Instilling the Entrepreneurial Mindset by International Development Project Work

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Dr. Singh’s recent work is focused on improved, energy efficient devices and systems for use in rural health clinics in developing countries.

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Abstract

The entrepreneurial mindset has a number of attributes including curiosity about the world around you, discovery of opportunities, prototyping and vetting technology/business solutions and then executing on the venture. International development projects offer many possibilities to learn about an environment that students are not used to seeing and through observation, see opportunities for technology-based solutions to developing world problems. We have used this methodology for several senior design projects in the past and more recently have developed courses specifically to develop these attributes in electrical and computer engineering students.

A two course sequence has been piloted for the first time this year. In the first course, taken by students in their junior year, the students are given the cultural context in a developing country (in particular, the present course’s focus has been on Nicaragua). This topic is followed by a Spring break trip to Nicaragua and the students live out in rural communities to discover potential projects that have technical merit and offer potential business opportunities. The project proposals are then developed by students from a US university and a Nicaraguan university.

In the second course, in parallel with the actual project design, the students take a business model development course to understand business models and how to produce them. They then use this knowledge to develop a business model for their particular projects.

In the paper, details of the two courses will be presented along with student outcomes being measured in terms of how well the entrepreneurial mindset is being instilled.

Introduction

Villanova University faculty and students have been engaged in service learning projects in Nicaragua over the last ten years. These projects have been centered in 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 one cell phone tower which provides reception to most of the region but sometimes requires walking 30 minutes to an hour to obtain reception.

For the past ten years, Villanova University’s Colleges of Engineering and Nursing have partnered with the local parish in Waslala to design and implement gravity-driven clean-water distribution systems from sources located above the animal grazing line and to impart health education to the community and to volunteer community health workers. More recently, Villanova university’s electrical and mechanical engineers have also traveled to the communities around Waslala to explore power generation using small scale hydroelectric systems.

Five years ago, Villanova University received a Sustainable Vision grant from the National Collegiate Inventors and Innovators Alliance (NCIIA, now Venture Well) to develop 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 byproducts of this project was the development of a partnership with the National Engineering University (Universidad Nacional de Ingenieria – UNI) in Managua, Nicaragua, the largest and most prominent engineering school in Nicaragua.

It was recognized that there are many needs in the rural communities in Nicaragua and a proposal was written to NCIIA (Venture Well) for funding to support the development of technologies to enhance the quality of life for rural Nicaraguans based on sustainable business models. The proposed project was to develop a two course sequence for both UNI and Villanova engineering students. The first course in the sequence was to be focused on providing the contextual background for students, especially at Villanova University, and orient them towards how to identify technology-based, entrepreneurial projects suitable for rural Nicaraguans. The second course was to be focused on the development of sustainable business models for the base of the pyramid customer. In addition, students would prepare a proposal for their capstone design project in the first semester course and then execute their design work in parallel with the second course on sustainable business model development. The projects were to be worked on jointly by teams comprising Villanova students and UNI students. Venture Well (formerly NCIIA) funded the proposal in January 2013 and the first offering of the first course took place in the Spring 2014 term. The second course on developing sustainable business models was offered to both sets of students in the Fall 2014 term. Also during the Fall 2014 semester, students at Villanova university took a senior design projects course while students at UNI worked on their senior thesis projects. The purpose of these courses was for the students to design and prototype their technologies. Both sets of students worked collaboratively on their projects but with somewhat different guidelines provided by their home institutions.

Previous International Collaborative Education Initiatives

Much work has previously been done in global education. In Europe, the Erasmus project has encouraged students to travel to different countries within the European Union to take classes at
universities outside their home institutions [3]. There have also been several papers written describing international curriculum development efforts [4-7]. There have also been many research partnerships between universities in which students and faculty have performed research at partner institutions. More recently, there has been a lot of work in the area of developing collaborative tools where students from various institutions work together on common design projects [8-12].

