2004

Service-Learning in Engineering: A Resource Guidebook

William Oakes

Service-Learning in

ENGINEERING

A RESOURCE GUIDEBOOK

WILLIAM OAKES, PE

"Tell me,
and I forget.
Teach me,
and I may remember.
Involve me,
and I learn."

BEN FRANKLIN

Campus Compact

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Campus Compact is a national coalition of more than 900 college and university presidents who are committed to fulfilling the civic purposes of higher education.

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> "Civil engineering is called the 'people serving profession;' you can't do that without getting out and serving the people."
>
> JAMES MCKINNEY, HEAD OF CIVIL ENGINEERING, ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Introduction

Several issues have motivated reform in engineering education over the past decade. Industry's call for more well-rounded graduates who are better equipped for today's fast-moving, global economy has motivated the Accreditation Board of Engineering and Technology (ABET) to redefine its accreditation criteria in a way that places professional skills such as teamwork, communication, and awareness of social issues into core engineering curricula. The continued underrepresentation of women and minorities in engineering has fueled innovative curricular models that integrate active learning with relevant engineering applications. At the same time, the overall decline in interest in engineering among high school students has prompted the development of K-12 outreach programs and high school engineering courses.

Service-learning has the potential to address many of the issues facing engineering education. Service-learning integrates community service with academic education; students apply their classroom content to community problems, thus enhancing learning while providing needed services to underserved populations. Research has shown that service-learning can enhance classroom learning (Eyler and Giles, 1999) and is consistent with theories for increasing student retention (Tinto, 1993). In addition, the community context and social relevance of service-learning are consistent with the characteristics advocated to increase participation of underrepresented populations in engineering (Rosser, 1995). Placing engineering within a local community context broadens the view of engineering for most students and therefore has the potential to attract a wider pool of students to the field. Finally, the focus on projects with real community application meets industry's need for greater real-world experience among graduates.

In parallel with engineering education's reform efforts, many other disciplines have undergone reform through service-learning. Although service-learning in engineering is a relatively new area of endeavor, many successful examples exist, including two pioneering models:

- Engineering Projects in Community Service (EPICS) brings multidisciplinary undergraduate design teams into long-term partnerships with local community organizations and agencies. EPICS teams design, develop, deploy, and support technology-based solutions to the issues facing their community partners (Jamieson et al., 2002; Tsang, 2000). Started at Purdue University but now found on many campuses, EPICS involves more than 20 disciplines in which undergraduates at all levels engage in long-term projects for the local community. Examples of projects include designing systems and structures for minimizing home construction and energy costs, designing and building therapeutic devices for children with disabilities, and designing wetland mitigation projects.

- Engineers without Borders (and partner organization Engineers without Frontiers) promotes and facilitates the integration of international service projects into local engineering curricula. Student chapters of these organizations have been started at campuses across the country. Service-learning projects carried out include improving rural water supply and sanitation, creating local community resource management capabilities, and supporting multi-functional energy platforms in developing nations.

Despite the numerous benefits of service-learning in engineering education and the existence of successful models, engineering continues to lag behind other disciplines in embracing this pedagogy. The hesitancy of engineering faculty to initiate service-learning is one motivation for the creation of this guidebook.

This guidebook grew out of a faculty development series sponsored by Campus Compact with funding from the U.S. Department of Housing and Urban Development (HUD). It has been used with success as a reference in a series of faculty workshops on service-learning in engineering held across the country. Eight faculty workshops were conducted in the following locations: Georgia Tech University, Louisiana State University, Massachusetts Institute of Technology, North Carolina State University, the University of Colorado, the University of Michigan, the University of Texas-El Paso, and the University of Washington. (An additional workshop was held at the 3M Corporation in Minnesota.) These one- to two-day workshops involved faculty and administrators interested in learning about service-learning and in implementing service-learning in their engineering curriculum.

The workshops had two purposes: first, to bring the concept of service-learning to these engineering schools, and second, to test and refine a curriculum that could be used independently by interested faculty and administrators. Instructors included William Oakes, co-director of the EPICS program at Purdue University (and author of this guidebook); Leah Jamieson, also of Purdue's EPICS program; Edward Zlotkowski, senior faculty fellow at Campus Compact; and John Duffy of the University of Massachusetts Lowell. This curriculum guidebook represents a compilation of the materials developed and refined during the course of the workshops.

Applications to Affordable Housing Construction

Since HUD provided support for the development of this guidebook, an area of special interest is the potential role for engineering service-learning in the area of building technology and/or affordable housing. This may involve one or more of the following applications:

- *Heating and cooling.* Mechanical engineering courses could include a service-learning component that focuses on designing heating, ventilation, and air conditioning (HVAC) systems for local affordable housing projects, which would include sizing heating and cooling plants, conducting heat load analyses, identifying energy-efficiency construction specifications, and other mechanical engineering applications.

- *Lighting and electrical systems.* Electrical engineering courses could include a service-learning component that focuses on designing lighting and electrical systems in local community projects.
- *Structures.* Structural engineers could test the application of building technologies such as structural insulated panels, insulated concrete forms, and other innovative building technologies.
- *Technology innovation.* Because of the fragmented nature of the building industry, residential construction is slow to incorporate innovative building technologies compared with other industries. Students could test or assess a wide range of building technologies and products as part of a service-learning experience. The Partnership for Advancing Technology in Housing (PATH) has identified an inventory of innovative products and appliances (see www.pathnet.org) that could be incorporated into a service-learning program.
- *Green building.* There is growing interest in the field of "green building"--construction that is environmentally friendly and energy-efficient. This involves new techniques for naturally ventilating buildings that are less reliant on mechanical systems and greater use of recyclable materials, use of energy and water efficient systems, and more.

A limited number of examples of engineering service-learning courses that are focused on affordable housing or building technology were identified during the development of this guidebook. These include a service-learning project at Purdue University that required developing new-construction energy efficiency improvements for a Habitat for Humanity project in Lafayette, Indiana; and a course at the University of Massachusetts Lowell, also in partnership with Habitat for Humanity, that required developing specifications for energy-efficient buildings products and techniques, including energy-efficient windows, passive solar systems, and added insulation. Students were required to conduct life-cycle costs for a solar-heated house compared with a standard home and estimate the savings related to solar heat.

How to Use This Guide

This publication and associated PowerPoint slides are designed to assist interested individuals in conducting faculty workshops on service-learning in engineering. With this text and accompanying materials, these workshops can be organized on campus or at the state or regional level. The appendices offer a range of informational tools that can be used in conjunction with each workshop.

This guidebook contains all of the material needed to conduct a training workshop for engineering faculty and administrators on the subject of service-learning in engineering. It is intended for use by faculty or administrators who have an interest in educating their colleagues about the potential for implementing new engineering-based service-learning courses or expanding existing activities in this area. The guidebook includes the following materials:

1. A detailed curriculum for faculty workshops, including an introduction to service-learning, a rationale for incorporating service-learning into engineering curricula, examples of current practice, and a guide to implementing service-learning in the classroom.

2. An appendix with a set of guided questions to help identify the needs and issues of both the department and the institution. These discussion questions were used in the service-learning workshops as an aid in developing an implementation plan.

3. A second appendix with examples of engineering service-learning projects, syllabi/course descriptions, and sample forms and evaluation tools.

4. A separate set of slides that can be adapted for use in presentations at campus workshops. These slides are available at the Campus Compact website, www.compact.org/faculty, and at the HUD website, www.huduser.org.

The Faculty Workshop Curriculum

The purpose of a faculty workshop in engineering service-learning is to help interested engineering departments develop strategies to (1) incorporate community-based work in their engineering teaching and research; (2) include community-based experiences as a standard expectation for engineering majors; and (3) further faculty interest in incorporating the service-learning concept into engineering curricula.

The curriculum is broken down into four chapters that are intended to structure the service-learning faculty workshop: These are as follows:

1. **What Is Service-Learning?** introduces the basic concepts of service-learning, including definitions and characteristics of service learning; a description of Kolb's "learning cycle," which provides a conceptual framework for the service-learning approach; and a section on what distinguishes service-learning from the traditional learning experiences and alternative approaches such as internships.

2. **The Changing Face of Engineering Education** discusses the relationship of service-learning to the Accreditation Board of Engineering and Technology's (ABET's) EC 2000 Criterion 3 requirements; the benefits of service-learning for engineering students, faculty, and community residents; and how service-learning can prepare engineering students for the work world.

3. **Current Use of Service-Learning in Engineering** describes the current state of the art of service-learning in engineering, including schools with service-learning programs, examples of how service-learning has been incorporated into academic engineering courses, and a look at engineering service-learning at the local, regional, national, and international levels.

4. **Implementing Service Learning** provides a step-by-step approach to implementing a service-learning program, from selecting a course to identifying community partners, selecting suitable projects, recruiting students, assessing the learning experience, monitoring community involvement, and analysis and reflection.

Complementary AAHE-Campus Compact Volume

All of the materials in this guidebook were designed to complement the engineering volume of the American Association for Higher Education (AAHE)-Campus Compact series on service-learning in the disciplines. The engineering volume, *Projects that Matter: Concepts and Models for Service-Learning in Engineering* (Tsang, 2000), contains more detailed descriptions of engineering service-learning programs and essays on teaching methods for effectively delivering an engineering curriculum.

It is recommended that this guidebook be used in conjunction with *Projects that Matter* to facilitate a workshop for faculty on revising their engineering courses in such a way that student involvement in meaningful and relevant community service can enhance academic learning objectives.

What Is Service-Learning?

The concept of service is not new to higher education, or to the engineering profession. The idea of integrating service with education has its roots in the creation of the land grant universities and their extension offices through the Morrill Act in the 1860s. John Dewey's work in the early decades of the 20th century brought a philosophy of experience into education. The 1960s saw numerous campus and community-based initiatives arise in connection with public issues.

As a discipline, engineering has been engaged with the community beyond campus boundaries through extension services, technical assistance programs, and the work of individual faculty serving as pro bono consultants to local community organizations. More recently, community engagement has also taken the form of economic development activities.

Service-learning is different from other forms of campus-based service in that it explicitly integrates classroom content with service to the local community. The service performed is directly related to the academic subject matter under study. In engineering, this integration complements and enhances the academic content of the course—whether it involves mechanical engineering, environmental engineering, or any other branch of the discipline—and provides a setting where students can learn about complex social issues and their roles as engineers in addressing those issues.

Definitions of Service-Learning

Many variations of the definition of service-learning can be found in the literature. A concise definition that captures the essential elements of service-learning is provided by Hatcher and Bringle (1997):

> We view service-learning as a credit-bearing educational experience in which students participate in an organized service activity that meets identified community needs and reflect on the service activity in such a way as to gain further understanding of the course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility.

Among the other definitions of service-learning is one from the United States Congress, written as part of the National and Community Service Trust Act of 1993 (as amended through December 17, 1999, P.L. 106–170):

The term "service-learning" means a method:

(A) Under which students or participants learn and develop through active participation in thoughtfully organized service that—

(i) is conducted in and meets the needs of a community;

(ii) is coordinated with an elementary school, secondary school, institution of higher education, or community service program, and with the community; and

(iii) helps foster civic responsibility; and

(B) That—

(i) is integrated into and enhances the academic curriculum of the students, or the educational components of the community service program in which the participants are enrolled; and

(ii) provides structured time for the students or participants to reflect on the service experience.

Key Components of Service-Learning

There are four key components of service-learning: the service component, the academic component, partnerships with community organizations or members (which provide the structure for the service component), and analysis and reflection.

SERVICE

Part of the service-learning experience involves service opportunities that assist the underserved in the local community and/or contribute to projects for the common good.

ACADEMICS

The service students perform must provide reinforcement of and connection with the subject material of the academic course.

PARTNERSHIPS

Service-learning involves partnerships characterized by reciprocity between those in the community and those on campus. Students and community members work together as partners in addressing a community need, and both groups benefit from the activity:

- The community increases its capacity and resources.
- Students are exposed to a richer learning environment.

The learning experience extends to students, faculty, and community members:

- Community members work with faculty to create a learning environment in which students can both increase their mastery of the academic components of a course and become familiar with the social issues they are addressing.
- Faculty develop familiarity with local needs, new student learning opportunities, and in some cases public research opportunities.
- Community members learn about the role in engineering and technology in community building, and about their implications for the local community (in addition

to deriving tangible services or assistance that can be applied to community problems).

ANALYSIS AND REFLECTION

Analysis and reflection are an important part of service-learning. Participants are intentionally guided through activities to reflect upon the work being performed, the processes by which the work is accomplished, and the implications of the work. This is important because metacognitive activities, including reflection, have been shown to improve learning (Bransford et al., 2000).

Metacognition—the monitiroing of one's thinking as one is acquiring new information, including assessing background knowledge, assumptions, and hypotheses—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.
- The role of the discipline in the context of large social issues.

Activities promoting analysis and reflection can take several forms, including open-ended questions, written or oral guided discussion topics, periodic written summaries of the work being undertaken and its implications, and assigned readings.

Service-Learning and the Learning Cycle

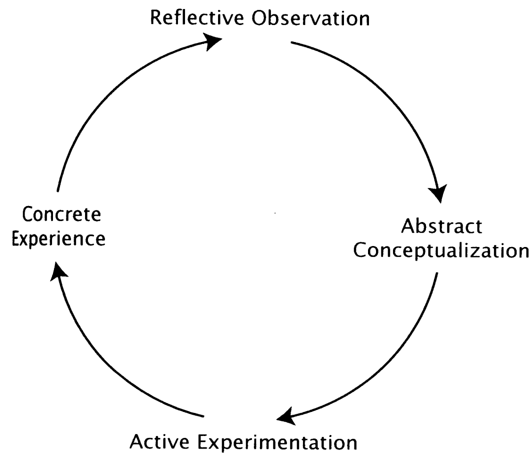
One of the most influential recent ideas in learning theory is Kolb's (1984) learning cycle. In this cycle, illustrated in Figure 1, metacognitive activity (reflection) becomes a link between the experience and the conceptualization of topics covered in a course. As Kolb puts it, "learning is the process whereby knowledge is created through the transformation of experience." Learners gain new knowledge by testing and adapting their existing knowledge through a process that involves abstract conceptualization (e.g., positing a theory or planning a project), active experimentation, concrete experience (observing and tracking results), and reflection (thinking about how to improve on the original abstract conceptualization).

With service-learning, the combination of classroom instruction, service activity that relates to the classroom instruction, and reflection provides an environment in which students can enhance their knowledge in precisely the way Kolb's model describes. The different aspects of the learning environment also allow learners with diverse learning styles to enter the cycle at different places and still complete the full circuit.

Distinguishing Features

Service-learning differs from other teaching methods and service activities in a number of important ways. It is useful to identify the differences between service-learning and other learning environments in order to be able to articulate what service-learning would add to a curriculum.

FIGURE 1: **KOLB'S LEARNING CYCLE**



Service-learning differs from **traditional courses** in that it:

- Provides an opportunity to complement traditional coursework with learning environments that speak to the diverse learning styles of students.
- Provides a more holistic approach to learning (see the Kolb model).
- Provides a connection with social contexts and real-world community issues.

It differs from **internships** and **cooperative education** in that it:

- Is not separate from academic coursework.
- Is not isolated from social and community considerations.

It differs from **extracurricular activities** and opportunities in that it:

- Is not isolated from academic coursework and is never conceived purely as a service activity.
- Includes guided metacognitive activities that enhance learning and reinforce academic content.

True service-learning creates a balance between service-based and academic learning, where each complements the other. Eyler and Giles (1999) have illustrated variations within this balance in a succinct table (Figure 2).

FIGURE 2: **THE BALANCE BETWEEN SERVICE AND LEARNING**

service-LEARNING	Learning goals primary; service outcomes secondary
SERVICE-learning	Service outcomes primary; learning goals secondary
service learning	Service and learning goals completely separate
SERVICE-LEARNING	Service and learning goals of equal weight and each enhances the other for all participants

The Changing Face of Engineering Education

Today's engineers are being asked to do more than just make calculations. They are expected to work on multidisciplinary teams in a multicultural environment, manage multiple projects, and compete in a highly diverse global marketplace. The technology explosion has created a situation where much of the knowledge students gain in college may be considered obsolete within only a few years. The Internet and the advancement of computer tools have radically changed both the way engineers work and the businesses in which they work.

