Engineering Projects in Community Service: The National Engineering Projects in Community Service (EPICS) Program

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It has become widely recognized that engineering students need skills that go beyond their technical strengths: skills in teamwork and project planning; awareness of the customer; and understanding of ethical and professional issues and of the social and global context in which engineering is practiced (American Society for Engineering Education [ASEE], 1994; ASEE, 1995; Dahir, 1993; Hissey, 2000; Peterson, 1993; Valenti, 1996; Fromm, 2003). Among the most dramatic statements about these skills has been the set of program outcomes at the heart of the engineering accreditation guidelines that went into effect in 2000, dubbed "Engineering Criteria (EC) 2000" (Accreditation Board for Engineering and Technology [ABET], 2002). Under EC 2000, in addition to "traditional" engineering knowledge of mathematics, science, and engineering and experience in engineering problem-solving and system design, students are mandated to be able to function on multidisciplinary teams, communicate effectively, and understand a wide range of issues in engineering. Integration of these dimensions into engineering courses is critical to the quality of education. However, it has also been widely recognized that traditional engineering programs are not graduating students who fully possess these skills.

There is also a growing sense that broadening the notion of an engineer's core competencies to include these skills may be critical to achieving a population of engineering professionals that is gender and ethnically diverse. Service learning, which integrates community service with academic learning, has the potential to integrate many of these aspects in the curriculum. The pedagogy is consistent with the literature on recruitment and retention of women in science and engineering with its social context, emphasis on general educational goals including communication, use of cooperative and interdisciplinary approaches, and problems with a "holistic, global scope" (Noddings, 1992; Rosser, 1990; Rosser, 1995). Matyas and Malcolm (1991) and Oakes et al. (1992) suggest that many of the same factors are relevant for attracting and retaining minorities.

While engineering educators seek to provide learning environments that prepare students for life as professionals, nonprofit organizations, such as community service agencies, schools, museums, and local government offices, face a future in which they must rely to a great extent on technology for the delivery, coordination, accounting, and improvement of the services they provide. They often possess neither the expertise to use nor the budget to design and acquire a technological solution that is suited to their mission. Thus, they need the help of people with strong technical backgrounds. Service learning links these two needs and provides a means to enhance both the community and undergraduate education.

The Engineering Projects in Community Service (EPICS) program was initiated at Purdue in 1995 to fulfill the complementary needs of engineering undergraduates and the community. Under this program, undergraduates earn academic credit for their contributions to long-term, team-based design projects that deliver innovative, technology-based solutions to problems identified by nonprofit organizations in the community. The unique structure and operation of EPICS enable solutions of significant benefit to the community to be delivered (Coyle et al., 1997; Jamieson et al., 2001, 2002; Slivovsky et al., 2004).

Current Status of EPICS

EPICS was initiated in the School of Electrical and Computer Engineering at Purdue University in Fall 1995, with 40 students participating on five project teams. The program has grown steadily in both size and breadth. In the 2003–2004 academic year, over 400 students participated on 24 teams, addressing problems ranging from data management for social services to mitigation of agricultural pollution 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 20 university departments.

Each EPICS project at Purdue involves a team of 8–20 undergraduates, a nonprofit community partner (for example, a community service agency, a museum or school, or a government agency), and a faculty 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 freshmen, sophomores, juniors, and seniors and operates for several years, from initial project definition through final deployment. 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 multiyear projects of significant scope and impact to be undertaken by the teams.

Each student in the EPICS program attends a weekly two-hour meeting of his or her team in the EPICS laboratory. During this laboratory time, the team members address administrative matters, do project tracking and planning, and work on the technical aspects of their project. All students also attend a common one-hour lecture each week. A majority of the lectures are by guest experts and have covered a wide range of topics related to engineering design, communication, and community service.

