AC 2012-3941: LEARNING FROM WORKING ON OTHERS' PROBLEMS: CASE STUDY OF AN INTERDISCIPLINARY PROJECT-BASED GLOBAL SERVICE-LEARNING PROGRAM

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Learning from Working on Others' Problems: Case Study of an Interdisciplinary Project-based Global Service-Learning Program

Abstract

In this paper we present a case study of an interdisciplinary global service-learning program. This program provides students the opportunity to engage in projects that address international development problems through long-term partnerships. The overall goal of the program is to teach students about social development issues, increase their understanding and awareness of global problems, and provide them with an understanding of design as a framework and methodology to bring about change. We conceptualize this project as reciprocal service-learning as both the students and faculty working on the projects as well as the project beneficiaries learn from each other. Concepts of prosocial and intrinsic motivations, and self-determination theory (SDT), theoretically inform our engagement in the field and the curriculum design. We use a design-based approach as it allows us to iteratively improve our program and demonstrate to students how to make a concrete difference through designing useful and usable systems and artifacts. In this paper we describe the initial conception of the idea, discuss how we built partnerships (across engineering and industrial design faculty and with NGOs in the field), and explain how the program has progressed over the past year through a series of activities, including: independent study, incorporation of design projects in a large freshmen course, summer REU (Research Experiences for Undergraduates) program, and a full-fledged class offering. We have identified the importance of picking a few key projects and clients and working on those projects and with those client partners for a longer time period. This infrastructure building is essential and allows for incorporation of mentors, more buy-in from the clients, improvement of the design and product over time, while providing enough variations to keep the students interested. We discuss key design projects we have undertaken including a financial literacy application and an immunization application. To provide empirical support for our ideas and implementation, we present both quantitative and qualitative assessment data collected from students using focus groups and survey. The goal of the assessment was to understand student motivation and to document students' experiences working as a part of interdisciplinary teams.

Introduction

Engineers are often motivated by the desire to have a real world impact through their work. This desire is present not only among practicing engineers but also among engineering students and faculty. Over the past couple of decades, engineering faculty members across institutions have leveraged this motivation to design courses and experiences for students where they can make a positive impact in the life of others and also learn important engineering skills. These experiences have been termed service-learning. In addition to curricular activities, various societies and groups such Engineers for a Sustainable World (ESW) and Engineers without Borders (EWB), have taken a hold across campuses increasing the opportunities for students to participate in community service activities. Many service-learning initiatives have been highly successful and have had a significant impact on engineering education. For instance, the Engineering Projects in Community Service (EPICS),[1] program at Purdue University received

the Bernard M. Gordon Prize by the National Academy of Engineering for Innovation in Engineering and Technology Education (Coyle, Jamieson & Oakes, 2006)[2]. The EPICS program exemplifies a pioneering educational innovation and has been adopted by dozens of institutions since its inception. In this program, students engage in long-term community service projects in local communities (Coyle, Jamieson & Oakes, 2005 & 2006)[2, 3]. Teams are relatively large, representing a small company, and the community organization acts as a client. Students can take the course similar to taking a lab and can enroll multiple times for up to four times. Another model that has emerged is to have project-based courses where the projects that students work on are driven by community needs. In this scenario the course looks similar to traditional courses but there is a significant difference where the course is driven by the project itself. This model makes it easier to engage communities and problems that might not be local to the educational institution, such as global or international development (Bielefeldt, Swan & Paterson, 2010; Swan, Bielefeldt & Paterson, 2010)[4, 5]. In addition to disciplinary engineering faculty, many scholars from the science and technology studies and engineering studies have also started to engage with service-learning approaches to examine the ethical and pragmatic difficulties faced in engaging with these projects (Nieusma & Riley, 2010)[6]. Irrespective of the model adopted, service-learning has become an important part of the engineering curriculum in many institutions since its introduction within engineering schools in the early 1990s. The newly formed ASEE community on service-learning is further evidence of its importance and adoption.

Moving beyond engagement with local communities and projects, an international or global flavor is also evident in many service-learning projects. In many cases this interest has emerged out of engineering faculty members' research efforts. Many faculty members in civil and environmental engineering, mechanical engineering, and other disciplines, are involved with research on global climate change, sustainability, and other global challenges. Several efforts in the area are also being driven by researchers in areas such as ICT for development and HCI for development where the role of information technology in addressing pressing global problems is being examined. Furthermore, many researchers and educators are driven by a prosocial motivation to help others in less fortunate circumstance. Engineers also realize that long term sustained development requires significant physical and material infrastructure as evident by the visible symbols of development such as dams and roads, but also found in the power and sanitation infrastructure. This belief, which is often at odds with the prevailing discourse on development represented primarily through economic functions such as GNP and GDP, is reflected in the engineered or material aspects of poverty reduction, health issues, financial literacy, or other issues identified in the U.N. Millennium Development Goals[7] report. For engineers and designers, there is also an increased awareness that there is a lot to be learned by working on problems in different contexts as they teach you about designing in constrained environments and lead to innovative ideas and concepts that are applicable universally.