To meet these challenges, engineering education has been undergoing changes promoted by the Accreditation Board of Engineering and Technology (ABET, 2000, 2002) and corporations that hire engineering graduates. Service-learning is well positioned to help engineering programs meet educational challenges that are often difficult to address in traditional courses while helping students master traditional elements of the engineering curriculum.

"Students are [sometimes] able to marshal a body of knowledge to solve problems presented in class but fail even to see a problem, much less the relevance of what has been learned, in a different setting. The new situation does not provide the cues associated with what has been learned; the 'key words' from the classroom are not present in the wider environment. A service-learning student will have more ways to access this understanding."

EYLER AND GILES, 1999

Service-Learning and ABET's Criterion 3

Service-learning offers many opportunities to address the Program Outcomes required for programs accredited under ABET's EC 2000 Engineering Criteria. EC 2000 Criterion 3 (ABET, 2002) stipulates that engineering programs must demonstrate that their graduates have:

a. an ability to apply knowledge of mathematics, science, and engineering;

b. an ability to design and conduct experiments, as well as to analyze and interpret data;

c. an ability to design a system, component, or process to meet desired needs;

d. an ability to function on multidisciplinary teams;

e. an ability to identify, formulate, and solve engineering problems;

f. an understanding of professional and ethical responsibility;

g. an ability to communicate effectively;

h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;

i. a recognition of the need for, and an ability to engage in, life-long learning;

j. a knowledge of contemporary issues; and

k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Service-learning can be mapped onto each of the criterion's stipulations, as detailed below.

ABILITY TO APPLY KNOWLEDGE OF MATHEMATICS, SCIENCE, AND ENGINEERING

Service-learning provides an opportunity for students to apply concepts and theory learned in the traditional classroom to new problems situated in contexts different from those to which they are accustomed. Success here requires that students be able to synthesize the knowledge they have acquired in their courses and apply that knowledge to community-based issues.

ABILITY TO DESIGN AND CONDUCT EXPERIMENTS, ANALYZE AND INTERPRET DATA

Service-learning requires students to design, produce, and deliver real products that will be used by real people. This real-world context provides a compelling need to analyze and predict issues correctly. Furthermore, students see first hand the "faces" of those who will use their products, and this adds a compelling reason for them to fully understand the issues involved in those projects.

ABILITY TO DESIGN A SYSTEM, COMPONENT, OR PROCESS TO MEET DESIRED NEEDS

Since service-learning requires the delivery of real products and real services to solve real problems, students are able to experience the entire design process from initial problem definition and specification development to design to manufacture and finally delivery of a completed product or service.

ABILITY TO FUNCTION ON MULTIDISCIPLINARY TEAMS

Because service-learning problems are real and often complex, they almost invariably require a multidisciplinary solution—rare is the problem in the real world that can be solved within the confines of a single academic discipline. These problems require engineering students to work with students from other disciplines or, at a minimum, to consult with experts in other fields to find solutions to community needs.

ABILITY TO IDENTIFY, FORMULATE, AND SOLVE ENGINEERING PROBLEMS

Service-learning provides a compelling context in which students can experience the process of identifying and formulating problems that require technical solutions. Service-learning requires students to work with their community partners to identify engineering issues in a community context and to decide how their expertise and resources can best be utilized to address those issues.

UNDERSTANDING OF PROFESSIONAL AND ETHICAL RESPONSIBILITY

The context in which service-learning projects are situated provides a natural opportunity for students to examine the professional and ethical responsibilities of their profession. The multidimensional reflection and analysis embedded in the service-learning process ensures that students will explore these issues in a guided manner to deepen their overall understanding of their roles as engineering professionals.

ABILITY TO COMMUNICATE EFFECTIVELY

Service-learning necessitates extensive communication with community partners—individuals who most often do not possess a technical background. For this reason, students quickly learn how vital clear communication is between team members and their clientele. Analytic and reflective activities also provide opportunities for students to improve their communication skills. Furthermore, because students are producing real products that will be used in a context outside of class, they become acutely aware of the need to provide sufficient documentation to continue and/or service the project.

BROAD EDUCATION NECESSARY TO UNDERSTAND THE IMPACT OF ENGINEERING SOLUTIONS IN A GLOBAL/SOCIETAL CONTEXT

Service-learning provides a context in which students can directly explore the impact of engineering solutions on society. The utilization of engineering skills in social settings provides an opportunity for students to receive a broader education than would otherwise be the case. Reflection and analysis help ensure that social contexts and issues will be explored in a guided and intentional manner.

RECOGNITION OF THE NEED FOR, AND ABILITY TO ENGAGE IN, LIFE-LONG LEARNING

Service-learning applications almost always require knowledge and/or skills that are new to students and beyond what they have learned in class. Thus, they gain a first-hand appreciation of the ability to acquire new skills and the fact that they need to do so in order to solve real problems. Reflection exercises can be used to reinforce this awareness.

KNOWLEDGE OF CONTEMPORARY ISSUES

The community context of service-learning projects guarantees, by its very nature, that students will become directly involved in contemporary social issues. Such direct involvement also helps students learn to appreciate the complexity of societal issues.

ABILITY TO USE THE TECHNIQUES, SKILLS, AND MODERN TOOLS NECESSARY FOR ENGINEERING PRACTICE

Service-learning provides a compelling context in which students can apply the knowledge acquired in their engineering courses to real problems with real constraints. Students are asked to apply knowledge in a context different from that of their normal classroom environment. Thus, they are constantly challenged both to evaluate and to synthesize the knowledge and tools they have acquired in the classroom and to ask how these can best be utilized to solve the problems at hand.

Classroom Context of Engineering Service-Learning

Service-learning helps engineering faculty provide a classroom context that meets students' needs for gaining real-world experience, community partners' need for important work, and the college or university's need to accommodate diverse learning styles and to attract and retain a diverse and highly motivated student body.

REAL-WORLD CONTEXT FOR TEACHING DESIGN

The design process is a full cycle, but traditional courses address only a piece of that cycle; simulating all phases, from initial planning through field testing and redesign, is difficult in a classroom environment. Service-learning allows students to:

- Define a real problem working with community partner
- Maintain the project once it is fielded
- Redesign after failures in the field
- See results used in the local communities

MOTIVATED CUSTOMERS, RECIPROCAL BENEFIT

Local agencies are motivated customers who are willing to work as a partner in the educational process. The benefits are reciprocal:

- Partners often lack the ability and/or budget to have work done elsewhere.
- Partnership brings value to the community agency.
- Community partners will demand excellence in projects because they rely on the results.
- Partners are attentive customers for the student team.
- Once community partnerships are established, they can last for several years.
- Local organizations reduce communication and transportation barriers.

COMMUNITY APPLICATIONS FOR CLASSROOM MATERIAL

By providing community applications for engineering science courses, service-learning brings to bear the benefits of experiential learning:

- Offers active exercises to engage students
- Accommodates diverse learning styles
- Answers *"When would I ever have to use this?"*

CONTEXT FOR RECRUITING/RETAINING UNDER-REPRESENTED GROUPS

Service-learning provides a different image of engineering and engineering products that can be highly effective in attracting and retaining a diverse group of students. For example, studies show a dramatic gender difference in interest in the fields of computer science and engineering—men are five times more likely to pursue a career in these disciplines than women

(Higher Education Research Institute, 2001). Providing a social context for engineering helps engineering departments appeal to students with a desire to help others directly (Rosser, 1995):

- Service-learning provides a link between issues related to helping people and the technical disciplines, which often appeals to women and other under-represented groups.
- Women at Purdue University participate in the Engineering Projects in Community Service (EPICS) program at twice the rate of the overall population.
- Minorities and women at the University of Wisconsin-Madison also participate in engineering (which has a strong service-learning component) at twice the rate of the overall population.

Preparation for Practice

In addition to being an effective pedagogy for teaching engineering, service-learning addresses many of the concerns of engineering companies seeking to hire new graduates. Many companies have raised such concerns—for example, the Boeing Co., one of the industrial leaders in engineering, which has established the Boeing Outstanding Educator Program. Boeing created a list of desired attributes of engineering graduates to assist engineering educators as they revise their curricula. As with the ABET criteria, service-learning can be mapped into these desired attributes.

Service-learning provides a context that allows engineering students to experience an authentic design environment that by definition requires a multidisciplinary approach and an understanding of concrete processes. The real community customers provide an environment that requires communication, critical thinking, and the ability to adapt to change—all desired attributes.

Desired Attributes of an Engineer

A good understanding of engineering science fundamentals.
- Mathematics (including statistics)
- Physical and life sciences
- Information technology (far more than "computer literacy")

A good understanding of design and manufacturing processes.
- (i.e., understands engineering)

A multi-disciplinary, *systems* perspective.

A basic understanding of the *context* in which engineering is practiced.
- Economics (including business practices)
- History
- The environment
- Customer and societal needs

Good communication skills.
- Written, oral, graphic, and listening

High ethical standards.

An ability to think both critically and creatively—independently and cooperatively.

Flexibility—the ability and self-confidence to adapt to rapid or major change.

Curiosity and a desire to learn for life.

A profound understanding of the importance of teamwork.

From the Boeing Co., www.boeing.com/companyoffices/pwu/attributes/attributes.html

Benefits of Service-Learning in Engineering

A useful exercise when advocating for service-learning is to articulate the benefits for the different constituencies that will be affected or that will need to support the effort. Below are summary lists of benefits for students, faculty, the institution, the community, and other stakeholders. These lists are meant to serve as a starting point that can be adapted to each college or university's institutional culture.

> "The project I work on today at Intel Corp. spans several years with hundreds of engineers working together. [Service-learning] gave me a forum to develop the skills to succeed in a project-based environment."
>
> MOYOLOSLA AJAJA, SOFTWARE ENGINEER, INTEL CORP.

FOR STUDENTS

- Real applications with hands-on opportunity
- Multidisciplinary team experience
- Project planning and management experience
- Development of communication skills
- Professional responsibility
- Realistic, long-term, start-to-finish design experience
- Leadership opportunities
- Mentoring opportunities—student to student, faculty to student, community member to student
- Expanded view of engineering in terms of community engagement
- Alternative learning environment for those with learning styles not well matched to traditional lectures
- Personal engagement with the local community
- Compelling context in which to explore local, global, and ethical issues
- Empowerment of students as learners, teachers, achievers, and leaders
- Emphasis on the relevance of education to students living in a real world
- Ability to learn job skills and prepare for careers after college

FOR FACULTY

- Opportunities to broaden the pool of engineering students
- Context to perform multidisciplinary work
- Encouragement to be innovative and creative in teaching approach
- Ability to enhance coursework with real applications and hands-on experience
- Mentoring environment
- Motivated customers for student projects
- Compelling context to motivate students
- Venue for teaching positive values, leadership, citizenship, and personal responsibility
- Innovative educational model with publication and funding opportunities
- Opportunities for building community and industrial partners

- Ability to make an impact on the community
- For some schools, ability to meet community service focus/requirements
- Part of retention package for tenure-track faculty
- Expanded opportunities for research proposals (e.g., incorporating service-learning as the education and/or outreach component in NSF grants)
- Opportunity to integrate personal and professional values
- Increased job satisfaction

> **"As an industry-based practitioner, I can attest to the similarities between [service-learning] and private-sector projects in the business world. Students gain experience in teamwork, leadership, and communication. They see the benefits of good engineering practices, including designing for ease-of-use, testability, and maintenance, while delivering real value to the community."**
>
> JON REID, CHIEF TECHNOLOGY OFFICER FOR MICRO DATA BASE SYSTEMS AND ADJUNCT ADVISOR FOR PURDUE UNIVERSITY'S EPICS PROGRAM

FOR THE LOCAL COMMUNITY

- Access to technical resources
- New capabilities, products, and services
- Creation of informed future advocates
- Affordable, high-quality technical services
- Solutions to specific community problems/challenges
- Long-term partnerships with the college/university
- Positive publicity
- Town-gown bridge: closer ties, investment of students in the town
- Linkages with local corporate partners
- Potential for outside funds and resources
- Retention of students in local labor force
- Increased awareness of the local community among the student population
- Ability to energize the community by getting young people involved

FOR THE INSTITUTION

- Improved relations with the local community
- Advantages in recruiting and retaining under-represented populations of students and faculty
- Improved overall student retention (Tinto, 1993)
- Recruiting advantages for students looking for engagement opportunities
- Context for multidisciplinary curricular infrastructure
- Increased corporate interest in partnering with community-based programs that are well matched with corporate criteria (e.g., Boeing list of desired attributes)
- Increased engagement in the local community, the state, and beyond
- Opportunities for positive visibility locally and statewide (e.g., legislature)
- Ability to support the institution's mission
- Self-preservation for public institutions (demonstrates public utility)

- Opening of new donor bases
- Increased educational vitality
- Broadening of faculty

FOR THE DEPARTMENT OR COLLEGE OF ENGINEERING

- Ability to meet ABET criteria
- Increased retention and cultural/gender diversity
- Broadening of faculty perspectives
- Real cases and applications for the curriculum
- Ability to address different learning styles
- Enhanced educational quality
- Positive public relations and perception
- Cross-disciplinary connections and efforts across colleges
- Unified faculty effort makes it easier to partner with employers or seek grant funding
- Potential for untapped funding
- Expanded opportunities to include education and outreach components in grant proposals
- Greater job satisfaction and unity among faculty

FOR THE ENGINEERING PROFESSION

- Real applications for the profession's code of ethics
- Enhancement of the public's positive view of the profession
- Ability to draw a more diverse group of people
- Students who are better prepared for jobs
- Retention of graduates in the profession
- Ability to prepare professionals for tough engineering jobs that have a social context
- Ethic of volunteering professionally

FOR THE PRIVATE SECTOR

- Graduates who are better prepared to enter the private sector
- Employee base with an ethical foundation and community awareness
- Opportunities for community and university partnerships
- Ability to leverage corporate resources to maximize impact
- Opportunities for positive publicity
- Ties to cutting-edge research
- Mentoring role for engineers and businesspeople in the private sector
- Ability to apply the values/mission of the corporation
- Stronger local community

Current Use of Service-Learning in Engineering

"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."

BRANSFORD ET AL., 2000

While the adoption of service-learning within engineering has lagged behind that of other disciplines, significant numbers of faculty are using this pedagogy for engineering education.

Who Is Doing Service-Learning?

Ten of the top 16 undergraduate engineering programs (as ranked by *U.S. News and World Report,* 2002) currently have service-learning programs within engineering. Among the many institutions that incorporate service-learning into the engineering curriculum are the following:

- Butler University
- Calvin College
- Case Western Reserve University
- Clemson University
- Colorado State University
- Georgia Institute of Technology
- Harrisburg Area Community College
- Humbolt State University
- Illinois Institute of Technology
- Iowa State University
- Kansas State University
- Louisiana State University
- Massachusetts Institute of Technology
- Messiah College
- Northwestern University
- Pennsylvania State University
- Purdue University
- Rose-Hulman Institute of Technology
- Stanford University
- University of Arizona
- University of California, Berkeley
- University of Colorado at Boulder
- University of Illinois at Urbana-Champaign
- University of Massachusetts Lowell
- University of Michigan
- University of Notre Dame
- University of Puerto Rico Mayaguez
- University of San Diego
- University of South Alabama
- University of Texas-Austin
- University of Texas at El Paso
- University of Utah
- University of Wisconsin-Madison

What Community Issues Can Engineering Service-Learning Address?

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 upon technology for the delivery, coordination, accounting, and improvement of the services they provide to the community. Yet they often possess neither the expertise nor the budget to acquire or design a technological solution that is suited to their mission. Thus, they need the help of people with strong technical backgrounds. Engineering students, even those in the early part of their education, often possess the required technical skills.

The opportunities for service are numerous and cover a wide variety of needs in the community. These include:

- *Building technologies and affordable housing.* Working with organizations such as Habitat for Humanity, students can apply mechanical, electrical, and structural engineering analyses to issues such as the energy efficiency of home designs, heating/cooling/lighting systems, construction processes, and building materials, resulting in reduced costs to the organizations, homeowners, or renters.
- *Organizational efficiency.* Industrial engineering principles can also be applied to the operation of community organizations themselves to improve their efficiency and effectiveness.
- *Environmentally friendly alternatives.* Students can identify opportunities to implement environmentally friendly technologies such as solar power, alternative building materials, or constructed wetlands.
- *Application of technology.* Engineering students can apply technologies using equipment at the college, such as thermal imaging cameras, to identify areas needing attention while refurbishing homes or buildings.
- *Information management.* Many agencies and organizations could benefit from customized information management systems to organize and manage information on their volunteers, staff, clients, and/or donors.
- *Assistive technologies.* Students can design and build assistive devices for adults and children with disabilities or can adapt commercially available products, such as speech recognition software, to specific individuals.
- *Customized educational environments.* Students can design and build customized educational products, displays, and devices for local schools, museums, and children's clinics.

