

Student Engineers Reaching Out: Case Studies in Service Learning and a Survey of Technical Need

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Abstract - We introduce Student Engineers Reaching Out (SERO), an EPICS team at the University of Notre Dame committed to Service Learning founded in engineering curricula. Two SERO case studies highlight the framework, implementation, challenges, and shared benefits of our unique Service Learning course developed specifically for engineers. The first study demonstrates the progressive refinement of a single project and the second study involves completion of numerous varied projects for a single client. For both studies we examine the application of Kolb's Learning Cycle, the Action Research cycle, and correlations with Community Based Research (CBR). Based on the success of the case studies, a comprehensive survey of the local non-profit community was undertaken. The overwhelming magnitude and variety of technical community needs are presented as new opportunities for additional Service Learning projects in engineering curricula.

Index Terms – Service Learning, Community Based Research, Action Research, Case Studies, Kolb's Learning Cycle, Technical Consulting

INTRODUCTION

The incorporation of Service Learning into engineering curricula is described in the work by Lima and Oakes [1,2] and embodied in numerous courses and organizations such as EPICS [2], ECOS [3], Think Cycle [4], TechBridgeWorld [5], Humanitarian Engineering [6], and ETHOS [7] to only name a few. We introduce Student Engineers Reaching Out (SERO), a team of student engineers functioning as a design and consulting firm as part of a Service Learning course at the University of Notre Dame in affiliation with the national EPICS project. Here we build on the Notre Dame Engineering Service Learning framework introduced by Madey *et al.* [8], and map the research, education, and community outreach goals onto two current SERO consulting projects.

The first project is a case study of a single extended consulting and design engagement focusing on the multi-year development of a SERO/client relationship and the inherent challenges of personnel turnover and evolving expectations. The second project is a case study focusing on the evaluation and undertaking of numerous varied consulting projects for a

single customer with unique manufacturing design requirements. The observations center on the experiences garnered from multiple dynamic client requirements of varied technical complexity and the subtle tradeoffs between client benefit, student education, and research objectives.

Following the case studies, we take a first attempt to position these and similar Notre Dame Engineering Service Learning courses of instruction, into the context of Community Based Research (CBR) [9] [10], Action Research [12,17-19], and the Kolb Learning Cycle [13]. We then provide introductory insights into our experience integrating these methodologies into our curricula with respect to the two case studies.

Motivated by the SERO success, a survey of local community engineering and technical needs was undertaken to research the magnitude and types of support required. A brief summary of the survey results is presented, demonstrating the large number of non-profit organizations in need of engineering and or technical consultation. It is our hope these results will serve as a starting point for new CBR and SL projects in engineering curricula.

We conclude with a review of our research project's current challenges and map out near and long term goals for future CBR projects.

CASE STUDIES

To evolve and improve our service learning course in the college of engineering, it is important that the students, faculty, and administration make careful critiques regarding observed successes and failures each semester. We are working to develop a more structured and rigorous evaluation procedure which can be applied methodically and adaptively to best correlate with the dynamic nature of our changing clients and projects. One component of this evaluation is the completion of case studies for each consulting relationship. In this work we share case studies for two of our larger consulting projects.

1. Course objectives:

Well defined course objectives are the necessary benchmarks against which a case study can reveal areas of success and failure. The objectives of our service learning course can be

loosely categorized into academic objectives, service objectives, and research objectives.

The service learning courses are offered by volunteer faculty and graduate student instructors as a technical elective for undergraduate engineering students. The students receive one credit per semester and typically take the course for at least three semesters. As a graded course it is essential that the academic objectives be clearly specified. The following key goals in this regard are found in the course syllabus:

- Learn operational fundamentals of an engineering firm including sales engineering, project management, design, review, revision, and practical safety/liability concerns
- Apply fundamental scientific and engineering principles in the design and engineering of technical products, projects, estimates, and proposals
- Develop technical communication and consulting skills to improve one's effective contribution when working within a multi-disciplinary team environment.

The social objectives of the course are founded, in part, on the following line from the Engineer's Creed as held by the National Society of Professional Engineers [20] "To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations." Further we are guided by the moral mission as outlined by the University of Notre Dame. By applying the skills and knowledge learned in the classroom to meet specific societal needs, SERO works to provide help and hope to others. These goals are also found in the course syllabus.

