Impact of Research Technologies on Service Learning

Saurabh Bagchi†, Carla B. Zoltowski, and William C. Oakes‡
Engineering Projects in Community Service (EPICS)
† School of Electrical and Computer Engineering
‡ School of Engineering Education and School of Mechanical Engineering
Purdue University
Email: {sbagchi, cbz, oakes}@purdue.edu

***Abstract* - While the effect of service learning in technology-based curriculum has been documented, it is as yet unknown what benefits or challenges are felt by the students when the technologies being applied in their service learning course lie in the research domain. We investigate these questions through a study carried out in the context of a service learning program called EPICS, in which teams of undergraduates develop real systems to address engineering and computing-based needs for a local community partner. Through a questionnaire, we study the students' perception of the availability of resources and skills for their project, and their perception of the value add of the project to their curriculum and to the community partner. The experimental group consists of four teams that use cutting-edge research technologies in their projects. The control group consists of three teams that develop prototypes using mature technologies that are easily available in the marketplace.**

The study uncovered that neither group of students felt hampered by a lack of resources or skills. However, the control group felt greater ease in dealing with the community partner. It is hoped that this effort will serve to increase the viability of integrating research and service learning activities.

Index Terms – Integrating research in service learning, EPICS, Value-add to community partner, Availability of resources.

INTRODUCTION

While the effect of service learning in information technology based curriculum has been well documented [1-10], it is as yet unknown what benefits or challenges are felt by the students when the technologies being applied in their service learning course lie in the research domain. Service learning has been used in engineering and technology domains as an integral part of the overall service learning concept. As these domains evolve rapidly, it is natural that some service learning projects will call upon the participants to grasp research-oriented concepts and then apply them to develop a concrete system, prototype, or other deliverable for the community partner. Service learning has, as a fundamental component, a community partner which expects to benefit from involvement in the projects. We realize that as cutting-edge research-oriented technology is brought to bear on the service learning projects, this creates both exciting opportunities and challenges.

The opportunities that are created by the inclusion of research-oriented technologies are multi-faceted. For the students, this enables them to get a taste of research in an applied context. The majority of service learning students are undergraduates and this gives a rare opportunity to them to engage with research-oriented technologies. For the community partner, this provides them with a unique value from the project, namely, deliverables that could not be readily acquired from the general marketplace. In some cases, this may give a competitive advantage to the organization over some other much larger and better-funded counterparts. Consider for example, a local children's museum which can lay claim to an innovative exhibit that integrates Radio Frequency Identification (RFID) technology with its exhibits for the purpose of tracking patterns of usage of these exhibits. Such technology is not available at any but a handful of museums worldwide today. Finally, for the faculty members involved in the service learning project, the integration of research gives a potent method for increasing the impact of their research. This potentially disseminates the benefits of the research to an audience much wider than would normally be feasible (i.e., niche researchers and graduate students in the faculty member's laboratory). The broad dissemination is a virtue being stressed by research funding agencies across the board, most prominently the National Science Foundation (NSF).

The integration of research in the service learning curriculum also creates several challenges. For the students, this adds to the challenges inherent in a service learning curriculum. Normally, the students are responsible for designing, developing, and deploying their prototype to the community partner. They engage in developing the prototype over the course of several semesters, typically 2-3 semesters for one completed prototype. This is challenging in itself in that the students have to realize a functional prototype that can be operated by people outside of their immediate technical discipline. With the addition of research, the students have to familiarize themselves with the promise and the pitfalls of the research technology. The technology is by definition, not completely mature and therefore bugs still have to be ironed out in it. Resources to support and develop the technology may not be as readily available as for more mature commercial products being used in the project. This adds a further dimension of uncertainty to the delivery schedule the students have to work under. As a natural corollary, the community partner faces the challenge that she has to accommodate some uncertainty in the delivery schedule for the prototype. She often has to interface more closely with the students participating in the service learning project to keep abreast of the timeline. Also, after the prototype is delivered to the community partner organization, operating it may require more skill than common-mode exhibits would. For example, going with the RFID application to the children's museum that we introduced before, the museum personnel now have to hand out RFID tags to the visitors so that these tags can be read off by the reader mounted on the exhibit. They have to ensure that a tag is not bent out of shape in which case the reader may not recognize it. Finally, for the involved faculty members, the integration of research in service learning can be challenging in that the students need closer supervision and more detailed guidance.

