Collaboration between XXX University in Guatemala and YYY University in the US on Humanitarian Engineering Projects for Computer Scientists and Engineers

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Abstract:

Villanova engineering professors and students have been working with Catholic Relief Services (CRS) for many years providing technical support to field offices in various countries. In 2018, Villanova University hosted several CRS staff from different country offices for a series of workshops. During this time, Prof. Singh met with Brenda Urizar of the Guatemala office of CRS. Later that year, Prof. Singh visited Ms. Urizar and an initial project was developed around building a low-cost computer lab for a school in a rural community. The project was launched in collaboration with the Computer Science Department at Landivar University in Quetzaltenango, Guatemala. The low-cost computer lab was based on the Raspberry Pi microcomputer on which educational resources would be loaded and shared over a local area network. Prof. Singh and his students made two visits to Landivar University to teach the Landivar University students and professors how to set up and configure the Raspberry Pi as a server and how to use the software on the Raspberry Pi. They also shared how to set up a network based on the Raspberry Pi server.

Funding for the computer lab was obtained through a grant from the Institute of Electrical and Electronic Engineers (IEEE) and using the knowledge gained from the workshops delivered by the Villanova University team, the Landivar University students were able to successfully set up and implement the lab.

A second, more recent project is building a mobile phone application for farmers in Guatemala to access CRS resources on seeds, fertilizers, etc. This project was started at Villanova University and recently two students from Landivar University have also become engaged with the two students at Villanova University in this project.

This paper will present details of the mechanisms for collaboration between Villanova University and Landivar University, the experiences of the students in collaborating on these two projects, and the benefits to both the students and the communities being served of these humanitarian projects.

Introduction

Humanitarian engineering is a growing field. The movement began through the introduction of the Engineers without Borders organization in 2002 by Bernard Amadei, a professor of Civil Engineering at the University of Colorado in Boulder [1]. This organization engages students in international development projects. The first humanitarian engineering minor program was started at the Colorado School of Mines in 2003 [2]. Most of the projects from these original programs were focused on the design of water distribution networks in developing countries that were designed by US engineering students and implemented with community members in various countries [3-5]. Other programs have been formed that focus on innovations for low

resource settings, including the Frugal Innovation Hub at Santa Clara University [6], the humanitarian engineering and social entrepreneurship program at Pennsylvania State University [7] and the Development Engineering program at the University of California, Berkeley [8].

In addition to these programs, a growing area of computer science and engineering is the field of Information and Communication Technologies for Development (ICT4D). Recognizing the importance of computers, tablets, mobile phones, internet connectivity, and computer software applications in international development has spawned many projects worldwide. The advent of low-cost, open-source hardware, such as the Raspberry Pi and Arduino platforms, and 3-D printers along with open-source software tools, such as the Android and Linux operating systems, are making prototyping of low-cost solutions to international development challenges more ubiquitous to students all over the world [9,10].

These types of projects are very motivating to engineering students in that they can use their technical skills towards making a difference in the world. These projects are also rich in learning dimensions for engineering students in that they often involve communicating with communities of different cultures, considerations related to engineering ethics, as well as sustainability aspects. These projects can therefore address the new ABET student outcomes that are placing more emphasis on including global, social, and cultural issues into system design considerations as well as in teaching students professional and ethical responsibilities [11].

Villanova University has been supporting students for over two decades on international development capstone student design projects. The model that has been used is one where students work with international development partners in developing countries serving as technical support for the international partner. One particularly close partner with whom Villanova University has collaborated is Catholic Relief Services (CRS). Projects in various countries have been conducted in partnership with CRS including water distribution projects in Madagascar, water projects in Liberia, and most recently, ICT4D projects in Guatemala.

While many international collaboration projects have been reported in the education literature, relatively little has been presented on the collaboration between two universities in the ICT4D space. The research question that is being considered here is: how can two university partners effectively engage to bring about social impact through joint ICT4D project work? In this paper, we present the evolution of a partnership between Villanova University in the US and Landivar University in Guatemala to perform ICT4D projects in collaboration with CRS Guatemala.

Villanova University, Landivar University and CRS Partnership Evolution

In summer 2018, a gathering of international CRS partners was held at Villanova University. During this visit, Prof. Singh had the pleasure to be introduced to Brenda Urizar from CRS's Guatemala country office. In the fall of 2018, Prof. Singh attended the IEEE CONCAPAN conference in El Salvador. During his conference trip, he made a side trip to visit Brenda Urizar in Quetzaltenango in Guatemala to observe the work that CRS was doing in the field. During this short visit, he went to a school in Santa Maria Chiquimula and met with teachers and the principal at the school. The CRS work was focused on supporting a bilingual (Spanish and Quechua) education program as well as a food and health program. During his visit, the principal

informed him that the students lacked computer education and he would love to have a computer lab at the school. Prof. Singh also visited Landivar University and gave a seminar on humanitarian engineering work to computer science students at the university. He was introduced to the faculty at the university by another CRS staff member, Liza Castillo, who was teaching at the university. A project was conceived to build a computer lab for the school in Santa Maria Chiquimula to provide educational resources on a Raspberry Pi platform with support from students at Villanova University and Landivar University.