- Investigate opportunities for community service through engineering, both as a student, and a practicing engineer.
- Enact the mission statement of the University of Notre Dame by serving the less fortunate members of our community through application of our engineering talents.

The third group of objectives is the latest edition to our evolving course framework. Research objectives are loosely grouped into two focuses: developing a greater understanding of the technical needs of local, national, and international non-profit charitable organizations and identifying factors key to the success and failure of student engineer consulting relationships. The SERO team recognizes this will require investigation into the economic, environmental, educational, and social concerns and obligations of our clients. In tandem to an improving understanding of the needs, we are studying the most effective ways for a team of student engineers to address this need. The solutions will be targeted to not only address present requirements, but make fundamental contributions toward more permanent reduction in technical needs through client education.

In the following case studies we will reference back to these objectives in order to identify successes and failures which will serve as points of refinement for future semesters. As the research objectives are a new contribution to the course syllabus, the correlation with these case studies was not found to be as strong as the academic and social objectives.

II. Logan Center and St. Joseph's Hospital Toys:

Our first case study involves a multiple year consulting relationship with the Logan Center and St. Joseph's Hospital focused on a single engineering project, the redesign and modification of toys for children with developmental disabilities. The Logan Center is a non-profit organization committed to supporting persons with mental disabilities and helping them to achieve a higher quality of life. As an important resource, the center has established a lending library of toys which have been modified to meet the needs of children with developmental disabilities. Similarly, St. Joseph's Hospital pediatrics uses modified toys as a part of their children's rehabilitation and therapy programs.

SERO began working with these two organizations by modifying off-the-shelf toys. Example changes include rewiring battery operated devices to incorporate a large touch-plate and replacing small switches or buttons with large knobs. SERO functions as a consulting firm to the Logan Center and St. Joseph's Hospital by providing the knowledge and experience necessary to adapt the toys. The team applies engineering skills learned in the classroom to resolve a specific technical issue for their client.

Since its initial involvement with these two organizations, SERO has become increasingly aware of parents' desire to provide modified toys for their children at home. In response to this need, SERO has worked to create a toy modification manual. This document is intended to provide clear instructions to parents who wish to safely modify toys for their children. In addition to the manual, SERO has begun to create kits that contain all the necessary tools and supplies. The team is working to integrate these kits into the Logan Center and St. Joseph's Hospital lending libraries. Allowing parents to borrow these kits, and then modify toys they already own, is an effective way of making modified toys available to the most children.

Throughout this consulting relationship, SERO has met the academic objectives to functional as a consulting firm by developing a better understanding of the needs our clients, the parents, and the children and providing technical solutions. In response to this increased understanding, the team has progressively refined procedures at the sales engineer, project engineer, and staff engineer positions. For example, client communication methods and frequency have been optimized, new standards have been instituted to identify which toys are economically and technically viable for modification, and finally a process internal to SERO has been setup to train new members in basic modification procedures. The team continues to research how it can better serve their clients at the Logan Center and St. Joseph's Hospital.

The service objectives are clearly met by the direct service to non-profit organizations and the families they serve. At the end of each semester client satisfaction surveys are provided to the client to help ensure and improve the quality of service provided. The following quote from our client reflects the SERO contribution "You have brightened the lives of many little ones who have taken the toys home after being adapted or repaired! Also, the parents want to thank you for

your time and are delighted by the growing selection of toys at the Toy Lending Library. The benefits their children with special needs receive while using them are priceless!"

Research objectives have been partially met through the evolution of our team's functionality in response to the analysis of the client's, parents', and child's needs. The introduction of the toy modification manual and toolkit directly educate and enable the target community members by removing technical barriers to a higher quality of life.

III. Logan Industries:

In this second case study we present multiple year consulting relationship with Logan Industries during which many various technical projects were undertaken. Logan Industries is a non-profit organization employing adults with physical or mental disabilities, helping them to develop job and life skills to enhance their quality of life. This organization is unique because it operates a variety of product assembly and packaging lines with a high level of dynamic flexibility to meet frequent changes in the production requirements. Since the assembly and packaging specifications vary for each product, a distinct challenge arises to efficiently suspend one product line and initiate another.