The long-term nature of the program has required some innovation in the lecture series because students may be involved in the program for several semesters. This has been addressed by rotating the lecture topics on a cycle of two to three years and by creating specialized lecture supplements called *skill sessions* that students can substitute for lectures they have already seen. Example skill session topics include learning to operate a mill or lathe, developing effective surveys, conducting patent searches, and tutorials on multimedia software. Students use the skill sessions as a way of gaining specific expertise needed for their projects and as an opportunity to broaden their experience, for example, a computer engineering student learning to use a lathe or a mechanical engineering student learning web programming. The unique structure and operation of EPICS enables solutions of significant benefit to the community to be delivered. The EPICS model of engineering service-learning has rapidly spread to 15 campuses around the country. The characteristics of an EPICS program can be described through a set of *core values* embraced by each EPICS program and a broader set of *goals* that each EPICS program strives to attain. The core values and goals are described below.

Core Values of EPICS Programs

The core values of EPICS programs are those elements shared by all EPICS.

1. EPICS students earn academic credit for participation in long-term, team-based design projects that solve technology-based problems in the community.
2. EPICS programs establish multiyear partnerships with nonprofit community organizations to fulfill mutual needs:
   a. The need for academic institutions to provide significant design experiences that develop the technical and professional skills of students in engineering, computer science, and related technologies
   b. The need for community organizations to have access to technology-based solutions for the delivery, coordination, accounting, and improvement of the services they provide
3. EPICS community partners assist the student teams in understanding community needs and context for the designs, work with the students throughout the development of their project, and deploy successful projects in the community without obligation for remuneration to the EPICS program.

Goals for EPICS Programs

The goals are the features of the structure and operation of the project teams that each EPICS program strives to achieve, subject to existing curricular structures and institutional culture.

Community partners. Each EPICS team is partnered with a nonprofit organization in the local community. This partner suggests projects that are screened by faculty to identify those that should challenge the technical abilities of a large team of undergraduates in engineering and computer science. The partner should be willing to make a commitment to participate as a partner with the students in meeting the community need and with the EPICS faculty in educating the students.

Long-term community relationships. Each partnership with a nonprofit organization in the local community should be made with the intention and/or opportunity for a long-term relationship if the partnership shows success. A long-term relationship provides more value to the community and a richer learning environment for the students.

Projects. All EPICS projects are performed for a nonprofit project partner and have a core engineering, technology, or computer science component. Examples of projects from EPICS sites at many universities are available at the national EPICS website at epicsnational.ecn.purdue.edu. The projects should be chosen according to their:

Significance: Not all projects can be undertaken, so those that should provide the greatest benefit to the community should be selected.

Level of technology: Projects must be challenging to, but within the capabilities of, undergraduates in engineering and the other disciplines involved on the EPICS teams. The technical content should be sufficiently high to challenge the upper-division students.

Expected duration: It has proven valuable to achieve a mix of short-term (one semester to one year) and long-term (multiyear) projects. The short-term projects build confidence and help establish the relationship between the student team and the community partner. Long-term projects provide unique learning opportunities, sustain the relationship with the community partner, and have the potential for significant impact in the community.

Long-term participation by students. Students should participate in EPICS for at least two semesters. Long-term participation on a design team provides students the opportunity to perform many roles and learn many technical skills and project skills, including teamwork, leadership, system design, and project management. The long-term participation provides students with the opportunity to experience the entire life cycle of their team's projects and creates an ongoing context for their academic and professional growth. The credit structure within EPICS should encourage participation in a team for at least one year and longer if possible. At Purdue, students may join a team as early as the second semester of their freshman year and remain on the same team, earning academic credit each semester, until graduation.

Academic credit for participation in EPICS. The many technical and project skills that students learn in EPICS are rewarded with academic credit. These credits should be structured to encourage the long-term participation in EPICS and should count toward their progress toward graduation. At Purdue, freshmen and sophomores earn 1 credit per semester. Juniors and seniors earn 1 or 2 credits per semester, according to their schedules and desire to fulfill course, design, and lab credit requirements. Depending on departmental policies, EPICS credits may count for senior design, design electives, technical elective, etc. In non-engineering disciplines, the credits can take other forms, such as counting toward a sociology core at Purdue in Liberal Arts. More information is available at http://epics.ecn.purdue.edu/registration.

