Generating entrepreneurship opportunities for the developing world through the engineering curriculum

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ABSTRACT: The proposed programme, *Entrepreneurs without Borders*, seeks to establish entrepreneurship opportunities for the developing world. This will be achieved through student teams that comprise both engineering and business majors at Rowan University in Glassboro, USA. The engineering and business students involved will perform a survey of local communities in the developing world, identified as having a need for engineering skills by Engineers without Borders (EWB). During this initial survey, students will identify local entrepreneurial opportunities that require the redesign or development of a device that will enhance the quality of life of the local area. Students will then work on the redesign or development of the device using local materials and input from the local community utilising funding from the Rowan University Venture Capital Fund (RUVCF). Business students on the team will perform a business feasibility analysis and present the plan to the community, which can then develop these devices for the local or wider region.

INTRODUCTION

The proposed programme, *Entrepreneurs without Borders*, will establish entrepreneurship opportunities for the developing world using engineering design, entrepreneurship and business skills available at Rowan University, Glassboro, USA. The programme employs longstanding collaborations between the College of Engineering, College of Business and Engineers without Borders (EWB). Teams of engineering and business students will conduct a survey of communities in the developing world with whom the College of Engineering has established relationships through EWB projects or which will be identified in the future to assess local needs and identify entrepreneurial opportunities. The programme builds upon earlier successes that Rowan has had with developing entrepreneurial skills, including the Undergraduate Venture Capital Fund and the development of the Technology Entrepreneur Concentration, which were funded by the National Collegiate Inventors and Innovators Alliance (NCIIA).

Active since 2004, the College of Engineering's chapter of the EWB has undertaken potable water distribution system projects in Honduras, El Salvador and Thailand, and a fish hatchery and geothermal power generation design for Cheyenne, South Dakota [1]. One of the emphases of the EWB is that personnel involved with project implementation in different regions of the world also maintain longstanding relationships with them. In addition, a social survey of the local population is required and designs being implemented must be approved by the community and not disrupt the social fabric.

The proposed programme will be implemented in the Junior/Senior Engineering Clinics, the last four semesters of the eight-semester engineering clinic sequence. Engineering Clinics allow students to practice a wide range of engineering skills in a multidisciplinary environment while honing their design skills throughout their four-year career [2]. The Junior/Senior Clinics offer faculty and students venues to conduct applied and fundamental research or design for the local or global community as with projects through the EWB. Students are chosen for these projects using a job fair model based on their interests, skill sets and required personnel.

An example of a project that could have uses in various parts of the developing world is the development of a human, animal or electric powered grain crusher. This project arose as a result of observation of local communities in the developing world and is already being implemented through the Junior/Senior Clinic. A group of three engineering students, junior and senior mechanical and civil engineering students, are investigating and designing an environmentally sustainable grain crusher that can be easily operated and built using locally available materials. The missing element in developing the product is the business perspective and market analysis. With the proposed programme in place, engineering students will be 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 that has very little access to resources.

CURRICULAR CONTEXT

Rowan University is a strong proponent of experiential learning, a *bottom-up* method in which general lessons and principles are learned through direct personal experiences and observations. Active modes of learning can enrich, broaden and deepen the knowledge base, which is gained from readings and class lectures [3-5]. It will be demonstrated in the following sections that experiential learning is a hallmark of Rowan's engineering and business curriculum, which will be utilised for this project.

Engineering Clinic Sequence

The College of Engineering at Rowan University had its origins in 1992 because a local industrialist, Henry M. Rowan,

made a generous gift of $100 million to then Glassboro State College [6]. As a result of the donation, the Rowan Engineering programme was started in 1996 with the primary mission of developing an innovative engineering curriculum that will produce engineers suited to meet the needs of a challenging workplace in the 21st Century. The Rowan engineering programme implements the use of innovative methods of teaching and learning to prepare students for entry into a rapidly changing and highly competitive marketplace [7-9].