At Villanova University, we have had several initiatives in inter-university collaborative senior design projects. Our initial foray into this area was with Purdue University’s Electrical and Computer Engineering department. This initial project was of limited success because of some lack of coordination between the two groups, different sets of expectations/requirements, and a lack of interaction between the student teams at the two institutions. We subsequently developed project work in coordination with the University of Dayton. Again, our initial attempt in this area had limited success primarily because of lack of coordination/interaction between the two teams. The second iteration of the project work with the University of Dayton was initiated with a face-to-face meeting over a weekend in a central location, Seven Springs Resort, near Pittsburgh, Pennsylvania. The students were engaged in various social activities as well as team building exercises. This face-to-face interaction proved invaluable in helping the students to bond and resulted in a more successful collaboration between the students on their design project. This type of face-to-face meeting has been incorporated in subsequent project work with the University of Dayton and has continued to foster closer collaboration of the students at the different universities.

Preparation for the First Course

During the fall 2013 semester, Prof. Maria Virginia Moncada from UNI took a Sabbatical Leave to attend Villanova University as a visiting professor. During this time, she attended several entrepreneurship classes, including a Creativity and Innovation course, an engineering entrepreneurship class, and a Social Entrepreneurship class. The first two courses were taught in the College of Engineering and the third class was taught in the Villanova School of Business.

Also, during her visit to Villanova University, Prof. Moncada participated in weekly meetings with Profs. Singh, Dougherty and Klingler to discuss the course content for the first course in the two course sequence. An outline of the week-by-week course content is shown in Table 1. During her visit, she also prepared course materials for the classes related to Nicaraguan culture, technology sectors in Nicaragua, current sustainable development programs in Nicaragua, and the design process.

The course began with an introduction to Nicaragua including its geography, history, culture and politics. The Villanova students were given an assignment after this first class to determine the impact of the country’s civil war on the economic development of the country relative to other countries in Central America. The next class in the course focused on a description of various
### Table 1. Class Schedule for First Course

<table>
<thead>
<tr>
<th>Date (2014)</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 14</td>
<td>Introduction/Course Overview/ Nicaragua: Geography, Culture, History and Socio-economic Analysis</td>
</tr>
<tr>
<td>21</td>
<td>Energy, Environment and Telecommunications Sectors in Nicaragua</td>
</tr>
<tr>
<td>28</td>
<td>Introduction to Entrepreneurship</td>
</tr>
<tr>
<td>Feb. 4</td>
<td>Current sustainable development programs in Nicaragua</td>
</tr>
<tr>
<td>11</td>
<td>Current sustainable development programs in Nicaragua (cont’d)</td>
</tr>
<tr>
<td>18</td>
<td>The design process</td>
</tr>
<tr>
<td>25</td>
<td>Customer needs/identification/interviewing process</td>
</tr>
<tr>
<td>March 4</td>
<td>SPRING BREAK in Nicaragua</td>
</tr>
<tr>
<td>11</td>
<td>Project proposal development</td>
</tr>
<tr>
<td>18</td>
<td>Project proposal development (cont’d)</td>
</tr>
<tr>
<td>25</td>
<td>Project proposal development (cont’d)</td>
</tr>
<tr>
<td>April 1</td>
<td>Project proposal development (cont’d)</td>
</tr>
<tr>
<td>8</td>
<td>Project proposal development (cont’d)</td>
</tr>
<tr>
<td>15</td>
<td>Draft Oral Presentation due</td>
</tr>
<tr>
<td>22</td>
<td>Final Oral Presentation</td>
</tr>
<tr>
<td>29</td>
<td>Final Written Proposal due</td>
</tr>
</tbody>
</table>

technology sectors in Nicaragua, including the energy sector, especially the renewable energy sector, and the information technology and communications sectors. The third class was an introductory presentation to entrepreneurship presented by Dr. Klingler. The fourth and fifth classes included guest lectures from technology-based organizations, non-governmental organizations (NGO’s) and for-profit companies based in Nicaragua. The sixth and seventh classes focused on the design process and understanding the “voice of the customer”, respectively. Also, Villanova students acted the roles of rural Nicaraguan and Villanova student to simulate interviewing rural Nicaraguans for learning what their lives are like and to uncover what technologies they could benefit from.

All of these classes from the first semester’s course were taught to Villanova students since UNI students were on semester break during this time.