How Is Service-Learning Recognized in Engineering Education?

At least two national engineering organizations have recognized engineering faculty for their innovations in incorporating service-learning into engineering curricula. Such formal recognition is an indication of increasing acceptance of the value of service-learning.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE)

- 1997—The Chester F. Carlson Award for Innovation in Engineering Education awarded to Leah Jamieson and Edward Coyle, Purdue University, for their creation of Engineering Projects in Community Service (EPICS).

- 2000—ASEE Annual Conference, Best Paper Overall awarded to Francois Michaud, André Clavet, Gérard Lachiver, and Mario Lucas, Université de Sherbrooke, for "Designing Toy Robots to Help Autistic Children—An Open Design Project for Electrical and Computer Engineering Education," *Proceedings of the 2000 Annual Conference of the ASEE.*
- 2000—ASEE Best Paper PIC II awarded to Nathaniel W. Stott, William W. Schultz, Diann Brei, Deanna M. Winton Hoffman, and Greg Markus, University of Michigan, for "ProCEED: A Program for Civic Engagement in Engineering Design," *Proceedings of the 2000 Annual Conference of the ASEE.*

NATIONAL SCIENCE FOUNDATION (NSF)

- 2001—NSF Distinguished Teaching Scholar Award presented to Leah Jamieson of Purdue University for her work with EPICS, specifically on the multidisciplinary nature of the service-learning program.
- 2003—Course, Curriculum, and Laboratory Improvement (CCLI) Program: National Dissemination Grant awarded to the national EPICS program for national dissemination of the EPICS model of engineering service-learning.
- 2003—NSF's Engineering Education and Centers Division creates a separate service-learning track in its Department Level Reform program. Microsoft and Hewlett-Packard partner with NSF to support the service-learning track.

How Is Service-Learning Integrated into the Engineering Curriculum?

There are four basic ways in which engineering educators have integrated service-learning into an engineering curriculum: starting with existing courses, working with co-curricular programs, developing new courses, and creating service-learning programs that span courses. Detailed descriptions of engineering service-learning programs can be found in the engineering volume of the AAHE series on service-learning in the disciplines (Tsang, 2000).

INTEGRATION INTO EXISTING COURSES

A common approach is to incorporate a service-learning component into existing engineering courses. These courses often contain a project component that can be placed into a community context. Examples include:

Mechanical Engineering

- University of Massachusetts Lowell—Class: Solar Systems Engineering. Students analyze the effects of design alternatives on homes built by Habitat for Humanity and propose their own design alternatives to improve energy efficiency. Professor: John Duffy.

Civil Engineering

- University of Utah—Class: Hydrology. In Hydrology (a senior-level course), students conduct a hydrologic analysis of a local lake. Professor: Rand Decker.

Freshman Projects

- University of Colorado—Class: GEEN 1400. Sections of an optional freshman design course are integrated with a service-learning approach to design and develop assistive technologies. Students team with adults and/or children with disabilities to identify, design, and build assistive devices. Professor: Melinda Piket-May.
- Louisiana State University—Class: Biology in Engineering. As part of an introductory course on biological engineering , first-year students design and build playgrounds for local area schools. Students learn about safety codes and standards as they analyze current playgrounds and design new playgrounds that are both fun and safe. Professor: Mary Beth Lima.
- Purdue University—Class: Engineering Problem Solving. Service-learning is integrated into this first-year course in a project to work with the local affiliate of Habitat for Humanity to assess the magnitude of the substandard housing issue in the local county. Professor: William Oakes.

INTEGRATION WITH CO-CURRICULAR COMPONENTS

In this approach, programs incorporate co-curricular activities with engineering-based projects in the community. The courses taken by students in this model may or may not be service-learning courses. A supplemental experience, in parallel or following the actual course, provides the integration with the community and reflection activities. Examples include:

- University of Michigan—Program: ProCEED. This program uses the ProCEED student organization (originally the Mechanical Engineering Honorary Society) to integrate service-learning into existing design courses such as senior design courses. Professors: William W. Schultz, Diann Brei.
- Universite' de Sherbrooke—Program: Designing Toy Robots for Autistic Children. This program integrates a first-year Electrical and Computer Engineering (ECE) design course with an optional follow-on experience. In the first semester, students design toys for autistic children. In the second semester, students then have the opportunity to follow up by building and deploying their designs for children. In this follow-on semester, the engineering students personally deliver their products to a group of autistic children and interact them. Follow-on reflection helps the students process their service-learning experience. Professor: Francois Michaud.
- University of Massachusetts Lowell—Program: International Projects. Students design and build projects in design courses, including the Mechanical Engineering capstone design course. These projects include solar power applications, small hydroelectric turbines, and water purification systems. At the conclusion of the semester, students deliver their designs to remote villages in the Andes Mountains of Peru. Professor: John Duffy.

NEW SERVICE-LEARNING COURSES

Some institutions have created separate courses for service-learning. These courses are usually design, technical, or lab elective courses that can be substituted for traditional courses. First-year courses that have been created to increase interest and retention in engineering are common. Examples of these and other courses follow.

First-Year Courses. First-year courses are designed to introduce students to real-world problems in engineering at the start of their education. Service-learning, with its integration of experiential learning and a local community context, is well-aligned with the retention literature and has shown to have positive results. Examples of such programs include:

- University of South Alabama—This service-learning course in mechanical engineering pairs first-year students with a local school to develop mechanical educational aids for teachers to use in their curricula. Professor: Edmund Tsang.
- Case Western Reserve University—This optional first-year course is open to all students entering engineering. Teams of students under the direction of a faculty advisor are paired with local community organizations through the university's office for community service. Projects include feasibility studies for repairing historic structures, construction of accessibility ramps and greenhouses, and installation of computer resource rooms. Professors: Arthur Huckelbridge, Glenn Odenbrett.

Senior Design Courses. Other courses that have been created include alternative senior design options. Often, these options are created to allow students to participate in projects with specific community partners, to allow for multidisciplinary participation, or to provide continuity with a local community partner. Examples include:

- Iowa State—Course type: ECE. This senior design course was created to partner with local organizations that worked with children with disabilities. Seniors participate in a two-semester sequence to design, build, and deploy toys and therapeutic devices for children with disabilities. This alternative course allows cross-listing with mechanical engineering to provide a multidisciplinary approach. Professor: Dan Berleant.
- Purdue University—Course type: agricultural and biological engineering (ABE). This course was created to pair teams of students with local farmers with disabilities to design, build, and deploy assistive devices to allow the farmers to continue to farm. Professor: William Field.

SERVICE-LEARNING PROGRAMS

A few institutions have created programs that span multiple courses, cut across disciplines, and last several semesters to meet the needs of local communities over a long period of time. A key example is the Engineering Projects in Community Service (EPICS) program. Started at Purdue University by Leah Jamieson and Edward Coyle (ECE), EPICS includes more than 20 disciplines in which undergraduates at all levels engage in long-term projects for the local community.

Examples of multidisciplinary projects include:

- Homelessness prevention: Computer engineers work with sociology students to design data management systems for local agencies that work with homeless and at-risk populations.
- Construction, computer, and mechanical engineers work with management and marketing students to design a system of volunteer tutorials for Habitat for Humanity's construction workers.
- Mechanical and electrical engineers work with child development students to design and build therapeutic devices for children with disabilities.

- Civil, environmental, and electrical engineers work with forestry and natural resources students to design and build a constructed wetland to mitigate agricultural runoff.
- Chemical, electrical, and mechanical engineers work with visual design and education students to design and build hands-on exhibits that illustrate fundamental concepts of fluids flow and density for a local children's museum.

EPICS programs are now also in place at Butler University, Case Western Reserve University, Georgia Institute of Technology, Iowa State University, Penn State University, the University of Illinois at Urbana-Champaign, the University of Notre Dame, the University of Puerto Rico, Mayaguez, and the University of Wisconsin, Madison. (For more information, see http://epicsnational.ecn.purdue.edu.)

Where Do Service-Learning Programs Take Place?

Service-learning in engineering has been implemented effectively not only in local communities but also on regional, national, and international projects.

LOCAL COMMUNITIES

The most common place to implement service-learning projects has been in the local community. Working with the local community offers a number of advantages:

- Project locations and community partners are easily accessible.
- Long-term partnerships are easier to maintain.
- Transportation and logistics are easier.
- Students feel connected to the larger community where they are studying. As noted earlier, this connection has been linked to retention (Tinto, 1993).
- Seeing the social issues in their local community helps students understand that the problems are "here" where they live (and may live in the future), and not only in faraway places they see on the news.

Examples of local partnerships include:

- Louisiana State University—In this partnership, students work with the Baton Rouge area schools to redesign their playgrounds to integrate current safety standards and practices. Professor: Mary Beth Lima.
- University of Michigan—Through the ProCEED student organization, the university partners with local Ann Arbor organizations to identify opportunities for the engineering students to address community needs. Professors: William W. Schultz, Diann Brei.
- Purdue University—Through the EPICS program, the university engages in multiple long-term partnerships with the local community. Professors: Leah Jamieson, Edward Coyle.

REGIONAL PROJECTS

Some service-learning projects are done outside of the local community; these may involve state or regional organizations and/or scope. These partnerships can produce a broader impact and allow students to experience needs beyond their local community. To arrange such projects, faculty have leveraged personal contacts in other areas, worked through regional and state organizations, and used extension offices at land grant universities. Examples of regional projects include:

- Notre Dame University—The Civil Engineering Department is working with municipal organizations in nearby towns to identify projects that can be addressed through service-learning projects. Professor: Lloyd Ketchum.
- Rose-Hulman Institute of Technology—The Civil Engineering Department has partnered with the Rural Community Assistance Program (RCAP) to address regional issues involving water systems in rural communities.
- Purdue University—The EPICS program has established a partnership with the Indiana Habitat for Humanity organization to work on building projects for the state organization.

NATIONAL PROJECTS

As with regional projects, national partnerships provide the opportunity to increase the scope and impact of the service-learning projects. One example of an active national partnership is between EPICS and the nonprofit group Habitat for Humanity. The Purdue University and University of Wisconsin EPICS programs have partnered with Habitat for Humanity's national headquarters to design and deliver information management projects that will be disseminated to local Habitat affiliates across the country.

INTERNATIONAL PROJECTS

The broadest scope for projects comes from international projects. With such projects, faculty members typically integrate projects that meet the needs of developing countries into their courses. They then often take a group of students abroad to deploy and/or implement the projects. Engaging students in this type of work provides cross-cultural experiences and a more global view, both of which are beneficial in the work world. In addition, the potential impact in developing countries is enormous. The logistics and resource issues are more complicated at this level, but there are many successful models, including:

- University of Massachusetts Lowell—Students design projects that are delivered to remote villages in Peru. Projects include water purification as well as solar and simple hydro-electrical power systems.
- University of Colorado at Boulder—In 2001, the university started the charter student chapter of Engineers Without Borders-USA (www.ewb-usa.org), an affiliate of the Canadian group Engineers Without Borders-Ingénieurs Sans Frontières (www.ewb.ca), which works with developing communities around the world. Since that time, numerous other campuses have started student chapters.
- Engineers Without Frontiers (www.ewf-usa.org), initiated at Cornell University in 2001, is affiliated with Engineers Without Borders and also addresses the engineering-based challenges of developing communities.

Implementing Service-Learning

> "When planning for the EPICS program started in 1994, we were able to contact many different service agencies by making a presentation about the envisioned program and its goals to the directors of all local United Way agencies. This single presentation led to many discussions with individual agencies and a long list of potential collaborations."
>
> COYLE ET AL., 1996

Implementing service-learning in engineering is not a simple task. Institutional and departmental barriers can be formidable. Yet many resources are now available to support efforts to integrate service-learning into the curriculum. The following sections outline the barriers and enablers of service-learning, as well as important steps in designing and implementing a service-learning program, including selecting a course, finding a partner, choosing a project, recruiting students, and other key isues and activities. Finally, it offers principles of good practice for implementing service-learning.

Resources for Adopting Service-Learning

Resources to help those interested in adopting service-learning can be found both on and off campus. The most important resource is likely to be campus staff who work in the Student Affairs, Community Service, Service-Learning, or Volunteer Services office. These staff members can help direct faculty to other on- and off-campus resources.

ON-CAMPUS RESOURCES

- Student Affairs professionals
- Community service/service-learning offices
- High-level administrators (can provide climate, resources, and faculty rewards/incentives)
- Faculty/staff that understand community needs (check across disciplines)
- Adjunct faculty (may be more connected to the community)

OFF-CAMPUS RESOURCES

- Faculty texts (e.g., *Projects that Matter: Concepts and Models for Service-Learning in Engineering,* AAHE, 2000)

- Journals (these provide both information and publishing opportunities—e.g., *Michigan Journal of Community Service Learning)*
- Higher education associations (sources for models, publications, workshops, grant funding—e.g., Campus Compact, AAHE, AAC&U)
- The National Service-Learning Clearinghouse (national information clearinghouse; www.servicelearning.org)
- Program models and syllabus listings (e.g., www.compact.org/programmodels; www.compact.org/syllabi)
- Proactive community agencies
- National Science Foundation (receptive to service-learning proposals)
- Professional associations (information, opportunities to network with faculty in other institutions)

Institutional/Departmental Barriers to Adopting Service-Learning

- Traditional thinking about teaching engineering (faculty/administrators may not see the value of adding a service component)
- Faculty time constraints (may be more pronounced in adjunct or non-tenured faculty)
- Lack of faculty compensation/reward
- Comfort of faculty in teaching in nontraditional venues
- "Competition" for time in classroom
- Cost factors
    - Teaching assistants and/or support staff
    - Infrastructure: specialized labs, meeting rooms
    - Materials to build projects for the community

Steps Involved in Implementing Service-Learning

SELECTING A COURSE

The first question to answer in getting started is, What course or courses are best suited to having a service component added? The answer to this question depends on the answers to a series of related questions:

- What are the learning objectives of the course?
- What would be the learning objectives for the service?
- What will the service add to the learning of the subject matter?
- What are the expected products/results of the service experience?

Service-learning is best suited to courses where the academic learning objectives can be enhanced through an experiential or project component or through a concrete context to frame abstract concepts. The most common example in engineering has been design courses where the designs are placed in a community context. Students tackle interesting problems and must interact with a real customers who usually do not have technical backgrounds. Knowing that their designs will actually be used and will benefit a person or organization in need is a powerful motivation for students.

Other courses where service-learning has been easily integrated are those that already have a project component. Community-based projects provide a different way to look at a topic and also provide a context the students wouldn't normally associate with their area of study. These courses may include junior and senior electives (e.g., solar systems engineering, where students may perform analyses to identify ways of reducing home energy costs in partnership with a local agency that builds homes for low-income families) or first-year introductory courses, where students learn about the engineering disciplines and demonstrate this understanding in a real-world situation (e.g., by creating and delivering mini-lessons on their majors to elementary or middle schools students).

Laboratory courses have also integrated service-learning by including real data or examples. For example, in a measurements lab, students might collect environmental data and present their findings to a civic or government organization. Real data that may have broad implications provides a context for discussions of the social and ethical issues involved in engineering.

Less common but equally powerful are engineering science classes. A service-learning component substituted for a traditional component can enhance the understanding of abstract concepts, as referenced earlier through the Kolb learning cycle. An example of such a model is the integration of service-learning into a kinematics course at the University of Massachusetts Lowell. Students analyze playgrounds and report on their safety to the local parks board. This project gives the concepts covered in the course a practical context since the students need to understand the motion of the children and define the magnitude of force that could injure or kill a child.

In any course, the question should be asked, "How will the service enhance the learning objectives of the course?" If the answer is that it won't, then that course is not the right one in which to introduce service-learning. If the answer is positive, the next question is how to implement the service-learning component. It is perfectly reasonable to start by offering the service as an optional component, a path taken by many practitioners of service-learning.

FINDING A PARTNER

The next logical question is, Where can I find a suitable community partner for the course? Related questions to ask here revolve around identifying appropriate community needs and finding on- and off-campus resources to assist in locating partners.

