Teaching Engineering Design with a focus on the developing world

Beena Sukumaran, Joshua Bonzella, Kevin McGarvey, Heather Klein
College of Engineering, Rowan University

Abstract

The paper describes a program, Entrepreneurs without Borders and a project undertaken through the program. The program seeks to establish entrepreneurship opportunities for the developing world. This will be done through student teams comprising both engineering and business majors at Rowan University. The engineering and business students perform a survey of local communities in the developing world, identified as having a need for engineering skills by Engineers without Borders[1]. During this initial survey, the students identify local entrepreneurial opportunities that require redesign or development of a device that will enhance the quality of life of the local area. The students then work on redesigning or development of the device using local materials and input from the local community. The business students on the team perform a business feasibility analysis and present the plan to the community, which can then develop these devices for the local or wider region.

The first project undertaken through the program was redesign of a human powered grain crusher for a community in Senegal. The grain crusher being designed at Rowan University has undergone many revisions to make it more affordable and sustainable. It can be powered using a bicycle and therefore can utilize human energy for crushing grains efficiently. The design process undertaken by a group of engineering students is described in the paper. They also interacted closely with a group of business students to develop a marketing and business plan, which is in the process of being developed.

The students benefited from the project by interacting in a group environment with a multidisciplinary group of students. In addition, they also learned about conditions in the developing world and coming up with sustainable designs that are sensitive of the local environment.

Introduction

The proposed program, called Entrepreneurs without Borders establishes entrepreneurship opportunities for the developing world utilizing engineering design, entrepreneurship and business skills available at Rowan University. The program utilizes long standing collaborations between the College of Engineering, College of Business and Engineers without Borders. Teams of engineering and business students will conduct a survey of various communities in the developing world with whom the College of Engineering has established relationships through Engineers without Borders. The program builds upon earlier successes that Rowan has had with developing entrepreneurial skills since its inception in 1998, including the Undergraduate Venture Capital Fund and development of the Technology Entrepreneur Concentration.

The College of Engineering has had an active chapter of Engineers without Borders since 2004 and has done potable water distribution system projects in Honduras, El Salvador and Thailand and a fish hatchery and geothermal power generation design for Cheyenne, S. Dakota. One of the emphases of Engineers without Borders is that project personnel involved with implementation of projects in different regions of the world also maintain long standing relationships with them. In addition, a social survey is required of the local population and designs being implemented be approved by and not disrupt the social fabric of the community. Previous works in the area that will be utilized by the projects include product redesign for the developing world as described by Weiss et al[2]. In their paper, they have described efforts at developing products that can be redesigned using local materials, are sustainable and done in consultation with the local population to identify the best redesign strategies to be adopted. In addition, the importance of the cultural context in redesigning and manufacturing is also explained in Bruun and

Meddford [3] and Thilmany [4]. Appropriate Sustainable Technologies used by Engineers without Borders (www.ewb-usa.org) will also be utilized to determine the appropriate technological framework to be used.

The program is implemented in the Junior/Senior engineering clinics, which are the last four semester of the eight semester engineering clinic sequence from the freshman to the senior year. Engineering Clinics allows students to practice a wide range of engineering skills in a multidisciplinary environment while honing their design skills throughout their four-year career[5]. The Clinics in the Junior/Senior year offer the faculty and students venues to conduct applied and fundamental research or design for the local or global community as done with projects through Engineers without Borders. Students are chosen for these projects using a job fair model based on their interests, skill sets and required personnel.

The project arose as a result of a visit to a community in Senegal for an Engineers without Borders project. From a survey of the local community, it was learned that there was an existing grain crusher, but the cost of the diesel to run the crusher prohibits some of the communities from using the grain crusher. Also, the women of the community are the ones who crush the grain, and to do so they wake up around 4:30 am to produce enough crushed grain for the day. The EWB team also found that if an easier and less expensive way was available for crushing grain, the members of the community would be very interested in availing of the product. As a result, design of a human powered grain crusher was chosen as the first device to be developed through the Entrepreneurs without Borders program. The goals of this project are rooted in developing a device which is not overly complex and could be made from readily available local materials so that the finished product could become available and be easily manufactured by the populations that desperately need assistance. A group of three engineering students, who are in the junior and senior years of study in the mechanical and civil engineering program are investigating and designing an environmentally sustainable grain crusher that can be easily operated and built using locally available materials. The other elements in developing the product are the business perspective and market analysis. Through the entrepreneurial program available at Rowan University, which is offered by the business school, the engineering students were able to obtain the help of business students to determine local business potential and draw up a small business plan for a rural community in the developing world with very little access to resources.