In this paper, we take this idea as the central driving force and present a case study of an interdisciplinary global reciprocal service-learning program. We first present the theoretical framework that drives our work, the implementation of the program, and discuss the outcomes in terms of design prototypes and student assessment. Finally, we end with a note on some lessons we have learned through this experience that might be useful for others.

Literature Review and Theoretical Framework

Service-learning as a curricular activity found a foothold in the 1980s and its presence in higher education has increased ever since. The benefits of service-learning projects are well documented in the literature. In a report that summarizes the main findings of research on service-learning, and includes an annotated bibliography of over 100 articles on the topic, Eyler, Giles, Stenson and Gray (2001)[8] found that service-learning has a positive effect on students' personal development such as sense of personal efficacy, personal identity, spiritual growth, and moral development and also on their interpersonal development, the ability to work well with others, and leadership and communication skills. Their review further identifies that service-learning has a positive effect on reducing stereotypes and facilitating cultural & racial understanding. Furthermore, service-learning experiences have a positive effect on sense of social responsibility and citizenship skills and students' commitment to service. In terms of learning outcomes, they argue that evidence shows that service-learning has a positive impact on students' academic learning and students or faculty also report that service-learning improves students' ability to apply what they have learned in "the real world". Finally, service-learning participation has an impact on such academic outcomes as demonstrated complexity of understanding, problem analysis, critical thinking, and cognitive development.

In one of the larger studies conducted on service learning (Astin, Vogelgesang, Ikeda & Yee 2000)[9], longitudinal data were collected from 22,236 college undergraduates attending a national sample of baccalaureate-granting colleges and universities. Thirty percent of the students participated in course-based community service (service learning) during college, and an additional 46 percent participated in some other form of community service. The study assessed the impact of service learning and community service on 11 different dependent measures. Service participation showed significant positive effects on all 11 outcome measures: academic performance (GPA, writing skills, critical thinking skills), values (commitment to activism and to promoting racial understanding), self-efficacy, leadership (leadership activities, self-rated leadership ability, interpersonal skills), choice of a service career, and plans to participate in service after college. The study further found that performing service as part of a course (service learning) significantly adds to the benefits associated with community service for all outcomes except interpersonal skills, self efficacy and leadership and benefits associated with course-based service were strongest for the academic outcomes, especially writing skills. Overall, service participation appears to have its strongest effect on the student's decision to pursue a career in a service field. The authors state that the positive effects of service can be explained in part by the fact that participation in service increases the likelihood that students will discuss their experiences with each other and that students will receive emotional support from faculty. Furthermore, both the quantitative and qualitative results suggest that providing students with an opportunity to "process" the service experience with each other is a powerful component of both community service and service learning. Compared to community service, taking a service-learning course is much more likely to generate student-to-student discussions and allow for reflective learning. In terms of motivation, the single most important factor associated with a positive service-learning experience appears to be the student's degree of interest in the subject matter. Subject matter interest is an especially important determinant of the extent to which (a) the service experience enhances understanding of the "academic" course material, and (b) the service is viewed as a learning experience. These findings provide strong support for the notion that service learning should be included in the student's major field. The second most significant

factor in a positive service-learning experience is whether the professor encourages class discussion. The qualitative part of the data analysis suggests that service learning is effective in part because it facilitates four types of outcomes: an increased sense of personal efficacy, an increased awareness of the world, an increased awareness of one's personal values, and increased engagement in the classroom experience. Both qualitative and quantitative results underscore, once again, the power of reflection as a means of connecting the service experience to the academic course material. The primary forms of reflection used were discussions among students, discussions with professors, and written reflection in the form of journals and papers.

Given that service-learning has demonstrated positive outcomes on student learning and development, it is important to examine why students, and faculty, might want to engage with these projects so as to use this knowledge in designing learning experiences. A review of the motivation literature alerts us to some potential reasons why students, as well as other stakeholders, might engage with service-learning projects and what faculty can do to leverage their interest and make their engagement stronger. The first explanation for working on service learning projects is prosocial motivation, which is the desire to expend effort to benefit other people (Batson, 1987, 1998)[10, 11]. When prosocially motivated, students are outcome focused and see their work as a means to the end goal of benefiting others. Another type of motivation that drives students is intrinsic motivation where they see the work as an end in and of itself (Amabile, 1993)[12]. When intrinsically motivated, the students engage with a task or project for the sake of joy or pleasure they get from that task irrespective of the outcome. These two motivations can also be understood from the perspective of a teacher. When a teacher is prosocially motivated, her efforts are based on a desire to educate students and she the outcome of student learning brings her fulfillment. On the other hand, an intrinsically motivated teacher finds enjoyment in the task of educating, in activities such as having a dialogue with students or in lecturing. In theory (Grant 2008)[13], prosocial and intrinsic motivations differ analytically along several dimensions but in practice they often act together, particularly in conjunction with self-determination, which I discuss next.

