AC 2011-1102: IMPLEMENTATION OF AN INTEGRATED PRODUCT DEVELOPMENT (IPD) COMPETITION IN A RURAL DOMINICAN COMMUNITY: LESSONS LEARNED

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Implementation of an Integrated Product Development (IPD) Competition in a Rural Dominican Community: Lessons Learned

Abstract

This paper describes the challenges in the development and execution of a product design and development competition for a rural community by a small engineering student team. The service-learning project was conducted by a four-person team, relying on the collaboration of a community partner organization in the Dominican Republic, and a small group of graduate student advisors. The goals of the project were to a) identify critical needs in the community to use as a theme in the competition, b) encourage team-building within the community, c) develop modules for product design and development, and d) host a competition for the entire community.

Preparation for the field project occurred over the span of 3 months, and was implemented within one month over the summer break. After undergoing a process of need identification, the community elected to pursue solutions to the poor road conditions as the theme for the competition. Enthusiastic community leaders were identified to aid with the recruitment of participants. However, leading up to the competition, the workshops intended for disseminating information were largely unattended. The competition culminated in the presentation of eight teams, and presented a valuable learning experience in the development of a business in a rural community for the student facilitators.

When implementing such a program, an educator should consider the collaboration of a local educational institution to provide a source of mentors and project leaders for community members. The collaboration from a local institution might provide the field project team with an invaluable resource in disseminating information to community members. Additionally, the inclusion of the entire community in a competition is very challenging.

In future efforts, we suggest that a distinct demographic (i.e., women or children) is targeted for inclusion in educational workshops and modules. We conclude that the implementation of an integrated product development competition by a group of engineering students can provide a challenging and rewarding service-learning experience. Additionally, care must be taken to provide sufficient resources for their success under highly constrained conditions, in addition to a through review of literature and/or case studies involving similar efforts to avoid the shortfalls committed by other groups in the past.

Introduction

Integrated Product Development (IPD) is a cross-disciplinary project development concept held as a full semester course in various academic settings. This concept most commonly brings together students from various disciplines such as engineering, business administration and the arts. Students are divided into teams that would plan, design, construct and market products based on a common theme. Team diversity is emphasized in order to give each member a specific support role in design, engineering, or product marketing strategies. The project typically lasts from 4 to 5 months and would culminate in a design exposition, where the public are encouraged to vote on the product of their choice and teams would be evaluated and ranked.
based on their sales, profits, and overall quality. Various institutions have offered IPD courses for interdisciplinary graduate and undergraduate student teams, including the University of Michigan\textsuperscript{1,2}, Lehigh University\textsuperscript{3,4}, and the University of Puerto Rico\textsuperscript{5}.

Recent changes by the accreditation board for engineering and technology (ABET) have prompted engineering programs throughout the country to expand their curricula to provide students “the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.” IPD courses provide engineering programs with the opportunity to address many of the desired student outcomes\textsuperscript{6,7}, particularly in collaborative learning and the broader impact of engineering solutions.

We attempted to encourage creativity and entrepreneurship through grassroots solutions to community issues in Rancho al Medio, a small rural community near the south coast of the Dominican Republic. While most of the youth in the community lacked formal education beyond primary school, we observed their considerable interest in craft and competition. We acknowledged that previous visits from our university to the community were primarily of a passive nature, as we would share presentations on health, water quality, point-of-use water purification, and energy that we designed prior to our visit. In an effort to effectively facilitate creativity and entrepreneurship among members of the community, we sought to provide structure and motivation. We implemented a customized version of an IPD course for the community. We expected that an integrated product development competition would introduce structure through project planning, reviews and management as well as motivation through its competitive nature. We hoped that it would ultimately lead to actual solutions that would be applicable and marketable to the community and beyond\textsuperscript{8}.

