Design for Economic Empowerment:
Student engagement and learning across cultures and disciplines

Donna Riley[*]
Picker Engineering Program
Smith College
driley@smith.edu

Susannah Howe
Picker Engineering Program
Smith College
showe@smith.edu

Nola Reinhardt
Economics and Latin American & Latino/a Studies
Smith College
nreinhar@smith.edu

John Farris
Product Design & Manufacturing, Padnos College of Engineering
Grand Valley State University
farrisj@gvsu.edu

Paul Lane
Marketing*, Seidman College of Business*
Grand Valley State University
lanepa@gvsu.edu

Abstract

In pursuit of an approach to education on issues of global development that simultaneously enhances in-country innovation capacities in the developing world and educates US students about global development toward socially just ends, we collaborated with colleagues in Nicaragua to stimulate employment through new product innovation as facilitated by education. Our multidisciplinary group of faculty from four

---

[*] Corresponding Author

institutions – two in the United States and two in Nicaragua – conducted a two-week short course in innovation and product development in Nicaragua, with five students from each institution. Non-hierarchical, multidisciplinary, cross-cultural teams utilized active learning techniques and interaction with community members to learn and apply the product innovation process. We conducted classroom evaluations during the two-week course and a follow-up open-ended survey a year later directed toward eliciting the meaning of the learning experience for students. Thematic analysis revealed Nicaraguan students' self-ratings of learning were highest for teamwork and understanding and applying the innovation process, followed closely by cross-cultural communication, while students from the United States rated their learning highest in the area of language, followed by cross-cultural communication, teamwork, and working across disciplines. Student responses illustrate these themes as well as other aspects of students' learning experiences; overall student's self-evaluation was quite positive, despite many obstacles inherent in the experience. Drawing on student reflections, we conclude that the collaborative education model was successful, though certainly not without flaws.

Keywords: product design, innovation, global development, social justice, engineering education

Introduction

As developing nations seek to address problems of poverty, building technological capabilities can be an important route for improving the standard of living. Yet there is a need to avoid past mistakes in development that have focused on one-way technology transfer from developed nations, or have not realized opportunities to utilize and build local resources for economic empowerment.

As faculty in the United States (US) working in the fields of engineering, economics, business, and product design and innovation, we recognize the need to educate US students about developing countries in a way that supports socially just ends. At the same time, we support the goal of developing product design and innovation capabilities at educational institutions in the developing world, because it is those students and institutions who are the most appropriate drivers of innovation in their own country.

Our dual goal for this project is somewhat different from the goals of other educational projects for global development in US engineering education. The typical focus for other projects has been on educating engineers with a global perspective(e.g., Mazumder & Bean, 2001; Bradley & Newberry, 2004; Mihelcic, Phillips, & Watkins, 2006) and on US student involvement in the projects of US non-profit organizations that partner with US universities on engineering projects for development (e.g., Amadei, 2003; Clewlow, 2005). This typical US engineering education model for global development has encountered numerous pitfalls (Riley, 2007), including an attitude that the developing world is the "classroom of the 21st century" (Amadei, 2003) for US students, conflicts of interest that place US students' learning goals above the goals of the development project or local community, a presumption of authority or knowledge on the part of US participants in the project, and a lack of consideration of the broader neoliberal political and economic context.

In pursuit of a more socially just approach to education for global development, and as a response to the challenges described above, we chose to pursue an educational approach to development projects in which the focus was on collaborative education of students in developed and developing countries alike. We were led by a desire of two Nicaraguan universities to enhance their curricula by incorporating engineering design and local manufacture of goods with business and marketing, creating product chains and building the local economy. After war and natural disasters made Nicaragua the second poorest country in the Western Hemisphere and undermined the local capacity for economic regeneration and development, neoliberal trends in economic development have reduced government support for local industry while increasing the exposure of local business to international competition (Kendrick, 2006).Thus even in a country that sought to depart from a capitalist economic system and among individuals who supported those goals, small business development is viewed as a compatible strategy to achieve economic empowerment. The envisioned long term goal for the project is a sound, collaborative process for technology innovation and product development that leads to local economic empowerment and is both replicable and transferable.

Our initial intent was that faculty at institutions in the US and in Nicaragua would collaborate as instructors, with students from both countries with different backgrounds

and areas of study. Expertise would be shared rather than delivered in a one-way fashion. We acknowledged that students and faculty from different universities would have different educational and programmatic objectives, and sought to work together to develop a set of objectives that would address the goals of a diverse set of students, faculty and institutions.

We decided that focusing on any single product was not suited to our interests, given the propensity for many new products to fail. Instead we chose to focus on developing the collaboration between students and faculty at the four institutions, and the capacity for the Nicaraguan institutions to teach design for economic empowerment at their institutions. By focusing on the development of the capacity to generate and assess multiple products, we sought to increase the likelihood of success for the institutions and economic empowerment in the local Nicaraguan community in the long run.

The work represented a partnership between two institutions in Estelí, Nicaragua – *Universidad Nacional Autónoma de Nicaragua -Facultad Regional Multidisciplinaria* (UNAN-FAREM), a regional campus of the national university with an active curriculum in small business development, and *Universidad Popular de Nicaragua* (UPONIC), a private technical institute with capabilities in engineering and technology – and two institutions in the US – Grand Valley State University (GVSU), a public comprehensive institution, and Smith College, a private liberal arts college for women. We involved faculty, staff, and students from all four institutions. The group was intentionally multidisciplinary, involving faculty and students from Engineering, Business, Latin American Studies, Economics, Spanish, English, Architecture, and Communications.

