Update on Partnership between Villanova University and Universidad Nacional de Ingieneria (UNI) on Joint Senior Design Projects

Pritpal Singh, PhD[1], Maria Virginia Moncada, MSc[2], and Saul Otoniel Nuñez, MSEE[2]
[1]Villanova University, USA, Pritpal.singh@villanova.edu
[2]Universidad Nacional de Ingieneria, Nicaragua, mariavirginia1965@gmail.com, zeledon1986@gmail.com

Abstract– Villanova Electrical and Computer Engineering students have been working with students from Universidad Nacional de Ingenieria (UNI's) faculty of electrical, electronic and computer engineering student for the last four years on joint senior design projects. The students at each institution takes a common, jointly taught, two course sequence focused on developing a technical proposal for their design projects and on developing sustainable business models for their products. We have previously presented a description on this two course sequence with some preliminary results of this initiative [1]. In this paper we provide an update on the progress of this course. We describe several more examples of projects that have been developed in the last two years and how some of the challenges previously faced have been overcome.

Keywords- international collaboration, capstone project.

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I. INTRODUCTION

Villanova University engineering faculty and students have been engaged in project work in Nicaragua for over 10 years. These projects, primarily water distribution projects, have been performed with the rural communities surrounding the town of Waslala, Nicaragua, located in North Central Nicaragua. These communities comprise about 50,000 people who are primarily farmers. There is very little infrastructure in this region with unpaved roads, no access to electricity in many of the communities and some cell coverage (although a 30 minute to one hour walk may be required to obtain reception).

Seven years ago, a new project was started to design and implement a tele-health system in the region around Waslala to improve access to quality health care for the members of the communities in that region. A system was developed and implemented and details of the project can be found in references [1] and [2]. One of the by-products of this project was the development of a partnership between Villanova University and the Universidad Nacional de Ingieneria (UNI) in Managua, Nicaragua, the largest public engineering school in Nicaragua. This partnership resulted in collaboration between electrical and computer engineering (ECE) students at Villanova University and electronic engineering (EE) students at UNI on joint senior design projects.

There are many examples of international collaboration on project work described in the engineering education literature. For example, students at Rose Hulman Institute of Technology's Civil Engineering department worked with students at Kwame Nkrumah University of Science and Technology in Ghana on a joint capstone design project [3]. The authors described the communication and scheduling challenges as well as the different expectations of the students/instructors at the two universities. Mechanical engineering students at Shandong University of Technology in China collaborated with students at the University of Missouri in the US to perform joint senior design projects [4]. The paper's authors describe that the students in China were expected to do more individual design work compared to the collaborative team-based project expectations of the US students. Furthermore, the US students used more software-based simulations in their design whereas the Chinese students performed more hand calculations.

While previous work has focused on the collaboration between the international team partners on performing design projects, our work has also included students going out into rural communities and seeking out opportunities for design projects that would benefit the community members. They have also had to consider the possibility of entrepreneurial solutions as well as sustainable solutions.

We have previously presented a description of the two course sequence as well as some initial experiences in implementing the joint capstone design sequence [5]. In this paper we present an update to the work including more reflection on the student experiences and successes/challenges.

II. COURSE DESCRIPTIONS

A. Design Proposal Course

The design proposal course was a single semester course offered one day per week to the Villanova ECE students in the second semester of their junior year. The class has been offered three times in the Spring 2014, Spring 2015 and Spring 2016 semesters. The course schedule has not changed significantly in that time. Table 1 shows the week-by-week course content for the class. The semester begins with an

introduction to Nicaraguan history, geography, culture and socio-economic analysis. Since the UNI students are on break during the months of January-March, the initial lectures were presented by Prof. Moncada of UNI only to the Villanova students. The lectures were presented over Skype. The subsequent classes focused on the technology sectors in Nicaragua including the energy (with particular emphasis on renewable energy) and telecommunications sectors. These classes were also presented by Prof. Moncada. The third class was presented by Prof. James Klingler of the Villanova School of Business and provided students with an introduction to entrepreneurship so that the students could start thinking about how their projects could potentially turn into entrepreneurial ventures. The following two classes were presented by guest lecturers from various Nicaraguan sustainable enterprises including Suni Solar, Pro Leña, Blue Energy and Grupo Fenix. These guest lecturers also presented over Skype.

Fig. 1 Villanova and UNI students learning about solar cookers

TABLE I
CLASS SCHEDULE FOR DESIGN PROPOSAL CLASS

WEEK	TOPIC
1	INTRO./NICARAGUAN GEOGRAPHY/ CULTURE/HISTORY/SOCIO-ECONOMIC ANALYSIS
2	ENERGY, ENVIRONMENT AND TELECOMMUNICATIONS SECTORS IN NICARAGUA
3	INTRODUCTION TO ENTREPRENEURSHIP
4	GUEST PRESENTERS; SUSTAINABLE ENTERPRISES IN NICARAGUA
5	GUEST PRESENTERS AS IN WEEK 4
6	HUMAN-CENTERED DESIGN
7	CONDUCTING INTERVIEWS
8	SPRING BREAK IN NICARAGUA
9	PROJECT PROPOSAL DEVELOPMENT
10	PROPOSAL DEVELOPMENT (CONT'D)
11	PROPOSAL DEVELOPMENT (CONT'D)
12	PROPOSAL DEVELOPMENT (CONT'D)
13	PROPOSAL DEVELOPMENT (CONT'D)
14	PROPOSAL PRESENTATIONS

The last two classes before Spring Break were focused on human-centered design and orienting students to conducting interviews of people in communities to prepare them for the spring break trip to Nicaragua. Many of the Villanova students spent their spring break in Nicaragua where they went out to the communities with the UNI students to uncover potential projects for their capstone designs. Figure 1 shows a picture of UNI and Villanova students visiting the Solar Center in Totogalpa learning about a locally manufactured solar cooker.