Another theory that helps us understand student engagement, not just with service learning projects but with all educational activities, and is particularly useful in guiding the design of learning activities is self-determination theory (SDT) (Deci & Ryan, 1985; Ryan & Deci, 2000; La Guardia, 2009)[14, 15, 16]. According to SDT three basic psychological needs – autonomy, competence, and relatedness – form the essential constituent of psychological development. Autonomy refers to actions that are self-initiated and self-regulated. Competence refers to experience of mastery and challenge and is evidenced in curiosity and exploration. Relatedness refers to the feeling of belonging and being significant in the eyes of others. SDT further suggests that people are naturally inclined to explore and dedicate much of their energies towards activities, role, and relationships that promote these basic psychological needs. "Of importance, from an SDT perspective, the social context – specifically relational partners' support of needs – informs one's self-concept, goals, and identity-related behaviors (La Guardia, 2009, p. 93)[16]."

Prosocial motivation, intrinsic motivation, and self-determination theory form the backbone of our program and curriculum design. We believe that our projects should provide students the opportunity to act on their prosocial motivation while also being intrinsically motivated by the task at hand. Furthermore, to design a learning environment that can engage both these

motivations we use SDT's three elements as a guide. We have found that design projects – where students work on designing something tangible – allows students to be intrinsically motivated as well as work towards something useful for others. Design-based projects also allow us to build significant autonomy as students in the course can work on the project without excessive oversight and own the project; projects allow each student to contribute and thereby display competence and build further expertise; and, given their prosocial motivation there is an inherent relatedness among the students which is further nurtured as they work the projects. We further engage with the relatedness aspect by building a community between current and former students as well as among the students, faculty, and other stakeholder. Finally, as suggested by prior research, dialogue and discussion forms a significant part of the course and interaction among students and faculty is encouraged. Brainstorming and design critiques are formally integrated into the course to create a culture of discussion and dialogue.

Program Design and Implementation

As discussed earlier, the overall goal of the program is to teach students about global development issues, increase their understanding and awareness of global problems, and provide them an understanding of design as a framework and methodology to bring about change. To achieve this objective, we engage with the students in diverse ways. We have designed summer research experiences, courses, independent studies, and trips to sites in India. Our primary approach has been design-based learning where we want students to engage with design of artifacts and products as opposed to lecture or seminar based course. Given that our student population is primarily engineering and industrial design students we have found this approach to be most applicable. We, of course, engage in discussions and provide readings to students but they are meant to support the design work.

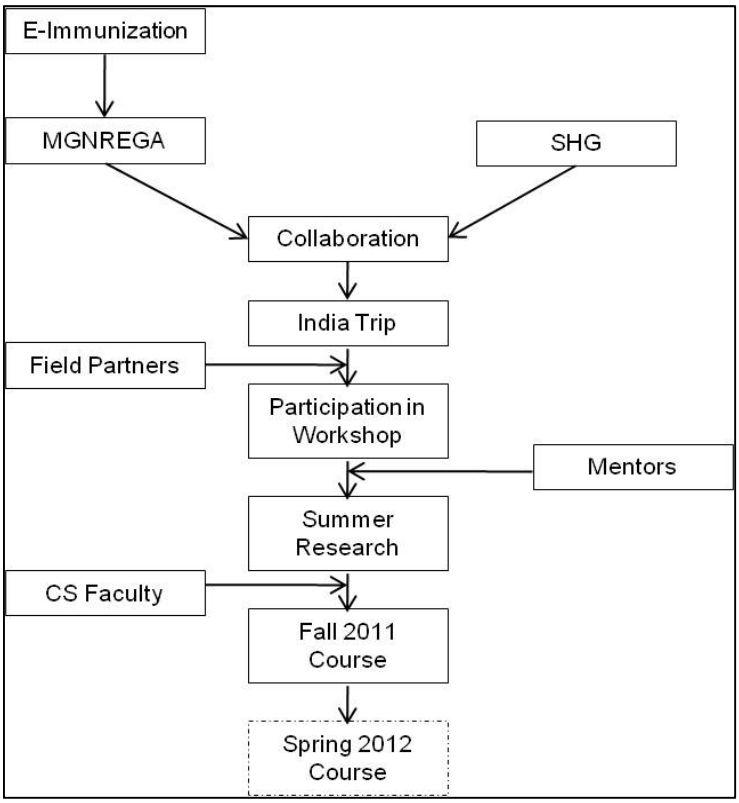


Figure 1: Program Pathway

The conception for the projects came from prior experiences of individual faculty members with different projects. For instance, one of the faculty members had previously engaged with a project on immunization (e-immunization) and conducted a study of rural employment (MGNREGA). Meanwhile, the other faculty member was working in parallel on a project on microfinance (SHG). The collaborative effort started when the second faculty member participated in a workshop organized by the first faculty and this resulted in joint projects and trip to India. Through this trip new partnerships were developed with NGOs and firms in India