Project Background

The project evolved from a history of periodic health brigades from the nursing program at GVSU dating back to Hurricane Mitch in 1998. The work of the nurses over years of visits, and the involvement of engineering and business faculty members in one such visit, led to a connection between university leaders in Estelí, Nicaragua and several GVSU faculty. In 2005, Nicaraguan administrators and faculty identified the three most pressing problems facing the community – resources for healthcare, unemployment, and poverty. They recognized the potential of UNAN-FAREM's entrepreneurship

programs to address these issues, but were concerned that emerging businesses were very similar to existing service businesses; moreover the institution lacked facilities for product design and development, which UPONIC could provide in a collaborative effort. Over several trips and discussions, the initial team identified partners and created processes to enable international collaboration on entrepreneurial projects. In December 2006, the emerging team – including faculty and administrators from UNAN-FAREM, UPONIC, GVSU, and Smith – committed to work together to stimulate employment through entrepreneurship and new product innovation as facilitated by education.

The effort focused on design and delivery of a new curriculum for collaborative, multidisciplinary product development. This curriculum was piloted during a two-week long course in Nicaragua in May 2007 that actively engaged multidisciplinary, cross-cultural teams of students in community-based innovation. May was selected because Nicaraguan students would be available on campus, and because US students would have completed spring semester finals but not yet begun summer courses or internships. During the two-week course, cross-cultural student teams from all four participating institutions identified and developed markets, partners, and technology for entrepreneurial ventures in Nicaragua, utilizing Nicaraguan materials and skills. This collaboration continued in a less structured manner after May 2007 through team-based product design and marketing work at and across the four institutions over the subsequent academic year.

The two-week course involved 20 students, five from each of the four participating universities, plus five US faculty members and five Nicaraguan faculty members/administrators. Each institution determined their own incentives for student participation and set their own criteria for selecting students, with varying emphases placed on prior experience with engineering or business curricula, language ability, and readiness for cross-cultural experiences. English skills were not a requirement for participation at either Nicaraguan school, and most of the Nicaraguan students did not speak English. UPONIC asked for volunteer students who were interested in a cross-cultural, creative opportunity. FAREM recruited students based on their previous business experience. GVSU similarly recruited students who had taken product design or innovation courses; three GVSU students were specifically recruited for their

engineering abilities. Smith selected participants based on Spanish language abilities and prior international experience. Three of the ten US students had no prior Spanish knowledge (not unusual among US engineering students); all of the US faculty members could speak some Spanish, but only one was near fluent in the language. In general, the students with the most prior exposure to the ideas of product design and innovation were the ones with the least Spanish. Both of these factors – the language capabilities of students and their familiarity with curricular content prior to the two-week course – were significant determinants of student experiences, as discussed further below.

The two-week long May course was conducted primarily in Spanish during the afternoons. To assist with the language barrier, we used translators: one US student who was a native Spanish speaker, the one near-fluent US faculty member, and one local professional translator. The US students and faculty also spent the mornings increasing their language skills by attending Spanish language and culture school, which combined one-on-one language instruction and outings to local small businesses and cooperatives.

Our initial intent was to collaboratively develop a curriculum with Nicaraguan and US faculty that would best suit the Nicaraguan context. However, in our meetings for curricular development, the Nicaraguan faculty asked that we demonstrate the curriculum used at the US institutions in country once, so that they could see it in action. With some reluctance and reservation at least among some members of the US faculty, we complied with this request. This was logistically far easier, though not preferable to a collaboratively developed curriculum. As it happened, several Nicaraguan faculty sat in on the course as students and participated to varying extents on teams. They were invited to participate in course evaluations and their answers are included in this analysis.

The team-taught curriculum was based on a course offered in the US (Lane, Farris, & Panse, 2005) and modified for the educational setting and compressed time frame. The course covered the product design and innovation process, including screen development, community needs assessment, ideation, concept formation, screen application, concept development, concept testing/refinement with community feedback, and presentation. Table 1 shows a schedule for the two-week course.

Table 1.   Daily Schedule for Two-Week Course

Week	Day	Topics
Week 1	Monday	Overview of course, team formation, team building, needs identification in the context of difference, discussion of development project failures
	Tuesday	Overview of innovation process with local examples, discussion of selection criteria, development of initial selection criteria, social demographics of Estelí, brainstorming opportunities and ideas, preparation for community survey
	Wednesday	Community survey (interviews with community members): needs identification
	Thursday	Discussion of converting needs to opportunities in context of community survey, continued brainstorming of opportunities and ideas with report out, discussion of features and benefits, grouping of ideas from brainstorming session, introduction to concept of target market
	Friday	Report on team activity identifying and marketing local tourist sites, refinement and application of selection criteria, sketching and description of best ideas plus report out, discussion of import analysis activity
Weekend	Weekend	Excursion (for US students) to nearby town, recreational activities
Week 2	Monday	Recap of previous week, discussion of iteration, implementation of iterative process on compressed time scale (brainstorming, evaluation, selection, refinement), description of five best ideas
	Tuesday	Introduction to market analysis, peer review of selected ideas/descriptions, presentation of "radically cheap" concept, preparation for second community survey
	Wednesday	Second community survey: feedback on selected ideas, report out on feedback from community
	Thursday	Discussion of market positioning, evaluation/ranking of ideas as informed by community feedback, preparation for final presentations
	Friday	Final presentations: run-through and actual (open to public), cultural event (dancing, music, food)

Learning outcomes included the abilities to think creatively, work on open-ended problems, work in teams, communicate cross-culturally, understand and apply the innovation process, learn from and incorporate other disciplines, meaningfully involve the community in the innovation process, and enhance language abilities. In this larger context, we expected students to make progress toward a final product, though the product was not itself the emphasis of the course. Classes utilized active learning

techniques and non-hierarchical collaborative teams composed of one student from each institution with a balance of disciplines. Participatory exercises included group brainstorming, an import-export analysis conducted in community shops, solicitation of community feedback on product ideas, and design reviews.

