles. It gave the students a real, hands-on application to the theory being presented in the class and gave affordable access to emissions reducing technology to the community.

Reciprocal Partnerships - Service-learning involves partnerships characterized by reciprocity between the community and the university. The concept of reciprocal partnership is very important and means that each one is contributing to the partnership. Each learns from the other. Students performing service-learning are not doing something for the community, but rather, with the community. Each member of the partnership contributes to the goals of the project and each member benefits from it. Students and community members work together as partners in addressing a community need, and both groups benefit from the activity.

Reflection– Reflection is a vital component of service-learning as well as in education in general. As part of the service-learning experience, participants are intentionally guided through activities to reflect upon (or analyze) the work being performed, the processes by which the work is accomplished, the implications of the work and the learning that is taking place. The traditional service-learning language, developed in disciplines outside of engineering, uses the term "reflection" which may seem foreign in engineering. However, good engineers reflect often on their work but we may call it "analyzing". It is the same basic process of guiding the students through metacognitive activities, which have been shown to improve learning. Metacognition or reflection can help students understand: the academic material covered by the course; how the course material relates to the service; the implications of the social context and issues associated with the need being met; and the role of engineering in the context of large social issues. There is an increasing awareness within engineering that the global engineer needs to be a reflective professional and reflection through service-learning can prepare them for such a career. Activities promoting reflection can take several forms such as answering open-ended questions, written or oral, being guided through specific discussion topics, and written summaries of the work being undertaken and its implications, and assigned readings. The benefits of reflection are not correlated to the length of the reflections but to their frequency and their connection with the learning of the experiences.

4. Research on Service-Learning

There have been many successful models for implementing service-learning across many disciplines (Zlotkowski, 1998) and within engineering (Tsang, 2000; Oakes et al., 2002; Oakes, 2004). The majority of research on service-learning has been done outside of engineering, and within engineering, much of evaluation has focused on the development of professional skills. Evaluations from the EPICS Program at the Purdue University showed students reported learning teamwork and communication as part of their participation in engineering design teams (Coyle, Jamieson and Oakes, 2005). A study of students participating on global design projects at Worcester Polytechnic Institute WPI documented their development in the area of life-long learning and showed gains based on their experiences (Jiusto and DiBiasio, 2006).

Reflection in service-learning is well-documented (Hatcher and Bringle, 1997). Bransford et al. (2000) documented the benefits of guided metacognitive or reflection activities to learning in general and not just in service-learning. Their work also cited a benefit of the experiences when placed into the context of the local community:

Learners of all ages are more motivated when they can see the usefulness of what they are learning and when they can use that information to do something that has an impact on others – especially in their local community. (p. 61)

It was been found that the length of reflections is not critical to the learning benefits, but rather the frequency and content of those reflections (Eyler, 2000).

While the self-reflection and awareness of the community is important for student development, many engineering faculty want to know how pedagogy relates to improving learning in the core concepts. There is much less documented in the area of service-learning and core engineering topics. One study where engineering students were included as part of a large study was by Eyler and Giles (1999) in Where's the Learning in Service-Learning. The authors found that a majority of service-learning students reported that they learn more and are motivated to work harder in service-learning classes than in traditional classes. They also found that a majority reported a deeper understanding of subject matter, understanding complexity of social issues, and being able to apply material they learn in class to real problems are among the important benefits of service- learning. Students were able to see applications of what they were studying.

Astin et al. (2000) examined the impact of service-learning across a sample of more than 22,000 undergraduates within the United States. In this study, they controlled for the impact of volunteering outside of class to assess the impact of curricular service-learning. What was found was that for all academic outcomes, as well as some affective ones, participating in service as part of a course had a positive effect over and above generic community service (outside of class). Among the academic outcomes enhanced through the service-learning were college grade point average, critical thinking skills and writing skills. The overall impact for students of course-based service-learning was significantly more than for students who participated in generic community service. Interestingly, they found that service-learning participants had slightly lower standardized test scores than non-participants when entering college.