Upon their return from Spring Break, the Villanova students worked with their UNI counterparts to prepare a proposal for a joint senior design project. At the end of the semester, both sets of students presented a joint proposal for their capstone design project. The UNI students either prepared a video which was shared with the class or jointly presented with the Villanova students over Skype.

B. Sustainable Business Models Class

The second course on Sustainable Business Models for Base of the Pyramid Customers was only taught once by Profs. Singh and Klingler in the Fall 2014 term. Unfortunately, the course was not offered in the Fall 2015 term because of low student enrolment (the class did not count as an elective for the Villanova ECE students and so there was little incentive for them to take the class). When Dr. Klingler retired from the faculty of the Villanova School of Business in Fall 2016, it was decided to discontinue offering the course. The aim of this course was for students to learn how to build sustainable business models around their technologies. The approach was based on the Business Model Canvas developed by Osterwalder and Pigneur [6]. The first half of the semester was spent on going through the different elements of the business model canvas and ways of innovating on the business model canvas. During the second half of the semester, the students worked on developing business models for their technologies and receiving critical feedback from the instructors. The students presented their final business models at the end of the semester. Dr. Singh and Prof. Klingler gave a separate introduction to entrepreneurship workshop to the UNI students prior to the Spring Break trip so that they would be oriented towards considering an entrepreneurial approach to commercializing their technologies. One student from UNI did sit in on the Business Models class remotely (the class was broadcast remotely and archived and the UNI student was given access to the class).

III. PROJECT DESCRIPTIONS

In the first year of the class, students went to three locations: Waslala, Jinotega and Villa del Carmen. In the second year, the students visited Waslala and Jinotega and in the third year they visited Waslala and Bluefields. We were very impressed

with the number of potential projects that the students uncovered in their visits to the communities. In the first offering of the course, students came up with several ideas and the final projects that the students selected were as follows:

1. Solar charge controller design (one Villanova student, one UNI student)
2. Design of a tele-health and remote education system on a smart phone platform (one Villanova student, two UNI students)
3. Design of a neo-natal incubator (three Villanova students, one UNI student)
4. Design of a local area network to provide Internet access to a school in a remote community (four Villanova students, two UNI students)
5. Design of a solar water pumping system (two UNI students)

In the second offering of the course, again came up with several project ideas and then finally selected the following projects:
1. Farm security system and cow tracker (two UNI students, two Villanova students)
2. Educational device for rural school children (three Villanova students)
3. Communication link extension (one UNI student, two Villanova students)
4. Internet Café (three UNI students)

In the third offering of the course, the following design projects were developed:
1. Electronic health record system for an island medical clinic (three Villanova students)
2. Glucometer interface for recording and transmitting data (two Villanova students, two UNI students)
3. Water tank level and water flow indicator (two Villanova students, two UNI students)

All of the projects were successfully completed by the student teams. Some of the projects were also implemented. The smart phone tele-health software, and Internet café project were implemented. The water tank level indicator, electronic health record system for the island medical clinic and the farm security system are all in their final phases and will be implemented in the near future.

The communication link extension projects both worked in the US and are ready to be deployed. However, the Nicaraguan telecommunications organization, Telcor, has to approve any communication devices being brought into the country and is very slow to process paperwork. We have therefore had the antennas for the communications links held up in customs for several weeks and ended up bringing them back to the US. Other companies with whom we have worked in Nicaragua have had similar experiences of long delays (several months) in getting imported items such as solar panels, inverters, and charge controllers through customs.

IV. SUSTAINABILITY ASPECTS OF COURSES

An important element of the designs was consideration of sustainability aspects. With the context of rural communities as the recipients of the projects, it was important to ensure that the projects would be long term sustainable. To account for sustainability, a whole systems thinking framework must be considered. In addition to the technical aspects of the project, social, economic and environmental aspects also need to be considered. Most of the project designs considered solar as the source of power for the devices since most of the rural communities did not have access to electricity.

Furthermore, the devices/software had to be designed to be contextually and culturally appropriate. This perspective was brought in by the UNI students and professors.