The concept of integrated product development was novel for the community, and such a concept was our first attempt in developing an active learning model for the community. Furthermore, it recognized the lack of formal resources (e.g., machine shops or project planning tools) and tailored it towards the local capacity and customs, such as sharing common resources. As opposed to rote learning, participants were encouraged to think, strategize and challenge ideas throughout the whole process. The final presentation, a community exposition, gave the participants a chance to be reviewed by potential consumers and at the same time revealing favouritism and perceived feasibility from the voters. Overall, the student team was charged with the goals of identifying critical needs in the community to use as the theme for the IPD competition, promote team-building, develop relevant educational modules, and facilitate the competition within a rural community.

**Methods**

**Student Preparation**

Overall, preparation for this competition was focused on the strategic aspects of running the competition and less on the resources, research and manpower needed for it. The competition in the community was facilitated by a small team of engineering students, whom over a one-month period carried out need identification assessments in the community, facilitated the IPD competition, and prepared a final report on their project. As a team, we concluded that the best way to engage residents and get buy-in was for community members to take ownership and
identify issues that were most important to them. Since the student team did not know what these issues would be, they could not plan for specific resources. The student team relied on an advisory team, consisting of a small group of graduate students, to provide assistance with research back in the United States once a topic was decided. Given this strategy, the student team prepared as follows:

1. **IPD Background and Process:** Scheduled team meetings to gain an understanding of IPD process. Over the span of 3 months, the student team was introduced to survey methodology, appropriate technologies for use in the community, and principles behind integrated product development.

2. **Strategy for Community Project:** Determined the best way to apply IPD concept to the community, given the strategy above, and developed a high-level schedule. The high-level schedule below also included constant communication with the advisory team, who provided essential support for research of identified needs.
   - Week 1: Identified community needs, chose competition topic, provided design workshop
   - Week 2: Worked with teams to begin design process, provided team workshop
   - Week 3: Helped teams with prototyping and technical issues, provided safety workshop
   - Week 4: Wrapped up project and voted for winning team

3. **Group Activities & Team Monitoring:** The team brainstormed, researched and tested ideas for community group and team building activities prior to the trip. The student team also discussed and created a plan to monitor community-based team progress. For example, some proposed activities and monitoring methods were as follows:

   **Topics and Activities Researched by Team**
   - Teamwork: Creating synergy and developing team dynamics
   - Electrical Safety: Insulation, conductivity, and safety tips
   - Competitive Nature: Small games preparing competitors on win-lose aspects & situations (i.e., smaller scale projects competition to prepare for the actual IPD competition)
   - Creative Method: Thinking outside the box using game formats
   - Design Process: Structure on various stages of a design project (e.g., idea collection, idea selection, and design planning)

   **IPD Timeline Review and Team Monitoring Methods**
   - Set weekly progress review appointments with at least one representation of each community-based team, reviewed structures such as things learned that past week, goal for the next week, and challenges and anticipations.
   - Set Office Hours 2-3 times per week for the student team to provide consultation for the community-based teams.
   - Provided notebooks/design journals for each time where they can present their progress for the reviews
4. **Materials and Available Resources:** The student team brainstormed and sorted through items from previous trips to the community that could be useful in a competition and brought those as well. They also created initial flyers to distribute and post in the community prior to the trip.

5. **Needs Survey:** The student team created a survey called the "IPD Focused Needs Survey" which asked key questions needed to gain an understanding of key issues (e.g., IPD, water, and sanitation). The four key questions pertaining to the competition were as follows:

   - In your opinion what are the community’s biggest needs?
   - What are the biggest problems you face in your everyday activities?
   - If there was an invention that could make your life easier what would it be?
   - Of the needs you listed if you could rank them in order of importance, what would it be?

**Communication**

The primary modes of communication throughout the project were face-to-face discussions, word-of-mouth, telephone communications, and written advertisements in public community areas. Within the student team, meetings, discussions, and brainstorming sessions were regularly scheduled throughout the duration of the project. The student team also communicated with the advisory team in the United States via telephone and e-mail, as needed. The student team engaged the community of Rancho al Medio through the use of community meetings, advertisements, or word-of-mouth. Community meeting or “charlas” were held in the elementary school building to present ideas to key community stakeholders and receive their feedback. Advertisement consisted of chalking and posters placed at strategic areas where many people would see them (e.g., water tank, community store, school) to remind the community of upcoming meetings. Word-of-mouth communication was carried out by the team by going door to door to ask community members if they were coming to the planned meetings and asking to spread the word to their neighbours.