EPICS Model

One program widely recognized within the U.S. and internationally for engineering service-learning is the EPICS Program. EPICS was initiated in the School of Electrical and Computer Engineering at Purdue University in 1995 (Coyle, Jamieson and Oakes, 2005) The program has grown steadily in size and breadth to where it is recognized as an independent academic program within the College of Engineering with dedicated laboratories. In 2012-13, EPICS supported over 90 projects distributed across 31 sections. In this same year, enrollment was for 410 for the fall semester and 409 for the spring semester. The program is explicitly multidisciplinary with about 70 majors participating in a typical year, and it includes students in their first-year to their fourth or final year. Each department or school determines how EPICS counts in their curriculum. For all of the engineering disciplines at Purdue University, EPICS courses will satisfy a technical elective (although some only allow upper level courses) and can be used as capstone for four disciplines. The curricular structure is designed to allow students to participate over multiple semesters or even years which supports long-term, reciprocal community partnerships. The long-term student participation allows projects to be developed over multiple semesters or years and allows projects in EPICS to address complex and compelling needs in the local or global community.

EPICS teams, or course sections, each consist of 8-24 students and are student led with a faculty or industry mentor (referred to as an advisor), and a graduate teaching assistant (TA). Each team comprises multiple sub-teams, each one of which supports a single design project. Once a project is delivered, a new project is then identified by students under the guidance of their faculty mentor(s) and community partner(s). Example projects include designing assistive technology for people with disabilities, developing database software for human services agencies, and developing energy-efficient and affordable housing solutions. Samples are shown in Table 1 (Oakes 2011).

5. Assessment in EPICS

The overall philosophy of EPICS is guided by two core values. First, it seeks to provide an educational experience that will prepare students for professional practice. Second, it seeks to meet compelling human, environmental or community needs. The assessment processes are integrated into the curriculum and designed to create artifacts that can be assessed. A key concept is to utilize authentic project artifacts (papers, reports, notebooks, blogs, reflections, etc.) that can be assessed and used to demonstrate student learning and achievement. Whenever possible, the assessments are integrated into processes and activities that advance learning, prepare students for their profession and add value to the development of the community-based design project.

These principles are employed along four dimensions of the program: 1) individual student learning and grading, 2) team and project assessment, 3) community impact, and 4) program assessment. These dimensions are described by the authors in (Cummings et al., 2013).

Table 1. Sample EPICS teams and Projects (Oakes 2011)

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, a sense of control, and a way to play with peers for children with physical disabilities.	CmpE, EE, MatE, ME, CS, Nursing, Child Development
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
University's Office of the Dean of Students Adaptive Programs	Design classroom furniture for college students with physical disabilities; develop closed-captioning systems for college students who are deaf or hard-of-hearing.	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 Industries	Develop aids to assist workers with disabilities as they perform simple manufacturing tasks.	EE, ME, IE, CmpE, 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

Table 2. Student responses to the question: What are the three most valuable things you have learned from being a part of EPICS? (Coyle et al., 2005)

Categories of responses (with representative variations of comments)	Number of student responses
Teamwork (teamwork, working with others, cooperation, accountability)	1751
Leadership (Leadership, responsibility, motivating self and others, taking initiative)	534
Communication (Communication skills, presentation skills, public speaking, report writing, communicating with clients)	1008
Organization and planning (organization, project planning, time management, meeting deadlines and timelines, goal setting,	793
Technical skills (technical expertise, programming, design process, testing, technical procedures)	754
Real World Experience (real applications, realistic view of working world, experience for real life)	222
Customer Awareness (Customer needs, customer support)	174
Community Awareness (Community needs, contribution to the community, value of service)	155
Total Number of respondents	2044