- What community needs would be appropriate and consistent with the objectives of the service-learning?
- Are there resources on campus to assist in matching faculty and community members?
- Is there a department for community relations with contacts and support services?
- Are there agencies or groups in the community that could provide contacts with a number of potential partners (e.g., the United Way)?

If your campus does not have an office for service-learning or community service, look for a student volunteer office. Most campuses have an office that works to place student volunteers in the community; staff there will have many contacts in the local area. Faculty colleagues can also provide excellent contacts. When selecting a potential community partner, it is helpful to evaluate both the organization and the people with whom the students will be working. The individuals at an organization can make or break students' experiences. If they work well with you, chances are they will work well with the students too.

SELECTING THE PROJECT

Project selection is equally important. The project must reflect the needs of the community, the academic goals of the course, and the students' level of ability.

- How will community voice be heard in the selection process?
- What are the students' capabilities?
- How much effort will be expected for the service component of the course?
- What is the available time? (students' time in school)
- What is the duration of the service (one semester, multiple semesters)?
    - Does the service opportunity require continuity from semester to semester?
    - Does it require summer involvement?

Service-learning seeks a balance between serving the community and academic learning. Finding projects that properly strike this balance with your own classes may require discussions with community partners. While the potential for impact in engineering is enormous, it is not always obvious to community service providers or engineering faculty how they can come together on a project. Discussions about community needs, the capabilities of the students, and the learning objectives for the courses are helpful in identifying potential matches.

Project Selection Criteria

Purdue University's EPICS program uses these criteria for selecting community projects. The EPICS program includes freshman through seniors and is designed for students to be involved for several semesters (Simon et al., 2002).

All community partners are local not-for-profit agencies or organizations.

Significance—Not all projects can be undertaken, so partners whose projects should provide the greatest benefit to the community are selected.

Level of Technology—Projects must be challenging to, but within the capabilities of, undergraduates in engineering.

Expected Duration—Projects that will span several semesters offer the greatest opportunity to provide extensive design experience on the academic side and to address problems of potentially high impact on the community side.

It has also proven valuable to achieve a mix of short-term (one semester to one year) and long-term (multi-year) projects, in that the short-term projects build confidence and help establish the relationship between the student team and the community partner.

Project Partner Commitment—A crucial element of the program has been the commitment of individuals in the partner organizations to work with the students to identify projects, specify the requirements, and provide ongoing critical feedback.

Location—Close proximity to campus makes regular contact easier for students.

ORGANIZING THE SERVICE

Up-front work in organizing the logistics of the service activity can be a major determinant of the success of the service-learning initiative. Being organized is critical for success in service-learning. Questions to answer early on include:

- What community members will be involved in the service-learning program?
- Who from the community agency will be the service-learning contact?
- Where will the service be done?
- How will the students get to and from the service location?
- Do the students need supervision while doing the service?
  - If so, who will supervise?
  - What will be the roles of the community professionals and the faculty?

RECRUITING STUDENTS

Student recruitment is another issue that should be considered early on in the process. The process used depends on the types of students who will be involved in the service activity (discipline, year) and the resources available on campus. If the service-learning is an optional activity, students will need to hear about it before they select their classes for the next semester.

- What types of students are needed to accomplish the service?
  - What levels of students are needed?
  - What disciplines/skills are needed?
- How will the opportunity be publicized?
  - What agencies on campus can be recruited to help?
  - What events can be used as a publicity springboard?
- What is the timeline for registering students?
- Who needs to be made aware of the opportunity? (Academic advisors? Other faculty? Other departments?)
- Do you need a special recruiting event such as a call-out? (The University of Notre Dame has had success using call-outs each semester to recruit students into its engineering service-learning programs.)

Service-learning provides a context for multidisciplinary work. However, students who are not used to taking classes in another major may not see its utility unless it is explained to them. The department that lists your service-learning course may have unintended (or negative) connotations for academic advisors and students. As a result, one may need to be proactive in informing both faculty and students of the benefits of this approach as part of the recruiting effort.

ASSESSING THE LEARNING

Assessment is an important component of service-learning. It is imperative to remember (and to communicate to students) that *students are assessed on the demonstration of their mastery of academic outcomes, not on the service itself.*

- What specific learning outcomes need to be assessed?
- What assessment measures will be used?
  - Traditional assessment tools
  - Peer evaluations
  - Other?
- Will students produce deliverables?
- What role will the community partners play in the evaluation?
- What is the faculty member's role/responsibility in evaluating student outcomes?
- Will teaching assistants be a part of the assessment process?
- Will students keep logs/journals/portfolios during the service?

MONITORING COMMUNITY INVOLVEMENT

Monitoring the involvement of community partners is essential to the success of the project. Without an established communication and feedback mechanism, it is impossible to know whether community needs are being met—and whether students are getting the most out of the learning experience.

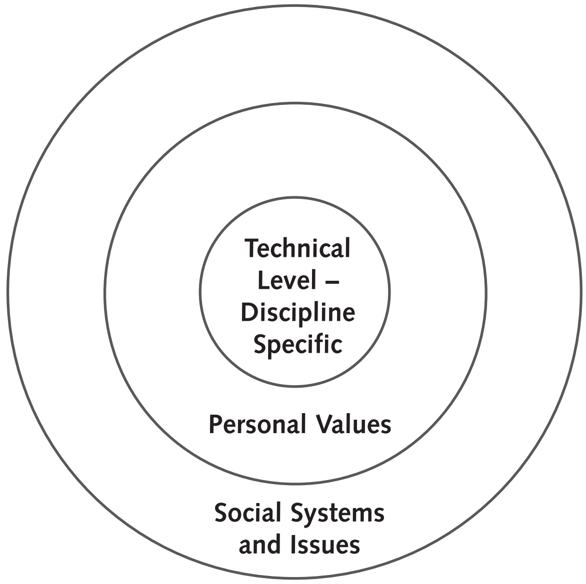
- Who will remain in contact with the community partners?
- What feedback mechanisms do community partners have?
  - Questionnaires
  - Visits with individual partners
  - Meetings for all community partners (these allow community partners to meet each other and discuss your program)
- Do you have a community service office on campus that you should be coordinating with or that can provide support and contacts?
- How will community voice be maintained as the project progresses?

ANALYSIS AND REFLECTION

As noted earlier, analysis and reflection are key to helping students build new knowledge. Therefore, designing the reflection component of the course is nearly as important as designing the service component. Reflection activities should incorporate reflection on the impact of the service on the technical work/knowledge, on students' personal values, and on broader social/civic systems and issues (Figure 3; Zlotkowsky, 2002).

- What types of reflection will students use?
  - Written responses to guided questions
  - Short essays about their experience
  - Guided small-group discussions
- Who will prepare and facilitate the reflection?
- What are the learning objectives for the reflection?
  - Academic learning objectives (e.g., the design process in a design course)
  - Community needs that are being met

FIGURE 3: **LEVELS OF REFLECTION**



- Social/community/civic issues encountered or addressed during the service
- Implications/connections with discipline and community needs
- Implications for the students themselves

LIABILITY ISSUES

Liability is one of the most common questions about service-learning and one of its biggest potential barriers. While we might wish that liability were not an issue when providing service, of course it is. It is key to check in with relevant departments on campus to ensure that the service-learning program complies with relevant college/university policies and that you have any necessary forms and releases. Questions to consider include the following:

- Is a "hold harmless" agreement needed when projects are delivered?
- Are you working with minors in the community? (You may need permission from parents.)
- Do you need to address any human subjects concerns? (If you are using people in your testing or development or if you are gathering data from people that may be published or presented outside the institution, you may need human subject approval; check with your local institutional review board for approval.)
- Licensing
    - What is your institution's policy on licensing products and services?
    - Does your institution have an office for licenses and patents?
- Off-campus permission
    - Do students need permission to travel off campus?
    - Universal waiver for the course will prevent having to fill out paperwork each time

- Photographs
  - A waiver form may be needed if photos of participants will be published in print or online
  - Does your institution have a publicity office that can help?

At Purdue University, products delivered by the EPICS program are released to the community partner only after a hold-harmless agreement, approved by the university's administration, has been signed. (This form is included in the appendix materials for reference.) The Rose-Hulman Institute for Technology handles liability issues in its work on water treatment designs in partnership with the Rural Community Assistance Program by contracting with a professional engineer. The PE takes the work of the students and signs off after review. The fees for the PE are paid by the local communities served.

MAINTAINABILITY

Some types of projects (e.g., a report on substandard housing, an alternative design for an energy-efficient home, or a presentation to high school students) do not require ongoing support once they are completed. However, when a project results in a physical deliverable (e.g., an interactive display for a children's museum, a database to track clients of homelessness prevention agencies, therapeutic devices for children with disabilities), follow-up attention may be required. In these cases, it is important to provide both a contact and a process for ongoing support to ensure the maintainability of the project and the continued cooperation of a valuable community partner.

- Who is responsible for the delivered projects? (e.g., the faculty member, students in the following semester's course, graduating students, a student organization, a community resource, or staff at the organization or agency)
- Does the project need ongoing support?
- If so, how will it be supported once it is completed?
  - Need clear expectations for maintenance and support of delivered projects
  - Who does the community partner go to for follow-on support?
  - How is the project supported in the summer?

SUPPORT MODELS

Several avenues are available for obtaining financial support for service-learning programs. The first step in seeking such support is to determine whether you actually need financial support and if so, how much. Once that determination is made, you can approach your institution, the business community, and government/private grant funders to seek the necessary resources. Most institutions have a development office that is responsible for fundraising and relationships with supporters. Development officers are often very interested in programs such as service-learning because they have the novelty and appeal to generate interest from potential donors. It is important to make sure your development office knows about your program so the staff can watch for potential funding opportunities.

- College/university support
  - Enlist assistance from the university or college development office

- Communicate regularly with the development office so they know what you are doing
- Use models of support from other design or project-based courses

• Does it make sense to seek corporate partners?

- Three-way partnerships (corporation, university, community)
- What would be the value of corporate partnerships for your program? For the company? For the community?

• Grant opportunities

- NSF Course, Curriculum, and Laboratory Improvement–Adaptation and Implementation (CCLI–A&I) Program
- Service learning track of the NSF Engineering Education and Center's Department Level Reform (DLR) Program
- Corporation for National and Community Service (CNCS) Learn and Serve America Program

Success Factors

PRINCIPLES OF GOOD PRACTICE

Jeffrey Howard (1993), one of the pioneers of service-learning, offers these principles of good practice:

• Academic credit is for learning, not for service.
• Do not compromise academic rigor.
• Set learning goals for students.
• Establish criteria for the selection of community service placements.
• Provide educationally sound mechanisms to harvest the community learning.
• Provide supports for students to learn how to harvest the community learning.
• Minimize the distinction between the student's community learning role and the classroom learning role.
• Re-think the faculty instructional role.
• Be prepared for uncertainty and variation in student learning outcomes.
• Maximize the community responsibility orientation of the course.

PLANNING, PLANNING, PLANNING

The key to a successful service-learning experience is to plan it well from the beginning.

• Provide students with timelines and/or structure for service
• Provide clear expectations for the service

- How much will the service be worth in the course?
- Is the service optional or required?
- How is the service linked to the learning objectives of the course?

- Provide feedback for students
- Be visible during the service, if possible
- Provide guidance to students on interacting with community members
- Stay in communication with community partners during the service
    - Monitor student experience and progress
    - Make sure community needs are being met
- Expect the unexpected—be prepared to help students (and community members) process events and issues that arise

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Appendix I: Guided Questions for Implementing Service-Learning

Service-learning can be implemented in several forms to meet students' educational needs. Some faculty members have integrated service-learning into existing courses; others have found that new courses or programs have to be created to meet their needs. Before making specific plans to implement service-learning, it is useful to take a step back and think about the key educational issues and needs of both the institution and the department. The following questions can help, and can be used as a teaching aid in the service-learning faculty workshop.

1. What are the most compelling educational needs of your department/institution? (e.g., realistic design experiences, multidisciplinary teaming opportunities, diversity of the engineering population, retention, etc.)

2. Which of these needs could service-learning help to address?

3. If you were not bound by current models (course structure, credit hours, semester timelines, etc.), what would the ideal course look like to meet the needs identified in #2?

4. Can any current courses or course structures be modified to integrate what you identified in #3?

    a. Yes: What modifications need to be made to the course(s)? Use this course as the example for the course revision exercise.

    b. No: What type of course(s) is required to meet these needs? Can one course do it, or is a series of courses or a full program required? Use these ideas in the rest of the exercise.

5. What are the learning objectives for this course or program?

6. How will service enhance the learning objectives?

7. How will service fit into the structure of the course or program?

    a. How much credit will be given for the service experience?

    b. Is the service optional or required?

    c. When will the service be done?

8. Who will the take the course or program? Does anything special need to be done to attract these students? Do any academic advisors or other faculty members need to be notified about the course or program?

9. What are potential service ideas to integrate with this course?

10. What community partners would be appropriate for this service?

11. What resources are available to identify community partners and community needs? Does your campus have a community service/service-learning/volunteer office? Could you attend a meeting of United Way directors? Does any other organization (e.g., Habitat for Humanity) have an affiliate in your area? Do any other faculty members have contacts with local community service organizations or schools?

12. How will the service be performed?

    a. Who will supervise the students?

    b. How will they get to and from the service?

13. Do you need waiver/liability/release/licensing forms?

    a. Special waiver or travel forms needed for the off-campus experience?

    b. Liability forms needed for the work in the community?

    c. Licensing or other agreements for intellectual property?

    d. Release forms needed for photos of participants?

    e. Human subject permission needed?

14. How will the products or services be maintained after the course(s) has ended? Over the summer?

15. How will the service-learning be assessed?

    a. Credit is given for demonstration of academic learning objectives. How will this be assessed?

    b. How will the student service experience and community partner experience be assessed?

16. What additional resources are needed for the reflection? Are guest facilitators needed (faculty, instructors, or students)?

17. What strategies will you use to have students process (reflect on) the many aspects of the service experience and connect these aspects to the rest of the course?

    a. Academic context and learning objectives

    b. Personal experience

    c. Connection to and implications for the profession/discipline

    d. Social/community issues

18. What resources will you need to implement this service? (e.g., space, funding, projects, students, etc.)

Resources Needed	In Place	Available	Need to Acquire

19. What potential sources of funding/resources/partnerships can help facilitate your planned implementation of service-learning?

20. Being able to articulate benefits of service-learning is important in advocating for needed resources. As an exercise, list the benefits from the service for each constituent group.

Constituent Group	Benefits of Service-Learning
Students	
Community	
Faculty/staff	
Department	
Institution	
Private sector	
Engineering profession	

Appendix II: Sample Service-Learning Projects, Syllabi, and Forms

Sample Projects from the EPICS Program

The following projects, drawn from EPICS teams at various institutions across the country, are examples of undergraduate engineering work in the community. More projects and other information can be found at http://epicsnational.ecn.purdue.edu.

PURDUE UNIVERSITY

Constructed Wetlands

Project Partner: Purdue Department of Forestry and Natural Resources.

Facts: Began in Fall 1998. Winner of the Spring 1999 AMD Design Award. Sponsored by Triad Associates.

Mission: Work with the Purdue Department of Forestry and Natural Resources to develop and construct a test wetlands area to clean up runoff from cattle, dairy, and swine farms and to treat creek water.

Delivered: Design of the four-cell constructed wetland with two sets of parallel cells, plantings of wetland plants in all four cells, pumping system from adjacent stream, inlet and exit weir boxes for flow measurement, analysis of flow measurements, storage shed, observation platform for visitors to the wetland.

Technologies: Environmental engineering, surveying, hydrology, botany, instrumentation.

Disciplines: Civil, Environmental, Survey and Electrical Engineering, Chemistry, Biology, Natural Resources, Agriculture.

Impact: Improved water quality. New techniques for mitigating agricultural runoff. Community facility for environmental education.

Area: Environment.

Habitat for Humanity

Project Partner: Greater Lafayette Chapter of Habitat for Humanity.

Facts: Began in Fall 1996.

Mission: Design systems, structures, and floor plans to minimize home construction and energy costs. Improve data management and access to resources for Habitat affiliates. Improve the efficiency of Habitat's operations.

Delivered: New design for house corners to minimize air leakage. Brochure for homeowners describing how to compute the cost of using different types of light bulbs. Thermal imaging of Habitat homes to determine efficiency of Habitat construction techniques. Pressure door to detect areas of heat loss. Web-based home selection guide for prospective homeowners; analysis of projected annual utility costs for available floor plans, parametric studies on home options (led to the addition of central air conditioning for all homes in Lafayette). Solar powered attic fan for resale store.