After the seven weeks of classes, four of the students in the class traveled to Nicaragua with Prof. Singh. After arriving in Nicaragua, the students met with the students at UNI and the initial socializing took place. Over the course of the next week, students and professors from UNI and Villanova University travelled together to various sites, including rural locations and did homestays in rural communities. They got to both interact with each other and with local rural
Nicaraguans. A picture of the Villanova and UNI students at the entrance to a Solar Center in Totogalpa is shown in Figure 1.

![Figure 1. Villanova and UNI students at the entrance to the Solar Center in Totogalpa, Nicaragua](image)

At the end of the week, a debriefing session was held to discuss the potential project opportunities that had been uncovered and a total of almost thirty projects were proposed. Another important consequence of this visit was the development of close relationships between the UNI students and the Villanova students.

**Workshop for UNI students**

Professors Singh, Klingler and Dougherty traveled to Nicaragua during the first week of January, 2014, to deliver a workshop on entrepreneurship to the UNI students. The 2.5 day workshop built upon an exercise conducted by Prof. Moncada in which the students had to visit a market commonly visited by tourists and interview the people working at the stalls in the market. The students learned topics such as value proposition, “voice of the customer”, opportunity recognition, prototyping, elevator pitches, and they heard the life story from a successful Nicaraguan entrepreneur, Vladimir Delagneau, Chairman of Tecnosol, a renewable energy company. They also heard about tech transfer/business incubation services available through UNI. This workshop also gave UNI students exposure to the Villanova professors and vice versa, another opportunity for relationship building.
When Dr. Singh traveled down to Nicaragua over Spring Break, he was able to reconnect with the students having seen them only two months earlier.

**First Course Implementation**

The first course in the two course sequence was implemented for the first time during the spring 2014 semester. The first two classes were delivered to the Villanova students remotely over Skype by Prof. Moncada from her office at UNI. The internet connection was good and she came across very clearly. The third class was delivered on campus by Dr. Klingler and the guest lectures from the NGO’s and companies in Nicaragua were also presented over Skype. Finally, the design process was jointly presented by Dr. Singh and Prof. Moncada, with Prof. Moncada presenting over Skype.

Eleven electronic and computer engineering students at UNI were selected to participate in this program. Nine electrical and computer engineering students were enrolled in the class at Villanova University. Prior to the Spring break trip, a Facebook page was set up for the group and the students from each of the universities were encouraged to post messages and biographies on this page. While there was some initial activity prior to the trip, the postings increased tremendously after the students met each other in Nicaragua.

**Assessment Survey**

A short survey was administered to the Villanova students taking the class after the first four classes. Six questions were asked of the students:

1. Have you developed a good sense of the Nicaraguan context for your senior design project?
2. Do you have a good understanding of the energy and information and communication technologies sectors in Nicaragua?
3. Did you find the presentations from the companies/organizations doing work with rural Nicaraguans helpful?
4. Did you find the presentation technology working in the presentations from Nicaragua?
5. Do you feel that you are starting to connect with the YY students?
6. Do you have an understanding of the special challenges of working with the “base of the pyramid customer”?

All but one of the questions were very positively answered, particularly question 3. The question that was answered with least enthusiasm was question number 5. However, the situation has changed dramatically in this particular regard following the trip to Nicaragua.

**Project Selection**

Both the Villanova and UNI students went through a down-select process to finalize their senior design project choices. They were given almost 30 projects to choose from (based on the ideas
and opportunities that they uncovered from their visits to rural Nicaraguan communities. They were asked to fill out a decision matrix where the components of the matrix and weighting of each field were:

1. Project alignment with electrical/computer engineering fields (weighting – 1)
2. Interest in the technology (weighting – 1)
3. Skill set to work on the project (weighting – 1)
4. Social impact (weighting – 0.5)
5. Business opportunity (weighting – 0.7)

As can be seen from these criteria, the social impact and business opportunity were important factors considered in the weighing of the projects.

Five projects were selected and were assigned students from Villanova University and UNI 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)

Second Course Implementation

The sustainable business models course was offered for the first time in the Fall 2014 term. The course used the business model canvas approach by Osterwalder and Pigneur [13]. This book along with a book that focuses on money flow amongst the poor, “Portfolios of the Poor” [14] were used as the textbooks for the course. The business model canvas provides a pictorial canvas with nine blocks in which may be entered different aspects of a business. These nine blocks include key partnerships, key activities, revenue streams, costs, etc. It is a platform that students may use to innovate business models.