A good example of the inclusion of social considerations in the design of the system was the educational device for rural school children. The device was a Raspberry Pi-based device with a touch screen about the size of a small cell phone. The child would have a very interactive, educational program loaded by the teacher onto the device at the end of the school day and then the student would take the device home to work on the device to reinforce concepts learned in class, i.e. to do homework. The next day the student would bring the device to school for the teacher to review the homework and to upload a new homework set based on the student's progress. A significant problem in the rural communities is student and teacher absenteeism. The battery in the device was sized to only retain energy for one day after which it would need to be recharged – the solar charging source being located at the school! In this way, the student is incentivized to go to school. The teacher is also incentivized because the progress on the student's work is recorded and tracked and can be checked by the regional school supervisor. This accountability is missing in the traditional school system.

V. COURSE ASSESSMENT

A. *Course Teacher Evaluations*

The student feedback from the Villanova students in their courses was obtained using the normal course-teacher evaluation forms used at Villanova University for course assessment. The scores in several categories are shown in table

II. These scores are on a 1-5 scale with 5 being the highest rating obtainable.

In the first offering of the course, the scores were relatively low especially in the organization and planning of the course. This is understandable given that a lot of the course logistics and lectures were being planned during this term. The scores in the other categories were reasonably good. However, by Spring 2015 the scores had generally improved significantly and by the most recent offering in Spring 2016, the scores were excellent!

TABLE II
COURSE TEACHER EVALUATIONS FOR PROJECT PROPOSAL
DEVELOPMENT CLASS

Term	Spring 2014	Spring 2015	Spring 2016
Organizes and plans course effectively	3.1	4.3	4.9
Course intellectually stimulating	4.0	4.4	4.9
Overall value of course	4.0	4.4	4.9
Quality of instruction	4.4	4.3	5.0

B. Student Comments and Reflections

As reported above, the students have generally enjoyed the learning in the course, working on real world, relevant projects and found the experience very enriching. For the Villanova students who travelled down to Nicaragua, they enjoyed the opportunity to interact with their UNI counterparts and were impressed with "how smart they are" and "how good their hands-on skills are". The UNI students, by comparison, found the opportunity to work with Villanova students enjoyable in that they were able to practice and strengthen their English language skills, get access to resources (e.g. some software tools) not readily available to them in Nicaragua, and the opportunity to learn entrepreneurship concepts. Some of the Villanova and UNI students formed close friendships and one of the students from the Spring 2015 term travelled down to Nicaragua in August 2016 to attend the wedding of one of the UNI students.

On the other hand, there were several challenges that the students faced. The first general area of difficulty was communication. Oftentimes, UNI students did not have access to the Internet at home and this could lead to significant delays in responses from them to the Villanova students. Skype calls sometimes proved to be unreliable because of the low bandwidth available to the UNI students. However, Facebook messaging proved to work well as an alternative medium of communication.

A second challenge was the mismatch of the students' schedules and the university's calendars. The UNI students had a week of vacation during the Easter Holy Week. While Villanova students also had some time off for Easter the period after Easter was the time that they had to finish up their proposals and so the lack of availability of the UNI students proved problematic. While this issue was serious in the first year, the professors informed the students of this situation in advance so that they could plan around it in subsequent course offerings. Also, the Villanova University students have their major break during the months of June-August, whereas the UNI students have a major break between their semesters during the months of January and February. This led to some lack of coordination during the months of June through August.

In the first year of the program, the students from the two universities had local advisors who did not participate in joint project meetings (although the students did collaborate, primarily communicating over Facebook). As a result, sometimes the two sets of students would get conflicting advice/guidance from their respective advisors. In subsequent iterations of the course, the students' project advisors held joint project team meetings and progress reports were shared with both advisors. This helped to make the projects run more smoothly in the 2015 and 2016 offerings of the course.

REFERENCES

[1] P. Singh, S. Kulkarni, E. Keech, R. McDermott-Levy, and J. Klingler, "Progress on Making Healthcare more accessible to Rural Communities in Waslala, Nicaragua, using Low-Cost Telecommunications, IEEE Global Humanitarian Technology Conference (Seattle, WA), Oct. 30-Nov. 1, 2011

[2] P. Singh, R. McDermott-Levy, E. Keech, B. Mariani, J. Klingler and M.V. Moncada, "Challenges and Successes in Making Health Care More Accessible To Rural Communities In Waslala, Nicaragua Using Low-Cost Telecommunications", IEEE Global Humanitarian Technology Conference (San Jose, CA) October 20-23, 2013

[3] J.H. Hanson, F. Annor, J. Aidoo, A.G. Adu, E. Davenport, A. Kline, A. Owusu and B. Soliman, "Capstone design: Insights from an international collaborative student team", *Procs. ASEE Annual Conference and Exhibition*, 2012

[4] Y. Lin, X. Wei, L. Wang, Y. Zhang, W. Yu and Y. Sun, "Synchronizing the teaching of capstone design course in two countries", *Procs. ASEE Annual Conference and Exhibition*, 2012

[5] P.Singh, M.V. Moncada and J. Klingler, "Two Course Sequence on Developing Sustainable Technologies and Business Models for Rural Nicaraguans", *Procs. Engineering Education for Sustainable Development 2015 (EESD '15)* (Vancouver, British Columbia, Canada) June 9-12, 2015

[6] A. Osterwalder and Y. Pigneur, *Business Model Generation*, John Wiley & Sons, 2010