Team structure and continuity. A large team size (8–15) is strongly recommended. When combined with the long-term participation of students, it provides significant continuity in team membership from semester to semester and year to year. As the seniors on a team graduate, they are replaced with new students and the team continues. This structure thus provides

- familiar contacts on the team each semester for the community partner
- the continuity and expertise necessary to complete and deliver large-scale projects of significant benefit to the community
- the ability of the team to manage multiple projects (e.g., short- and long-term projects) for their community partner.

Multidisciplinary teams. EPICS projects usually require expertise from multiple disciplines to ensure the best possible project outcomes for both the community partner and the

students. Each team must be intentional about establishing a proper environment to allow the multidisciplinary teams to succeed. Each student contributes knowledge and expertise from his or her discipline while learning the importance of the knowledge and expertise of other disciplines. The wide variety of disciplines from which EPICS students are drawn at Purdue can be seen on the student registration forms at http://epics.ecn.purdue.edu/registration/Default.htm.

Advisors for teams. A faculty member from the discipline that most closely matches a team's project(s) should advise the team. Programs at Purdue and Case Western Reserve have shown that local industry and community personnel, as well as staff with appropriate backgrounds, can also serve as effective advisors. The faculty must maintain a strong presence in the program to ensure academic credibility. Advisors may be paired so that advisors with complementary expertise co-advise a team. Advisors monitor the team's progress on the project, provide guidance on technical issues, provide advice on project management, answer students' questions, monitor each student's progress, verify that the needs of the project partner are being met, and assign grades. Information on the responsibilities of advisors for EPICS teams at Purdue can be found at http://epics.ecn.purdue.edu/staff_documents/Responsibilities_Advisors.htm.

Social context and impact. The EPICS program should provide opportunities for students to develop an understanding of the social context and impact of their projects, as well as their own place as future professionals and citizens in the community.

A highly mentored experience. The more experienced students are expected to be the team's leaders and to have primary technical and managerial responsibility. Their responsibilities include long-range planning, system design, solving technical problems, and training, monitoring, and directing the students who are newer to the team and/or less experienced.

Collaboration with other EPICS programs. The EPICS national program provides a network of faculty, students, and community members working to improve engineering education and their local communities. Each EPICS site will collaborate with other institutions through national conferences, regional workshops, sharing of data and course materials, and communicating with the other sites in the National EPICS Program.

National EPICS Program

The EPICS program was created at Purdue University in the fall of 1995, and its new model for large-scale engineering design projects in a community context has spread very quickly. By 1997, EPICS programs were also underway at the University of Notre Dame and Iowa State University. The National EPICS Program was created in 1999. The universities currently participating in this program are Purdue, Notre Dame, Iowa State, the University of Wisconsin–Madison, Georgia Tech, Case Western Reserve, Penn State, Butler, Illinois at Urbana–Champaign, the University of Puerto Rico–Mayaguez, Columbia, the University of California at San Diego, San Jose State University, Worcester Polytechnic Institute, and the University of California at Merced.

The existence of EPICS programs at several sites opened the possibility of addressing community and educational needs that extend beyond those of a university and its local community. The first multi-site EPICS project, the Homelessness Prevention Network (HPN) project, was initiated in 1997 when the newly formed HPN team at Notre Dame began working not only with agencies in its home city of South Bend, Indiana, but with the Purdue HPN EPICS team as well. The local goal for each team was to enable its partner agencies to share demographic and services-provided information about their clients. The agencies could then produce duplicate-free counts of homeless individuals and families, meaningful data on the use and effectiveness of services, and a record for each client that can be used for case management across all agencies and all available services. The common goal of these two HPN teams was the sharing of data on homelessness between Lafayette and South Bend.

The second multi-site EPICS project was initiated in 2002 with the Habitat for Humanity. The Purdue, Wisconsin, and Notre Dame EPICS teams are working with the staff of Habitat for Humanity International to produce a set of construction tutorials for national distribution and a database for affiliates to use for assessment data of homeowners from across the country. The national staff of Habitat for Humanity serve as the project partner and offer the opportunity for students at multiple sites to collaborate on common projects. Each site also works with the local affiliate of Habitat for Humanity to ensure that the products being developed meet their needs and will be used by such affiliates.