Technologies: Power electronics, solar cells, heat flow, materials, energy-efficient structures, construction, data management.

Disciplines: Civil, Mechanical, Electrical and Computer Engineering, Computer Science, Landscape Architecture.

Impact: Lower-cost houses and lower home operating expenses for the working poor.

Area: Human Services.

Elementary Science Improvement

Project Partner: Happy Hollow Elementary School

Facts: Began in Fall 1997 at Burtsfield School; transitioned to Happy Hollow Elementary School in Fall 1998 when Burtsfield School closed. Winner of the Fall 1997 AMD Design Award and the Spring 2000 AMD Design Award. Sponsored by Boeing.

Mission: Develop technology-based interfaces to improve the usability of school science, computing, and media facilities, including a weather station and a TV studio. Develop interactive activities and exhibits for the school's new science museum.

Delivered: Web page software, electrical design for school's TV studio. Weather station instruments and instrumentation that feeds weather station data to a web page. Water garden, including waterfall for the school's rainforest room, which encourages environmental awareness among the students. Science museum exhibits: Life-size camera: A flash wall that uses strobe lights, a dark room, and phosphorous sheets to capture students' shadows cast on a phosphorescent wall. Color wall: Demonstrates principles of colored light. Memory basketball: Score-keeping electronics added to an electronic basketball game to compare hits and misses for shots taken with and without vision distorting goggles. Tornado: Project that simulates a miniature tornado in a Plexiglas box. Laser harp in progress.

Technologies: Software, electronics, computer interfaces.

Disciplines: Electrical and Computer Engineering, Mechanical Engineering, Education.

Impact: Improved educational resources and educational experience for 4th-6th graders.

Areas: Education and Outreach.

Homelessness Prevention Network

Project Partner: Eight Agencies of the Tippecanoe County Homelessness Prevention Network. Two agencies in Anderson, Indiana.

Facts: Began in Fall 1995. Concluded in 2003, with statewide initiative to establish a commercially supported homelessness management information system. Winner of the Spring 1998 AMD Design Award.

Mission: Design and implement a centralized database that allows agencies to coordinate their services, track their clients, and assemble accurate reports without violating clients' confidentiality.

Delivered: Client machines and server deployed with agencies. Version 5.0 of the software included security and encryption features, full report generation capability, duplicate client-file merge algorithm on server, and a custom, private email system to enhance interagency communications. In 2001, the county, in conjunction with the EPICS team, was awarded a federal grant from the U.S. Department of Housing and Urban Development (HUD) to participate in a study of homelessness; the county was one of only 19 in the U.S. that had a homelessness management information system that met HUD's qualifications.

Technologies: Databases, cryptography, communications software.

Disciplines: Computer Engineering, Computer Science, Electrical Engineering, Industrial Engineering, Sociology.

Impact: Improved coordination of agencies serving the homeless; a better understanding of homelessness in Tippecanoe County and Anderson, Indiana.

Aids for Students with Disabilities

Project Partner: Purdue University's Office of the Dean of Students Adaptive Programs.

Facts: Began in Fall 1997. Sponsored by PPG and by a grant from the Christopher Reeve Paralysis Foundation.

Mission: Design aids for Purdue students with disabilities.

Delivered: Determination of critical display refresh frequencies that trigger photosensitive epilepsy. Remote Classroom Captioning system that uses wireless microphones and networking to allow a remote transcriber to generate near-real-time class notes for hearing impaired students. Classroom furniture: adjustable chair for students with chronic back problems; adjustable table for students in wheelchairs (75 chairs and 25 tables placed in classrooms around campus as needed by Purdue students). In progress: The Interactive Campus Map, a web-based software system that will allow students to find the best wheelchair-accessible path between any two points on campus. Also in progress: The Global Positioning System Device for the Visually Impaired, a handheld navigation aid for students who are visually impaired. It will help students find the shortest path between two points on campus and will give audible directions via an earpiece as they walk to their destination.

Technologies: Communications, GPS, human-computer interfaces, programming, ergonomics, mechanical advantage, linkages, machining, CAD design.

Disciplines: Computer Engineering, Computer Science, Electrical Engineering, Industrial Engineering, Liberal Arts, Mechanical Engineering, Health Sciences.

Impact: Improved accesses to the Purdue campus for students with disabilities.

Areas: Access and Abilities.

CASE WESTERN UNIVERSITY

Solar Power

Project Partner: Cleveland Area Utility Companies.

Description: Case Western Reserve University has several electrically driven maintenance vehicles that it wants to operate using solar power as a demonstration project for the community. A previous project has done basic charging system design. However, all designs are dependent upon the actual power demands of the vehicle. The goal of the team is to instrument a vehicle (and its associated charger) to determine the charging power requirements. A data logger would collect the data over a period of time and the project would analyze the data to specify the solar charging requirements. This project will work with local utilities to specify a system that would feed daytime solar generated power back into the local power grid avoiding the need for battery energy storage at the charger.

GEORGIA INSTITUTE OF TECHNOLOGY

Home Accessibility Inspection Program

Project Partner: Community Housing Resource Center (CHRC).

Description: The mission of the CHRC is to support balanced community revitalization through housing stabilization, community networking, technical and professional services, education, and information sharing. The Home Accessibility Inspection Program, sponsored by AT&T, is a pilot project to develop the process and system to deliver a home inspection service to senior homeowners. If the pilot project is successful, the program will grow into a nationwide service offering. The CHRC is looking to the Georgia Tech EPICS program to play a critical role in delivering this project. Students will own specific deliverables in each phase of the project as well as participate in milestone reviews and project management.

IOWA STATE UNIVERSITY

Device Design for Children with Disabilities

Project Partners: Parents and Teachers of Children with Disabilities in Central Iowa.

Description: Began in Fall 1997. Team activities include design, fabrication, testing, documentation, and delivery of devices that improve the quality of life for children with disabilities in Central Iowa. Typically these devices are for children with severe speech disabilities due to multiple sclerosis, Down's syndrome, cerebral palsy, or other diseases. Project examples include developing a switch extender designed to provide children with limited mobility and/or limited coordination with a device that will aid them in operating switches encountered in everyday life. Another team delivered an Audio Communicator for a 3-year-old girl that allows easy audio recording and playback keyed to one of six images.

PENN STATE UNIVERSITY

AgrAbility

Project Partner: AgrAbility for Pennsylvanians.

Description: First team began in Spring 2001. The team is developing tools that will create new opportunities for farmers with physical disabilities to continue farming.

UNIVERSITY OF NOTRE DAME

St. Joseph River Project

Project Partner: The Cities of Elkhart, Mishawaka, and South Bend, Indiana.

Description: Began in Fall, 2000. This EPICS group works on the creation of a web-based data entry system for use by the cities of Elkhart, Mishawaka, and South Bend. Working closely with a representative from the Elkhart Public Water Works, the group is customizing an online database to serve as a mechanism for the storage and retrieval of measurements and readings used to monitor the changing water quality of the St. Joseph River as it flows through these three cities on its way to Lake Michigan.

Indiana LED Signal Adoption Study

Project Partner: Indiana LED Signal Adoption Study (ILEDSAS).

Description: This EPICS group will evaluate the feasibility of replacing the current incandescent traffic signal lights with new high-brightness light emitting diode (LED) technology. It will perform an analysis of the significant energy/maintenance savings provided by the LED devices and study methods of financing the initial capital investment. The group will work with city leaders to assist them in the decision making process during the adoption of the LED devices, and perform outreach to other communities interested in this technology. The group will also track long-term energy/maintenance savings and LED performance/reliability.

Water Supply Studies

Project Partner: Small Community Mentoring Center (SCMC).

Description: The objective of the SCMC EPICS project is to assist small nearby communities more effectively supply water and treat wastewater. During each of the last three summers, teams of students visited the plants to assess needs. Students were then teamed with plant operators to conduct full-scale plant studies to address a well-defined need.

UNIVERSITY OF PUERTO RICO, MAYAGUEZ

Aquadilla Expressway Project

Project Partner: City of Aquadilla, Puerto Rico.

Description: Student EPICS teams are addressing the road transportation needs of special communities in the western region of Puerto Rico, chiefly the conversion to expressway of the PR-2 from Añasco to Hormigueros. More than 500 students from engineering, business administration, social sciences, and humanities, as well as faculty members and government officials, have been involved directly or indirectly with the EPICS initiative at UPRM during its first year of operation. Close to 1,000 families from the La Vía community will be affected by the students' recommendations once the analysis and evaluation of the proposed project is complete. The active participation of the students has already impacted Mayagüez and the western region in a positive manner; an injection of funds for highway reconstruction for 2003-2004 on the order of $95 million is in the works, based on the findings of a feasibility study of converting PR-2 highway to expressway and other lane widening needs on critical sections of the highway network.

UNIVERSITY OF WISCONSIN, MADISON

Rehabilitation Medicine Projects

Project Partner: University of Wisconsin Department of Rehabilitation Medicine.

Description: Began in Fall 2000. The goal of the teams is to expand the capabilities and control over their environment of patients with physical disabilities. The teams work on the development of engineering-based systems to assist in providing care for the patients served by Rehabilitation Medicine. Projects include an automated pill crusher, a device to assist in making patient records, and a system for maximizing ease of use of equipment to measure vital signs.

Other teams are working to design and implement modifications for wheelchairs, design improvements for a hand-powered cycle, design a sip-and-puff casting device for a fishing rod, and design a sip-and-puff page turner.

Information Systems Projects

Project Partner: EPICS clients and teams.

Description: In EPICS Information Systems (IS), the teams focus on developing quality web pages that integrate active server pages, databases, and other web-based tools to solve specific information technology needs for nonprofit clients. EPICS IS teams combine talents from computer engineering, electrical engineering, technical communication, computer science, marketing, business, communication, political science, English, art, journalism, human ecology, and other majors. Students can be of any class (freshman through graduate), and can be from any major. Team make-up consists of skill sets from as many majors as possible in order to assure depth and breadth of experience. *Project teams* form to work on providing solutions for a specific client from the community. *Functional teams*— technology or service based—form as part of the EPICS infrastructure to provide solutions and/or tools that can be used by all project teams. For example, a functional team may develop a web-based calendar that can be used by any of the project teams to meet client needs.

Syllabi and Course Descriptions

HYDROLOGY

University of Utah, Civil and Environmental Engineering 452

Hydrologic Analysis of the Decker Lake Outlet; Balancing Design Criteria

Service-learning may be defined succinctly as the "exercising" of course content and learning objectives in a fashion that addresses and meets a recognized community need. The ideal is simple, and hence, compelling; improve the quality of teaching/learning environments while fostering and enhancing individuals' sense of civic responsibility and value.

During the spring semester, students in the Department of Civil and Environmental Engineering's hydrology class will continue to perform a portion of a broader service-learning hydrologic analysis of Decker Lake. Decker Lake is a 35-acre lake in West Valley City that is managed as a flood control/detention basin by Salt Lake County. The lake is bordered by I-215 to the west and Redwood Road to the east. It is surrounded to the north and south by the Decker Lake Business Park and the E-center. The surrounding drainage sub-basins that flow into Decker Lake include industrial, residential, and undeveloped agricultural and former agricultural land. The Decker Lake outlet drains under Redwood Road to the Jordan River.

Over the years, Decker Lake has suffered the deleterious effect of urbanization, resulting in sediment filling in the lake and chemical/biological pollution. An ongoing effort is under way to restore the lake and its surroundings by the Decker Lake Wetlands Preserve Foundation (DLWPF). Conversely, Salt Lake County has an ongoing need to use the floodwater capacity of Decker Lake for storm water management in the Jordan River watershed. The DLWPF is a private, nonprofit community service organization established in 1994 to promote the preservation, as well as the recreational and education uses, of Decker Lake and its surroundings. The Foundation correctly recognizes that successful restoration of the lake will require integrated community and technical efforts. There is both EPA and US Army Corps of Engineers involvement at Decker Lake.

Decker Lake in filled from a 10 mi^2 urban watershed that is divided into five sub-basins. Several of these sub-basins are quite small and highly urbanized (~3 acre paved parking lots, for example). The outfalls from these sub-basins into Decker Lake are, for the most part, via un-engineered canals and culverts. There is one outlet from Decker Lake to the Jordan River, through a culvert located on the east end of the lake.

One of the dominant questions of the DLWPF is the maximum lake level that could be realized under "worst case" inflow conditions. This question is motivated by a concern about flooding of lakeside trails and constructed facilities such as handicapped access, picnic shelters, and interpretive/ educational displays. The elements of a hydrologic analysis to answer this question included:

What is the "worst case" cumulative inflow storm hydrograph from the five drainage sub-basins of Decker Lake? What is the stage (depth)–storage relationship for the lake itself? What is the stage–discharge relationship for the existing Decker Lake outlet, and what type of alternative, engineered outlet could be recommended to minimize the peak lake level?

In a previous service-learning hydrology class, the land use characteristics of the individual sub-basins were considered, along with the hydro-meteorology of the central Salt Lake valley, leading to the development of a "worst case" cumulative inflow storm hydrograph for Decker Lake.

In the following year's service-learning hydrology class, this inflow hydrograph was routed through Decker Lake using a detention/storage flood routing technique known as Puls' routing. The results of this analysis indicate that, depending on the hydraulics of an engineered outlet to the lake, Decker lake can be managed hydrologically as either a flood water impound or as a recreational facility and urban wildlife habitat. The former supports the needs of Salt Lake County, while the latter supports the envisioned uses of the DLWPF.

You will bring your valuable professional skills to bear on this engineering problem of great importance to a nonprofit foundation, that is working to addressing a recognized community need, as well as public sector agencies.

Specifically; First, you will be responsible to "balance" the disparate design criteria for the hydraulics of the lake outlet, based on the needs of both the DLWPF and Salt Lake County. Second, you will be responsible to design a hydraulic structure for the lake outlet that has the potential to address both the DLWPF's and Salt Lake County's needs at site.

During the semester, you will: 1) establish design teams; 2) develop "client-engineer" relationships with the Decker Lake Wetlands Preserve Foundation, and Salt Lake County; 3) establish and document scopes-of-work for individual tasks; 4) convene a pre-design workshop with the "stake-holders" at Decker Lake and then perform the requisite analysis; 5) integrate the results of the analysis and make appropriate design recommendations; 6) Orally and as a written document, present your results and recommendations to the engineering and non-engineering "clients" in an understandable and useful way; and 7) individually keep an engineering log to describe your work, the man-hours invested, and the impact you believe your efforts have had on the community, the practice of civil engineering, and the relationship between these two elements and your skills and commitments as a civil engineer.

Your efforts from this service-learning project will be evaluated and graded as the "design" homework project on the course syllabus (worth 1/2 of the total homework points available; ~50 pts). A citation will be placed on your transcripts showing that the course was taken as "service-learning."

In addition to exercising the learning objectives of the class in a realistic design environment, this Service Learning project will provide a valuable experience in a typical "client-engineer" working environment.

Lastly, the service component of the project will give you the opportunity to consider how, after graduation, you might integrate or set aside a portion of your professional engineering practice for projects that meet a recognized community need but are otherwise uncompensated.

CIVIL AND ENVIRONMENTAL ENGINEERING

University of Utah, Civil & Environmental Engineering 4910: Senior Design

Varied Structural Design Projects

LEARNING OBJECTIVES

The objective of this course is to provide engineering students with a comprehensive project design experience that is similar to those that will be found in practice. The students will work in team environments, using engineering analysis and design skills gained from their prior class work. These design projects will have open questions, requiring initiative, creative and technically accurate thinking and problem solving on the part of the students. There will "clients" for these design projects. Meeting the needs of these clients, while "practicing for the public good," will be paramount.

Additionally, there will be a number of lectures and external guest speakers who will provide insight into the engineering design process, the role of engineers in modern society, and issues of professional relevance, professional development and organizational/team skills. The synthesis of this information is a requisite element of the course.

It is anticipated that the students will gain capabilities and sensitivities to the following:

- Apply knowledge from mathematics, sciences and engineering to solve engineering problems.
- Design and a constructible and sustainable civil engineering system, component or process.
- Function on multi-disciplinary teams.
- Formulate and solve civil engineering problems in several of the following areas: structural, geotech, transportation, environmental, and water resources engineering.
- Gain an understanding of civic, professional and ethical responsibilities applicable to the practice.
- Effectively communicate in written, graphical and verbal forms.
- Develop a clearer understanding of the ethical, economic, environmental, social and political impact of civil engineering in a societal and global context.
- Develop mechanisms and habits that allow you maintain a perspective on contemporary issues that impact our infrastructure and environment.