In May 2019, Prof. Singh returned to Quetzaltenango along with two students from Villanova University to deliver workshops to the computer science students at Landivar University on the Raspberry Pi platform. Raspberry Pi kits were donated to Landivar University by Villanova University. In summer 2019, Edward Tohom of CRS, a monitoring and evaluation specialist in the organization, in collaboration with a visiting CRS intern, prepared and submitted a proposal to the IEEE Humanitarian Activities Committee (HAC) to build a computer lab in the school in Santa Maria Chiquimula as well as putting educational resources on a Raspberry Pi server which could be accessed from the computers in the lab. The IEEE Special Interest Group in Humanitarian Technology (SIGHT) group in Guatemala was awarded funding to build the computer lab in the school and the students at Landivar University were able to set up the Raspberry Pi server, as well as purchase and configure the computer lab in the school. Prof. Singh and two other students delivered another workshop in November 2019 on configuring the Raspberry Pi to be a server and then setting up a network with the Raspberry Pi. Additional workshops on Machine Learning and Wireless Mesh Networks were also delivered at that time. A picture of one of the Villanova University students, Javier Urquizo, delivering a workshop to the students of Landivar University is shown in Figure 1. The computer lab was inaugurated in March 2020 as shown in Figure 2. However, it saw relatively little use for about 18 months because of the onset of the Covid-19 pandemic.

Figure 1. Villanova University student, Javier Urquizo, delivering a lecture to Landivar University students

on the Raspberry Pi platform

Figure 2. Inauguration of Computer Lab at a school in Santa Maria Chiqimula, Totonicapan, Guatemala

Evaluation of Second Series of Workshops

An evaluation of the second series of workshops delivered in November 2019 was conducted by the partners from CRS Guatemala. The student participants were asked what the positive aspects of the workshops were, and what were the areas in which the workshops could be improved. The compiled student responses for the three workshops are provided in Table 1. The students appreciated the workshops and found them to be interesting. They thought they were well delivered, and the content and exercises were engaging. The main complaint of the students was that there was not enough time for the workshops, and they would have preferred for them to be longer.

Mobile Application Development Project for CRS

A new project was inaugurated in Spring 2020 based on discussions with the ICT4D team at CRS. The project was focused on the development of a mobile application on an Android platform to connect farmers in Chiquimula, Guatemala to CRS resources to help farmers improve their farming practices. Such resources include, fertilization and seed requirements, weather monitoring, crop blight information, etc. Another feature of the software was to connect farmers to CRS staff to provide guidance and expertise directly to farmers. This project was to be performed by a capstone design team, initially at Villanova University but later on included two students from Landivar University.

Questions	Student Responses				
Describe positive aspects from the Raspberry Pi workshop of 11/18/19	Parts of this workshop were dynamic and very practical	Got to know low-cost alternatives	Facilitators had good knowledge and experience	It is an innovative and interesting topic to apply at work	Learned about this accessible technology and how it can be used for applications in various fields
Describe things that could be improved from the Raspberry Pi workshop of 11/18/19	Needed more time; interesting topics but not enough time	Little time	Very little time for the workshop about this tool		It would have been great to have a longer workshop on this topic
Describe positive aspects of the machine learning workshop of 11/19/19		Understood how Internet of Things works	The content of the workshop was easy to understand	The topic was not known to me, but it is important to have a database where you can interact and create programs	It was interesting to learn about this programming system
Describe things that could be improved from the machine learning workshop of 11/19/19		Little time	More practice is required	It was difficult to fill the database because of the computer terms that were used. Expand the topic to provide more detailed explanation of the terms used.	The workshop was at an advanced level, and it was difficult to follow at some points.
Describe positive aspects of the wireless mesh network workshop of 11/20/19	While the activity was performed, we were advised by the presenter	To know the challenges and benefits of a mesh network, its operation and scope	The practical activity or teamwork was very helpful to understand more about topics related to wireless mesh networks	My knowledge was expanded in terms of the characteristics and components that make up a wireless mesh network	Very interesting to know how the wireless networks work, most of all to know their benefits against wired networks

Describe things that could be improved from the wireless mesh network workshop of 11/19/19	More time was needed to work on the exercises	Little time	More time was needed to widen the content of the workshop	Only one application was known on cell phone that did not work at the time of installation; there should be more applications for practice activities	
Any other comments	The workshops should be increased from half a day to a full day			Excellent workshop: we can use what we learned in our lives	Thank you for these workshops; we would like to have more in 2020

Table 1: Student responses to questions about workshops at Landivar University

The capstone design sequence in the Department of Electrical and Computer Engineering at Villanova University begins in the spring term with a proposal development course. Faculty and students may propose a project and during the first half of the semester, a series of topics is presented on how to develop a project, project management, skills training on different platforms (including the Arduino and Raspberry Pi) and standards. Also, during the first half of the semester, the students select their top three project choices and are then assigned their projects before the midterm break. The students then spend the second half of the semester developing a project proposal which they present at the end of the semester. The actual design work is performed in the fall semester of the students' senior year, and they write a final technical report and give a final project presentation in their spring semester of senior year.