and existing partnerships were strengthened. The preliminary collaborative work was presented at a workshop and subsequently an opportunity emerged to engage students for summer research experiences. Students from our home institutions as well as other external institutions worked on projects over the summer. Some of these projects were extension of prior work done by the faculty and other students. The summer projects were further solidified in a course offered in Fall 2011 were 20 students from engineering and industrial design worked together on projects. A faculty from Computer Science, who does research on computers and social development, also joined the team. Together the faculty team has experiences in a range of settings and projects including Asia and Africa and areas of work such as health, education and literacy, energy, and others. Throughout the effort, partnerships on the ground were deemed important and cultivated through regular interaction with collaborators. Inter and cross-disciplinary work was emphasized as real world problem solving requires different viewpoints and expertise. So far, over 30 students have participated in the project.

Examples of Projects

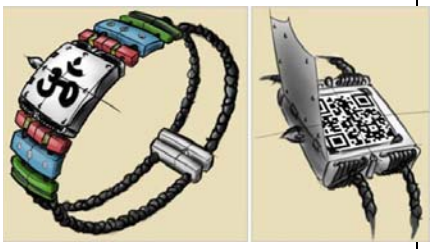
In this section we present in-depth examples of two projects to illustrate the nature of work we do and to show how different aspects of a larger problem can be broken into smaller but challenging problems. These examples also emphasize the importance of building long-term partnerships so that different iterations of the project can be taken to field for testing and evaluation. In addition to the two projects discussed below, students have also worked on other projects related to prosthetic limbs, solar charging of mobile phones, bicycle charging of mobile phones, push-cart for vegetable vendors, a projector-based learning device, and design of a biometric device carrier. More information about the projects is available at the following websites:

a. http://filebox.vt.edu/users/ajohri/teaching/enge2984/index.html
b. http://www.id4learning.com/ (this site includes video demos of prototypes)

Project Description and Prototype

Project: Improving Immunization

More than 30 million children in India lack immunization because of lack of a standardized system. Immunization efficiency can be improved by easing the entry and retrieval of immunization record by health care workers. Because of the prevalence of mobile phone devices in India, our approach developed a centralized database that stores the individual immunization records for children as they are vaccinated. Health care workers can access this database via an application on a mobile smart phone and easily view, edit, and add entries. Each child will have a personalized identification code kept on their person and the health care worker will be able to use his or her cell phone to scan the code and view that child's record. To store the record, QR codes can be embedded on commonly found items such as bracelets or toys. The images on the right display the QR code captured by the phone camera being displaced on a PC with the database in the back. The image below presents conceptually the idea of having a QR code in a bracelet.



Project Development Timeline

The seeds for this project were sowed in 2005 when one of the faculty worked on this project while completing his graduate studies. Subsequently, a handheld model developed as part of that project was filed tested but was not implemented on a large scale. The problem still remains and therefore with the large scale use of mobiles other solutions have been tried. The physical-digital interface idea is critical given near field communication and also the value of physical artifacts among rural populations. The current version is being tested with health workers. The project started out as a way to improve data storage and access using handheld devices in the mode of PDAs. After research and testing a handheld device manufactured locally in India was acquired and an application related to that developed. The project was field tested. As devices changed, mobile phones became common place changing the practice of health workers and what needed to be done. Furthermore, engagement of parents was assessed to be critical and therefore an aspect that would engage parents was needed. Therefore, the requirements changed and another problem emerged. This problem was then tackled by students. After the QR code issues was resolved, students worked again on the development of a software on an open source platform and Android was utilized.

Project: Financial Literacy

We have designed a digital financial literacy system to teach compound interest to semi/illiterate women in rural India engaged in micro financing. The system will work hand in hand with the previous analogue *Bahikhaata* to facilitate comprehensible training for Self Help Group (SHG) members. This system will be designed for the SHG facilitators, providing them with more efficient educational and engaging methods for the SHG members to learn about the intricacies of financial literacy and financial planning. The digital system includes: simulation of micro financing meetings, with both scenarios of all members present and some members absent; simulation of loan distribution; simulation of repayment and resulting compound interest gains, including what happens if all money is loaned in entirety versus the continuation of how the money is currently being loaned out; and a visual simulation of who has loans and when those loans are due. The underlying goal is for SHG members to best understand the responsibilities they are about to take on and help them understand and establish the best way for the women to maximize their savings.