The course reviewed each of the blocks and different techniques for innovating business models. It went through examples and in-class exercises for each of the blocks and the different techniques for innovating business models within the context of fictitious businesses in developing countries. An example of such an exercise was as follows:

- Villagers in a remote community have limited access to health care. When they do come down to the hospital in town, it is ill-equipped, short staffed and very crowded. As an entrepreneur, you would like to provide a better quality of health care to the members of
Innovate a business model to provide a better quality of health care to these community members. Do this through a story-telling approach.

The first half of the semester was spent going through the various blocks and techniques covered by the Business Model Canvas approach. During the second half of the semester, the students were asked to innovate business models on their particular technologies with a final business model being presented, both as an oral presentation and a written report, at the end of the semester. The professors served as coaches and mentors, critiquing aspects of the business models as the students were developing them.

**Aspects of the Entrepreneurial Mindset Instilled by these Courses**

The entrepreneurial mindset comprises several different aspects. As defined by the Kern Engineering Entrepreneurship Network entrepreneurial mindset framework [15], there are several attributes that are desired in a student with an entrepreneurial mindset, including:

1. Apply creative thinking to ambiguous problems
2. Apply systems thinking to complex problems
3. Evaluate technical feasibility and economic drivers
4. Examine societal and individual needs
5. Form and work in teams
6. Understand the motivation and perspectives of others
7. Convey engineering solutions in economic terms
8. Discern and pursue ethical practices
9. Contribute to society as an active citizen

The problems discovered in developing technologies for rural, base-of-the-pyramid community members tend to be complex and require a multi-dimensional, systems approach to determining a solution as opposed to simply a technological solution. In preparing for their visits to the communities, the students were taught some basic interviewing skills and had to apply them as they stayed overnight in the rural communities. They also needed to observe the daily routines and work habits of the people living in the communities. They discovered a number of problems/opportunities through these in-field observation exercises and interviews with community members. For example, as some of the students visited a “hospital”, they noticed an incubator that was not working. It had a UV lamp used to treat jaundice in newborns but the unit used mains electricity, was relatively expensive and no spare parts were available for the malfunctioning unit. This inspired the students to come up with a more sustainable, economically viable concept - a low cost, solar-recharged battery powered incubator/jaundice treatment unit. The design not only had to consider the technical design factors, but also the economic and sustainability of the unit. Another issue that was considered for this particular project was the requirement for a heating source to maintain the infant’s body temperature. Since heating elements in the incubator would require energy, an option was considered where the mother’s
body could be used as a source of heat. There is also evidence that the physical contact between a mother and her baby promote better infant development [16]. This is an example of coming up with a creative, low-cost solution to a real world issue. This is a very important aspect of the entrepreneurial mindset for engineering students.

The students are forced to examine the individual and societal needs for the communities with which they are working. The dire economic conditions drive solutions as much as the technology itself. Oftentimes, political aspects must also be considered. Many ethical dilemmas arise as solutions are being proposed for these types of customers and engagement with the potential customers is critical in producing a successful solution. An example of this arose in the development of the tele-health project. A project called the MesoAmerica project is being sponsored by the Bill and Melinda Gates Foundation, the Carlos Slim Salud Foundation and the Inter-American Development Bank [17]. This project equips community health workers with smart phones and uses proprietary, relatively expensive database software for storing census data that is transmitted by the community health worker via texting through a set of interactive forms on the smart phone. In our version of the tele-health project, we use basic feature phones that are much less expensive and more durable than smart phones and have the community health workers text the data into an open source database, Rapid SMS, developed by UNICEF. There are many rich ethical questions that need to be addressed when reviewing these choices of technical solutions that offer insight into some important political aspects that are again important for the students in learning the entrepreneurial mindset.