A first group of students began the mobile application development project in the spring 2020 term. Three female computer engineering students took up this project and developed an initial prototype in the fall 2020 semester. A second group of students, two other female computer engineering students, continued to further develop the project. However, given the small size of this second group and the relatively large scope of the project, Prof. Singh reached out to his colleagues at Landivar University to recruit an additional two students to collaborate on the project. These students supported the project in the fall 2021 semester and will continue to work with Villanova University students in the spring and fall 2022 semesters.

The workload for the second iteration of the project which included the Landivar University students was divided between the two groups of students. However, the Landivar University students were brought in about halfway through the fall semester and so they needed some time to become familiar with the project as well as learning to interact with the Villanova students. While there was only a short time that the two sets of students worked together, the experience proved to be rich for both sets of students.

At the conclusion of the project, two questions were asked of each student:

1) What were the positive benefits of working with your counterparts at the other university?
2) What were some of the challenges that you faced working with the students at the other university?

The answers from the Villanova University students were as follows:

1. What were the positive benefits of working with Students 1 and 2 at Landivar University?

● Student 1 at Villanova University: *Working with student 1 at Landivar University brought many benefits to our project. Since we were only a two-person team, students 1 and 2 at Landivar University brought a much-needed added horsepower to our team. It was also really beneficial to directly work with someone from Guatemala. Landivar student 1 was able to give beneficial feedback such as utilizing icons for accessibility issues regarding literacy of farmers.*

● Student 2 at Villanova University: *Working with students 1 and 2 at Landivar University was interesting. While working with student 2 at Landivar University directly, she helped to do some additional research when looking into what API would work well for the mobile application's weather API. She was able to provide some suggestions on what can be included or removed from the user interface of the application.*

2. What were some of the challenges of working with students 1 and 2 at Landivar University?

● Student 1 at Villanva University: *The major challenges of working with student 1 at Landivar University mostly stemmed from communication. It took some time finding our footing, learning student 1's strengths, and knowing when to delegate work. There was a learning curve in communicating effectively what I wanted and needed student 1 to do without seeing him in person. This meant having multiple Zoom meetings with him 1-on-1 to discuss exactly what the idea was and show him how to implement it. It was also difficult working with student 1 at Landivar University since sometimes his Wi-Fi would not work due to the unstable WiFi connectivity in his town. Although this was a challenge, it inspired student 2 at Villanova University and I to create new infrastructure that works regardless of connectivity.*

● Student 2 at Villanova University: *The difficulty of working with students 1 and 2 at Landivar University mostly derived from the lack of communication. While they are an hour behind us, the time difference didn't make a difference in our communication as Zoom meetings were available to us all. With our main communication method between us all being WhatsApp, it was difficult to determine if they received our messages due to their WiFi being unreliable. Due to being unable to meet in person or know student 2's general schedule, I do not know how much work and research student 2 completed during the course of both teams working together.*

Only one of the two students from Landivar University responded. Here are his responses:

1. What were the positive benefits of working with Students 1 and 2 at Villanova University?
- *The cordial communication they maintained in each of our interactions.*
- *That they showed skill in handling the issues they required.*
- *Their availability when solving doubts.*
- *The patience that both showed at the time of the conversations, helped that the language barriers were not so great.*

2. What were some of the challenges of working with students 1 and 2 at Villanova University?
- *The way to carry out the work was difficult as we did not work with a repository like Github.*
- *That we were not given the time to train and reach a full understanding with them.*

It is clear from these reflections from the students that communication was a significant challenge, a common observation when teams of students from different countries try to collaborate. Also, as mentioned earlier, the students from Guatemala were brought into the project halfway through the design process and so they lacked some of the background. The third important comment was not using a common repository for the files so that the students in Guatemala could not access them (this has since been rectified).