Design of the grain crusher

The process of design of the grain crusher is described in the following sections. When the project commenced, it was decided that the most reasonable device to fulfill the purposes of this project would be the quern, which is essentially two circular stones, one on top of the other, with an axle in the center and a handle attached to the top stone. The grain to be ground is placed between the two stones and the top stone is rotated about the axle. On more advanced designs, a small hole in the top stone allows for the continual introduction of fresh grain into the space between the stones. The quern was constructed using circular cement “paver” stones and a steel rod as an axle. It was tested by grinding various types of grains and proved to be adequate as a working model. Then the student group started to contemplate what improvements could be made to a device that had existed in various forms for thousands of years. It was at this time that the realization was made that the quern had very little development potential for mechanization at an affordable rate and hence the design was abandoned.

Having realized that making a quern would not allow for improvements beyond what already existed, the focus of the project shifted to a grinder that is produced in Uganda by Compatible Technology International (CTI), an organization that helps to improve food processing operations throughout Africa. Discovering the Ewing III grinder allowed the design team to shift its focus from designing a complete grinder to developing improved methods to power an existing grinder. The design team attempted to contact CTI in an attempt to acquire a Ewing III but never received a response. As an alternative, the team selected the Country Living Grain Mill as a comparable substitute to the Ewing III grinder.

For powering a grain crusher, a device is needed to convert human power to mechanical power for the grinder. During the research, some previous designs with similar project goals were found. Designs included bicycles or stationary bicycles modified with a chain or drive belt used to turn a crank on a personal, kitchen type grinder. The group decided that a bicycle stand for an existing bicycle would be the best idea for the scope of the project. A bicycle stand was constructed with intentions to be attached to a pre existing grinder.

Of critical importance to the design was a wide range of adjustability so that the final product could fit a variety of bicycles. The stand would need to fit bikes with tire diameters ranging from 20" to 26", and also with varying rear axle widths. The design also had to allow for adjustment of the tension in the drive belt, so it was decided that the grain crusher's location would be adjustable to provide such tension. The only fixed components would be the center drive axle and its supports. An overview of the previous design is shown below in Figure 1 (Bonzella et al., 2006). An effort was also made to use as many off-the-shelf pieces as possible. This would limit machining time.

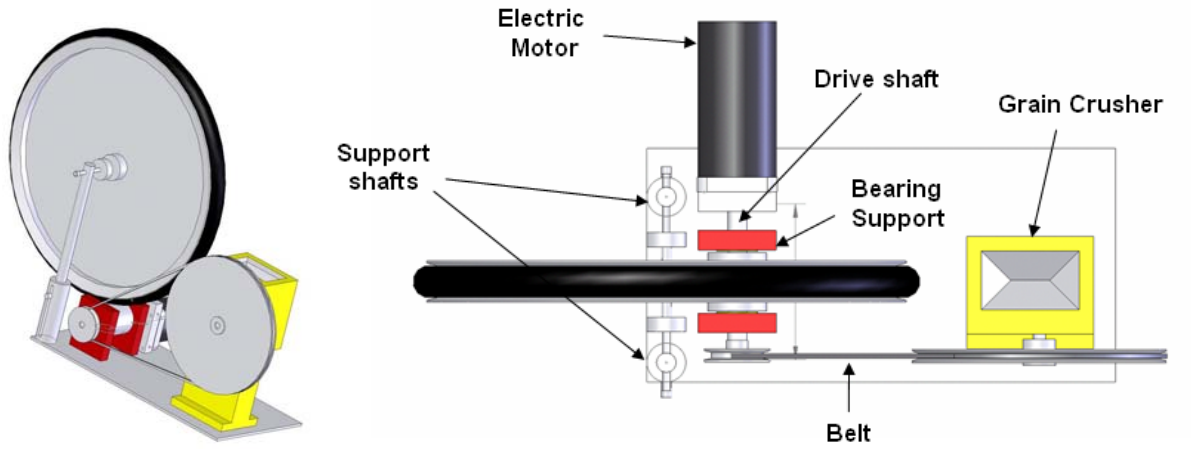

Figure 1: Initial Design of the Bicycle Powered Grain Crusher[6]