Over the next year, each institution implemented a different structure for continuing the collaboration. Students at all four institutions built and developed prototypes. The Nicaraguan institutions held weekly meetings for current and new students to continue developing product ideas; Nicaraguan participation was largely motivated by students' interest in the project without a formal credit-based course structure. Smith continued with a four-credit independent-study course, with students meeting biweekly and pursuing economic and technical aspects of the projects in small groups. Smith students communicated directly with the Nicaraguan students and visited the following January. At GVSU, most participating students graduated, but the faculty continued to hold teleconferences monthly with the Nicaraguan faculty colleagues, and new GVSU students developed one of the product designs as part of a course and delivered it in Nicaragua the following December.

Evaluation occurred on both a project level (that is, are the projects successful, is community involvement meaningful, are the products meeting their intended objectives as viewed by students, faculty, and community members) and on an educational level (are students achieving the anticipated educational outcomes; are instructors effective; what meanings do students draw from the learning experience). This paper focuses on the second educational evaluation; the outcomes of specific product development were addressed elsewhere (Farris, Lane, Howe, Riley, & Reinhardt, 2008). It is too soon to evaluate the impacts of the project regarding long-term economic empowerment, job creation, etc., but tracking the initiative overall is ongoing.
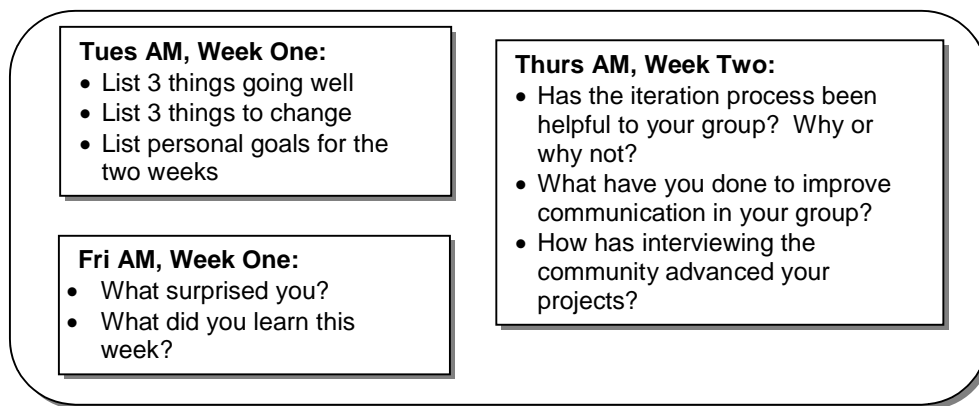
Evaluation Methods

Our methods for evaluation focused primarily on the two-week intensive course in Nicaragua. The intent of the evaluations was to capture students' reflections on their learning as well as to obtain real-time feedback to improve the course. As such, these evaluations are not a direct measure of student learning, but rather provide insight into

students' experiences with and after the course. We conducted evaluation early and often (we term this ongoing effort "constructive evaluation") in order to be responsive to different pedagogical and cultural experiences and expectations that emerged as we worked through the first iteration of the course. Through these constructive evaluations we would be able to modify course instruction to improve educational outcomes and enhance the student learning experience.

Constructive classroom evaluations with open-ended response questions were conducted on three different occasions spaced roughly evenly across the two-week course (Figure 1). A final quantitative/qualitative survey was administered to capture students' evaluation of the fulfillment of learning objectives at the completion of the two-week course (Figure 2). A follow-up open-ended survey conducted a year later elicited the meaning of the learning experience for students (Figure 3).   All evaluations were administered in both Spanish and English. Evaluations were anonymous and the two-week course was ungraded, therefore it was unlikely that student responses would be influenced by factors beyond the usual normative expectations of the faculty-student relationship. Students were aware that they were participating in a pilot project, and the collaborative approach generated a sense of open communication between faculty and students, valuing student opinion and soliciting honest critiques in order to improve the process. Results were analyzed using thematic analysis (Boyatzis, 1998).

Figure 1.   Constructive Classroom Evaluation (during two-week course)

Tues AM, Week One:
- List 3 things going well
- List 3 things to change
- List personal goals for the two weeks

Fri AM, Week One:
- What surprised you?
- What did you learn this week?

Thurs AM, Week Two:
- Has the iteration process been helpful to your group? Why or why not?
- What have you done to improve communication in your group?
- How has interviewing the community advanced your projects?

Figure 2.   Final Evaluation (end of two-week course)

Quantitative Questions:
Scale: -2 = strongly disagree to   2=strongly agree
- I have increased my ability to think creatively.
- I have increased my ability to work on open-ended problems.
- I have increased my ability to work in teams.
- I have increased my ability to communicate cross-culturally.
- I have increased my understanding of the innovation process and my ability to apply it.
- I have increased my ability to learn from and incorporate other disciplines.
- I have increased my ability to meaningfully involve the community in the innovation process.
- I have increased my language abilities.
- I have made noticeable progress toward a final product.

Open-Ended Responses
- Did this course meet your expectations? Please explain.
- What did you like most about this experience?
- What would you change to improve it?
- Briefly, how would you describe this experience to your friends?

Figure 3.   Follow-Up Evaluation (one year later)

- Describe your involvement with the Estelí Innovation project since the May 2007 two-week classroom experience. For example: what products did you work on, what did you do, who did you communicate with, how often did you participate, etc.?
- Describe up to three obstacles that you faced during your involvement and explain how you dealt with them.
- Describe the three most important things you have gained (so far) from your experience with the Estelí Innovation project.
- Describe one success you experienced in the development of a product. How did your classroom experience in May 2007 relate to this success? What did you learn from this success?
- Describe one failure you experienced in the development of a product. How did your classroom experience in May 2007 relate to this failure? What did you learn from this failure?
- Describe how you would change the classroom experience(s) you have had with the Estelí Innovation project to increase the effectiveness of the effort overall.