Combining the opportunities and challenges arising from the integration of research in service learning, *the overall question we pose is how are these conflicting factors perceived by one of the two most important stake-holders, the students.*

We investigate these questions through a study carried out in the context of a service learning program at Purdue University called the Engineering Projects in Community Service (EPICS). EPICS is a program in existence since Fall 1995 in which teams of undergraduates design, build, and deploy real systems to solve engineering-based problems for local community service and education organizations. Through a questionnaire, we study two aspects of the impact of research on the service learning course experience of the students:

1. The students' perception of the availability of resources and skills needed for the successful execution of their project, and
2. Their perception of the value add of the project to their curriculum and to the community partner.

This paper presents the results of the study and discusses the lessons that can be drawn from it. Further, this paper lays out the necessary questions that will need to be answered from the other stake-holders (prominently, the community partners) for us to draw up an effective template for integrating research-oriented technologies in service learning projects.

STRUCTURE OF THE STUDY

For the study, we consider a sample of students that participated in the EPICS program in Fall 2007. In EPICS, the students are organized in teams (divisions) of 8-20 students. Each division shares a common community partner. Each division is subdivided into project teams that range in size from 2-10, depending on the complexity of the project. Students may be assigned to multiple project teams.

Experimental Group

A subset of teams (the experimental group) is supervised by faculty members that have active research programs in the specific technical discipline of the team. These teams engage in developing prototypes and methodologies that involve technologies in the research domain. These technologies are currently under active research in the laboratories of the supervising faculty members and are supported by research funding from several federal and state funding agencies, such as the National Science Foundation and Indiana 21st Century Research and Technology Fund.

The experimental group comprises four teams. These are listed Table I together with their community partners.

TABLE I. TEAMS IN THE EXPERIMENTAL GROUP OF OUR STUDY

Team	Community Partner
Chemical Sensing Initiative (CSI)	Tippecanoe County Sheriff's department, that is looking to inhibit illegal drug making laboratories through use of chemical sensors
C-SPAN	C-SPAN, which houses its archives of video database at their center in West Lafayette
CSOPS	An Engineering Research Center funded by NSF that is looking at more efficient means of pharmaceutical drug production
ISB	Imagination Station, the local children's museum that is looking to provide more interactive cutting-edge exhibits

Examples of the research technologies under consideration in our study include wireless sensor networks, chemical sensors for drug detection and identification, and automated video detection and video database technology.

Control Group

The remaining set of teams in our study (the control group) is involved in projects, which are of great value to the community partners but use technologies that are available in the market today. These activities include developing educational materials, designing custom educational products involving both hardware and software, and developing museum exhibits. These teams and the community partners are listed in Table II.

TABLE II. TEAMS IN THE CONTROL GROUP OF OUR STUDY

Team	Community Partner
ZOO	Columbian Park Zoo. It designs educational materials to be used by the zoo.
KES	Klondike Elementary School. It designs custom educational products involving both hardware and software.
ISG	Imagination Station, the local children's museum. It provides interactive exhibits for the museum. In contrast to ISB, the exhibits use technology that is relatively mature and widely available in the open market.

Availability of Resources

All the teams have supervising faculty members or industry members with domain knowledge, a pool of teaching assistants available to provide detailed help, and flexibility under reasonable budget limits to acquire equipment needed for their project. The equipment may be research-oriented equipment available from specialized vendors and often needing integration, or equipment available commonly from the marketplace.

DETAILS OF PROJECTS

Here we give the details of the research technology that is used by each of the teams in the experimental group.

The Chemical Sensing Initiative (CSI) team is working with local law enforcement, and Tippecanoe County Sheriff's department to integrate the use of sensors into crime prevention, with a specific of focus will be the inhibiting of drug making laboratories using sensors and sensor networks such as chemical detectors. Detection of chemicals and identification of different drugs is be developed through the use of technology and sensors. Cyber-crime prevention through computer engineering is also being investigated such as database and search algorithm development to assist law enforcement in identifying drug use and abuse.