GRADING

• Attendance (including regularly scheduled team meetings):	20%
• Individual (Written) Homework Assignments:	10%
• Class Notes, Speakers Log, Fieldtrip/Site Notes:	20%
• Team Projects:	50%

Project Proposal (including client interview & project schedule)

Progress Reports (two)

Interim Progress Presentation

Final Progress Report

Final Project Presentation

PROJECT DESCRIPTIONS

1. One of the dominant methods for reducing the risk of snow avalanches on communities and transportation corridors in the European Alps is through the use of snow supporting structures in the avalanche starting zones. Through client interviews and by exercising other appropriate, traditional engineering design elements, you will establish the scope of work, project schedule, for an initial generic unit design (Phase I) and final design (including cost analysis) for a deployment of avalanche mitigating snow-supporting structures for a site (Phase II) in the domestic intermountain west. The European design guidelines for these structures will be used. They are written in German.

2. The Colorado River is a typical global scale mega resource system. It provides ~85% of the community and agricultural water supply for the semi-arid west and southern California. There are a variety of agencies, NGOs, and private sector organizations that will benefit from a concise, but complete understanding and visual representation of the Colorado River system and resource. The final product of this effort will be four (4) copies of a traditional wall-size "storyboard" that depicts the Colorado River system, its sources, inflows, outflows, users, and other important water resource attributes. These public information storyboards will be of sufficient quality that an agency or other organization would display them prominently in their lobbies or conference rooms. Through client interviews and by exercising other appropriate, traditional engineering design elements, you will establish the scope of work, project schedule, for an initial and final design for these informational displays and attendant documentation.

3. The Americans with Disabilities Act (ADA) provides a codified environment for the construction or modification of structures and/or structural and facilities access for individuals with physical limitations to their personal mobility. The final product of this effort will be an inventory/assessment of the "problem areas" on the University of Utah campus with the ADA requirements, a visual rendering of recommended routes-of-travel for the disabled, recommendations and final designs (including a cost analysis) for a suite of potential constructed modifications to various campus facilities that will allow for enhanced compliance with ADA codes. Through client interviews and by exercising other appropriate, traditional engineering design elements, you will establish the scope of work, project schedule, for initial and final designs.

MECHANICAL ENGINEERING (ERGONOMICS)

University of Utah, Mechanical Engineering 515: Ergonomics

Ergonomics and Seniors

Ergonomics short course notes supplemented by OSHA publications, journal articles and other relevant material. It is recommended that students purchase a 3-ring binder so that additional information can be added during the quarter.

Week	Start Date	Key Topic
1	28 Sep	Anthropometry (HW 1, Anthropometry, handed out)
2	5 Oct	Upper Extremity Cumulative Trauma Disorders and Seated Workplace Design (HW 1 due; HW 2, UECTD, handed out)
3	12 Oct	Manual Material Handling (HW 2 due; HW 3, MMH, handed out)
4	19 Oct	NIOSH Work Practices Guide (HW 3 due; HW 4, WPG, handed out)
5	26 Oct	Metabolic Load and Heat Stress (HW 4 due; HW 5, Metabolic, handed out)
6	2 Nov	Ergonomics and the Senior Population (HW 5 due; focus on project from here on)
7	9 Nov	Vibration and Noise, Hearing
8	16 Nov	Controls and Displays, Lighting
9	23 Nov	The Americans with Disabilities Act
10	30 Nov	OSHA involvement in Ergonomics Project Presentations
11	7 Dec	Project Presentations
Finals Week		FINAL EXAM (covers all course material and project presentations)

The first half of the course will be an intensive introduction into basic ergonomics concepts and analytical techniques required to analyze and redesign a workplace, living environment, or other environment in which people spend a considerable amount of time. The first half of the course will contain most of the lecture material, all quizzes, and all homework

The last half of the course will include less intensive course work. Groups of 3-5 people will focus on the field application of the tools and techniques used in the first part of the course. In addition to other group meetings and field work, each group will be required to meet with the instructor each week to discuss the group project. This “meeting” may take place in the classroom or in the field.

It is expected that the projects for the autumn class will involve field studies involving the elderly population. Projects for this class might include the ergonomic analysis of nursing homes, in-home resident situations or the transportation requirements of seniors. These projects might also involve the training of personnel who work in facilities serving the senior population in work methods to reduce the potential for ergonomic disorders such as cumulative trauma disorders (carpal tunnel syndrome, etc.) or back injuries which might result from lifting patients or children. It might also be feasible to actually initiate modest ergonomic "self help" programs in some facilities. Potential project sites will be dismissed during the first haft of the course. Note that these are only proposed ideas and students may develop projects that meet these general criteria. A proposal will be due from each group during the fifth week of class that outlines the proposed project. This will be reviewed and returned the next week.

DRAFT POINT DISTRIBUTION:

Exam	100
Homework (5 X 1 0)	50
Quizzes (5 X 4)	20
Project Report	100
Project Presentation	50
TOTAL	320

There will be five 4-point ergonomics quizzes given during the quarter for a total of 20 points. These will be given at the beginning of the class and will cover the material assigned for that class. Each quiz will also contain four points relating to college or professional basketball. The BB questions will not count toward the ergonomics course grade; however, the student with the highest total quiz points for the quarter (20 points for the ergonomics questions plus 20 points for the BB questions for a total of 40 points max) will receive two tickets for a UTAH JAZZ game.

GENERAL FORMAT FOR TERM PROJECTS

- Cover Page: Use normal paper. The cover should include:
    - Name of author(s)
    - Course title and number
    - Project Report title
    - Submission date
    - Instructor's name
- Abstract: One or two paragraphs summarizing the project.
- Table of Contents (with page numbers for major sections).
- Introduction/Background: Discuss the general background of the subject area. Include any relevant previous research or information. Introduce the project and note why it is important.

- Method (for an empirical research project): For an empirical research project discuss the method of experimentation. (For other projects the Method Section and Results/Discussion Section are combined into the general body of the report, which can be called Results/Discussion.)
- Results/Discussion: Summarize the results of the experimentation or research. Include tables and figures if appropriate. If a great deal of data is collected, summarize the results and include relevant raw data in an appendix. Figures are graphic illustrations of things or data. Tables are arrays of data with headings to identify the entries.
- Conclusion: Draw out key findings contained in the previous Results/Discussion section and present the implications of those findings.
- References: Include information (in any accepted format with which you feel comfortable) that will facilitate retrieval by an interested reader. Reference facts that are not common knowledge or opinions of others.
- Appendix: Include secondary data such as raw data. Don't include figures and tables. They belong in the text.
- Other Stuff: Put tables and figures as close as possible to (but not preceding) where they are first mentioned in the text. When tables and figures are oriented lengthwise, the bottom should be toward the right. The axis on figures should have a zero point on the axis or a notation to show otherwise.

Project Groups "Next Action" should be discussed with the instructor next week. Additional reference material is available in the office.

1. Development of a folding/portable ramp or system to allow a person in a wheelchair to access a van. This might be the same as a portable device to allow a person in a wheelchair to access an elevated surface such as a stage. This might be hand, air or C02 powered. Next Action: Develop performance specifications such as weight, lift distance, lift capacity, type of power, etc. and preliminary design ideas. Develop ideas of physical ability of potential user.

2. Move from wheelchair to standing/semi-standing position. This device will also help a person with poor hand function to stand up from a wheelchair to exercise or balance. **Next Action:** Develop performance specifications such as weight, lift distance of seat, lift capacity, type of power, etc. and preliminary design ideas. Develop ideas of physical ability of potential user.
3. Develop a device to hold a book or a newspaper for an individual with poor hand function (arthritis?) or other disability. **Next Action:** Develop performance specifications and preliminary design ideas. Develop ideas of physical ability of potential user.
4. Analysis of patient handling task in burn unit at UU hospital. Present recommendations and short training session to nursing staff. **Next Action:** Become more familiar with UM biomechanical model. Review nurse/lifting research. I have some for you to start with. Approval to do study at UU hospital has been received.

5. Analysis of lifting hazards in the sterilization unit at UU Hospital. Present recommendations and short training session to nursing staff. **Next Action:** Become more familiar with UM biomechanical model. Review nurse/lifting research. I have some for you to start with. Approval to do study at UU hospital has been received.
6. Stair climb assist device. I envision this as a “bar” across the stairs at waist/chest height that can be moved or indexed ahead of the user. The bar would be able to move ahead of foot or two and “lock” so the user can hold on to the bar while climbing or descending. The bar might attach to the existing handrail or require that a new guide or track be attached to one or both walls. **Next Action:** Develop performance specifications such as grip strength, hip and knee extension strength, push strength, potential vestibular dysfunction, etc. and preliminary design ideas. Develop ideas of physical ability of potential user.
7. Analysis of lifting hazards for nursing personnel in local nursing home. Present recommendations and short training session to nursing staff. **Next Action:** Become more familiar with UM biomechanigal model. I will review this with you next week. Review nurse/lifting research. I have some for you to start with. Preliminary approval to do study at Saint Joseph Villa has been received.
8. Ergonomics review of VDT workstations in ME administrative offices. Present recommendations and short training session to ME staff. **Next Action:** Become more familiar with seated and VDT workstation design. Attend special 1-hour lecture.
9. Device/system to allow a user with weak hands to insert and remove plugs from the wall and/or connect a plug to an extension cord.

BIOPROCESSING

University of Utah, CVEEN 569: Bioprocess Fundamentals

Design of Systems for Separation and Purification of Biological Products

CRITERIA FOR DESIGNATION OF SERVICE-LEARNING CLASSES

Needed Service: Students will work in groups of 3 to 5 on a project that is needed by the Salt Lake Valley Solid Waste Facility. The 10-week project will be to gather information and to conduct experiments on the use of dump leachate to moisturize compost heaps. Each group will investigate one possible configuration out of several. After the project, the most successful configuration will be used for further investigation by the Solid Waste Facility. Thus the service provided will be technical as well as benefit the community as a whole.

Relevance to Subject Matter: The information and experiments will demonstrate the principle of composting, which will be covered in class towards the end of the quarter. Thus it will provide the students with first-hand experience in working with a process discussed in textbooks and in class. Several basic principles of biochemical engineering that are taught at the beginning of the class will also be emphasized in the project.

Thinking About What They Learned: Each student group will present a brief oral report (<5 min) on the progress of their experiment to the class every two weeks. The instructor, in as much as possible, will relate what they have experienced to the class subject matter at hand and ask the students to speak about what they have learned that week to what is happening in the "real" world.

Assessment: At the end of the quarter the student groups will be required to submit a written final report on their particular project, including a background (literature) section as well as an explanation of the experimental results. This will provide the instructor with an opportunity to assess whether they have understood the service project as well as the technical subjects it covers. The final report will constitute 10% of their final grade for the course. Everyone in each group will receive the same group grade.

Evaluation of Service by Recipient: During the course of the project and, particularly, at the end, Mr. David Lore, Environmental Engineer with the Salt Lake Valley Solid Waste Facility, will be working with the student groups and their projects. The instructor will ask Mr. Lore of his evaluation of each group and of the participation of each student in that group.

Civic Education: The project will enable the students to see the value of their technical background in solving some of the local environmental problems. Working with the local solid waste management facility will hopefully show them the value of recycling and other community efforts that will help the local community.

Knowledge Enhances Service: Since the project is technical in nature and is related to class subjects, the knowledge gained from the textbooks can be applied directly to the service provided and enhances the learning of biochemical engineering principles.

Learning from other class members: Since students will be working in groups of 3 to 5 they will have an opportunity to interact with one another and learn from each other. The group presentations will also give them another opportunity to organize their thoughts collectively. All groups will also discuss the results from the other groups and all students will learn from others' experiences.

COURSE DESCRIPTION:

Application of chemical-engineering principles to biological, biochemical and environmental engineering systems. Design of systems for cultivation of microorganisms and for separation and purification of biological products. Students will be working on a service-learning class project in groups of 3–5 with a local city, county, state, or national agency which will provide technical assistance to that agency that is related to the subject matter discussed in class. This is a 3-credit hour course taught every Winter quarter and serves as a prerequisite to other biochemical engineering courses taught in the Department of Chemical & Fuels engineering.

COURSE SUMMARY:

PRE-REQUISITES: For Chemical & Fuels Engineering Students: CHFEN 350-Fluids, CHFEN 366 - Mass Transfer, BIOL 240 - Cell Biology. Recommended prerequisites or corequisites are CHFEN 364 - Heat Transfer, CHFEN 362 - genetics, and CHFEN 210 -Numerical Methods or their equivalents. For Civil & Environmental Engineering Students: CVEEN 463 - Intro. to Envir. Engr. I Recommended prerequisite or co-requisite is CVEEN 464 - Intro. to Envir. Engr. 11.

OBJECTIVE: To apply engineering principles to biological and biochemical systems and to introduce the concepts of bioprocess engineering. Problems in enzyme kinetics, cell metabolism, bioreactors, biological waste treatment and immobilized cells will be addressed.

TEXT:

James E. Bailey and David F. Ollis, *Biochemical Engineering Fundamentals,* 2nd ed., McGraw-Hill Publishers, 1986.

REFERENCES ON RESERVE:

Michael L. Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, Prentice-Hall, 1992.

James M. Lee, *Biochemical Engineering,* Prentice-Hall, 1992.

H. R. Bungay and G. Belfort, eds., *Advanced Biochemical Engineering,* Wiley Interscience, 1987.

S. Aiba, A.E. Humphrey, and N.F. Millis, *Biochemical Engineering,* 2nd ed., Academic Press, 1973.

B. Atkinson, F. Mavituna, *Biochemical Engineering and Biotechnology Handbook*, 2nd ed., Stockton Press, 1991.

Harvey W. Blanch and Douglas S. Clark, *Biochemical Engineering,* Marcel Dekker, Inc., 1996.

Jens Nielsen and John Villadsen, *Bioreaction Engineering Principles,* Plenum Press, 1994.

University of Utah, Civil and Environmental Engineering 420: Traffic Engineering

Traffic Engineering Studies

TOPICS:

Speed studies

Volume studies

Flow/density/speed

Shock wave

Gap theory

Queuing theory

Intersection design

Intersection and highway capacity analysis accident analysis, road safety

Transportation planning

CLASS DESCRIPTION

The Course Goals are to introduce the theoretical concepts that underpin traffic engineering and to apply these ideas to a series of practical traffic engineering problems. The course objectives are to learn report writing and library research skills; how to analyze and design traffic facilities and data analysis techniques. The course will introduce advanced transportation concepts of traffic flow theory, traffic control system design and intelligent transportation systems.

How the class will meet the required criteria for SERVICE-LEARNING designation: Students will have the opportunity to take either a conventional course or a service-learning structure. The former will rely on 40% of the grade awarded through traditional problem solving. The latter will rely on 40% grade from the service-learning component. The service-learning element is detailed below.

SERVICE-LEARNING PROJECT

The service-learning project will:

- Address real traffic problems in real communities.
- Relate to the practical application of the theory provided formally in class.
- Enable students to follow the way that theoretical principles help the professional engineer to help communities to resolve transportation problems.
- Assess the learning derived through peer group evaluation of projects and presentations.
- Provide service interactions in the community facilitated through the presentation to the communities of reports, and through the participation of the local groups in the assessment of student contributions.

- Enhance civic education through student exposure to the complex interaction between small local groups and municipal authorities.

SERVICE-LEARNING PROJECT REPORT FORMAT

Your reports will be evaluated on both their technical content and quality of presentation, including English composition. Mathematical equations, diagrams, data sheets, etc., can be done by hand, but all text must be typewritten. While you will be working in groups, your reports will be individual. Minor details may vary, but reports should usually follow the structure suggested below:

1. *Title Page* - This should include the title, the class name and your name.
2. *Executive Summary* - Succinctly identify the nature and motivation of the study, the general characteristics of the methodology, and the principal conclusions and recommendations.
3. *Background* - Describe in more detail the nature of the study, the questions being addressed, the theoretical basis for the analysis, and any other pertinent background information.
4. *Approach* - Describe in moderate detail what you did, with specific reference to the theoretical justification for your work.
5. *Results* - Present your results in summarized form that is easy to follow, using summary tables and charts where appropriate. Detailed work sheets and voluminous interim results should be banished to an appendix, or omitted altogether, if this helps to improve legibility. Include any recommendations and their justification.
6. *Appendices* (if necessary).