Results and Discussion

At the completion of the two-week course, students completed a final evaluation specifically focused on the learning outcomes of the course. Students were given a set

of affirmative statements in the form "I have increased my ability to X", where X corresponded to a specific learning outcome (see Figure 2) and asked to respond using a five-point Likert scale ranging from 2=strongly agree to -2=strongly disagree. The average results of these responses are shown in Figure 4, divided by Nicaraguan and US response. All students from both countries and three Nicaraguan faculty completed the quantitative survey.

As shown in Figure 4, all average responses were positive (and, in fact, only one individual response to one statement was less than zero), and most responses fell between "1=agree" and "2=strongly agree". We conducted a one-sample sign test to determine if the median response score was significantly different from zero. For the Nicaraguan sample, for every question we were able to reject the null hypothesis that the median was equal to zero at a 95% confidence level. The same was true for the US sample for all questions except the one about community involvement. This suggests that the respondents, as a whole, believed that they improved their abilities in nearly all the topics listed and thus achieved the learning outcomes intended for the course.

However, these results may be influenced by the fact that the question phrasing was biased toward the positive. Within this context of positive responses, the mean Nicaraguan responses were higher than their US counterparts (though not statistically significant in most cases; Mann-Whitney U test p-values below 0.1 are noted in the graph). The highest Nicaraguan responses were for teamwork ability and understanding/application of the innovation process, followed closely by cross-cultural communication. The one case in which US students responded more favorably was for improving language ability (p=0.003). Language ability was, in fact, the highest US response – not unexpected, given that the program was conducted in Nicaragua largely in Spanish. The US students rated cross-cultural communication the next highest, followed by innovation.

Figure 4.   Average Nicaraguan (n=13) and US (n=9[1]) responses for the final
evaluation at the completion of the two-week course. Response choices
were on a 5-point Likert scale (-2 to 2, where 2=strongly agree);
see   Figure 2 for full questions.
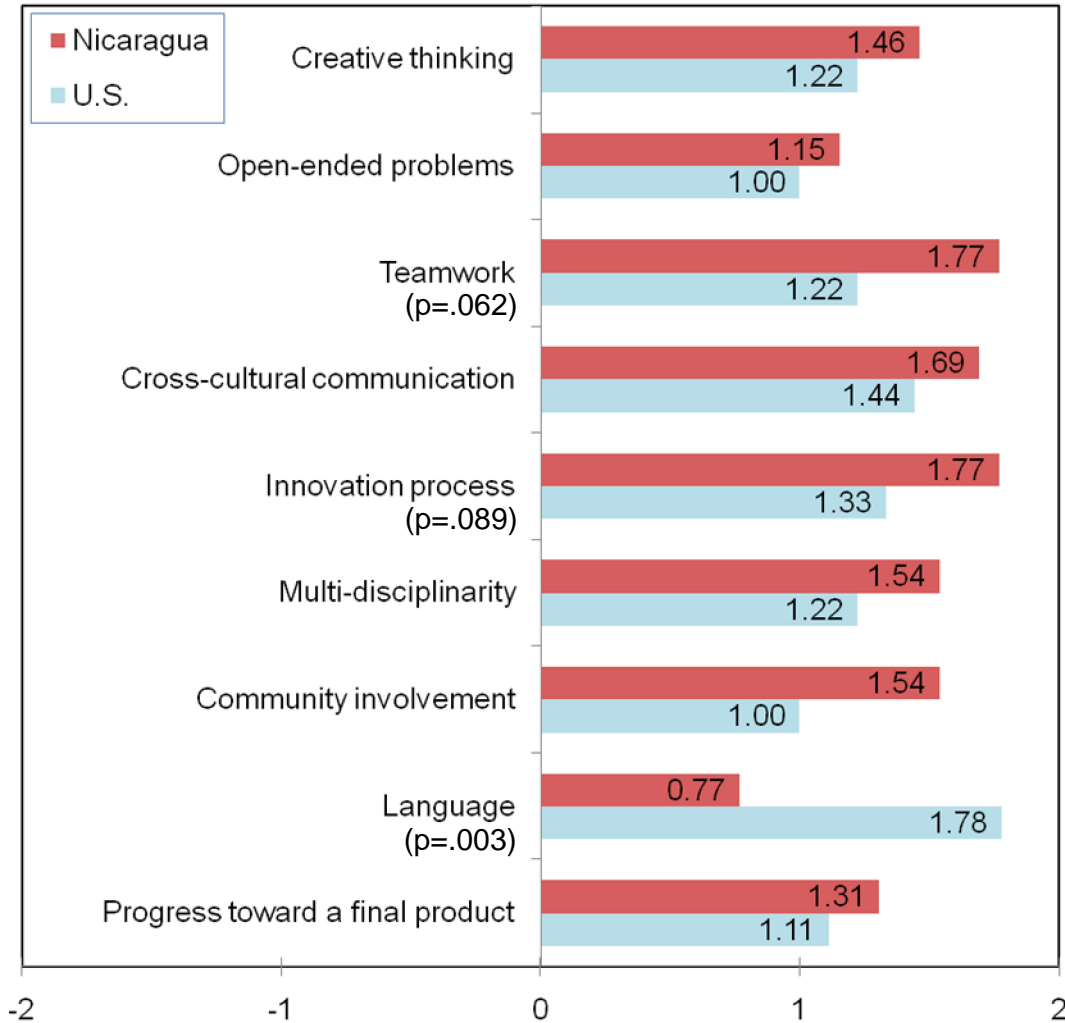
(1. One of the US students left in the middle of the first week due to a family emergency)

The quantitative evaluation results displayed in Figure 4 are further explained and
enhanced by data from the other evaluations administered during the two-week course
and the follow-up survey a year later. The following sections detail these results,
organized by emerging themes: teamwork, language, culture, teaching/learning,
curricular content, community, future change/empowerment. Quotes from Nicaraguan
and US students are marked with either an [NI] or a [US], for reference.