The hallmark of the Rowan engineering programme is a unique common set of classes known as Engineering Clinics – an eight-semester course sequence from the freshman to the senior year. The Clinics are designed to address the challenges arising from changes in engineering education that require the incorporation of more design into the curriculum. Design represents the solution of open-ended problems that challenge students to apply higher-level skills such as analysis, synthesis and evaluation. Many engineering programmes currently include a capstone design course to meet design needs, but this approach has shortcomings. In a one- or two-semester course, the need to include varied skills in communication, project management and teamwork takes away from the focus on design skills development. In addition, the traditional capstone design course often is not multidisciplinary, which is a valuable experience for preparing students for the workplace. Finally, the capstone project occurs at the end the undergraduate career, minimising opportunities for students to continuously apply skills learned in supporting coursework. In contrast, Engineering Clinics allow students to practice a wide range of engineering skills in a multidisciplinary environment while honing their design skills throughout their four-year career.

The Engineering Clinic sequence is shown in Table 1, including the design emphasis in each semester and the incremental design experience from the freshman to the senior year. Students earn a total of 20 credits through the Engineering Clinics. Students in the Junior/Senior Clinics have a more rigorous research or design experience, possible because of their experience in the freshman and sophomore clinics and classes. The projects are also highly diverse in terms of their deliverables, collaborations and nature of work performed. The Junior/Senior Clinics offer the faculty and students venues to conduct applied and fundamental research as well as pursue entrepreneurial opportunities and ideas.

Table 1: Overview of course content in the eight-semester Engineering Clinic sequence.

Year	Engineering Clinic Theme (Fall)	Engineering Clinic Theme (Spring)
Freshman	Engineering Measurements	Competitive Assessment Laboratory
Sophomore	16-Week Multidisciplinary Design Project/Composition & Rhetoric	16-Week Multidisciplinary Design Project/ Public Speaking
Junior & Senior	Multidisciplinary Capstone Design/Research Project	

Collaborations and industrial partnerships range from projects with regional industry to international projects with universities, businesses, and local and global communities. The Clinics at this stage also allow students to propose their own ideas and be funded through the NCIIA Rowan Undergraduate Venture Capital Fund (RUVCF), specifically earmarked for the development of original inventions by multidisciplinary student teams within the Junior and Senior Engineering Clinics [10][11]. In addition, students also work on service-related projects like EWB projects and the Rowan Katrina Relief project. The mechanism for the development of e-teams and entrepreneurship opportunities using the RUVCF is elaborated on below. The same mechanism can be used for this proposed work. The flexibility in the curriculum and the further opportunity for collaboration with the College of Business enables this proposed work to be pursued. Business students involved in this project will primarily be undergraduate and MBA entrepreneurship students.

Business Discipline Context

The theory and practice of entrepreneurship is becoming increasingly important for solving economic and social challenges. Rowan University students are taught to understand global economic, social, political and environmental events, problems and opportunities as they impact on emerging enterprises, non-profit entities and corporate extensions. Students are infused with authentic information, valid conceptual frameworks and models, as well as an emphasis on innovation and venture effectiveness using entrepreneurial problems and cases. They apply this knowledge skill and values through faculty-coordinated project-based learning experiences, and exposure to opportunities to actively engage with new and growing ventures and individual entrepreneurs.

Experiential and Project-Based Learning Emphasis

Rowan University's Rohrer College of Business emphasises outside of classroom learning experiences to help students integrate their formal classroom education with *rolling up their sleeves* to work on business, economic development and non-profit organisation projects. Entrepreneurship students can bring business and social awareness skills and abilities as they work with engineering students to evaluate and plan the business components of this project. Students from courses including *New Venture Development* (business plan course), *Consulting* (senior capstone course) and *Social Entrepreneurship* will be on hand to move the project forward.