The goal of the C-SPAN EPICS team is to create a database of minutes and videos of local (Lafayette, West Lafayette, and Tippecanoe County) community and governmental organizations that is accessible to the local community. Automated video processing techniques such as the ability to extract thumbnails and cluster similar images, have been developed for the C-SPAN archives to facilitate the processing of the large amount of programming that the C-SPAN channels broadcast. The C-SPAN EPICS team has worked to incorporate these automated video processing techniques, like those used by the C-SPAN archives.

Center on Structured Organic Particulate Systems (C-SOPS) is part of the education component of an NSF funded ERC. The C-SOPS team is advised by faculty working on the ERC and designs projects that educate pre-college students about the topics in the ERC. The team is designing portable and interactive displays to take into area schools and museums to demonstrate and investigate the characteristics of pharmaceutical mixing techniques.

Imagination Station (ISB) is one of two teams working with the local children's science and technology museum to create interactive learning experiences for elementary and middle school-aged children. The ISB team's projects include the application of wireless sensor networks to improve the learning experience of the children and to allow museum staff to track usage and operation of the museum's exhibits. The students have developed a prototype to personalize the experiences of individual visitors by giving them RFID tags. These are worn in the lanyards that will be handed out to the visitors and read off by the RFID readers embedded in the exhibits. The visitors can then review their visit—which exhibits did they go to, how much time did they spend at each exhibit. This information can also be made available to the museum staff for troubleshooting their exhibits. Other projects within this team include building a prototype Mars Rover that has the capacity to be steered on a mockup of the Mars surface with the goal of accomplishing certain specific missions (such as, digging for water in some crater).

The descriptions of the teams in the control group have already been provided in Table II.

FORMAT OF THE STUDY

An anonymous survey was given to all of the students on both the control and experimental teams in the last week of the semester (Fall 2007). The questionnaire was divided into two logical sections which addressed the students' perceptions of the availability of resources and the effect of research on service learning.

In the first section, eight five-level Likert items (listed below) were presented to evaluate the perception of the students regarding the sufficiency of the resources available to them to successfully complete the service learning project. The resources include their personal training and background in the skills that will be needed for the project as well as personnel and equipment resources needed. For the responses, we use the standard five-level Likert scale, where a response can be any one of the following. Note that we did not have a response "Not Applicable".

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

1. I have the instructor resources needed to successfully complete the project.
2. I have the Teaching Assistant resources needed to successfully complete the project.
3. I have the requisite skill set in my project team to successfully complete the project.
4. I have the requisite equipment needed to successfully complete the project.

5. I have the requisite technical background needed.
6. I have the requisite skills in inter-personal relations to deal with an external community partner
7. I have the requisite skills in inter-personal relations to deal with other students on my team.
8. I can pick up any relevant skill needed for successfully completing the project, if I do not have it already.

In the second section, seven five-level Likert items were devoted to exploring how utilization of research technologies impacted both their learning and the service that is being provided to the community partner.

9. The fact that I am using technologies and techniques that are in the research domain makes the service learning project more meaningful to me.
10. My project is more useful to the service learning partner because it uses technologies and techniques from the research domain.
11. I feel unacceptably challenged because I have to learn technologies and techniques from the research domain.
12. I feel motivated to participate in the service learning project because I have to learn technologies and techniques from the research domain.
13. The taste of research I get through this service learning project makes me consider seriously the possibility of pursuing a higher degree beyond the bachelors.
14. The research oriented technologies and techniques that I learn here make me appreciate better the concepts taught in lecture classes that I take as part of my curriculum.
15. The research oriented technologies and techniques that I learn here makes it more likely for me to continue my involvement with service learning.

RESULTS OF THE STUDY

Analysis of the data was done using the SPSS statistical package. Table III shows the averages for the responses for each item of the control teams and the aggregate mean across all control teams. Table IV shows the average and aggregate responses of the experimental teams.

An independent t-test was conducted to determine if there was a significant difference between the means of the two groups in response to any of the questions. The differences between the means, Mean (Control) – Mean (Experimental), and the results of the significance test on each of the questions are given in Table V. For the data obtained, only the result of one item was found to be statistically significant at a level of significance $\alpha = 0.05$, namely item 6. The way to interpret the values in the table is as follows. If the numeric value of significance in the table is less than α, this means that the probability of making an error by considering that the mean of the control group and the mean of the experimental group are different, is less than α. This is what is needed by the setup of the test (significance level of the test = α = 0.05).