The opportunity for students to work in multi-national, multi-cultural teams on the projects forces the students to examine the motivation and perspectives of others, especially people who come from a very different background than theirs. In one of the projects, extending Internet access to a school from another location where Internet access was available, understanding local regulations governing transmission of information and the available frequency spectra proved to be an important element of the implementation of the system (beyond just the design element). The Villanova students had to work with the UNI students to source parts in country as well as contract work, such as setting up a tower and mounting antennas to relay the data signals from one location to another. The Villanova students also learned, through an experience, about Nicaraguan customs regulations. A group of students took down two antennas for the system and these antennas were held up in customs. The customs agents needed documentation from the telecommunications regulation agency, Telcor, authorizing import of the goods. They also needed a letter from UNI to indicate that these antennas were being used in a university-sanctioned project to avoid having to pay import duties. These issues related to supply chain, component sourcing, regulations, and contracting, are all important aspects of entrepreneurship that the students on this particular project learned through their project experience.

As the students were building out their sustainable business models in the second course, using the business model canvas, the students were required to think about the sustainability of their projects. In the case of the wireless internet project, the students had to conduct a survey of the
community members that were going to be served by the technology to make sure that they had a viable business model. They developed a survey jointly with the UNI students and community leaders asking questions such as: How much would you be willing to pay for Internet service? How many hours per week would you expect to use the Internet? Etc. These questions then formed the basis of the business model that the students developed. This type of market survey and business model development is not typical in standard senior design projects. This again emphasized the fact that the approach being adopted in our courses is to have the students think entrepreneurially rather than simply designing a technology which may or may not be long term sustainable. As a part of their sustainability consideration, the students also had to consider system ownership, security, repair and maintenance, etc. Again, all of these factors are important in determining the long term viability of a project. At a workshop with colleagues from Catholic Relief Services, Dr. Singh was informed that the Business Model Canvas is a tool widely used in this international NGO. This comment validated the approach that we are using in our course.

Challenges in Collaboration between UNI and Villanova Students

There were many issues faced by Villanova and UNI students collaborating on their design proposals, business models and the development of their prototypes. The first general area of difficulty was communication. Oftentimes, UNI students did not have access to the Internet at home and sometimes there could be significant delays in responses from them to the Villanova students. Also, Skype calls were sometimes not reliable. Times of the calls were sometimes inconvenient for one or other of the parties. The UNI students had the week of April 14th off for the Easter Holy Week. While Villanova students also had time off for Easter from April 17th to April 21st, they were working in the early part of the week and given that the final proposal and presentation for the Villanova students were due April 29th, this holiday came at a critical part of the semester for the UNI students. Nevertheless, the student groups successfully pulled it all together and gave joint presentations for the final proposal presentations at the end of the spring 2014 term, with the UNI students presenting over Skype.

Another issue that arose was the mismatch of the two university’s calendars. 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.

A further major problem was limited resources at UNI. Parts were very limited in supply and it was not easy for parts to be shipped there. Furthermore, they had limited access to software tools. Much of the hardware prototyping therefore had to be done at Villanova University while a significant part of the design work was done in Nicaragua.

Conclusions and Summary

A new two course senior design sequence focused on the development and commercialization of technologies for rural Nicaraguans has been implemented as a joint program between Villanova
University and UNI. The courses were implemented for the first time in the spring 2014 and fall 2014 terms. The courses went well despite many challenges. The students of Villanova University and UNI bonded well and the communications technology for delivery of lectures over Skype worked very well.

The students discovered projects through traveling in Nicaraguan rural communities and interviewing local members of the communities. The student teams worked together remotely to develop their project proposals and subsequent prototype designs and business models.

The face-to-face interaction of the students had a catalytic effect in establishing a good relationship between the students and the students effectively used social media to maintain and further develop those relationships. While there were cultural and language barriers that made the collaboration challenging, the students found a way to overcome these barriers and succeed.

This collaborative project work focused on base-of-the-pyramid customers is a rich opportunity for students to develop many aspects of the entrepreneurial mindset. The students worked together in multi-cultural, multi-national teams; they collaborated remotely with students of different backgrounds; they had to be creative in coming up with solutions to ambiguous problems; the students needed to communicate effectively; the base-of-the-pyramid customer forced the students to carefully consider the economics of their proposed solutions as well as the technical viability; and the students needed to be very resourceful and adaptable to overcome challenges that they faced in working together.

Since much effort went into preparing the courses and arranging the logistics of the travel, engagement between the two sets of students, etc. an area that was neglected in the first offering of this two course sequence was the development of a good assessment approach. This aspect will be addressed in subsequent offerings of the course.

Acknowledgements

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References