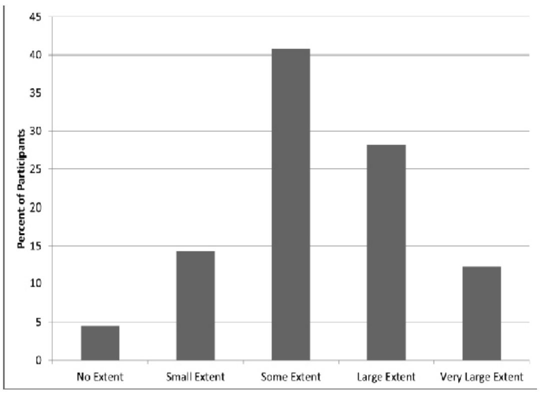

Figure 1. EPICS' contribution to participants' preparedness for the workplace. (Cummings et al., 2013)

6. Programmatic Assessment of and Research on EPICS

Programmatic assessment follows the ABET philosophy of gathering information to inform the development of the program. Summative course evaluations are done each semester on the course, teaching assistants and instructors and include self-reflections on their own learning. An example of the self-reflection is a question where students were asked to identify the three most important things they learned from the course. Results are shown in Table 2.

In addition to the learning, student experiences were also examined. One study specifically examined the experiences of women in EPICS. Women from Computer, Electrical and Mechanical are represented in EPICS at an average of over 80% higher rates than within their home departments. The experiences of the women cite the desire to gain experience as their reason for choosing to participate in EPICS (Matusovich,. W. C. Oakes, and C. B. Zoltowski 2013).

To measure the impact of the EPICS Program on participants' professional preparation, we conducted a mixed-methods study that explored the the experiences and perspectives of alumni after they have been out in the workforce. First, the experience and perspective of alumni were probed with an alumni survey designed to provide a perspective from alumni. Then interviews were employed in order to probe how the alumni related their experiences in the program to their professional preparation and their work in industry.

The survey questions were described by Cummings, Huff, Oakes and Zoltowski (2012), and 523 alumni responded to the survey. A summary of the data showed that more than 80% of EPICS graduates felt that the service- learning experience had prepared them at least to some extent prepared them for their industry careers (Cummings et al., 2013).

A diverse range of alumni (n=27) were purposively sampled from participants of the survey. The interview questions and protocol were informed by the results of the survey responses and included follow-up questions for specific subjects based on their own answers to the surveys. The interviews were recorded and transcribed. The transcripts were then carefully read and reread and then coded for quotes that followed similar themes. To maintain anonymity of the participants, each participant was given a pseudonym different from their own name. The results of the detailed analysis have been submitted by the authors for publication.

The alumni described the benefits of their experiences. Examples of these include Will who described how he developed communication skills and found an interest in a corporate career

“The things that happen in the real world don’t happen in school. So because of EPICS, I was able to learn how to speak in front of people and do those presentations. I think there were maybe two or three of them. The first one was really hard, and the second one was good, you know, was better, and by the third one, I was like, hey, this is easy. And that was really—you know, that year was really the click, where then I was able to . . . you know, when the career people came in, I was like, ‘Hey, this is what I’m looking to do. This is what I’m good at. This is what I’m not good at.’ And I could really work with the recruiters to find the right fit for me.”

Vijay was asked to compare EPICS to other undergraduate experiences. He responded with

“I think here you pick up a lot more skills, and instead of just saying, ‘Oh, I know of this, I heard of this,’ you actually get to say, ‘I’ve heard of it, I’ve done it, and here are my results.’ Not a whole lot of undergraduates get to do that. Study abroad was great, but classes . . . There’s a very big difference between saying you did it as a class project and you did it as an EPICS project. I never used the word ‘class’ and EPICS together. I just think it’s wrong. I think I even did EPICS without credit one time…EPICS is way more of a commitment than just two credits…You know, I think at the end of the day, EPICS, it was a great adventure, and you learn a lot of things that you’re not going to learn anywhere else. They’re very different environments, and they’re very different skills, and you learn on the job, essentially.”