TABLE III. MEAN FOR THE CONTROL GROUP ON EACH QUESTION

Item	ISG N=17	KES N=8	ZOO N=13	Total N=38
1	4.41	4.25	4.08	4.26
2	3.65	3.63	4.08	3.79
3	3.94	3.25	3.54	3.66
4	3.88	3.13	3.85	3.71
5	4.00	3.38	3.15	3.58
6	4.53	4.50	4.38	4.47
7	4.59	4.50	4.46	4.53
8	4.41	4.00	4.15	4.24
9	3.94	3.88	3.77	3.87
10	3.88	4.00	3.69	3.84
11	2.35	2.13	2.77	2.45
12	3.59	4.00	3.77	3.74
13	2.88	3.50	3.00	3.05
14	3.71	4.00	3.38	3.66
15	3.76	3.75	3.77	3.76

TABLE IV. MEAN FOR THE EXPERIMENTAL GROUP ON EACH QUESTION

Item	CSI N=15	CSOPS N=13	C-SPAN N=7	ISB N=20	Total N=55
1	4.40	3.46	4.14	4.35	4.13
2	4.07	3.08	4.00	4.05	3.82
3	3.73	3.38	4.14	4.00	3.80
4	4.20	3.46	4.14	3.50	3.76
5	3.33	2.77	3.57	3.85	3.42
6	4.07	4.08	4.00	4.30	4.15
7	4.27	4.31	4.29	4.60	4.40
8	4.07	3.92	4.14	4.30	4.13
9	4.00	3.77	4.14	4.30	4.07
10	3.80	3.62	4.00	4.15	3.91
11	2.53	2.69	2.71	2.45	2.56
12	3.80	3.46	4.00	4.15	3.87
13	3.40	2.69	4.00	3.40	3.31
14	3.53	3.15	3.57	4.05	3.64
15	3.67	3.15	3.71	3.85	3.62

TABLE V. RESULTS OF HYPOTHESIS TEST ON DIFFERENCE OF THE MEANS BETWEEN THE CONTROL AND THE EXPERIMENTAL GROUPS

Item	Mean Diff	Sig. (2-tailed)	Item	Mean Diff	Sig. (2-tailed)
1	0.136	0.307	9	-0.204	0.263
2	-0.029	0.891	10	-0.067	0.678
3	-0.142	0.440	11	-0.116	0.553
4	-0.053	0.778	12	-0.136	0.410
5	0.161	0.399	13	-0.256	0.258
6	0.328	0.029	14	0.022	0.916
7	0.126	0.299	15	0.145	0.425
8	0.110	0.441			

α = 0.05, N = 38 Control, N=55 Experimental

CONCLUSIONS FROM THE STUDY

Interestingly, of the 14 items that did not have a significant difference, 8 had a negative value for the mean difference (i.e., the experimental group had a higher mean) and 6 had a positive value. This means that the students in the two groups had conflicting views on different aspects of the two issues—availability of resources and impact of the research technology. For some questions, the control group felt more strongly that they had the resources and for some others the experimental group felt more strongly, though in all questions except number 6, the difference was not significant at the α=0.05 level. The same split responses are seen for the second section of the questionnaire.

The study uncovered that neither group of students felt hampered by a lack of resources or skills. Thus, reassuringly and a little surprisingly, the research group felt to the same extent as the non-research group that it was able to pick up the relevant skills, which are often outside of what they learn in their regular curriculum, and acquire and develop the requisite equipment. However, the non-research group felt a greater ease in dealing with the community partner, possibly due to the fact that the timeline for the deliverables is more predictable with the non-research-based technologies. It is also possible that the research teams felt a tension between the research technologies and the needs and opportunities of the partners. This question is one that will be a topic in a follow-on qualitative study.