Teamwork and relationship building

Collaborative teams were an essential and very successful component of the project, especially for the Nicaraguan participants. When asked on day 2 to cite their goals for the course, students mentioned teamwork: "*Make a real contribution to the team*" [US] and relationship building: "*To analyze the person with whom I'm developing the project, to see their knowledge*" [NI].Students were already listing teamwork, group work and relationship building as things going well in the course, pointing to the advantages of "working in teams where everyone brings something different" [US] and "*the mode of social interaction with the group*"[NI]. At the end of the first week, one Nicaraguan student reported their surprise that "*sharing experience with the group leads to learning more.*" Another noted finding that "*in a group I work better and each learns something about each one here.*" [NI]

Later evaluations indicated continued appreciation of the value of the team approach. Towards the end of week two, in response to whether the iteration process was helpful to the group, eight Nicaraguan students commented specifically about learning from each other. Comments included **"*because one realizes that others have ideas, and give it form, questions, and change and one realizes how the team works, and for me that is all good*"** and **"*it has been useful because working in teams required us to give our points of view, opinions, and from all this will come a unique conclusion. If there are aspects of the work that we realize aren't good, we give support to improve them, between all of us.*"** On the last day, when asked whether the course met expectations, several Nicaraguan students specifically noted group work and relationship building: "*Yes, my expectations were met since during the process I learned new things, I learned to relate with my group, the students of the US…*". Regarding what they liked most, four US students and eight Nicaraguan students mentioned teamwork or relationships – for example, "*I enjoyed learning about work in a group with different backgrounds (especially cultural) and work with each other*" [US] and "*Among the most important is the teamwork, with people who know and understand what is being requested*" [NI].

Nevertheless, collaborative teamwork had its challenges. For one thing, it tended to be more time-consuming than a more authoritarian process. As one US student warned,

"Engage in an experience such as this if you are someone who is willing to devote a lot of time to work and can deal with pressure and issues with working in groups." Furthermore, while the ideal of collaborative, non-hierarchical teamwork can be difficult to achieve in any circumstances, it is especially so when participants bring different skills and backgrounds to the group. There is always the danger that participants may impute more knowledge or authority to some members of the group, either undervaluing or overvaluing their own abilities or those of others.

Student responses suggest that this was true in at least some cases. Some US students seemed to feel that their knowledge was superior, noting that "*Nicaraguan students need to be explained why we are doing certain things"* or that "*I know a lot about product design and can educate others.*" When asked to discuss a product development failure related to the May course, several students noted breakdowns in teamwork that highlight two important themes. First, students from the US who were already familiar with the product development process tended to dominate in idea generation and selection. Second, students from the US who were in the role of translating tended to take personal responsibility for involving all group members. "*One of the failures of my group was that I do not think we created an inspiring product. It was a decent idea, but failed to capture the imagination of my Nicaraguan team members. To keep them interested, I could have more actively involved them in the project. At times, it seemed like I was just a translator and couldn't bring the group together well."*

A third challenge was the difficulty of forging a sense of teamwork in a compressed time frame. US students noted that it would be helpful to "find a way for groups to work together better," suggesting "more outside hangout time with group." A year later, one US student recollected that "*Working with the team was at times difficult, we had a team member who often just did not show, so we learned to work without him. We had conflict about …our final product… and that conflict set us back a bit.*"

Despite these challenges, the majority of the students, both US and Nicaraguan, appeared to view the collaborative process as one of reciprocal interchange, with all members contributing to the success of the group. Students reported several approaches to improving communication in their group that related to teamwork and relationship building, including spending time together, developing friendships, and involving everyone in the work. Nicaraguan students said they tried "*to be friendly and*

respectful' and "*to encourage each one of us in our point of view without criticizing; the decisions had to be made by the group, nevertheless everybody had to have a chance to speak and give our opinions. We asked everybody what they thought.*" A US student confronted the differences in backgrounds by trying "*to make sure that everyone talked and that my partner knew what was going on and felt comfortable enough to ask questions.*" The US student reporting group conflict noted that "*compromise became very important in the context of the team.*" In describing the course to a friend, Nicaraguan students brought up group work and relationship building in very positive terms: *"Unforgettable because I met more friends from another country and I am able to be in contact with them.*" "*This process was of great importance because … your capacity to work in teams is something about which one can learn a lot.*"

Language and Communication

One of the challenges of collaborative cross-cultural work is communication across different languages. In our project, most of the Nicaraguan students had only limited English language facility, and as noted above, three of ten US students did not speak Spanish. To accommodate this, classroom instruction was given in English and translated into Spanish by one of the US faculty members or by a Nicaraguan professional translator. However, Nicaraguan students frequently needed additional explanation during team exercises, and the US students who did speak Spanish, including the one native speaker, found themselves called upon to provide this explanation. In addition, they were called upon to translate in communication between group members. Some US students found it difficult to juggle these multiple roles, especially if they themselves were unfamiliar with the curriculum. As one noted, "*I think the language barrier definitely merits warning to participants if they will be translating for teammates, it was definitely the frosting on the cake for me in an already overwhelming experience.*"

A year later, US students reflected on the difficulty of communication as an obstacle:

> "*While in Nicaragua, I was the communication link between a student from GVSU and the Nicaraguan students while not speaking the language fluently. I dealt with these problems by drawing diagrams and learning engineering terms in Spanish.*"

> *"The language barrier was a big obstacle that was unexpected. Trying to understand and speak Spanish for myself as well as for my GVSU teammate was definitely a challenge as I lacked much of the technical vocabulary to be able to communicate his ideas well. Spanish classes in the morning were helpful as was living with a host family however the only effective way to deal with the language difficulties at that time was to ask (the native speaker or the professors/professional translator) for communicating more complex ideas and in other situations consult dictionaries or work with what I could try and say."*