Project Development Timeline

This project started two years ago with a visit to an NGO in India that works with Self-Help Groups (SHGs) of women in rural India to help an infrastructure of microfinance. The NGO trains the SHGs on the benefits of microfinance and helps them start microfinancing within their group with goal of making the SHG successful enough to get a joint account with a registered financial institution such as a bank. In lieu of bank loans rural citizens are likely to take credit from a local moneylender on exceptionally high rates and in dire circumstances and never have the ability to actually pay back. At first the NGO we worked with identified a problem for us and asked us to work on a solution. The problem they identified was a high failure rate of SHGs due to a significant cost of hiring an accountant for bookkeeping. Given extremely low literacy rates among the SHG women, it was impossible for them to maintain their bookkeeping. The accountant cost them almost 20% of their annual savings thereby making them run at a loss (as the interest on which they lent money to each other was lower). Due to this negative outcome, the SHGs dismantled. Our first solution for this problem was a bookkeeping system. The system was tested successfully and was welcomed by new SHGs but not by SHGs that had been running for a while. They argued that since they had enough savings and expenditures they could easily bear the cost of an accountant. Therefore, the goal of our design shifted from a bookkeeping system to a system that educated SHGs about finances – particularly the idea of interest. It was important to make a SHG realize that even though the cost of an account appeared prohibitive at the start over time it would become a really small part of their overall expenditure as their pot of money will increase significantly from the interest they earned. And for this it was important that they loaned out all their capital. Therefore, in the next stage the bookkeeping system designed earlier was modified into a board game to teach SHG members about financial literacy. In the third round of design a software component was added to help the NGO facilitator in training SHG members by being able to do long term calculations specific to a given SHG and its financial future. The description above is about this third phase of design.

Evaluation of Student Experience

The objective behind using a design-based course was to engage students with global issues in a concrete way so that they could work on projects that made a difference. After our initial engagement with this program, we offered an interdisciplinary course open to industrial design, architecture, and engineering students in Fall 2011. Towards the end of the semester quantitative and qualitative data collected from students using focus groups and surveys to assess the course offering. The research protocol was reviewed through the institutional review board and participants consented to their participation. Below, we present some findings from the study.

Focus groups

Two groups of six students each participated in the focus group near the end of the semester, after they had presented their final projects but not submitted their final project report. Each focus group lasted between 30-45 minutes. The focus group protocol was open-ended and started by asking all participants to write down whatever came to their mind when they thought about the course (Morgan, 1997)[17]. The objective of this exercise was to prevent groupthink and ensure that each student made time to write down their thoughts. Students were then asked to read aloud a few of the issues they wrote down, which was used as a starting point for the focus group; subsequently, the written notes were collected at the end of the focus group for further analysis. During the focus group each participant was given enough time to express their thoughts and participants were called on to ensure equality of participation. Overall, the participants expressed their thoughts openly and were not hesitant to critique the class.

The findings from the focus groups highlighted many interesting issues. From the outset, students expressed positive feelings towards many aspect of the class such as its interdisciplinary nature, open-ended but real world projects, the ability to spend time on the project and do in-depth work, and, the ability to positively impact someone's life in a developing country (in this course, India and Kenya were the target countries). All students agreed that they were really motivated with the opportunity to work on projects that would be field tested and that were identified as real needs of users, as one participant commented, "We all have some interest in social development. We have the blessed opportunity to go to a school like this but it is important to realize that something as small as charging a mobile phone can change somebody's complete day." They also suggested that since all of them had self-selected to take this course, they were all equally motivated (except a couple of students). They further expressed their opinion that the class would not have been as effective if it was a required course as real interest and passion was needed to labor through many difficult issues that emerged as they worked on their projects.

In addition to a prosocial motivation, students also expressed other motivations for taking the course. First and foremost was the ability to work with students from other disciplines. The course was open to students in the industrial design and architecture programs as well as all engineering disciplines, including computer science. It attracted students from six different disciplines. Each team had at least one student from design/architecture and one student from an engineering discipline. Students reported that they learned that everyone thinks differently and the engineering students reported that they realized that not all that was technically feasible could be designed into a usable product and the design students reported that they realized that just the

design of form does not mean technical feasibility. Interestingly, computer science students reported that they learned a lot even from working with other students in their major as they rarely got a chance to collaborate this closely on a project as most of their class assignments were more competitive in nature (each student had to solve the same problem). The students also commented on the nature of problems as a motivator beyond their content per se. As one student remarked, “Given the context, the level of accessibility is easy since the projects haven’t reached a level of complexity where you can’t really contribute, here you can actually contribute.” Another student added that she thought that what made the class unique was the fact that a connection with a field site was already made for the students.