**Results**

**Need Identification**

The student team identified the top needs of the community to be water, roads, electricity, and jobs, through their crafted needs survey. More specifically, community members reported that there was not enough water in the well at times, especially in the dry season (Figure 1); that the public well did not work when electricity was out; and that in general, the well was located too far away.
The roads in the community were found to be in very poor condition. With the exception of the main road, which has a stretch of it filled in with gravel, the dirt roads around the community are filled with pot holes and gullies created by erosion when it rains (Figure 2). As a result, few cars were willing to make the drive up the hill to the community and most people were forced to rely on motorcycles as the mode of transportation. Such conditions make it dangerous for drivers and pedestrians alike when it rains, makes it difficult to transport the sick in case of medical emergencies, and also keeps the town’s development stagnant because it is isolated from all business potential.

During the duration of the project, the student team found electricity to be intermittent and of short duration in the community. Electricity usually came on for at least an hour a day. This allowed for cell phone and camera charging, refrigeration, and pump operation in the public well and in private reservoirs. Many households were found to have makeshift connections put in place by local electricians, which directly led to intermittency issues in the local electrical grid and safety concerns in the community (Figure 3).
Community members reported the unemployment in Rancho al Medio to be a significant need. Without local employment, the men were forced to look for work in nearby cities during the week, while the women and children stayed behind. Small ventures in the local community were limited to a few local stores, motorcycle taxis, cattle-raising, and small-scale farming. Some women expressed an interest in learning vocational trades like dressmaking or hairstyling, but had no means to do so. Given the results of the need survey, the student team asked the community to vote on the theme of the IPD competition from the four big problems (e.g., roads, electricity, water, jobs). The roads were then selected by a landslide of 20 out of 28 votes.

**Team Building**

After the selection of the IPD competition theme, the student team soon discovered that it was highly difficult to track the formation of participating teams. Three community leaders were identified in different regions of the community and were entrusted to explain the competition to families in their region. Leaders were given sign-up sheets for the teams in their regions. These community leaders were very active and willing to help. However, even though community leaders were able to obtain a long list of names, the sign-up sheets did not prove too useful as they had difficulty successfully describing the competition to participants, and had trouble providing contact information for people who had signed up.

**Development of Educational Modules**

The team was concerned that the community members participating in the competition would need guidance with their ideas, prototypes, and business plans from the student team. However, they discovered that no one wanted their help, nor did the community-based teams want to work on their ideas before the final presentation day. When community members were asked about their progress, they would simply say that they are working on it and that they did not need assistance. When the student team tried to hold helpful workshops for the competition, no community member attended. They learned that people were more interested in learning things that were directly necessary in their everyday lives, such as medical issues. Engineering design, however, did not seem to top most people’s list of priorities.
IPD Competition Results

About an hour before the meeting, many groups started to gather in the classroom. Many people seemed to be just starting to form teams or brainstorming then and were not well prepared. After reviewing the rules of the competition, teams were given a few minutes to make final adjustments before the presentation. Many people were adamant on presenting about issues other than solutions for the road or medical centers, so the student team expanded the topics to water, electricity, job creation, the roads, and a medical clinic to spur brainstorming in different topics. Each team was encouraged to present detailed plans, with the more detailed the better, so as to answer the who, what, where, why, and when, but most importantly, how. At this point, prototypes and business plans were deemed out of their scope and, therefore, unnecessary for the competition.

A total of eight teams presented. The first seven presentations were similar ideas for building a medical clinic in the community. Most presentations lacked details and consisted primarily of stating that the community needed a clinic. One particular team provided the most detailed plan, which included a list of all the materials they would need for the construction and facilitation of a clinic. This team clearly stated the “what” and the “why”, but they were especially weak in the “who,” “when,” “where” and “how,” which are the most important components in planning. The first seven teams treated the competition as yet another opportunity to complain about the current situation and declare their need rather than actively pursuing a solution.