Named an "exemplary program" by the Corporate and Foundation Alliance (http://www.cfalliance.org) and selected as a model for national dissemination under the NSF CCLI National Dissemination program, EPICS has gained recognition as a model for meeting changing educational needs. The National EPICS Program provides the infrastructure to support the growing number of EPICS programs nationally and, hopefully, internationally. Through the support of the NSF CCLI National Dissemination grant, annual national and regional conferences have provided a forum for faculty to come together and share the results and best practices of their programs and to learn from others. Common assessment and web tools are being developed to support the directors and faculty involved in these programs to facilitate the initiation and growth of EPICS programs. Microsoft, Hewlett Packard, and National Instruments have established partnerships with the National EPICS Program to provide resources and expertise to individual EPICS sites and to assist in the dissemination of EPICS to other institutions. Through national dissemination, EPICS strives to meet the complementary needs of educational institutions and community nonprofit organizations while creating a culture of engineering in social context.

Acknowledgments

The National EPICS Program is supported by a grant from the NSF CCLI National Dissemination program (DUE-0231361) and by gifts and donations from Microsoft Research, National Instruments, and Hewlett-Packard.

BIBLIOGRAPHY

ABET. 2002. *Engineering Criteria 2002–2003*. Accreditation Board for Engineering and Technology. http://www.abet.org/criteria.html, Accessed May 2002

ASEE. 1994. *Engineering Education for a Changing World.* Joint project report of the Engineering Deans Council and the Corporate Roundtable of the ASEE. http://www.asee.org

ASEE. 1995. Educating tomorrow's engineers. *ASEE Prism* 11–15, May/June.

Coyle, E. J., L. H. Jamieson, and L. S. Sommers. 1997. EPICS: A model for integrating service-learning into the engineering curriculum. *Michigan Journal of Community Service Learning* 4: 81–89.

Dahir, M. 1993. Educating engineers for the real world. *Technology Review* August/September: 14–16.

Fromm, E. 2003. The changing engineering educational paradigm. *J Eng Educ* 92: 113–122.

Hissey, T. W. 2000. Education and careers 2000. *Proceedings of the IEEE.* 88: 1367–1370.

Jamieson, L. H., W. C. Oakes, and E. J. Coyle. 2001. Documenting service learning to meet EC 2000. *2001 Frontiers in Education Conference,* October. Piscataway, NJ: IEEE.

Jamieson, L. H., W. C. Oakes, and E. J. Coyle. 2002. EPICS: Serving the community through engineering design projects. In *Learning to Serve: Promoting Civil Society Through Service Learning.* 277–295. Norwell, MA: Kluwer Academic.

Matyas, M. L., and S. Malcolm (Eds.). 1991. *Investing in Human Potential: Science and Engineering at the Crossroads.* Washington, DC: American Association for the Advancement of Science.

Noddings, N. 1992. Gender and curriculum. In *Handbook of Research on Curriculum.* P. W. Jackson, Ed. 659–684. New York: Macmillan.

Oakes, J., A. Gamoran, and R. N. Page. 1992. Curriculum differentiation: opportunities, outcomes, and meanings. In *Handbook of Research on Curriculum.* P. W. Jackson, Ed. New York: Macmillan.

Peterson, C. R. 1993. Why integrate design? *ASEE Prism* 26–33. May.

Rosser, S. V. 1990. *Female-Friendly Science.* Elmsford, NY: Pergamon Press.

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

Slivovsky, L. A., W. C. Oakes, C. B. Zoltowski, F. DeRego, and L. H. Jamieson. 2004. An analysis of the reflection component in the EPICS model of service learning. In *Proceedings of the 2004 ASEE Annual Conference.* Salt Lake City, UT, June. Washington, DC: ASEE.

Valenti, M. 1996. Teaching tomorrow's engineers. *Mechanical Engineering* 118: 64–69. July.