Todd described how he felt ownership over the projects.

“I guess what I found in EPICS was it gave you the ability to try to be in charge of something, big or small, and then it was a way to—you know, you had something big and you could subdivide and say, ‘I want to try this.’ “

Phillip described how important the teamwork and the multidisciplinary experience in EPICS

“I didn’t know anything (laugh) about design, and even as I started civil, I didn’t have any kind of in-depth design experience. And we were working with guys from biomed, we were working with guys from mechanical and electrical and, you know, I think we even had some other non-engineering majors involved with the project. It was important to keep everybody engaged and to realize the value in those different perspectives.” The interviews provided more details on the benefits of their experiences in EPICS and provided insights beyond what could be determined by the surveys alone. Beyond just their satisfaction with the program, we were interested to see if their experience prepared them for the careers in industry. The answer was a resounding “yes” is almost every case. For example, Aditya described how the experience helped prepare for industry even though the context was different.

“And it’s very similar to industry. What we do here is very similar to what you guys do; it’s just that the customers are different, I think there is more of a customer focus in what you do, but that’s because the job that you do is more integrated and in a much more smaller scale…Like, I’m not kidding when I say that EPICS has that . . . it’s the same exact thing that you’re doing, it’s just the different workloads and maybe a different industry, different application.”

Brook described how EPICS prepared her for engineering practice

"Yeah. I think EPICS was the closest thing at school that I had to the job environment, or a real workplace. Working in the multidisciplinary teams, you're given a project and you actually have to complete something on it, and you are working with your customer, and your customer should be holding you accountable."

Doug identified the opportunities to participate in different roles on the EPICS team and how those translated into his preparation.

"Looking back, they were great roles and experiences to prepare me for what kind of career that I ultimately went into, and didn't really know I wanted to go into"

Craig described specific practices and skills that he developed in EPICS that have helped his career.

Well, EPICS taught you that there were a lot of other resources for whatever I was doing, like when we were doing the research and you spent a lot of time on the Internet, you spent a lot of time in books trying to figure out what was going on. So I guess it just kind of gave you sort of a sense of empowerment, because the stuff we were doing, I had no idea about before. I'd never created a prototype, I'd never even thought of creating a prototype. There was quite a bit of information out there about how to—and then also, like the functions that are inside the light, that deal with the delays and the timing, that was also neat. So just like finding that type of stuff out was a big deal, it helped…That (the ability to acquire new knowledge) is because of the journal thing. I think having a journal is, like, the most important thing I've learned. Probably the most important thing I learned in college…It's just extremely important to always have a log of what you've done because you're probably not gonna remember everything. And it's also important for a contractual basis, because you need to know what you told people at certain times."

7. Dissemination of EPICS

The success of EPICS has been widely recognized for its curricular innovation by the U.S. National Academy of Engineering with the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education (2004), and as an exemplar of programs "Infusing Real World Experiences into Engineering Education (2012); by the U.S. National Science Foundation's Corporate Foundation Alliance as an Exemplar Program (2002); and by the American Society for Engineering Education with the Chester Carlson Award for Innovation in Engineering Education (ASEE) (1997 and 2012). EPICS was recognized as a signature program of the IEEE Foundation in 2013. The success and recognition motivated the creation of a network or consortium of universities and colleges interested in integrating a similar model. In the current consortium, there are 22 universities within the U.S and abroad. Further expansion of the model into pre-university schools created the EPICS High School program that now have more than 50 high schools in the U.S. and over 50 abroad through a partnership with IEEE.

Elements of EPICS programs that are shared by all EPICS programs are referred to as core values. These core values reflect a model of service-learning, as are as follows:

1. EPICS students earn academic credit for participation in team-based design projects that solve engineering, computing, and technology-based needs in the local or global community;
2. EPICS teams provide service to the local or global community by partnering with not-for-profit community organizations, educational institutions, and governmental agencies;
3. EPICS programs support these reciprocal partnerships over multiple years without obligation for remuneration to EPICS.