An hour into the meeting, a team of young boys, approximately of 14 years of age, arrived to present. Their team came closest to reaching the goal of the competition, as they built a working prototype and provided a detailed business plan. Their prototype was a hand-made lamp and their business plan included a list of materials with prices for each material and their plans for making a profit with making and selling the lamps (Figure 4). Although the plan was more or less unrealistic for the community, it was refreshing to see such a young group fully understand what was asked of them to do for the competition. However, the audience treated the business plan as though it was a novel, yet unfeasible, solution.

After the first few presentations, the student team allowed time for questions. When no one had any questions, some practical questions were asked, such as, “do you know anyone we could consult with to learn about more information on clinics,” or, “where do you think a good location for this clinic would be,” or, “how do you think we can obtain money for all the materials we need,” or, “who is going to build it,” or, “how can the clinic expect to make money,” etc. The participants seemed annoyed by these questions, and the popular response was that they would have another meeting to discuss them.

IPD Competition Voting

Two rounds of voting were held to prevent teams from voting for themselves instead of the best idea. The first round was used to identify the two leading teams. Participants were encouraged to vote for other teams, although the vast majority did vote for their own group. The second round was used to vote for one of two teams identified in the first round. Everyone seemed to be very pleased with this process; however, voting turned into a popularity contest where family voted for family. For example, the group of young boys did not receive any votes. When asked if they
even voted for themselves, they replied that they voted for an adult relative, when they didn’t even see their presentation.

![Image of 14-year-old boys with their lamp prototype](image)

**Figure 4. Team of 14-year-old boys with their lamp prototype**

**Discussion**

**Lessons Learned by Facilitators of the IPD Competition:**

The IPD competition provided a valuable learning experience and should be used as a stepping-stone for additional active learning projects pursued within the community. In retrospect, there were a number of areas that could have been approached differently. Some of the challenges encountered were:

*Team formation and follow up:* Our initial plan for identifying teams was founded in the hope that team members would come to the first workshop. When only one person showed up to our first workshop however, we tried using sign up sheets. The sign-up sheets were given to community leaders. The problem with this was that even though many people signed up with the community leaders, most were single entries as opposed to teams. So although this gave us little to work with, we were encouraged that the competition was at least being promoted.

In our surveys and interviews, the community expressed interest in and excitement for the IPD competition as well as the prospect of improving road conditions, water collection and employment opportunities. Many members of the community reported to be working on their proposals for the competition when we checked on their progress at numerous points along the way. However, there was a clear disconnect between the feedback from the community and their actual engagement in the IPD project, as seen by the results in the competition.
Structure and time frame: Most of the teams brainstormed ideas on the day of the presentation. If the IPD was to be repeated, we propose giving teams a maximum of one week to develop their initial idea and spend the remaining 3 weeks helping teams refine their ideas and develop much more detailed plans or prototypes.

Business plans: The business plan was hard for community members to grasp. It was difficult to explain, and participants had a difficult time estimating prices for quantities of materials. It would have been difficult for anyone, even for university students, to find a way to turn solutions into realistic businesses. We eventually decided to tell people not to worry too much about the business plans but rather focus more on the actual solutions.

Competition theme: As previously mentioned in the results, our chosen theme was to find a way to fix the roads. However, many people did not want to work on this project because it was a political issue. Other participants believed it was just too expensive and they didn’t have the resources. In regards to the competition, no one knew how to make a prototype of the solution nor did they know how to turn it into a business. For these reasons, we encouraged participants to expand their ideas to transportation and water carrying methods, and we encouraged people to experiment with out-of-the-box solutions.

Prototyping: Most people did not understand the idea of a prototype. When people were asked if they needed assistance with prototypes, most people confidently declined; however, since one team produced a prototype, it is possible that with a more clearly defined competition topic, participants could produce prototypes.