Lessons Learned

Working on developing partnerships between universities located in two different countries provides many opportunities and challenges. In the first project where students from Villanova University traveled to Landivar University and delivered in-person workshops, the interactions were very positive, and the disappointments were around not having sufficient time for the workshops. Nevertheless, the students at Landivar University were able to complete the setup of the Raspberry Pi servers and successfully install them in the school and set up a computer lab to access the resources on the servers. Clearly, the outcome of these workshops led to a successful outcome. Important factors in this collaboration were the in-person workshops. Furthermore, one of the students from Villanova University who delivered the workshops, Javier Urquizo, was from Ecuador and so his communication was very fluid with the Landivar University students. This also helped with trust-building, an important element in successful education.

On the other hand, the remote interaction between Villanova University students and Landivar University students has been less successful. Challenges in communication and internet infrastructure in Guatemala, as well as bringing the students from Landivar University rather late into the project led to the limited success of the project.

We plan to continue to work on the second project with a new set of students from Villanova University and may include a trip to Guatemala for those students to both get a better contextual understanding of the country as well as meet the students from Landivar University. In previous

projects conducted between students at Villanova University and Universidad Nacional de Ingenieria (UNI) in Managua, Nicaragua, we have found that having students meet each other and then start a collaboration on a joint senior design project has proven to be more successful [12]. We have started the new project with the new set of students and are integrating the project right from its beginning. Indeed, one of the students from Guatemala worked on the project last year and allows for continuity from the previous iteration of the project. We are also planning to use Github as a repository for project files so that it can be easily shared between the students at the two universities.

This project will continue to explore the research question posed in the introduction as to how two university partners can effectively engage to bring about social impact through joint ICT4D project work.

Conclusions

A partnership between Villanova University's Computer Engineering program and Landivar University's Computer Science Department was established to support humanitarian projects in Guatemala with CRS. Two joint projects have been conducted between Villanova University and Landivar University students. The first project was the development of a computer lab in a school in Santa Maria Chiquimula in Guatemala in which educational resources hosted on Raspberry Pi servers could be wirelessly accessed on computers, tablets, and phones in the computer lab. Computer science students at Landivar University had no experience in using the Raspberry Pi platform and so students from Villanova University traveled to Guatemala and delivered a series of two in-person workshops to the Landivar University students on this platform. Based on these workshops, students from Landivar University were able to set up and configure the Raspberry Pi microcomputers for a school in the rural community.

In the second project, two students from Landivar University were brought in to support two senior design project students at Villanova University on the development of a mobile application for connecting farmers to CRS resources to support their farming practices. The students from Landivar University came into the project about halfway through the semester and needed some time to get up to speed. There were some communication challenges between the two groups and the collaboration ended up with limited success. This project will continue in the upcoming senior design cycle and a new set of students from Villanova University will work with the one of the two existing students from Landivar University. Hopefully, the Villanova University students will get to travel to Guatemala to meet the students from Landivar University. It is expected that the in-person connection will help to drive a more successful collaboration.

Acknowledgments

References:

[1] https://www.ewb-usa.org/mission-and-history/ (Accessed February 24, 2021)

[2] J.P. Delplanque, J. Gosink, and J. Lucena, "Initiating a Program on Humanitarian Engineering: Rationale, Implementation, Problems and Perceptions", Procs. 2004 ASEE Annual Conference and Exposition, Salt Lake City, UT

[3] D. Budny, S. Arjmand and D.V.P. Sanchez, "Comparison of student' outcome to different types of project based service learning experiences for CEE senior design", Procs. 2016 ASEE Annual Conference, New Orleans, LA June 2016

[4] T. Thompson and L. D. Zavodney, "On providing engineering students with culturally-appropriate design experiences in developing countries", Procs. 2008 ASEE Annual Conference, Pittsburgh, PA June 2008

[5] M. Vaughan and J. Ellzey, "Training engineering leaders through international community development projects", Procs. 2009 ASEE Annual Conference

[6] https://www.scu.edu/engineering/labs--research/labs/frugal-innovation-hub/ (Accessed February 24, 2021)

[7] HESE program at Penn State University https://www.sedtapp.psu.edu/hese/index.aspx (Accessed February 13, 2022)

[8] Development Engineering program at UC Berkeley https://developmentengineering.berkeley.edu/ (Accessed February 13, 2022)

[9] S. Qureshi, "Perspectives on development: why does studying information and communication technology for development (ICT4D) matter?", *Information Technology for Development*, vol. 25, no. 3, p 381-389, July 3, 2019

[10] D. Lopez, F. Sanchez, D. Franquesa and J. Cabre, "Participatory learning process through ICT4D projects", Procs. TEEM 2015: 3rd International Conference on Technological Ecosystems for Enhancing Multiculturality", pp. 553-557 October 7, 2015

[11] https://www.abet.org/ (Accessed February 24, 2021)

[12] Prof. Z, J. Klingler and M.V. Moncada, "A Two Course Sequence on Developing Sustainable Technologies and Business Models for Rural Nicaraguans", Procs. Engineering Education for Sustainable Development 2015, June 10-12, 2015 (Vancouver, British Columbia, Canada)