When asked specifically about what they learned, in addition to social development issues, students commented on many other aspects of the course showing that the learning extends beyond a specific issue and can be transferable. One student remarked that, “I learned the importance of having people from different majors to do design. All I usually do in my mechanical engineering classes is work with other mechanical engineers and we all think similarly.” Another student from industrial design expressed her learning succinctly by stating that she learned to “Try to think of a problem from someone else’s perspective.” She further stated that she formed an understanding to keep in mind to be very aware of how different people you are designing for are and check everything before moving forward as it might be completely wrong. Another student gave an example of how they were trying to use Green and Red buttons to designate going forward or stopping in an interface they had designed before she realized that when she had visited the site in India she had not seen a single traffic light. A similar example was given by a student from a team that designed a bicycle powered phone charger. He said that they realized that the charger will have to engage with the bike against the chain as opposed to the tires as the tires got damaged quickly and the riders could not afford to change tires frequently. Therefore, students learned about taking context into the equation and also thinking about different business models or financially viable solutions. The solar charger was designed as a ‘station’ for charging multiple phones so that it could be a profitable venture for a small shop owner.

Students gave specific examples of how the project in this class overlapped with other courses and helped them improve their outcomes in other classes. For instance, once student who was working on the design of mobile phone software talked about his experience working on the Android platform. He said that he leveraged that for another classes and by using the same platform across assignments he was able to learn things a lot quicker. He said that he realized that the abstractness of Computer Science, particularly of software design, makes it harder to share and show what one has done and therefore he realized that in addition to documentation one needs to trust the other person and their skills. Students also noted that they were faced with many choices and options, even when working on a limited design problem, and they learned to deal with ambiguity and design for appropriation of the design by the users. For instance, a design student working on a QR code artifact interface said that after experimenting with many options he realized that the best option is to design it so that the users can put the QR code on any artifact they prefer.

Finally, students commented on their positive team work experience. Barring a couple of students, all students engaged highly with their team members. There was good communication

between the groups as well as with mentors at the field sites in India and Kenya. There were some issues with communicating with field mentors, but they were resolved by engaging through different communication media. Students mentioned that interdisciplinary team work enforced creativity as brainstorming among students was common. Bigger and better ideas came from their group work and slowly they learned about the expertise of each member which helped them maximize their productivity. Overall, the students' responses were also reflected in the survey that was administered subsequent to the focus group interviews.

Survey results

The students were asked to take a survey about their course experiences subsequent to the submission of their final project report. The survey consisted of 10 items that assessed various aspects of the students' experiences. The primary purpose of the survey was to triangulate the data acquired through the focus group interviews and to give students another avenue to talk about the shortcomings of the course.

Open-ended Survey Question	**Student Responses**
What are some things you learned through your participation in this class?	I learned the importance of testing out what is already on the market because in doing so you can learn a lot about the current issues in the design. I also learned not to try and think of the best solution to a problem immediately, but instead to do background research and think about any and all possible options. After coming up with a number of options, I then learned the importance of moving on to the next part of the project and not getting caught up on the selection process or any other part. I learned how important it is to understand the many different view points on a particular problem. Working with people from different disciplines not related to engineering also helped our design work much better than if we did not. Information is hard to find on some topics, but most everything has something online. I also learned the basic elements of the design process. I developed technical skills related to the Android platform (Android Fragments, ActionBar, ViewPagers. Photoshop Actions). I also learned how industrial design students generally go about designing. I learned about microfinancing and about requirements analysis. I learned about difference in problems across areas, such as in America how different Immunization is from India. As well, how different majors can join in to design something truly of purpose. I learned a lot about teamwork in programming, which was something I had been unfamiliar with. I also learned a lot about the medical system in India and I thought it was interesting that we had the ability to work on a real life solution for it. Though having taken this class before as well, it was interesting to work with a computer science student one and one. There was a lot of back and forth dialogue to get to what was implementable in the given amount of time. I also learned of problems in other parts of the world- mostly the Kenya project- and how that is something that I never would have even thought of or imagined being a problem (lack of power/electricity shortage). I learned about how challenging it is to design for social development but also how helpful it really could be in developing countries. I also saw the importance of working in teams, especially with people from different backgrounds. I now understand the importance of making

	several different models/prototypes to get a better idea of what a design is and whether or not it will work. Working in interdisciplinary teams helps balance creativity and practicality. Project designs perform their best when they meet the maximum number of constrains, like financial and social constrains for example. Always allot double the amount of time you originally estimate the completion of something. It is far more difficult to design for a different culture than I had thought.
The most FRUSTRATING aspect of this course was:	I didn't really think there was anything that was particularly frustrating, but if I had to choose one thing it would be trying to think of a solution that would best benefit the Kenyans because we aren't there observing their day-to-day lives so we just had to create something based off of what we knew from our research and interview (with mentor in Kenya). It was frustrating when some of our group members didn't show up on time or even at all, but that's not really the course's fault. Having to work with people who just don't care Not enough time to work on projects. Trying to understand an NGO member's accent while in a Skype call with her. Email would have been better. Being a mechanical engineer major, my topic was mainly focused with programming, which was hard to join in on. I think that the nature of our project made it difficult for us to always be working evenly. For example, the research phase was well split up, but when it came to our actual project development it was a little unbalanced because there were some days where I would be coding non-stop and other days when I didn't have much to do at all. Coming up with a mutual idea we could all agree on to get the project rolling -took waaay too long to describe SHG and get a good firm understanding on it in order to design something for it. Did not help when some members would read the material online and others would not. Therefore when in class the next day have to back track to get the other member caught up to the rest of the group just to begin throwing out ideas. The inability to test our final design It was tough learning to work with a computer program who thinks so differently than me. I really didn't have too many complaints for this class besides my own inability to fully focus for 2 hours in the morning. Low interaction with the rest of the groups. More information/teaching about how to design for developing countries and important considerations. Direction for further reading on the subject. Getting stuck, sometimes, at one point for a while. Yet, having the professors pushing us to the next step helped our team to move on. Confusion. It was not until over halfway through the course that we finally had a concrete direction. Too many weeks were spent trying to decipher the real intent of the project. Being in a group with a project dedicated to android programming with only one computer