SERO functions as a consulting firm for Logan Industries applying project management skills and engineering knowledge to the product line planning and upgrades. As a non-profit organization, Logan Industries has a very unique goal to design and operate each product line at low cost while working to maintain or, at times increase, the number of employees on each line. This goal must be carried out with strict sensitivity to safety, product quality, and overall efficiency. As Logan Industries' consultant, the SERO team shares these challenges and goals.

Since its initial involvement with this organization, SERO has helped to design and implement multiple product assembly and packaging lines. For example, the team researched and designed a platform and auger intended to reduce a production bottleneck requiring significant physical labor. SERO also researched, designed, and implemented an assembly line involving several pneumatic devices. Each project provides new challenges and experiences for the SERO team.

The consulting relationship developed with Logan Industries has met the academic objectives by enabling SERO to improve project management skills and engineering design knowledge. Each project has allowed the team to directly apply learned engineering skills such as computer-aided design, manufacturing, and packaging. The frequent project turnover allows the team to become better acquainted with the client while constantly redefining project constraints and requirements. Further the team members adjust to the realities of accelerated or delayed production schedules and the speculative design estimates for potential production lines for prospective clients.

Service objectives are met through the direct support of Logan Industries to develop cost effective manufacturing, management, and technical sales processes necessary to

maintain the organizations viability and thus continue its service mission. Additional benefit is shared through the interaction between the student engineers and Logan Industries employee's with developmental disabilities. The students come to appreciate the capabilities and limitations of their fellow community members who are always excited to see the visiting students take a direct interest in their work.

SERO continues to research ways to improve the consulting relationship with Logan Industries to include response time for critical deadlines, format and presentation of technical content, and more economical "manpower friendly" designs. More robust research into the classification of best suited manufacturing projects is planned to assist in the sales engineering phase of Logan Industries' project cycle.

IV. Student Feedback:

To close the case study section we present selected student engineer comments collected from their end of semester reports during which they are required to provide comments and critiques on the course.

- "SERO stresses social responsibility. I feel that social responsibility, tied so strongly to the engineering discipline, has really improved my perception of engineering and its importance. For me personally, SERO has helped to define engineering's relation to the community."
- "SERO's role in service learning has changed my perception of engineering to focus on making projects as feasible as possible by using practical engineering. It is very important when working with the local non-profits to clearly understand the requirements and desired results for a project. That way, the most efficient, cost-effective, and practical solution can be achieved."
- "With graduation looming, I will struggle to find such a satisfying way to contribute to society after three years of SERO. I have truly enjoyed using my engineering to help those in need and working with our talented team members. Based on my experiences with SERO and service learning, I truly believe that it should be an integral part of the complete education of a Notre Dame engineer."
- "Service learning was an interesting and enjoyable way to learn about engineering in a different context and a great way to help real people in the real world"
- "Having completed two semesters now, I can see with increasing clarity the focus of not only helping our community partners with their engineering needs, but also giving the group a different perspective on engineering. Service learning has a unique aspect in that its activity between the student and client is mutually beneficial."
- "When I came to college, I did not really have a reason for choosing engineering, beyond that I was good at math and science and my brother seems to enjoy it. But after doing SERO for three semesters, I feel like I have a reason. With SERO, we are actually doing something to make the world better."

INTERSECTIONS: ENGINEERING SERVICE LEARNING, COMMUNITY BASED RESEARCH, AND ACTION RESEARCH

The authors are currently working to better position and develop our service learning course within the fields of service learning, community based research, and active research. Given our unique course framework and the case studies presented, we give a brief summary of our on going efforts to integrate our course with these education and research methods. We are currently conducting a community-based research project on factors influencing the success of engineering service learning projects in the local university community. We have employed a hybrid methodology combining principles of engineering Service Learning and Action Research [1,2,12,17-19] to evaluate SERO projects such as the two case studies presented here.