I would expect your reports to be about 15 to 20 pages of double spaced typed text, including tables and diagrams but excluding appendices. To achieve a good score, the report must be both a high-quality piece of technical writing (in presentation and content) and exhibit a high degree of insight into the problem and analysis methods. You should note weak assumptions and important issues overlooked in the formulation of the assignment, weaknesses in the data, and weaknesses in the analysis methods, and suggest possible remedies to these weaknesses as well as alternative approaches.

LOCAL ORGANIZATIONS COOPERATING WITH/BENEFITING FROM THE PROGRAM

Salt Lake City Council

UDOT Research and Development

Wasatch Front Planning Organization

WFMPO Salt Lake County

West Valley Resident Group

West Bountiful Community Council

Millcreek Lions Club

Sugar House Community Council

Arcadia Heights Community Council

Center for Liveable Streets

University of Massachusetts Lowell, Dynamics 22.213

Mini-Project on Local Playground Safety

The goal of this mini-project is to provide you with a chance to apply the theory and tools of engineering dynamics to an actual system and an opportunity to help your local community. Our class will be working with MASSPIRG and an AmeriCorp volunteer to help evaluate and improve the safety of local playgrounds. With our knowledge of dynamics, we will estimate the speed, forces, momentum, and potential injuries to children on various playground devices and recommend safety improvements. We will proceed in steps as outlined below.

BACKGROUND (FROM THE NATIONAL PROGRAM FOR PLAYGROUND SAFETY:

(www.uni.edu/playground/resources/statistics.html)

> Each year approximately 205,860 preschool and elementary children receive emergency department care for injuries that occurred on playground equipment. From January 1990 to August 2000, CPSC received reports of 147 deaths to children younger than 15 that involved playground equipment. Injuries to the head and face accounted for 49% of injuries to children 0-4, while injuries to the arm and hand accounted for 49% of injuries to children ages 5-14. For children ages 0-4, climbers (40%) had the highest incidence rates, followed by slides (33%). For children ages 5-14, climbing equipment (56%) had the highest incidence rates, followed by swings (24%). Falls to the surface was a contributing factor in 79% of all injuries. Most injuries on public playground equipment were associated with climbing equipment (53%), swings (19%), and slides (17%). Data reported in Tinsworth, D. and McDonald, J. (April 2001). Special Study: Injuries and Deaths Associated with Children's Playground Equipment. Washington, D.C.: U.S. Consumer Product Safety Commission.

TECHNICAL OBJECTIVES

1. Estimate the maximum speed of children on various rides, including swings, slides (straight and helical), and merry-go-rounds.
2. Estimate the potential forces exerted on the children by the rides and by other children coming off the rides by exiting or falling off.
3. Estimate the impact of children hitting the ground from exiting or falling off the rides.
4. Inform your community about maximum speeds, forces, and impacts on children on local playground equipment and the potential for injuries.

5. Suggest improvements to the playgrounds in general (eg., warning signs) and to designs of the rides (e.g., railings) to make them safer.

LEARNING OBJECTIVES

By the end of this project the student should be able to:

1. Apply the theory of kinematics to estimate the velocity, acceleration, forces, momentum, and impact on children of typical playground rides,

2. Evaluate the potential positive and negative impacts of the technology on the local community,

3. Write a brief report describing the analysis, results, conclusions, and suggestions of this mini-project. Write a section to be given to parents and community groups with information important to them.

You may work in groups of three persons, at most. If you choose to work in a group, turn in a joint group report.

Part I

Velocity, Acceleration, Forces

In this part of the mini-project, you will be assessing the velocity, acceleration, and forces possible on children using playground rides found near where you live. Choose a playground near where you live. Measure important parameters of the equipment such as height, length, ride material and finish, and ground surface material beneath the ride. If you can, take photos to document your study and to help in future analysis. Use the parameters from the rides in your playground in place of those below. If your playground does not have the specific ride mentioned in the questions below, substitute a ride that your playground does have or else use the default parameters for the ride in the question. You may make any reasonable assumptions about the size and weight of children.

1. A classic slide starts at a 10-foot height, has a ramp down at a 45 degree angle, and has a short horizontal section 2 feet in length and 1.5 feet off the ground. Assume in the worst case that the slide is wet and that friction is negligible. (a) What will be the speed of a child coming off the end of the slide? (b) If a child falls off the top of the slide, what is the speed of the child just before she/he hits the ground?

2. A helical slide is 13 feet in height, has a radius of 5 feet, has two revolutions, and exits one foot above ground level. Again assume the slide is wet and there is negligible friction in the worst case. (a) What will be the maximum velocity of a child coming off the end of the slide? (b) What will be the maximum force exerted on the child by the edges of the slide? (c) What will be the maximum acceleration of the child?

3. A swing is 10 feet long. (a) What will be the maximum velocity of a child on the swing? At what position will that maximum velocity be attained? (b) What is the

maximum acceleration and force exerted by the swing seat on the child? (c) If a child fell off the swing what would be the maximum velocity of the child just before she/he hit the ground? Where would the child fall off to achieve a maximum velocity?

4. A merry-go-round is 8 feet in diameter, is 1.5 feet off the ground, and has bars for holding on. (a) Estimate the maximum rotational speed of the ride based on your estimates of the maximum speed of a child running to turn the merry-go-round before jumping on. (b) What would be the acceleration and force acting on the child by the bar if the child were seated at the edge of the ride? (c) If a child fell off the ride at this speed, what would be the speed of the child just before hitting the ground?

Part II

Impacts

With the force and velocity values you estimated (and corrected, if necessary) in Part I, (a) Estimate the maximum impact and effective deceleration of a child exiting or falling off each ride (whichever is worse) onto whatever surface material is present in your playground. (b) Suggest devices for parts of a ride that might be improved to keep the child on each ride. (c) Suggest surface materials that might be improved in your playground. Be specific as to type and depths of material for each ride. [If you do not have four rides in your playground, use one of the "default" rides above.] (d) If a non-rider walked in front of a swing, what would be the result if the rider were at your estimated maximum speed?

A safety survey form used to study playgrounds throughout the country, including some in Lowell, is available at: www.pirg.org/reports/consumer/playground2000/index.html. At this site is also safety information as well as the results of the national survey.

Suggestion for analysis for part (a): You could probably treat the surface material as a linear spring. You could estimate the "spring constant" by applying a known force (your body perhaps) over a surface area equivalent to the head or elbow of a child and then estimating the deflection of the surface. You could assume the velocity of the child reaches zero at the maximum deflection of the surface material. You could then use the principles of work and momentum and impact that we have covered in class to estimate the force and deceleration of the child's body part (average or as functions of displacement or time deflecting the surface material). Relate equivalent forces and deceleration rates to probable injury. [See ASTM F1292 and ASTM F355 for additional information.]

Part III

Outcomes

1. The accrediting agency for our engineering program requires that graduates demonstrate (among other things) a "broad education necessary to understand the impact of engineering solutions in a global and social context" (ABET, 1998,

"Engineering Criteria 2000," Accreditation Board for Engineering and Technology, Baltimore, MD). The impacts of your engineering information to inform parents and those responsible for the safety of playgrounds—including the physics and potential speeds and forces on their children—and of your possible solutions to improve the playground rides could be in the social, economic, and environmental domains of the local community.

2. Briefly describe at least two positive impacts of your information and engineering solutions on the local community.

3. Briefly describe one potential environmental, sociological, or economic problem that could arise as a result of your engineering solution.

Part IV

Recommendations

Make recommendations to be given to those responsible for your playground. Include only those rides that are actually in your playground (not the "default" rides that you might have used for calculation purposes).

In terms that non-engineers and non-medical people can understand:

1. Summarize key existing parameters of your playground: dimensions of rides, distance apart (if relevant), surface material, signs, barriers to keep non-riders from walking in front of riders (as near swings), conditions of ride surfaces and structural elements (corrosion, splinters, paint peeling…). You might want to consider using the evaluation form at www.pirg.org/reports/consumer/playground2000/index.html. Photos would be very helpful here.

2. Explain the possible dangers in your playground; include quantitative estimates as much as possible of equivalent force or deceleration as, for example, number of "g's"; heights of rides (type and thickness); repairs; barriers between rides; spacing of rides; removal of rides (if warranted); signs; railings to prevent falls; higher sides to keep children on rides, etc.

REFLECTION EXERCISE FOR FIRST-YEAR ENGINEERING STUDENTS

This exercise is used in a first-year engineering service-learning class at the University of San Diego. Students work in teams to create or improve on computer-controlled electromechanical models of systems, including providing full technical documentation. They then present their projects at a local high school. The academic goal for the engineering students is to communicate effectively with a non-technical audience. The high school students gain encouragement to pursue math, science, and engineering studies.

Before Going to the High School

PLEASE BRING YOUR BLUE BOOK WITH YOUR ANSWERS TO THESE QUESTIONS TO CLASS ON MONDAY, MAY 1.

Please respond in writing to the following questions. Your responses will not affect your grade, but will be used to help evaluate the NIFTY project. Please write as much as you can to elaborate on your answers. Respond in your blue book.

1. How relevant do you think this service-learning project is to your training as engineer? What makes it relevant (irrelevant)?
2. What tools and skills have you acquired so far that will help you in this service-learning project? Specify what they are and how they will help you.
3. What concerns do you have about the service-learning project that make you anxious? Specify your concerns and why they make you anxious.

After Going to the High School

PLEASE BRING YOUR BLUE BOOK WITH YOUR ANSWERS TO THESE QUESTIONS TO CLASS ON FRIDAY, MAY 5.

Please answer each of these questions with respect to your experience presenting your NIFTY project at Kearny High School.

1. What do you think are the most important things you learned?

2. What surprised you the most? What was the most fun?

3. If you had this presentation to do over again, what would you do differently? Why?

4. What do you think your audience (the students at Kearny) learned?

5. Were the concerns you had before you went to Kearny addressed? Specify your concerns and why they made you anxious.

6. Would you recommend that future Engr 20 students present their NIFTY projects at Kearny? Why or why not?

Developed by Dr. Susan Lord, University of San Diego, based on an assessment tool from Dr. E. Tsang at the University of South Alabama. Used with permission.

EPICS MILESTONE SCHEDULE, FALL 2002

The following is a sample EPICS team schedule; parallel schedules are established for teams continuing from the previous semester and those starting as new teams.

WEEK	CONTINUING TEAMS	NEW TEAMS
1	DURING LAB: Develop Semester Plan: Objectives Statement for team's projects, Semester Timeline (Gantt chart) with project milestones, Status Summary of Delivered Projects, Team Budget, Team Organization Chart, and Team Continuity Plan. Update information on "My EPICS."	DURING LAB: Begin discussion of team organization, individual and team goals. Update information on "My EPICS."
2 or 3	DURING LAB: Meet with project partner one week; do team dynamics exercises the other week.	DURING LAB: Meet with project partner one week; do team dynamics exercises the other week.
2	TEAM: Complete Responsibilities Form; turn in Semester Plan (turn in at start of week 2 lab and post on team's home page). Turn in team budget request. INDIVIDUAL: Turn in Team Transition checklist; deadline for having a design notebook. Weekly reports due at end of lab.	TEAM: Complete Responsibilities Form. INDIVIDUAL: Deadline for having a design notebook. Weekly reports due at end of lab.
3	Personal semester goals in the weekly report.	Personal semester goals in the weekly report.
4	TEAM: Demo in lab, including technical appendix; written proposals due for teams with major new project. Team dynamics. INDIVIDUAL: Review of design notebooks. Pre-register for peer evaluation.	TEAM: Written proposal due at time of lab, including budget requests. Team dynamics INDIVIDUAL: Review of design notebooks. Pre-register for peer evaluation.
5	DURING LAB: Progress report planning session.	DURING LAB: Proposal presentations.

WEEK	CONTINUING TEAMS	NEW TEAMS
7	TEAM: Written progress report posted on web. DURING LAB: Progress presentation. PROJECT: Senior design project descriptions. INDIVIDUAL: Senior design outcomes assessment.	PROJECT: Senior design project descriptions. INDIVIDUAL: Senior design outcomes assessment.
8	DURING LAB: Design review planning session. Review of Senior Design Outcomes Matrices. INDIVIDUAL: Review of design notebooks. Self-assessment and peer evaluations.	DURING LAB: Progress report planning session. Review of Senior Design Outcomes Matrices. INDIVIDUAL: Review of design notebooks. Self-assessment and peer evaluations.
9	EPICS CALL OUT Invite reviewers to the design review.	EPICS CALL OUT Invite reviewers to the design review.
10	TEAM: Mail Design Review documents to reviewers.	TEAM: Mail Design Review documents to reviewers.
11	DURING LAB: Design review.	TEAM: Progress report. DURING LAB: Progress presentation & process design review.
13	PROJECT: Deadline for final approval of senior design project descriptions. INDIVIDUAL: Final senior design outcomes assessment.	PROJECT: Deadline for final approval of senior design project descriptions. INDIVIDUAL: Final senior design outcomes assessment.
15	TEAM: Deadline for deliverables to project partner.	TEAM: Deadline for deliverables to project partner.
16	TEAM: Written end-of-semester report due. INDIVIDUAL: Review of design notebooks. Self-assessment and peer evaluations.	TEAM: Written end-of-semester report due. INDIVIDUAL: Review of design notebooks. Self-assessment and peer evaluations.
17 (exam)	TEAM: End-of-semester presentation. Milestones Checklist: Verify that all team reports and presentations are posted on the web.	TEAM: End-of-semester presentation. Milestones Checklist: Verify that all team reports and presentations are posted on the web.

HOLD HARMLESS AGREEMENT FOR DELIVERED COMMUNITY PROJECTS

Waiver, Release and Hold Harmless Agreement

This Waiver, Release and Hold Harmless Agreement is made on this ___ day of _______, 200_ by [**insert full corporate or other name of recipient of EPICS services**] ("Recipient").

WHEREAS, Purdue University ("Purdue") participates in Engineering Projects In Community Service ("EPICS"), a program under which Purdue faculty members and students provide certain types of services at no charge to and for the benefit of not-for-profit organizations such as Recipient to solve engineering-related problems faced by such organizations; and

WHEREAS, in consideration of the willingness of Purdue and its faculty and students to provide such services at no charge, Recipient is willing to execute this Waiver, Release and Hold Harmless Agreement;

NOW THEREFORE, Recipient, on behalf of itself and its heirs, assigns and all other persons or entities claiming by, under or through Recipient, represents, covenants and agrees as follows:

1. Recipient acknowledges that in the course of providing services under the EPICS program, Purdue or its faculty members, students, employees, officers, agents or representatives might cause injuries, death, property damage or other harm to Recipient or to third parties. Recipient accepts and voluntarily incurs all risks of any such injuries, damages, or harm which arise during or result from any activities of or services provided by Purdue or its faculty members, students, employees, officers, agents or representatives, regardless of whether or not caused in whole or in part by the negligence or other fault of Purdue, the Trustees of Purdue University, and/or its or their departments, affiliates, faculty members, students, employees, officers, agents, representatives or insurers ("Released Parties").

2. Recipient waives all claims against any of the Released Parties for any injuries, damages, losses or claims, whether known and unknown, which arise during or result from any activity of or services provided by any of the Released Parties under or in connection with the EPICS program, including but not limited to any such injury, damage, loss, or claim arising from any engineering services or any other services provided as part of the EPICS program, regardless of whether or not caused in whole or part by the negligence or other fault of any of the Released Parties. Participant releases and forever discharges the Released Parties from all such claims.

3. Recipient agrees to indemnify and hold the Released Parties harmless from all losses, liabilities, damages, costs or expenses (including but not limited to reasonable attorneys' fees and other litigation costs and expenses) incurred by any of the Released Parties as a result of any claims or suits that (i) Recipient, (ii) anyone claiming by,

under or through Recipient, or (iii) any third party, may bring against any of the Released Parties to recover any losses, liabilities, costs, damages, or expenses which arise during or result from the participation by, or services supplied by, any of the Released Parties in the EPICS program, regardless of whether or not caused in whole or part by the negligence or other fault of any of the Released Parties.

4. Recipient acknowledges having carefully read and reviewed this Waiver, Release And Hold Harmless Agreement, and Recipient represents that it fully understands and voluntarily executes the same.

EXECUTED this ___________________ day of____________________, 20_______.

[**Insert Full Name Of Recipient**]

By: ____________________________ Title: ____________________________

From Purdue University; used with permission.