Previous works in the area that will be utilised by the project include product redesign for the developing world as described by Weiss, George and Walker [12]. In their paper, they have described efforts at developing products that can be redesigned using local materials, are sustainable and carried out 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 refs [13] and [14]. Appropriate sustainable technologies used by the EWB will also be utilised to determine the appropriate technological framework to be used.

SUGGESTED APPROACH AND EXPECTED OUTCOMES

The programme builds on longstanding collaborations between the College of Engineering and the Rohrer College of Business in the development of the technology entrepreneur concentration, and hopes to strengthen it by involving business students in Engineering Clinics, especially as it pertains to the development of entrepreneurial opportunities for the developing world. The proposed programme also utilises collaborations between the College of Engineering and the EWB. Indeed, the EWB chapter at Rowan has worked on potable water delivery system

projects in diverse countries such as Thailand, Honduras and El Salvador. In addition, it has worked on a fish hatchery project in Cheyenne, South Dakota. This has enabled undergraduate students who work on these projects, mostly through the Junior and Senior Clinics, to build long-term relationships with these communities. The proposed project will use some of these contacts and develop new contacts through the projects that the student chapter will adopt in the future.

Specific entrepreneurial efforts will be developed based on an assessment of the local needs and economy and will be carried out jointly by engineering and business students in e-teams. The students will utilise a Participatory Action Research (PAR) approach, which is also recommended by EWB [15]. The PAR approach is to use the local population in the developing world to identify the problems that affect their community and to find solutions to their problems by involving them in the design. It has been shown that the PAR approach results in the most sustainable and environmentally friendly solution utilising local materials and knowledge.

Rowan University has a successful history of utilising e-teams to develop innovative technology-based products and transform these product ideas into viable business opportunities. Many of these projects have been funded through the RUVCF, which has been generously supported by a series of grants by the NCIIA and the Rowan Family Foundation.

Funding of up to $2,500 per team is awarded to student teams based on a competitive proposal process. To date, over $120,000 has been raised and awarded to over 30 student teams, resulting in various start-up companies. The following are recent examples of products/companies that were initiated from seed funding from the RUVCF:

- ClutchKnobs: Guitar Tuning Device (US Patent 6,703,547);
- ChemoTemp;
- SnoRhino (patent pending);
- The Helping Hand (patent pending);
- Drill Bite;
- DigiTails (patent pending);
- Eyezon;
- Systems of Apollo;
- Sport-specific Knee Brace;
- Tree-based Web Visualization (patent pending);
- Pet Finder.

With the mechanism in place to conduct projects for credit within the Engineering Clinic and to obtain funding for original student enterprises via the RUVCF, the present *Entrepreneurs without Borders* programme can be seamlessly implemented. Students will develop technological solutions to problems identified by the survey group, as determined during their surveys of the community. Two projects will be carried out each semester through the Junior and Senior Clinics, and each team will include one or more business student. Alternate designs will be generated, if necessary, and presented to the community. Most of the projects will be focused on developing devices or solutions that will have a market potential in the area, as well as globally in the developing world. The design and development of devices or design solutions will only be undertaken after a market evaluation.

From the College of Business's perspective, this will be a wonderful opportunity to expose US entrepreneurship students to grassroots opportunities in radically different parts of the world, giving them a special sense of global markets. The College of Business has courses in international business management, international marketing and international finance, as well as a full suite of entrepreneurship courses. Student participation will be invited from all of these courses, as well as a broad international faculty. The College's effort to broadly implement project-based learning is strongly supported by the Rohrer Foundation. Business students participating in this project will be eligible for travel funding from the Rohrer Foundation funds.