In addition, some teams found that communication difficulties related to inadequate language facility impeded the progress of their projects. When asked in the follow-up survey to comment on any project failures, one US student highlighted this difficulty:

> *"It was very frustrating for me to listen to one teammate explain why the product wouldn't work and not be able to adequately explain it in Spanish to our other teammate. I think in the end our market research definitely settled the subject but it would have been more useful to spend our time developing other products."*

The program did include Spanish language classes for the US students, which they found helpful. At the end of the first week, one student was surprised by how much Spanish s/he knew, and three students mentioned learning more Spanish. Another US student noted the importance of community research in language development: *"I gained confidence both in my Spanish and my people skills by going out into the community during the 2 week class."* When asked during the second week what they had done to improve communication in their group, students mentioned four strategies: translators, repetition, learning language, and non-verbal communication. They "*translated lots, hung out together outside of class, made sure to include everyone.*" [US]

Nevertheless, the lack of general language facility remained a significant challenge for the students. Some admitted to not having a strategy: "*I don't know if we really have improved communication in our group…improving communication has been hard.*" At the end of the course, one student mentioned communicating in another language as a highlight, but five students (four US) recommended language-related changes to the course, such as bringing in outside translators, bilingual faculty, and conducting the course in a single language. When asked how to improve the classroom experience overall, language figured prominently in answers from US students who served in the translator role: "*most importantly, I would require more Spanish and a demonstrated desire to learn it*" and "*Clearer communication. I think it would be beneficial for all*

participants to have some basic understanding of both English and Spanish." This is definitely an aspect of international engineering education that deserves more emphasis.

Culture - exchange vs. exposure

As noted in the section on teamwork, one of the challenges of cross-national collaboration is the need to bridge cultures as well as languages. While inter-cultural exchange can bring many rewards, it can also pose a number of potential stumbling blocks.   Initially, US student goals tended to focus on the personal benefits of exposure to a new/different culture, rather than on the benefits of cultural exchange as an element in the design of the Nicaraguan curriculum. Comments such as the desire to *"learn about Nicaraguan culture so that I can be more creative when coming up with concepts*" or to "*better communicate across cultures which could be beneficial in the US*" suggest an "extractive" approach on the part of these students. An equally problematic approach was the desire for a one-way transmission of knowledge from the US to Nicaragua expressed by one of the US students: to "successfully communicate the ideas about entrepreneurship…"

One US student, however, expressed an understanding of the possibilities for exchange of knowledge rather than its extraction or one-way transmission, citing as an initial goal to "*Possibly learn new methods of innovation from the Nicaraguans.*" Some Nicaraguan students also initially expressed such an awareness, hoping to "*Share ideas between both countries and among the different universities in order to have a multicultural vision of innovation.*"

Student responses suggest that their participation in the course enhanced their appreciation of the usefulness of a cross-cultural exchange of ideas. When asked at the end of the course what they liked best, 12 of 19 students (split evenly across countries) specifically noted the intercultural aspects of the experience. Five of six Nicaraguan students mentioned exchange between cultures and the sixth highlighted the friendships that had developed. Three of six US students commented about working across different cultures, but all US responses contained an element of exposure to a different culture: "*It was very interesting and in some instances mind blowing to see how the other cultures think.*" They also reflected on the value of cross-

cultural teamwork as an important learning outcome: "*The opportunity to work on a global team and work cross culturally,*" and "*It really helped to develop these cross-cultural relationships in the context of developing a product for a foreign market.*" In the quantitative final evaluation, the category 'increased ability to communicate cross-culturally' got the highest average rating from the US students and the second-highest from the Nicaraguan students.

This aspect of the course might perhaps have been enhanced through more pre-country preparation for the US students. A year later, US students suggested this would have been useful:

> *"I realize it was the first time we did this, but knowing a little bit more about Nicaragua and our project before going would be helpful. It felt as though we were thrown into a situation and place about which we knew nothing."*

Nevertheless, it is clear that the format of the program was quite successful in realizing the benefits of cross-cultural communication for both groups of students.

Another type of cultural difference is disciplinarity; the students in this course represented a range of disciplines and worked in multidisciplinary teams. At the end of the course, students agreed that they had increased their abilities to work across disciplines. It is interesting to note, however, that none of the students' open-ended responses from the end-of-course evaluation or the previous constructive evaluation addressed multidisciplinarity. The course drew on cultural, business, and engineering perspectives in such an integral way, students may not have even been aware of the extent of multidisciplinarity:

> *"This experience provided me with insight on how a business works and how important it is to understand the needs of the environment, and as engineers, provide solutions to problems."* [US]

Here the student's comment reflects the multidisciplinary nature of the course without naming it specifically as an outcome achieved.

Learning/Teaching

The active learning and team teaching methods employed in the course, plus the nature of open-ended projects, created a tension for students between flexibility and freedom on the one hand, and a desire for more structure on the other. For example, when asked on the second day about things going well in the course, all US students and all Nicaraguan students cited teaching and learning as a positive. The majority of comments were related to the teaching methodology: "*all of us participate*" [NI], "*faculty enthusiasm*" [US], and "*it has been dynamic and this is good*" [NI], and "*process has flexibility to include multiple faculty perspectives"* [US]. At the same time, when asked what could be changed, students commented on the need to improve organization, and a desire for less teambuilding. There were reports of confusion, with four Nicaraguan students not clear on the process or the project. On a related note, four Nicaraguan students requested more guidance; they may not have had prior experience with learner-centered approaches in the classroom. Two US students requested more involvement from Nicaraguan faculty. Up to that point, there had been little, at least in front of the classroom.