In addition to the core values, there are attributes of EPICS Programs that provide a richer learning experience and add value to community partnerships, described by Oakes, Zoltowski and Drummond (2014).

The approach for dissemination has involved workshops for faculty and administrators with an

Table 3. Factors in managing complex change (Kolomos and de Graaff, 2007) cited in (Thousand and Villa, 1995)

Vision +	Consensus+	Skills+	Incentives+	Resources+	Action Plan	= Change
	Consensus+	Skills+	Incentives+	Resources+	Action Plan	= Confusion
Vision +		Skills+	Incentives+	Resources+	Action Plan	= Sabotage
Vision +	Consensus+		Incentives+	Resources+	Action Plan	= Anxiety
Vision +	Consensus+	Skills+		Resources+	Action Plan	= Resistance
Vision +	Consensus+	Skills+	Incentives+		Action Plan	= Frustration
Vision +	Consensus+	Skills+	Incentives+	Resources+		= Treadmill

interest in the model of service-learning within engineering or computing as well as individual mentoring and coaching. The workshops were designed to equip faculty with the skills to manage diverse teams, assess individual students and community partnerships. Key elements of the program have been identified and shared through the workshops and supporting materials from EPICS.

While each institution provides a unique combination of faculty, disciplines, institutional culture, leadership, students, curriculum, and community, common themes that have emerged of indicators of success. To provide a framework to organize these themes so they can be extended to benefit a broader audience, we examine the literature of change to understand the factors and processes that influence educational innovation. In his seminal work, Diffusion of Innovations, Rogers (1995) identified a number of key elements that influence the rate of adoption of new ideas and technologies. In his examination of unsuccessful transformations, Kotter, (1995) recognized the importance of having both a sense of urgency and a vision for the transformation to be successful.

Vision was also one of six necessary factors that Knoster (Knoster, 1991; Knoster et al., 2000) identified to manage complex change; they include: vision, consensus, skills, incentives, resources, and action plan. When all are present, change can occur. However, the table below shows the negative effect missing factors on the change effort. An analysis of the successful and unsuccessful attempts of integrating EPICS into an institutions curriculum aligned with this model for change (Oakes, Zoltowski and Drummond 2014). How each of the factors was expressed within the adoption of EPICS is described in Table 4.

8. Global dissemination of EPICS

EPICS began in the U.S and most of the early dissemination was focused on U.S. institutions. IEEE has partnered with EPICS to accelerate the global dissemination. Specifically, IEEE adopted a hybrid model to introduce EPICS where IEEE members mentored teams that may be in a course or outside of a traditional course. The stated purpose of the EPICS in IEEE program is to further incorporate EPICS into IEEE worldwide, by empowering student branches and IEEE GOLD groups to work with high school students on EPICS community service-related engineering projects, and by institutionalizing the program within IEEE. Through this worldwide expansion, Educational Activities will build a mechanism for sustaining and disseminating the EPICS model to other sections. (www.purdue.edu/epics)

The IEEE sponsored projects follow the four classifications developed by the Purdue EPICS Program. They are Access and Abilities, Education and Outreach, Human Services and the Environment. Several of these projects have been sponsored within India and a sample of these is shown in Table 5.