	science student. We were limited in our time capabilities for what could be done in android. This left three ID students to design basic user interfaces, as well as plenty of research. Sometimes it felt like there was not enough work for the ID students.
The most INTERESTING aspect of this course was:	Being able to go through all of the different steps in the design process all the way up to developing a working prototype. Also, the amount of freedom we had in doing so and being able to work on a "real-world" issue that would actually benefit someone somewhere. The fact that we got to work with other people from different disciplines and work on real world problems. Being able to think for yourself Fitting in with a pre-existing design. Practicing everything. Actually helping people. Seeing how different groups interacted, and the final design of each project. Being able to work on a project that wasn't severely restricted in terms of deliverables and grade scale. Seeing how all the projects grew and where they ended up. Hope to get feedback on the projects and see where they go. Being able to work in teams of different disciplines Creating a working product in the end. I like the concept of tackling real world problems for countries of lesser development, because the problems weren't too complex to find a solution. Also, the fact that our solution could be implemented and make a difference in an entire community is very satisfying. Working in interdisciplinary teams. It was also good to have predetermined projects with goals. Having three professors that are passionate about the course. Seeing how real life problems could be solved and how people from different fields could work together to solve them. Actually working on something that has the opportunity to make a difference, or at the very least elicit further discussion into matters that are often overlooked.

This course _____ my interested in social issues in developing countries:		
Greatly increased	10	(63%)
Partially increased	6	(38%)
Neither increased nor decreased	0	(0%)
Partially decreased	0	(0%)
Greatly decreased	0	(0%)

My understanding of design increased as a result of the hands-on projects:		
Strongly agree	10	(63%)
Agree	5	(31%)
Neutral	1	(6%)
Disagree	0	(0%)
Strongly disagree	0	(0%)

I found it useful to interact with someone in India and/or Kenya:		
Strongly agree	11	(69%)
Agree	3	(19%)
Neutral	2	(13%)
Disagree	0	(0%)
Strongly disagree	0	(0%)

The survey responses shed more light on student experiences with the course and also provided some quantitative data on student learning. We plan to do a follow-up of student assessment next semester to assess students' transfer of learning across course. We also plan to analyze student design solutions from early in the semester to later designs to see the development of ideas over time.

Consistent with SDT, students expressed appreciation for the autonomy they were provided in conducting the project. The faculty acted primarily as mentors and guided the students towards producing useful design. Students were able to leverage their existing expertise but also advance their understanding. They were free to explore different avenues before narrowing down their solution. The design problem consistently challenged them. Finally, by working as members of an interdisciplinary team, students were able to relate with other students as well as develop new relationships.

Lessons Learned

A program of this nature requires significant resources. It also takes time to put into place the infrastructure required to engage with such projects. Therefore, one of the first caveats we wish to bring to the attention of those considering such courses is to be certain that they are willing to commit to it seriously. The downsides are many, including no learning experience for the student and actually harming the partners on the ground. But once the motivation is there, here are some specific issues that can help improve the outcomes:

Long term partnerships on the ground

It is absolutely essential to build long term partnerships on the ground or at least engage with stakeholders with the intent of building a long term partnership. Quite often socially leaning projects are undertaken impulsively because the instructor or students are excited about an issue. Although this is a critical motivating factor, the hurdles and barriers faced in actual implementation are immense and the challenges can be addressed better with a long term vision. A long term partnership also ensures that projects are tested in the field and there is a feedback loop between the work done and its impact.

Needs assessment on the ground

A second issue, related to the first, is to ensure that the needs assessment leverages the context of the problem. Often the tendency is to define the problem first and then look for appropriate settings or to define but not refine the problem once a setting is selected. More often than not this approach results in interesting designs with little feasibility or future.

Have mentors from the project places

One way to ensure that needs assessment is done contextually is to have mentors from field sites as part of the overall course/project infrastructure. These mentors can provide feedback to students as they work on the projects thereby ensuring that if the students are not on the right track, they get that feedback early. Students, and most designers, are reluctant to revisit their ideas if they are too deep into the process. Therefore, early and frequent feedback from the ground is important.