By the end of the course, some Nicaraguan students expressed an appreciation for the learning methods employed in the course. One commented "*it is a form of learning that allows interaction with many people; creating better ideas"* [NI],and another cited "*the methodology of learning to do and learning to learn*" [NI] as a highlight of the course. US students echoed these sentiments, but also suggested changes in teaching and learning, focused primarily on a perceived tension among course faculty, plus better organization guided by a syllabus.

The condensed time frame of the course was clearly a problem. This is a fairly common occurrence with intercultural exchanges due to resource constraints. Students definitely raised problems with time throughout the course and in retrospect after a year. Initially suggestions focused on more time for different aspects of the work; some students wanted more time in the classroom, others more time to work on the project outside of class. Some wanted more time for breaks, and others wanted more time with their groups for both working and social bonding. We adjusted the schedule to allow for more breaks, but the other suggestions were both contradictory and not possible to realize in

the compressed time of the course. At the end of the course and again a year later, the students' comments focused more on the overall sense that more time is needed for the course.

"have more time because we barely were developing our ideas" [NI]

"I realize that there are institutional constraints involved in setting the time frame of the course, but the number one thing I would say is to increase the length of time with the initial course." [US]

Curricular Content

Despite the compressed time frame, students were able to learn a great deal about product design and innovation. Throughout the constructive evaluations and in the final evaluations, students highlighted the creative elements of the innovation process as well as the benefits of learning a structured approach to innovation. After the first week, when asked what surprised them, students commented on the number of steps/length of the process, the wealth of ideas generated in brainstorming, and "*the rollercoaster of excitement/intensity*" [US]. Specific elements students reported learning after the first week included the steps in product design, product ideas, and business and marketing, as well as the "application of econ theories to reality" [US] and "*ideas that can be implemented, patented, and the product taken to market.*" [NI]

The tension between different approaches to learning (structured vs. flexible and participatory) was evident again in students' comments on the curricular content. For example, when asked whether the iteration process was helpful to their group, 90% said yes unequivocally and 10% said "yes and no". Those who found the process helpful cited the power of concept generation and selection: *"[the innovation process] has helped us develop more ideas and eliminate the ones that are not feasible or least likely to be successful."* [US] One who felt the process was not helpful noted, *"at points the process was disorganized and inefficient. The disorganization decreased the usefulness of the process."* [US] One student who had some prior experience with the innovation process commented "*it is the correct process.*"[US] This may reflect a belief that successful innovation results from a prescribed path, perhaps not surprisingly the path this student had been taught previously and had already applied successfully.

Four students, all Nicaraguan, noted the innovation process in connection with the course meeting their expectations: "*Because I was part of the innovation process, something that I had not done before, I really liked the work process, the brainstorming, and the selection of all of our products"* [NI]. Five US students and one Nicaraguan student mentioned the process as something they liked best about the experience, addressing both learning about and applying the process. In describing the course to a friend, one Nicaraguan student said, "*This process was of great importance because through it you can learn to improve your creativity…*" [NI]

A year later, students strongly recollect the curricular content of the course and how it changed their way of thinking:

> *"[I learned] 1. Knowledge of the market: Potential clients that might buy my product, places where I could sell it, improving my products by carrying out trials … 2. Where to start when creating a product: knowing the needs of the population and looking for available materials to make the product. 3. Brainstorming"* [NI]

> *" [The course] significantly changed my way of thinking about product design, development, and marketing, i.e. an increase in creative thinking."* [US]

Community Involvement and Local Needs

The product development curriculum presented in the course incorporated community needs and feedback at multiple stages, encouraging the students to design in context. Likewise, at the beginning of the course students from both countries expressed personal goals related to understanding community needs, community involvement, or making a difference for the community: "*to help the society…what will be needed*" [NI], "*to obtain knowledge of the needs of our Estelian population*" [NI], and "*work with my teammates to come up with an idea that will benefit the Nicaragüenses*" [US]. It is worth noting here that the Nicaraguan students enjoyed a relative privilege in the Estelí community; they themselves were not necessarily representative of the community they involved or wanted to help.

At the end of the first week, students noted having learned about the community, specifically needs, resources, and local capacity: *"I was surprised by the capabilities of*

the machine shops. The homemade blow torch." [US] and "*I was surprised that here in Nicaragua there are many opportunities and that we can and we are capable of producing one or various new things.*" [NI] As a result of the import analysis the students completed and visits to local industries, students commented on the prevalence of imported products and the local manufacturing limitations in the community: "*I was surprised at the variety of Nicaraguan commodities, but that they are exported because of the lack of businesses that can buy or because of the lack of manufacturers that make packaging for these products.*" [NI]

When asked specifically about how community involvement aided their projects, students from both countries commented that interviewing community members strengthened the students' understanding of local needs and gave them insight into how community members value the potential products.

> "*Interviewing has given us a better idea about what the people want. It has also allow [sic] us to see if they see the perceived benefits.*" [US]

> "*We are realizing the necessities of the community through these interviews. Also how much they would like some products*" [NI].

> "*The project took another turn, it was developed further and it made it real.*" [NI]

A year later, a student reflected on the value of community involvement in the development of products: "*Hearing their input was essential to developing our ideas and understanding their concerns*" [US] and "*I gained confidence both in my Spanish and my people skills by going out into the community during the 2 week class. I learned the importance of going out and talking to people to get information.*" [US]

The community involvement component focused more on needs identification and marketing and did not involve the community in the innovation of the product designs. As such, this stage could more aptly be termed "mid-course community feedback" rather than "community involvement", although the latter was desired by at least some of the students and faculty. At the conclusion of the course, 5 of 19 students noted that working in the community was something they enjoyed most in this course. In addition, no students suggested changing the community involvement process or critiqued the limited nature of community involvement. Our interpretation of the student comments

related to community involvement is that the students appreciated the applied nature of their design work and the potential to benefit their community, but did not fully value the need to involve the community at a greater level throughout the innovation process.