Table 4. EPICS description of Categories for Effective Change

Category	How it is realized in the application of EPICS
Vision	Presences of an administrator and/or senior faculty member who can connect the EPICS with the goals and mission of the institution
Consensus	Agreement of enough of the faculty through traditional academic processes (e.g. faculty senate, curriculum committees) of the benefits of EPICS
Skills	Faculty mentors who can manage student project teams, guide them through a design process and can manage community partnerships
Incentives	Faculty are given teaching credit for the EPICS courses and students can count the EPICS as credits toward graduation
Resources	Space to design and build projects, the equipment needed to conduct the project work and funding for materials
Action Plan	A plan for the growth and ultimately the sustainability of the program through the institutionalization of the program.
Vision	Presences of an administrator and/or senior faculty member who can connect the EPICS with the goals and mission of the institution
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Incentives	Faculty are given teaching credit for the EPICS courses and students can count the EPICS as credits toward graduation
Resources	Space to design and build projects, the equipment needed to conduct the project work and funding for materials
Action Plan	A plan for the growth and ultimately the sustainability of the program through the institutionalization of the program.

Table 5. IEEE sponsored EPICS Projects in India

Location (IEEE section)	Description	Area of Impact
NIT Warangal (Hyderabad Section, India)	a device to assist children with disabilities with communication	Access and Abilities
NIT Warangal (Hyderabad Section, India)	a device to assist communion of people with disabilities based on hand gesture recognition	Access and Abilities
• National Institute of Technology Karnataka, Surathkal (Bangalore Section, India),	Humanitarian computing local solutions for the visually impaired.	Access and Abilities
• Bangalore GOLD (Bangalore Section, India),	video learning system for rural schools	Education & Outreach
• IES College of Engineering (Kerala Section, India),	synchronous traffic control system;	Human Services
• IES College of Engineering (Kerala Section, India),	Solar powered electric cart to transport children, accessible for wheel chairs	Environment

EPICS has also collaborated with the Indo U.S. Collaboration for Engineering Education (IUCEE) in the area of faculty development on service-learning. Beginning in July 2008 where 13 institutions were represented, service-learning has been introduced to faculty through webinars and in-person workshops co-sponsored by IEEE in 2012 and 2013.

While service-learning was not traditionally part of the curriculum, the ethic of service to the community was very much a part of the campus culture through extra-curricular programs. In some cases, credit is given or required for a certain amount of service hours for each student to receive their degree. Some of these service opportunities were related to technology while others were more generic service that could be carried out by any discipline. An example of where such service is related to technology includes the BV Raju Institute of Technology (BVRIT) who collaborated with the University of Massachusetts at Lowell to create an assistive technology lab. Students can work outside the curriculum on projects that address needs of people with disabilities supported by the lab. Some institutions have integrated community- based projects into the curriculum through the minor and/or major projects. BITS Palani requires students to participate in two semesters of design before their major projects and some of these projects involve community projects.

These examples, however, remain the exception within the Indian engineering education curriculum. Yet, EPICS has begun to partner with institutions to implement EPICS in the curriculum. Examples include NIT Warangal where IEEE projects have been successful and in 2014-2015 EPICS projects will begin within the curriculum. Also in Warangal, SR Engineering College has also begun to integrate EPICS into the 2014 curriculum.

9. Conclusions

Research has shown that service-learning can improve learning of undergraduates in many disciplines, including engineering. With the advances in technology, there are enormous opportunities to impact our local and global communities with products, systems and services that are designed to meet the needs of the underserved. EPICS has been shown to be a model for integrating service-learning into the engineering curriculum to address needs within our communities and to better prepare graduates for the practice of engineering. Within the U.S., India and many other countries, industry calls for better prepared graduates for today's global economy. EPICS is a model that can be part of an effort to improve the way we prepare students to be our future leaders. It is also a way to leverage the enormous resources in our institutions and energy of our students to address needs of the underserved. Democracies such as the U.S. and India thrive with educated and engaged citizens. EPICS is also a way to prepare students to be active citizens and leaders of our democracies. It is a way to equip the global leaders of tomorrow while making a difference in our communities today.

No one institution or program can change education or society. However partnerships, such as those between IEEE, IUCEE, EPICS and individual colleges and universities can make a significant impact on the educational system and society together. That is the hope and vision for the EPICS consortium and the emerging partnership in India.

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