Prior research on the effectiveness and outcomes of similar service learning projects has been conducted for engineering and/or computer science projects, but at other institutions. In comparison, the Notre Dame engineering service learning experience is uniquely different. These differences include, 1) the religious private university character of Notre Dame, 2) the availability of an institutional level service learning center to help identify community clients and support service learning activities that many other institutions do not have, 3) the smaller student and faculty size of the College of Engineering at Notre Dame (e.g. when compared to Purdue's EPICS program), and 4) the decentralized organization of service learning in the College of Engineering (e.g., when compared to Purdue).

Three factors influence the research methodology used on this study. First, we have selected a limited number of case studies (consulting engagements) over the planned study period. Second, service learning as an educational philosophy is based on Kolb's Learning Cycle [13] and includes discrete learning steps of 1) concrete experience, 2) reflective observation, 3) abstract conceptualization, and 4) planning. (See Figure 1). Third, the student engineers and the faculty mentors can be structured as a system of student practitioners and participating researchers. For these three reasons, we developed our hybrid research approach using both Action Research and Service Learning principles.

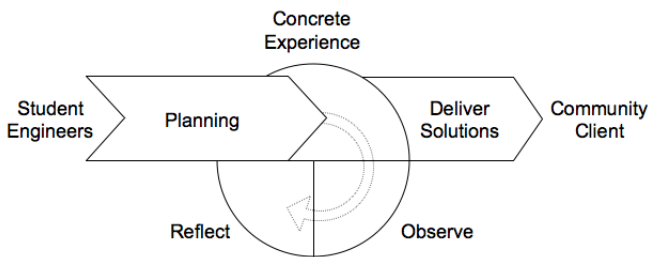


Figure 1. Engineering Projects: The Student's Service Learning Cycle

Action research is also related to other research approaches, including participatory research, collaborative inquiry, contextual action research, and participatory action

research. It is based on ideas proposed by social psychologist Kurt Lewin and others. It is especially applicable to this research because the action research cycle (data collection, evaluation, action, critical reflection, data collection, evaluation, etc.) parallels the Kolb Learning Cycle that is the basis of service learning. (See Figure 2). Data collection includes student-practitioner service learning reflections, faculty-research reflections, client interviews and surveys, and scorecards.

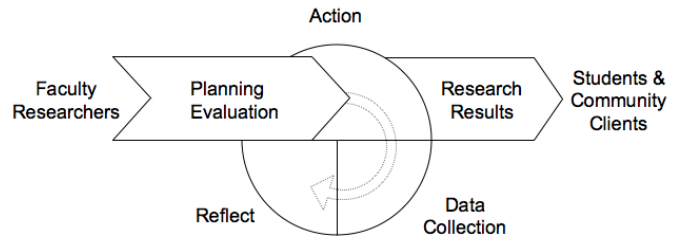


Figure 2. Action Research in support of Community Based Research Parallels the Student's Service Learning Cycle

For demonstrative purposes we now correlate the student service learning cycle and researcher's action research cycles with each of the ongoing case studies presented.

I. Application to Logan Center and St. Joseph Hospital Toys:

The SERO team's relationship with the Logan Center and St. Joseph's Hospital reflects the discrete learning steps outlined above in the Student's Service Learning Cycle. For example, students gain understanding and familiarity with the toy modification projects through concrete experience of making modifications themselves. Also, new SERO team members observe the more experienced members. During weekly SERO meetings, the team reflects upon the most effective and successful of various modification techniques. Through this cycle of concrete experience, observation, and frequent reflection, the SERO students are able to plan and deliver useful solutions to their clients at the Logan Center and St. Joseph Hospital. Both the student team members and the instructor perform active research by collecting data on the fundamental patterns and classifications of non-profit technical need, then reflecting on and re-evaluating the most mutually beneficial path forward.

II. Application to Logan Industries:

The phases of the Student's Service Learning Cycle are also evident in the SERO team's work with Logan Industries. Due to the high turnover of projects, students are continually engaging in concrete experiences, observation, and reflection. For example, whenever a new product line is to be initiated, the team visits the Logan Industries site in order to best understand the needs of their client. This essential planning phase is combined with previous concrete experience in order to design and implement the most appropriate solution. The SERO team also conducts weekly meetings to observe progress and reflect upon the project goals, schedule, and

budget. For every project undertaken, it is this cycle of planning, experience, observation, and reflection which allows the SERO team to provide the most beneficial solutions to Logan Industries.