Future Change, Empowerment, and Personal Growth

The theme of future change and empowerment at a community level was evident from the evaluation results throughout the course. US and Nicaraguan students both raised the idea of future change as a goal from the beginning of the course: "*create a significant change in the city of Estelí"* [US] and "*one goal is to help there be a better world*" [NI]. At the end of the first week, one student commented on having learned the importance of changing the economic reality. This was likely the result of the import analysis conducted by the students highlighting the vast number of products imported from neighboring countries and across the globe. To place the project in the context of a global economy indicates students' recognition of larger issues as the students work for local economic empowerment. When asked at the end of the course how they would describe it to a friend, US and Nicaraguan students both mentioned positive impact and empowerment: a US student described the course as an opportunity to develop a product idea that "*could be used to improve life/provide jobs in Nicaragua*" and Nicaraguan students said "*It is important to know that we can make products to change our economic situation and that we will be able to help our country and our society*."

Personal growth also emerged throughout the course. In the beginning, US and Nicaraguan students both set personal goals for growth. A US student expressed a desire to "*expand my world perspective*" while Nicaraguan students expressed desires to "*develop my abilities*" and "*to be something in life*." At the end of the course, Nicaraguan students said "*I had to think about things that perhaps seemed difficult and therefore I avoided doing them*" and "*To my friends I would describe the experience as something very important in my professional career*." One US student noted the course "*gave me a lot of things to think about*" and another described it as "*life changing*."

Ongoing and Future Work

The Nicaraguan institutions have been developing infrastructure to enhance their capacities for design and innovation, including the establishment of an industrial engineering department at FAREM and the inception of business courses at UPONIC. Both institutions are interested in establishing a center for community-based design and innovation, and visited a number of university-community partnerships for innovation and entrepreneurship in the US in the summer of 2008. As the collaboration continues, project faculty members have built new connections with local and regional manufacturers, expanding the capabilities for product realization, and ultimately job creation.

GVSU faculty and the Nicaraguan faculty have monthly video conferences, with GVSU visiting Estelí two to four times a year; they have involved additional faculty from other disciplines, expanding initiatives outside of product innovation. They plan to offer the product innovation course in both Estelí and Managua in the future. While FAREM and UPONIC faculty have not yet taken leadership roles in teaching subsequent iterations of the course, they have been picking up more active learning techniques in their teaching.

As subsequent iterations of the course develop, it will be important to improve our evaluation techniques through more objective survey construction, and incorporate assessment of learning as well.

Conclusions

We employed a collaborative, participatory, intercultural, and multidisciplinary process in a two-week course in Nicaragua with the goals of educating both US and Nicaraguan students in innovation and product development, cross-cultural communication, and collaborative teamwork, while building institutional capacities in innovation and product development for local economic empowerment. The results of the course evaluations suggest that this is a viable approach to educating students that can empower both US and Nicaraguan students, and raise awareness among US students about the developing world, with lasting impacts.

However, this approach is not without its challenges, and requires a great deal of advance planning and flexibility. More time is required in country, as well as increased language abilities on the part of US students. As we look forward to continuing the collaboration with Nicaraguan colleagues, we look for more contributions from Nicaraguan faculty, even as we recognize the structural difficulties presented by their often part-time positions, making equal contributions to the collaboration challenging. We also look to the continued efforts in Nicaragua to establish a center for innovation in Estelí that connects the universities to the community, and hope for increased community involvement in both the educational and product development processes.

Acknowledgments

References

Amadei, B. (2003). Program in Engineering for Developing Communities: Viewing the Developing World as the Classroom of the 21st Century. *Proceedings – 33rd Frontiers in Education Conference*, v 2, 2003, p F3B1-F3B6. Piscataway, NY: IEEE Publications.

Boyatzis, R.E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage.

Bradley, W.L. & Newberry, B. (2004). Science and appropriate technology for underdeveloped countries: One emphasis in the master of engineering program at Baylor University. *2004 International Symposium on Technology and Society, ISTAS '04 Globalizing Technological Education*. Piscataway, NY: IEEE Publications

Clewlow, R. (2005). Engineers working for peace through sustainable development. *Peace Engineering: When personal values and engineer careers converge*. A. Vesilind, ed. Woodsville, NH: Lakeshore Press.

Farris, J., Lane, P., Howe, S., Riley, D., & Reinhardt, N. (2008). Opportunity Identification across Cultures and Disciplines. *Proceedings of the 2008 USASBE Conference.* Boca Raton, FL: United States Association for Small Business and Entrepreneurship.

Kendrick, F. (2006). How the United States continues to manipulate Nicaragua's economic and political future. Council on Hemispheric Affairs, June 22, 2006. Retrieved January 15, 2009 from http://www.coha.org/2006/06/22/how-the-united-states-continues-to-manipulate-nicaraguas-economic-and-polical-future/,

Lane, P., Farris, J. & Panse, S. (2005). The Research Game: Fiddling with the Fuzzy Front End*, Proceedings of the 9th Annual Meeting of the NCIIA*. Hadley, MA: National Collegiate Inventors and Innovators Alliance.

*Mazumder, A. & Bean, J. (2001).*Global concentration in engineering. *ASEE Annual Conference Proceedings*. Washington, DC: American Society for Engineering Education.

Mihelcic, J.R., Phillips, L.D. & Watkins Jr., D.W. (2006). Integrating a global perspective into education and research: Engineering international sustainable development. *Environmental Engineering Science*, 23(3): 426-438.

Riley, D. (2007). Resisting neoliberalism in global development engineering*. ASEE Annual Conference Proceedings*. Washington, DC: American Society for Engineering Education.