In Spring 07, redesign of the grain crusher was undertaken to reduce the cost of the device. It was found that if the team could create its own grain crusher, the cost of the overall product would be greatly reduced. Keeping the same idea of the prototype in mind, the total price of materials was a large difficulty. The pricing goes hand in hand with the conservation of materials, so when the excess material was trimmed down, the total cost of the product was reduced. The Spring '07 design had a motor ($225), Grain Crusher ($375), and construction materials ($200), so the cost of this design was approximately $800 to build. For the Fall '07 design, the cost of the materials to make the crusher itself is approximately $224. The new design costs $151 less than the old one, excluding the motor. The motor was also eliminated from the design, saving more on the cost of the project. The reduced cost model also reduced the weight of the product because the new crusher was made from aluminum instead of much heavier cast iron. Figure 2 shows the revised design.

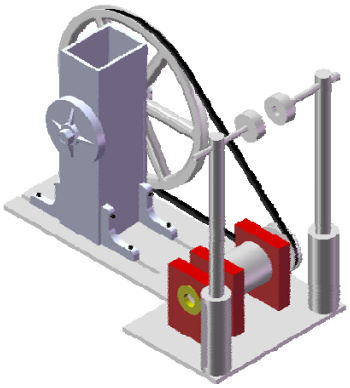

Figure 2: Revised Design[7]

Marketing

At the beginning of the spring semester, the Rowan University Business Department showed interest in working with the project through the Entrepreneurial course. The engineering team met with a group of business students to show them the drawings and explain the concept of the project after which they decided to work on the marketing side of the project. At present, the business team is doing research on areas the finished project can be marketed to. They are also presenting to a group of possible entrepreneurs that might be interested in becoming involved with the project.

To provide visibility for the product being designed, a website was assembled to showcase the Grain Crusher project. It gives a brief background of the project as well as our current status and can be found at: *http://users.rowan.edu/~bonzel84/Clinic /HomePage.mht*. It also gives links to the types of products used to create the grain crusher device. The site is currently up and running and has been updated recently with a photo gallery and video clip of the working model.

Conclusions

The specific outcomes that are produced as a result of projects through Entrepreneurs without Borders is to generate technological solutions to problems faced in the developing world using detailed opportunity recognition evaluations and development of prototypes. The first of the series of the projects was completed, though the business feasibility analysis study to determine the market potential of the product for use in the local or regional community is to be completed. The community will have an opportunity to provide feedback on the business plan and implementation. In summary, as a result of the project, engineering students are able to provide the following:

- Business feasibility analysis studies;
- Detailed opportunity recognition evaluations;
- Community-oriented business plan evaluations;
- Community-specific solution designs and implementations; and
- Prototypes.

The products that are generated as a result will alleviate poverty in the region and will be replicable in other developing world communities with small modifications for local materials and customs. The products will also generate local entrepreneurial opportunities, which will result in local economic growth. The students also get considerable experience with developing sustainable solutions and working on multidisciplinary teams with business majors and also to learn entrepreneurial skills.

References

1. Engineers without Borders website, http://www.ewb-usa.org.
2. Weiss , J., George, C., and Walker, J. (2006), *Redesigning an Appropriate Technology Shredder for Manufacture in a Developing Country*, International Journal for Service Learning in Engineering, Vol. 1, No. 1, pp. 11-26, Spring 2006.
3. Bruun, P., & Medfford, R.N. (1996). *A Framework for Selecting and Introducing Appropriate Production Technology in Developing Countries*. International Journal of Production Economies, 1996:46-47:197-209.
4. Thilmany, J. (2005). *Managing Across Cultures*. ASME magazine, 2005:127:2:41-43.
5. Sukumaran, B., Jahan, K., Dorland, D., Everett, J., Kadlowec, J., and Chin, S. (2006). *Engineering Clinics, An Integration of Research into the Undergraduate Engineering Curriculum.* CUR Quarterly, Vol. 26, No. 3, March 2006.
6. Bonzella, J., Choma, S., O'Brien, K. (2007), *Development of Human Powered Grain Crusher For Developing Countries*, Final report for Engineering Clinics, Spring 2007.
7. Bonzella, J., Klein, H., and McGarvey, K. (2007), *Development of Human Powered Grain Crusher For Developing Countries*, Final report for Engineering Clinics, Fall 2007.