A SURVEY OF TECHNICAL NEED

The authors decided to develop a survey to assess the technical needs of local non-profit organizations in the community; based on the success of our past service learning projects as discussed in the case studies, and a desire to expand the action research component of the community based research endeavor. The target goals were to: 1) introduce the organizations to collaborations with technical service learning programs, 2) gather data on technical needs through a simple set of pre-selected services, 3) provide the organizations an opportunity to identify new technical needs, and 4) finally elicit the contact information for additional organizations with whom we might collaborate. Our process is broken down into three phases: distribution, review of technical need, and the SERO reply. A numeric summary of the survey data can be found in Table 1.

In the distribution phase we first developed a list of local non-profit agencies with the help of the Center for Social Concerns at the University of Notre Dame. The initial list included some governmental organizations, student led organizations, and service units not officially registered as non-profits. These organizations were removed from the list in order to focus primarily on established 501(c)3 non-profits as defined by the United States Internal Revenue Code. Eighty surveys were distributed via regular mail and an online survey was developed which will remain accessible year round to gather new information about organizations and their technical needs. The online survey can be found on our team’s website at <http://www.nd.edu/~epics2/SERO>.

We received 25 completed surveys via mail and 2 completed online surveys, yielding a response rate of approximately 34%. Not all respondents indicated a present technological need. The majority of respondents requested information technology support with web and database needs as the two primary subfields. The second most requested support was construction estimates for facility renovations and upgrades. Other technical requests included software design, structural analysis, and mentoring students in K-12 participating in science focused competitions. Examples of those requests deemed insufficiently technical by our staff include: cost estimates for display booths and disaster preparation plans.

The SERO team response to the surveys included immediate support, requests for clarification, wait listed support, and referrals. The decisions regarding those to immediately support and those who were waitlisted centered on the capability and availability of team members in the matching technical disciplines. SERO operates with every intention to meet the clients stated needs while openly sharing our immediate technical and time table limitations.

While our survey focused on the broad science and engineering technology needs of our local community, it is

important to acknowledge the existence of larger targeted surveys by such institutions as the Digital Divide Network [21], NPower [22], and TechSoup [23]. In future articles we plan to review and correlate data from the most current and widely distributed nonprofit technology needs surveys. Through this correlation we hope to identify more fundamental sociological, economic, and environmental factors leading to the unanswered technological requirements. By addressing these fundamental factors, we hope to make a more comprehensive and lasting contribution to the community.

TABLE I
SUMMARY OF SURVEY RESULTS

Phase	Component	Number
Distribution	Initial List	100+
	Surveys Sent via mail	80
	Surveys Returned via mail	25
	Surveys Completed Online	2
Review of Technical Need	Information Technology Support	9
	Website Design and Upgrades	4
	Dynamic Databases	3
	Construction/Renovation Estimates	3
	Other	2
	Non-Technical	5
SERO Reply	Immediate Support	4
	Waiting List	9
	Requested Clarification	3
	Referral	10

SUMMARY & CONCLUSIONS

SERO (Student Engineers Reaching Out) is a team of student engineers participating in a service learning course and collaborating with faculty researchers to learn more about critical success and failure factors associated with service-learning projects in engineering. We have described initial work to correlate service learning and community-based research. Two case studies and a survey of local community non-profit organizations have provided initial research data. Our hybrid research approach combines, in parallel, the Kolb Learning Cycle and the Action Research Cycle to collect related data and participant reflections. By combining action research methods with an on-going service learning project, community-based research is facilitated. We believe this hybrid approach can be adapted to most service-learning projects, opening up and enabling new scenarios for community-based research.

Our team is currently working on the next phase of this research project which can be grouped into two core challenges. The first challenge is the identification of key factors influencing the success and or failure of consulting relationships. This will be accomplished through the thorough analysis of multiple case studies including the two presented here. The second challenge is the identification of factors fundamental to the technical hurdles hindering non-profit organizations. We plan to address this challenge through the correlation of our detailed local survey with larger national

surveys and the inclusion of an analysis of select non-profit organizations.

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