In addition, the proposed programme will expose entrepreneurship and engineering students in developed countries to developing world challenges and opportunities. Students need to see that the range of problems and the range of solutions are really much wider than they normally experience within 100 miles of home. That exposure is likely to lead to broader thinking and more creative solutions to large classes of social, economic and technological problems. A natural inclination to help others less fortunate will take on real meaning, and will be refined by a much deeper understanding and respect for people living in very different conditions. Working on a multi-disciplinary team with business and engineering students will also bring different strengths to the team that will enhance the students' learning experience. Engineering students will utilise their technical skills and technical literature knowledge, while business students will bring their market analysis skills and capital knowledge. The exposure to different perspectives, knowledge base and literature will be a valuable experience provided to students by this project and will generate a new generation of entrepreneurs.

Communication between students and faculty supervisors will be undertaken weekly, as is customary in engineering clinics and the project-based learning courses in business. In all projects involving the EWB, there is a partner that the team is in constant communication with during the design. The project team will also secure additional local contacts like universities in the area who will assist with local cultural factors and available local materials during the design phase. Communication with end users will be realised through local contacts during the design phase, but input will be solicited during the initial survey and implementation phases.

The specific outcomes that will be produced as a result of this project will be to generate technological solutions to problems faced in the developing world using detailed opportunity recognition evaluations and the development of prototypes. This will be developed in collaboration with local communities in the developing world. In addition, students will provide a business feasibility analysis study to determine the market potential of the product for use in the local or regional community. The community will have an opportunity to provide feedback on the business plan and implementation. In summary, Rowan University students will provide:

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

The products that will be generated as a result will alleviate poverty in the region and 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.

EVALUATION AND SUSTAINABILITY PLAN

This project is being designed to achieve both business and ecological sustainability. On the business side, it is a known fact that many worthwhile ventures with ecological merit do not achieve full financial break-even. By involving the entrepreneurship students, the e-teams will have to find the most viable economic models. With this new programme in social entrepreneurship, students will be exposed to alternative financial models. Students will be expected to apply a full range of financial alternatives, including public and foundation support, as they assess business sustainability.

The engineering and business team will also develop collaboration with both local for-profit and non-profit organisations or nearby schools to reach out to the rural community to understand the rural behaviours and preferences. The team will then develop a structured communication process for creating long-term implementation and will focus their efforts on the selection of the right kind of people for training and effective community outreach, including a targeted contact programme, to achieve financial self-sustainability [16]. The effective development of new ventures in these environments has been rare. The team will consider these projects to be successful to the extent that:

- They approximate financial break-even;
- They create value-added jobs, ie jobs that pay participants more than they would otherwise have earned;
- Economic activity (eg circulation) increases in the primary communities;
- Economic activity occurs (ie sales to third parties, real receipts, purchases of materials and labour).

The assessment of these performance measures will be conducted through discussions with community leaders to recreate a community-level economic history going back some years. This will identify the number of adults and children in the community over time, including mortality rates, net migration, as well as the types and qualities of employment and self-employment. Over several years, changes in the patterns will be assessed in terms of these variables. Alternative explanations for the patterns around the time of the projects will be sought so as to obtain a clear assessment of the project's impact.

The evaluation of the learning experiences of the students will be carried out using traditional and non-traditional assessment tools. The College of Engineering already has programme- and college-level assessment tools in place for the Clinics, including quantitative and qualitative measures. The education assessment coordinator, who will be hired as an external consultant from the College of Education, will work with the engineering assessment committee and the Clinic committee to expand efforts to address the needs of this project and create new, or modify existing, rubrics as needed.

CONCLUSIONS

In this article, the authors present a model for developing entrepreneurial opportunities in the developing world utilising engineering and business students. It is important to expose business and engineering students in the developed world to challenges and opportunities in the developing world. Students need to become aware that the range of problems and solutions is really much wider than what is normally prescribed through a traditional classroom experience. Working in multi-disciplinary teams, these students will see both the need for other kinds of knowledge, as well as the potential for real problem-solving when multiple perspectives and skill-sets are applied. A natural inclination to help other less fortunate will take on real meaning, and be refined by much deeper understanding and respect for people living in very different conditions. A model is presented for how this valuable opportunity can be incorporated into the curriculum, which can also be adapted for use at other universities.

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