Office hours irrelevant: The concept of office hours was irrelevant in this setting because no one felt as though they needed help. Even when there was confusion, we found that we had to approach specific leaders in the community to gauge the progress of teams. This may have been due to the language barrier, lack of time or lack of interest on the part of the people.

Workshops not relevant: There was a lack of interest in the engineering design workshop mainly because most of the people involved in the competition were women with no interest in engineering work. This discouraged us from pursuing the other engineering workshops.

Audience: One of the biggest drivers on the results of our competition was that our participants were mainly women who had no desire to work on engineering projects. As a result, there was no interest in engineering. However, topics on vocational trades may be of more interest in the future for these women.

Men in the community were primarily the individuals who earned household wages. They left early in the morning, and came back late at night to earn money. These men were important in community decision-making, improvement, and most likely would have influenced the IPD concept. However, their need to leave Rancho daily to work in more urban communities trumped their desire to participate in the IPD competition. Since the men were away from Rancho many hours of the weekdays, the student team group did not have access to the thoughts and opinions of the people primarily capable of physical improvement.
All the teenagers we spoke with in the beginning seemed interested initially but generally lacked interest. Since few men showed up to meetings on the weekends, we gathered that they are either uninterested or just had other things to take care of on the weekends.

*Scheduling meetings*: Scheduling meetings seemed complicated. The men would leave during the week to work in the city, and were more interested in leisurely activities upon their return. The teenagers were generally unmotivated to participate in anything, and the women would usually stay at home, cleaning and taking care of their many children. The best solution that we could think of was to go to each home, individually, to spread news and offer our help.

In general, there seemed to be signs of disinterest and confusion regarding the competition. Despite our offers to provide assistance with the competition’s projects, participants declined and were disinterested in the prepared innovation workshops.

*Promoting the competition*: We found that the best way to promote our meetings or the competition was by word of mouth. We walked through and talked to people about an hour before each ‘reunion’. We also chalked the public well and the pavilion.

*Community connection*: We felt as we had little community connection or partnership. We only had connection to one local non-governmental organization (NGO) that was unable to be actively involved in our project. We also tried to work with the leaders of the community, but felt that we never successfully communicated the intent and process of the competition. Even when community members expressed that they understood the competition, we felt that we were still not on the same page. We operated largely on our own and with limited Spanish proficiency. Having the support of key community leaders and respected community partners to drive the conversations and understanding would have been helpful.

**Lessons Learned by Educators Implementing an IPD Competition:**

When implementing an integrated product development competition, an educator should consider the collaboration of a local educational institution to provide a source of mentors and project leaders for community members. The collaboration from a local institution might provide the field project team with an invaluable resource in disseminating information to community members. Challenges encountered include:

*Preemptive Communication*

It was very difficult to communicate with any members from Rancho al Medio prior to the trip to the Dominican Republic. A local NGO acted as a proxy for the student team to understand aspects of the Rancho al Medio community, but the local NGO was difficult to reach, even within the country.

Initially, the student team did not even know that strong communication lines with Rancho al Medio would be helpful and significant in ultimately providing a sustainable solution for the community. Ultimately, it was concluded that a sustainable solution for Rancho al Medio was one that the community members would be motivated to support and develop after the student team left. For the community members to continue development after the student team left, they would need to realize why it was worth their time, and energy.
Cultural Understanding of Rancho al Medio

The student team did not clearly understand what the Rancho al Medio community members felt was primarily in need of improvement and innovation, before arriving to Rancho al Medio. The Rancho community expressed that roads to and from the community were in awful shape (i.e., unsafe to travel via car or motorbike), if they existed at all. This not only made it difficult for community members to travel to work outside of Rancho, it also hindered and deterred community from outside of Rancho from wanting to visit Rancho for any goods and services. Many community members felt that as long as the roads leading to and away from Rancho were in poor shape, the community as a whole would be dependent on government assistance to survive. While this dependence existed, community members felt that they could not escape the poverty that has plagued them for decades.