In terms of the added value of the project to their service learning experience, we did not find any significant difference between the groups. This can be attributed to several possible factors. The students may be too involved in learning the basics of the technology to be able to perceive the longer term effect of the project on the community partner or their own service learning experience. They may also be hard pressed to make an objective decision since typically one student has not experienced both kinds of projects – using mature technologies and using research technologies. Overall, both classes of students have felt a significant value-add of the service learning project to their curriculum. Going forward this points to the possibility of addressing explicitly to the students the benefits and the challenges of incorporating research oriented technologies in their service learning projects. We believe different students will react differently to these factors, some deciding to embrace the research aspect and some shying away from it.

RELATED WORK

Although there are researchers who have incorporated research goals into the service-learning model, very little prior work has been done to explore the impact of incorporating research concepts and techniques into the service-learning projects.

Researchers at Creighton University reported about a series of research projects in which technologies such as Geographic Information Systems and decision technologies have been incorporated into service-learning projects which “assist residents of low income areas to develop reliable methods for identifying specific neighborhood problems, and to use those methods to mobilize appropriate governmental and private-sector agencies to assist in remediation.” [11] The researchers describe many expected benefits for this integrated research and service-learning project for a number of beneficiaries: the Discipline, the Community, Creighton University, College of Business Administration, Department of Information Systems & Technology, and the Students. However, questions of whether or not these benefits had been achieved, or the impact of the integration of the research into the service-learning projects on both the community and the students, were not addressed.

The SERO (Student Engineers Reaching Out) team at Notre Dame is another example of how service-learning and research objectives are being combined. [12] Two primary community based research projects are described. The object of the first study is to identify key factors to the success or failure of the consulting relationships formed by the students and the community organizations. The second study seeks to understand the fundamental factors of the technological hurdles that the community organizations face. Although this work does combine the service-learning and the research projects to understand factors contributing to the success or failure of service-learning, and applying that research to the service-learning model, it differs in that it does not focus on the application of research-based technologies into the service-learning projects.

Even within the EPICS program here at Purdue, we have integrated research and service-learning objectives through a variety of projects. In a recent example, Matusovich, Follman, and Oakes [13] explored why women choose to participate in EPICS via an exploratory qualitative study. However, as with the other integrated research and service-learning projects, the focus of the study was not to evaluate the impact of the integration of the different objectives, but the research objective was intended to inform the impact of service-learning on women.

FURTHER WORK

In our questionnaire, we omitted a "Not Applicable" response. As a result, we did not discern whether a student felt her project involved research-based technology or not. In hindsight, we should have done this. With the current study, it is possible that a student's perception of whether her project involved research technology is at odds with our perception. As we continue the data collection this semester, we will be adding a question to determine the student's perception. The student will then have the option of answering "Not Applicable" to some questions, e.g., if she feels her project does not involve research technologies, then the questions that deal with the effect of research technologies on her learning become irrelevant.

This study focused on one of the two most important stake-holders in service learning, namely the students. We are planning to perform a study asking the community partners what their perception is. Do they feel that research technologies hamper the timely completion and adoption of the projects in their organizations or do they see the cutting-edge nature of such projects providing a competitive advantage to them. We will ask the students identical questions and evaluate the correlation between responses from the community partners and the students.

Finally, the current study was solely quantitative. It did not even have any free form question for the students to express their views. We will be adding a qualitative component to the next study through focus group interviews with selected students. Since many students from Fall 07 (timeline for this study) are taking EPICS in Spring 08, we will have many subjects to choose from. By using students who were part of this current study, we will be able to derive consistent conclusions. We are interested in understanding the causes for satisfaction and challenges the students feel in using research technologies in their service learning curriculum.

CONCLUSIONS

This study has shown that service-learning projects that are linked to current research areas can provide positive experiences for students. The study has shown that incorporating research technologies does not significantly add to the technological challenge felt by the students. This is a heartening result, indicating an ability among the students to be adaptive to changing technology and learning and using new technology to deliver working projects. We would like to build upon this work by conducting interviews and/or focus groups of students in both of the groups to explore their experience and the understanding of the research connection.

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AUTHOR INFORMATION

Saurabh Bagchi, School of Electrical and Computer Engineering, University, Purdue University, bagchi@purdue.edu.

Carla B. Zoltowski, EPICS Program, Purdue Univerity, cbz@purdue.edu

William C. Oakes, EPICS Program Director, School of Engineering Education, Purdue University, oakes@purdue.edu