Capture video and audio data from the ground

A related step is to provide contextual information in the scenario that students are not able to experience the context first-hand. This has often been the case in projects we have undertaken as they have been international in nature. In such cases, what we have done is build a repository of video and audio data that the students can peruse. In addition, we have developed a list of secondary resources that the students can go through to learn more about similar projects as well

as condition on the ground. Finally, with the use of the Internet significant information is available to students and allows them to understand the context better.

Interdisciplinary teams
One of the key learning we have derived from our experience is that the nature of problems we tackle require interdisciplinary teams. Interdisciplinary/multidisciplinary teams bring different lenses to bear on a problem. This is true for students as well as faculty teams, where possible. These problems have a material aspect where something is to be designed and technical know-how as well as design process know-how is essential and is easier to find in interdisciplinary teams. Finally, working in interdisciplinary teams has an immediate positive outcome as it leads to the ability to communicate an idea across boundaries.

Prosocial motivation needs to exist
One of the important issues we discovered in our student focus groups, and which at some level is not very encouraging, is that prosocial motivation specific to international issues needs to exist in students. The concrete outcome of this is that the class should not be required and will not work if it is a required course. Of course, there is a dilemma here in terms of how they will ever get motivated if they do not have exposure but the seeds can be sowed in earlier courses before they work on a long term project. Sometimes students develop the motivation through other projects such as EWB, ESW, etc, and these should be leveraged where possible.

Specificity is good
Another key lesson we have learned is that it is absolutely fine if the projects are specific in nature as opposed to very open-ended. Although there are many benefits to open-ended projects, such as the development of cognitive flexibility, we have realized that even specific/defined projects require students to develop contextual understanding to a large degree. Plus, given the time constraints of a course students are lose their interest if any one stage of the project takes too long.

It's OK to continue projects across classes and teams
In terms of the execution of the projects, it's absolutely fine and useful to continue a project across courses and allow students to tackle different aspects of the problem. First, you can develop a useful knowledge base, and second, it is easier to be specific about what the students should tackle. Finally, this aligns with long-term partnerships with clients and allows you to incorporate their feedback over time.

Move students along
We have also realized that it is important to move students along periodically. Often, a lack of first-hand experience with the client and design make it hard for students to trust themselves and their solutions. Therefore, they tend to linger at any one stage a lot longer than they should. Therefore, firm deadlines have to be placed to move along to the next design stage.

Prototyping and end-product matter
Finally, we have realized that it is important to prototype early and often. Given the goal of the course – to design a product – it is essential that students get their hands dirty. Through prototyping they get to think about the issues in different ways and are more likely to take real

world constraints into account. Prototyping accelerates design thinking and also moves them along a final product that is good enough to be tested in the field or demonstrated to the client to get useful feedback.

Discussion and Conclusion

In this paper were have presented a case study describing the development of a long-term global service learning program. We strongly believe that working on international projects related to global development not only provide students the opportunity to positively impact others but also to learn from their experiences. This "reciprocity" aspect is essential from our perspective for having global projects – we can learn a lot from working on *others'* problems. We also believe that these projects teach students one of the most important skills they need to work in the professional world – the ability to examine something from the perspective of others'. As one of our students responded, taking others' perspective was an essential but tough thing to do. Throughout this paper we have been quite descriptive as we believe that learning happens from interpreting contextually rich data, as opposed to reading a list of 'best practices.' Therefore, although we present lessons learned at the end, we have tried to present a fair view of the overall process so that readers will be able to take away what is relevant for them. We have argued for building long-term partnerships, of carrying on projects across courses, and of working in interdisciplinary teams. We have also provided fairly descriptive data from student evaluation to show what students' themselves think they have learned. Of course we could add objective measures but we believe the outcome or products are the real measure of student success.

We want to end with a note on the need to make service learning projects, particularly long-term global/international projects, more central to the engineering curriculum. At most institutions service-learning or community-learning experiments often exist in tension with other aspects of the engineering curricula and are seen in opposition to the overall 'engineering science' culture of engineering education. Similar to the marginalization of users that service learning projects aim to overcome, such projects face a similar marginalization within the curriculum particularly when they are interdisciplinary in nature and involve other liberal arts majors. One way for service-learning initiatives to become mainstream is to reject stereotypical associations such as, "girls like to help people," "racial minorities want to service poor communities," or "white males are driven by profit and high tech," and demonstrate their usefulness for all engineering and design students. Furthermore, the service learning community should recognize that intellectual exclusion, within academia, often forms the basis for social and economic exclusion, and aim at appropriating those activities that enjoy higher status such as research, publishing, award-winning, and fundraising. The service-learning approach increases inclusiveness in engineering education and provides valuable affinity space for a sub-set of the engineering student population.

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