It would have been expensive to have a student group member, necessarily fluent in speaking Spanish, visit (especially on a weekend – to access the working men) Rancho prior to the exposure of the IPD concept to the community. However, this would have been invaluable to gather information that could have shown that improvement of Rancho roads was a project that Rancho members had a vested interest in. Knowing the vested interests of the community would have provided a solid framework to introduce the IPD concept. Understanding the vested interests of the community better would have likely influenced the community to continue work on the IPD concept, well after the student team left Rancho.

Relevant Expertise

As the team came to understand the needs of the community and realized that it was out of the scope of their current capabilities, it may have been better to use the time to research the various needs proposed and postpone the competition. Victor Papanek, in his book *Designing for the Real World*, noted that it is critical for any designer in a developing nation to spend some time understanding the needs of the people there. Although the team tried to understand the culture and needs of the team, perhaps we could have taken it a step further by identifying how solutions to their key issues were currently being addressed in the Dominican Republic. Information such as material costs, political processes, governmental agency contacts and engineering professionals with experience implementing such projects in-country, for instance, could have been identified.

After gathering this information, it may then have been more appropriate to regroup back at the university, and consult with local experts to draft proposed plans to address the community's needs. With expertise from the host nation identified, the team, on the next trip could then adopt the "train-the-trainer" approach, where local experts could work with in-country partners and community members to assess the feasibility of proposed solutions. With this initial structure, critical expertise, and in-country contacts identified, the community could then be involved in a more focused competition. The community's scope of involvement in a solution for poor roads for example, could then structured around selection of the best-proposed solution, how it could be tailored to the town and ideas for funding the project. It is more likely that the community would be more involved and motivated when they have evidence of attainable solutions and in-country partners to support it. These partners could then be the "trainers" needed to mobilize and sustain the effort.
**IPD Competition**

Were roads appropriate for an IPD? In retrospect, this is dependent on the scope and complexity of the project. In the case of the IPD competition attempted in this community, roads offered a theme with a wide scope of potential products. Depending on whether teams considered the road as the problem to solve, or addressed how other aspects of life (e.g., water access or transportation) could overcome the existing road conditions. The complexity of the projects in the IPD competition may have been too high if fully implemented, but opportunities were available to develop relatively simple products, capable of incorporating local materials and expertise.

In the end, the success of projects developed by student teams within an IPD competition is dependent on many things. These successful project characteristics, as outlined in the course description, depend on: a final product that the end user realizes as something that is useful and necessary; growth and education of the students, faculty and administration involved; and the improvement and development of the course overall, annually. While the students and faculty involved in this particular IPD competition for a rural Dominican community were careful to target all three of these elements for project success, more time should have been spent in the concept development stage of the project design so that the first goal of having the end user realize a useful and necessary product could have been better realized.

Efforts to include elements of successful community projects – like those noted by Baillie – such as inclusion of a needs assessment, determination of key players in the community, and a feasibility study were consciously made. However, further review of the community development project literature, such as that written by Hammer, who enumerated the many of the potential chasms in implementing community development projects based on several case studies, and similarly by Lucena and Nieusma would have saved time and effort by both the project group, and the rural Dominican community. Thus, it is not only recommended that student groups follow the IPD project guidelines and goals carefully when targeting a foreign community as a product end user, but also that a thorough literature review and understanding of previous successes and failures in community development and sustainability projects are executed preemptively.

**Conclusion**

Based on our experience with an integrated product development competition, we learned that understanding the primary concerns inhibiting socioeconomic improvement of the community was key in introducing the IPD concept successfully. Additionally, we learned that having more fluent Spanish-speakers in the student group would have: led to a clearer understanding of the community’s socioeconomic concerns, allowed for a better communication of the goals and structure of the IPD competition, and maximized the impact that the group given the short time they spent with the community. We conclude that the implementation of an integrated product development competition by a group of engineering students can provide a challenging and rewarding service-learning experience, but care must be taken to provide sufficient enough resources for their success under highly constrained conditions.
Bibliography