SAMPLE PHOTO RELEASE FORM

Model Release Form

I do hereby grant permission to Purdue University, its agents, and others working under its authority, full and free use of video/photographs containing my image/likeness. I understand these images may be used for promotional, news, research and/or educational purposes.

I hereby release, discharge, and hold harmless the University and its agents from any and all claims, demands, or causes of action that I may hereafter have by reason of anything contained in the photographs or video.

I do further certify that I am either of legal age, or possess full legal capacity to execute the foregoing authorization and release.

____

Name (please print)

____

Guardian's Name (please print)

____

Signature Date

____

School Address

____

Home Address

Parent(s) Name and Address (if different from home address; only fill out if you are under 18 years of age)

____

____

From Purdue University; used with permission.

Reporting and Evaluation Tools

STUDENT EVALUATION MATRIX

Instructors use this matrix as part of their student evaluation. The matrix takes into account both ABET's objectives and Bloom's taxonomy, which emphasizes six key areas: knowledge, comprehension, application, analysis, synthesis, and evaluation.

COMPETENCIES	BEGINNING	DEVELOPING	ACCOMPLISHED	EXEMPLARY
Technical Skills - Ability to apply technical skills (from the student's major) to the work	Able to recognize basic technical needs of the project. Able to define basic technical skills and tasks needed for the project(s).	Able to identify technical issues related to one's field. Able to apply concept from major's core courses to project. Applies basic understanding of technical knowledge to project.	Able to apply concepts from advanced and/or multiple courses in one's major to the project. Able to distinguish technical issues of the project. Able to describe concepts needed for the project to teammates.	Able to apply knowledge from multiple courses to the project. Able to organize the project's technical issues into parts that can be done by teammates. Able to teach teammates from other disciplines relevant concepts needed for the project.
Design Process - Ability to describe and apply the engineering design process	Able to describe and explain the design process.	Able to schedule tasks to fit within and to complete the design process. Able to use the design process to organize and identify tasks to complete the project.	Able to appraise progress on the project(s) relative to the design process. Able to determine when the project is off sequence and needs correction.	Able to take a leadership role in defined necessary steps in the design process. Able to develop tools for effective use of the design process by teammates. Able to arrange tasks to complete the design process successfully. Able to predict results of team progress relative to the design process.
Communication- Ability to communicate effectively using written and oral presentation methods	Able to arrange information for presentations and reports. Able to present details of project when provided by others. Able to modify reports or presentations when given direction. Able to present position with limited supporting details.	Able to present position with some supporting details. Presentation exhibits some planning but lacks organization. Able to interpret project results in oral or written presentations.	Able to present position with adequate supporting details. Presentation uses clear language choices. Presentation exhibits adequate planning. Able to demonstrate project results in presentations and reports. Able to design a presentation similar to previous formats.	Able to take leadership in the design of reports and/or presentations. Clearly and concisely presents solid positions during team meetings. Able to assess presentations and identify areas needing change. Presentations are made clearly and effectively. Reports are well written, clear, complete and concise.

COMPETENCIES	BEGINNING	DEVELOPING	ACCOMPLISHED	EXEMPLARY
Teamwork- Ability to function on a multidisciplinary team	Has awareness of team roles Able to be a responsible team member.	Able to perform in more than one of the team roles. Able to identify their roles and those of their teammates.	Able to perform in multiple team roles. Able to take some leadership role. Able to do peer and self-assessment. Participates in activities that build team cohesiveness. Assists others in assimilating to the team.	Able to lead team effectively and creatively; delegates tasks. Able to develop tools or systems that allow the team to function more effectively. Initiates activities that build team cohesiveness.
Resourcefulness- Ability to acquire and apply knowledge from outside standard courses	Able to use resources that are readily available. Able to master simple new skills to accomplish tasks.	Able to look beyond available resources for additional ones.	Able to gather potential resources prior to beginning work. Able to discern quality of resources. Able to acquire basic skills needed for the project.	Able to identify resources needed prior to beginning work. Able to gather needed resources. Able to predict what will be resource-intensive. Able to master new skills needed for the project.
Community Awareness	Able to describe the project partner's organization. Able to describe how the project will benefit the community.	Able to describe project partner's role in the community. Able to interpret how team's work will impact the community.	Able to identify appropriate projects that could benefit the community. Able to articulate their own potential role as an individual and as a professional in the community.	Able to propose new projects for the team that will benefit the community. Able to lead the team in a new direction based on perceived need. Able to evaluate community impact of projects.
Professional Ethics	Able to discuss ethical issues.	Demonstrates basic ethical behavior toward team members and project.	Able to distinguish ethical issues individually and as a team.	Able to initiate team activities to enhance understanding of ethical issues. Able to evaluate ethical issues related to themselves and/or team activities.

Developed by Jennifer Kushner (University of Wisconsin-Madison) and William Oakes (Purdue University).

DESIGN NOTEBOOK EVALUATION

EPICS students are taught to keep design notebooks to document their work during projects. The notebooks become a place to record technical information, team progress, and responses to reflection questions. This form is used to evaluate the notebooks, which reflect both students' work and their ability to record it.

EPICS: Design Notebook Evaluation Form

Name:_________________________ Login: _________________ Team:___________ Credits_____

Class: ___ENGR 170 ___CE296/EE290/ME283 ___CE496/EE490/ME483 ___CS490E ___SOC 493
___CS290E ___CE396/EE390/ME383 ___CDFS 390E ___EDCI 490T ___Other

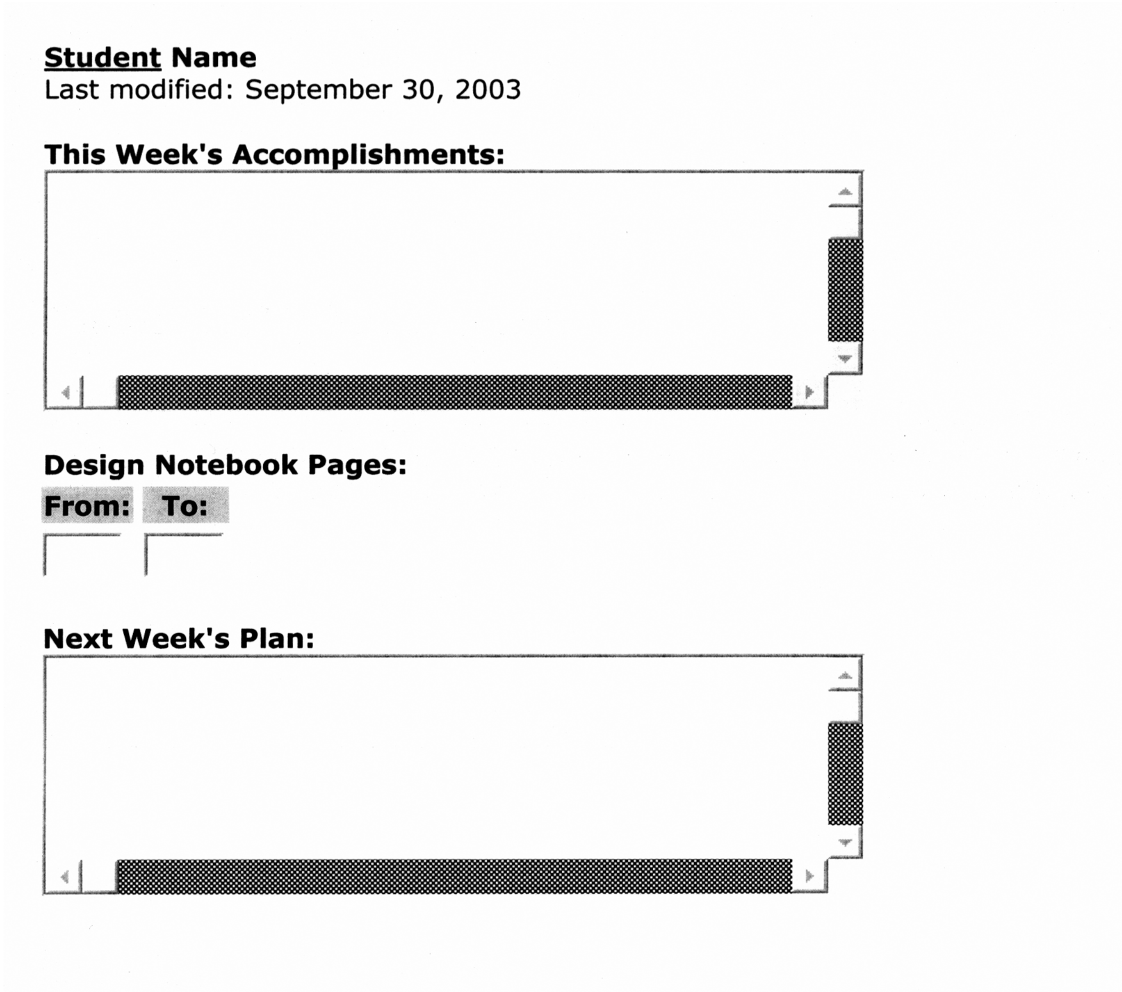
Requirements for Cover: Student's Name _____ E-mail Address _____ Team Name ____ Phone Number _____

	Points Possible	1st Evaluation	2nd Evaluation	3rd Evaluation
Entries Showing Individual Work and Accomplishments	**40**			
Level of Detail	**35**			
Readability and Clarity	**5**			
Entries for Lab & Group Meetings	**10**			
Dated Entries, Pages Numbered	**5**			
Loose Pages Attached to Notebook, Entries in Ink	**5**			
Project partner and community issues	Individual pages included in notebook (-5 pts each if not included)	Page:		
Entries for contacts and resources		Page:		
Design process		Page:		
Teaming			Page:	
Ethics				Page:
End of the semester personal reflection				Page:
TOTAL POINTS	**100**			

Comments:

ONLINE WEEKLY REPORT FORM

Students in the EPICS program at Purdue University use this online form to track their weekly accomplishments and plan ahead for the coming week. It also allows them to monitor their design notebook entries, one element on which they are assessed. (See the Design Notebook Evaluation Form on the previous page.)



Student Name
Last modified: September 30, 2003

This Week's Accomplishments:

Design Notebook Pages:
From: To:

Next Week's Plan:

PEER EVALUATION FORM

In the EPICS peer evaluation form, students are asked to evaluate several roles the other students do or could play. The roles are listed on an online form (below), along with spaces for students to score their peers on these roles. Explanations of the roles and scores, which are provided for student evaluators on the EPICS website, follow the form.

Name	Course	Credits	Role 1	Role 2	Confidence in your Scores	Distribution of 10k bonus
	EE490	2				
	ME383	1				
	ENGR170	1				
	CE396	2				
	Soc493	2				

Name	Course	Credits	Area of Greatest Contribution	Comments
same names appear here	EE490	2		
	ME383	1		
	ENGR170	1		
	CE396	2		
	Soc493	2		

Submit Form | Clear Form

Explanation of Roles:

TECHNICAL CONTRIBUTIONS: Technical work that pertains to the project. Technical contributions may take many different forms, depending on the project and the team members' disciplines. Contributions to the content of the project.

TASK DEFINITION: Activity in the early phase of the design process leading to problem definition and identification of tasks that the team will work on to address the project partner's needs.

REPORTING/DEMOS/PRESENTATIONS: Work on team reports, demonstrations, design reviews, talks, and/or poster presentations, either for EPICS milestones or for the project partner.

LEADERSHIP/CONTRIBUTIONS TO KEEPING THE TEAM ON TRACK: Team or project leadership; group task roles such as Coordinating, Summarizing, Harmonizing, Gatekeeping.

TEAMWORK: Contributions to the overall smooth functioning of the project group or team. Absence of self-oriented (selfish) behaviors.

INTERACTIONS WITH AGENCY: Interaction with the project partner.

EFFECTIVENESS IN PERSONAL TASK(S): In whatever job(s) the team member is involved, how conscientiously and well has he or she done the job?

Scoring Guidelines:

1 **Poor:** Does NOT recognize his/her role on the team in this area. Functioning below what is expected in this area. Minimal initiative shown in this area. Often misses meetings or commitments in this area.

3 **Below average:** Can define and/or identify his/her role in this area. Needs help identifying future tasks. Occasionally takes initiative in this area. This person is not as effective as other team members.

5 **Average:** Schedules tasks to meet established goals. Applies basic knowledge/experiences to accomplish his/her tasks. Sometimes takes initiative in this area. Does basically what is asked to do.

8 **Good:** Analyzes and tests options, questions, actions when appropriate. Provides constructive feedback to the team when appropriate. Regularly takes initiative in this area and is very dependable. Does at least his/her share for the team in this area.

10 **Outstanding:** A key member of the team. Consistently shows initiative. Takes responsibility for a significant share of the team's work. Assesses options, advocates for the most effective solutions.

CONFIDENCE IN YOUR SCORES: Rate how familiar you are with each team member's activities and contributions. You are to evaluate all team members; this column allows you to indicate that you are not very familiar with the contributions of team members with whom you have not worked directly.

DISTRIBUTION OF (HYPOTHETICAL) $10K BONUS: Enter amounts as integers (e.g., 2000 rather than $2,000 or 2K). The entries must sum to $10,000.

AREA OF GREATEST CONTRIBUTION: May be in any project or a contribution to the team in general.

STUDENT SELF-ASSESSMENT FORM

Name (please print) | Team | Date

SR JR SO FR | 1 2

Major | Year (circle one) | Credits (circle one)

Please list your major accomplishments for the semester in the following areas. Note that you do not need to have accomplishments in each category. Return this form to your advisor. Advisors are to make comments and return completed forms with the course grades at the end of the semester.

Category: Technical (as it applies to the project and/or your major)

Advisor ❒ I agree with the student's assessment

Comments

Category: Communication

Advisor ❒ I agree with the student's assessment

Comments

Category: Teamwork and leadership

Advisor ❒ I agree with the student's assessment

Comments

Category: Any other areas of significant accomplishment

Advisor ❒ I agree with the student's assessment

Comments:

At Purdue University, students in Electrical and Computer Engineering may elect to take an EPICS course as a substitute for the traditional capstone design course. Because EPICS is an engineering-centered but multidisciplinary service-learning program, documentation protocols were developed to ensure that students taking it for senior design are fulfilling their requirements. Each student completes two forms, one project description and one outcomes matrix. Examples of each are shown below.

SENIOR DESIGN PROJECT DESCRIPTION FORM

Advisor Approval (initials/date):	
EPICS Approval (initials/date):	

This form is to be completed for each EPICS project on which one or more students are using senior-year EPICS registration to fulfill the BSEE or BSCmpE senior design requirement. Senior design students on the project should work together to complete the form. Submit one form per project. If an EPICS team has several projects involving senior design students, submit a separate form for each project.

Semester	
Course Number & Title	EE 490 Senior Participation in Engineering Projects in Community Service (Senior Design)
EPICS Team	
Name(s) of Advisor(s)	
Project Title	
Senior Design Students	
Graduation Date	Name

Name	Major	Area of Expertise	Expected Graduation Date

Project Description: Provide a brief technical description of the design project, including the following:

a) A summary of the project, including customer, purpose, specifications, and approach;

b) A description of how the project built upon knowledge and skills acquired in earlier ECE coursework;

c) A description of what new technical knowledge and skills, if any, were acquired in doing the project;

d) A description of how the engineering design process is incorporated into the project;

e) A description of the multidisciplinary nature of the project;

f) A summary of how realistic design constraints are being incorporated into the project. As appropriate, include economic, environmental, ethical, health & safety, social, and political constraints, and considerations related to sustainability and manufacturability.

SENIOR DESIGN STUDENT OUTCOMES MATRIX

Student's Name

Team

Project

Semesters Recorded

Enter date(s) of documentation of outcome			Describe how the student's realization of the outcome is documented.	Initials of individual recording the outcome.
sem 1	**sem 2**	**Outcomes**	**How documented**	**Initials**
		i. applies technical material from their discipline to the design of engineering products ii. demonstrates an understanding of design as a start-to-finish process iii. demonstrates an ability to identify and acquire new knowledge as a part of the problem-solving/design process iv. demonstrates an awareness of the customer in engineering design v. demonstrates an ability to function on multidisciplinary teams and an appreciation for the contributions of individuals from other disciplines vi. demonstrates an ability to communicate effectively with both technical and non-technical audiences vii. demonstrates an awareness of engineering ethics and professional responsibility viii. demonstrates an appreciation of the role that engineering can play in social contexts		