AC 2011-974: ENTREPRENEURSHIP IN THE IRON RANGE ENGINEERING (IRE) MODEL

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Entrepreneurship in the Iron Range Engineering (IRE) Model

The aim of this paper is to describe a new model for engineering education that has entrepreneurship, in its many forms, as a focus. Issues involved with integrating student-based entrepreneurship into the educational process are also described.

Background:

Entrepreneurialism in engineering education has a long history[1,2]. As the pace and importance of innovation in a global economy increases, the need for improving the efficiency of the innovation and commercialization becomes more critical than ever. Many engineering programs in other countries are examining the entrepreneurial process in the context of engineering education[3,4,5,6]. Concurrently, there have been a number of calls for a shift in engineering education, most notably from the National Academy of Engineering[7,8,9]. Out of these realities, a new educational model has recently evolved.

Model description:

In the heart of Minnesota's Mesabi iron range, a new model for engineering education began delivery in January 2010. The Iron Range Engineering (IRE) model is a project-based-learning (PjBL) program in which students work closely with industry on design projects or projects leading to start-up companies throughout their 3rd and 4th years. The goal of this approach is to produce graduates with significant integrated technical/professional knowledge and competencies and produce economic development for the region.

IRE students are upper-division engineering students who are enrolled at Minnesota State University Mankato and are typically graduates of Minnesota's community colleges, most commonly from Itasca Community College Engineering (Grand Rapids, MN). At present, 24 students are enrolled (all juniors because this is IRE's first year) with the target enrollment placed at 50 total (25 juniors and 25 seniors).

The majority of the student learning is done in the context of industry engineering projects, in contrast to the traditional distinctly topical engineering classes. Their degree will be a B.S. in Engineering with emphases along a spectrum between what might be traditionally called mechanical engineering and electrical engineering. Each student creates their own emphasis for the degree, by choosing particular courses or projects which appeal to them. This empowerment promotes the interest level and motivation of the student, and leads to the ability for deeper learning and longer retention of the material. This program aims to break down engineering disciplinary silos and prepare engineers who are "able to understand issues that transcend disciplinary boundaries and to be able to offer effective solutions"[10].

The IRE model is roughly a 40 hour-per-week experience in an engineering-type office/lab setting where students learn engineering design through actual practice and managing engineering projects for industry clients. Students manage the acquisition of their technical competencies by learning and applying the engineering concepts in context with their design.

Roughly, 20 hours per week are dedicated to design execution and 20 hours to technical learning with the goal of synergy between the two. At IRE, PjBL model allows for multiple semester immersion in a sequence of entrepreneurial design project as a foundation for the students' engineering knowledge acquisition, in contrast to a single course or a design course sequence with one project[11,12].

The IRE model offers three value propositions: First, the students perform design, teamwork, and project management tasks every day, with the intention of developing a more work-ready graduate and industry gets to know new engineering talent and has a better chance at recruiting known new talent. Second, by performing tasks important to the company it is intended that the company's global competitiveness will be maintained or enhanced. Third, by encouraging students to transform their intellectual capital into start-up companies, the region benefits from economic development.

Forms of entrepreneurial activity:

At IRE, ideas for commercialization can be from external or internal sources. External sources include innovators, investors, and industry. Internal sources are students and faculty of IRE. The focus of this paper will be in detailing the entrepreneurial process for investors, innovators, students, and faculty. The process used by industry is discussed in a separate paper and will not be addressed here. Students are encouraged to pursue their own ideas as projects during their attendance, since combining education with the pursuit of personal interests fosters an interest in entrepreneurship[13]. Some ongoing examples include a fluid dynamics based portable generator and a low cost computerized custom-fit clothing tailoring process.

Process overview:

For external sources, such as innovators and investors, confidentiality agreements (CDA) are signed before substantive discussions begin about an idea. If the idea is deemed suitable for a student project, intellectual property (IP) agreements are then signed that spell out the terms of IP ownership and rights [14]. If the idea may lead to a new startup, additional documents are drafted to delineate the company management structure, by-laws and operations in addition to the IP documents. Otherwise, for internal sources of ideas, the students and faculty are under a blanket internal CDA and are reminded about their professional responsibilities in protecting others' information. As with external sources, the idea may lead to a new startup and the company documents are drafted as described above.

The students begin technical work on the project and have weekly design meetings with either internal or external clients. The engineering students also begin developing a business plan using a template from a business plan competition as a guide. Regional economic development offices help the team with rudimentary business plan development. In our region the Arrowhead Growth Alliance – a consortium of various governmental and business groups – offers assistance to the student teams in the development of the business plan[15]. Through weekly reviews and external advice, the student team moves the concept through technical and business development cycles that culminates in a submission to a business plan competition. In our region, our target business plan competition is the Minnesota Cup's student division[16].

Depending on the feedback the team receives from the MN Cup and, if the external investors agree, the team prepares a SBIR/STTR proposal to the appropriate federal agency. The SBIR/STTR proposal receives a vigorous pre-review from a panel of outside reviewers under protection of CDA.

If successful, the team and internal or external clients then start the new company or proceed with development of the idea on a commercial scale. After receiving SBIR/STTR funding, other external investment agencies will contribute to the newly formed company moves external to IRE and the institution. Because of the IRE PjBL model, IRE can continue to assist the new external business by providing new student teams to work on new company projects.

Considerations for entrepreneurial activities in the educational process:

The number one consideration in integrating entrepreneurial activity into the educational process is IP policies. In essence, each investor or innovator may keep the IP directly resulting from the assigned entrepreneurial project work, because of a progressive student work IP policy at Minnesota State University – Mankato (MSUM) [14]. This IP can then be shared with the students or program as described in the related IP documentation as detailed in the process section above. If MSUM's IP policy were to change and become more protective of undergraduate student work and/or demand more university ownership, the entrepreneurial and education synergy would most likely suffer.

Working on a new idea will sometimes involve patentable works. IRE encourages the patenting of any innovative work by the investors or innovators and the students. The patent process can be expensive, so balancing the up-front costs with the ownership of the work becomes an important topic for discussion. Much of this can be spelled out in the company management document, if applicable. Similar to a business plan, the patent process itself is very rigorous and lengthy. Student time must be managed wisely if they are the initiators of the patent process. The ownership of the patent can be negotiated, but the listed inventors must contain all of the individuals who made significant contributions to the patent claims.

Conflict of interest and conflict of commitment issues abound in the entrepreneurial activities in education. Conflict of interest can occur between the parties – especially when there is a perceived power differential (student-faculty or faculty-director, etc) in which the faculty direction is heavily weighted towards project results rather than student education and improvement, by coercion. Conflict of commitment usually arises between faculty and their employer and deals primarily with the primary role of the faculty – to engage in education or to develop the idea. Conflict management plans can be bulky to administer and require a sometimes prohibitive personnel cost. Currently, IRE manages conflicts by inviting students and faculty, in writing, to discuss perceived conflicts with the appropriate administrators. Faculty conflict of commitment issues have not yet arisen, because our faculty are, at present, not involved as a partner in the business development. To reduce some of the future potential issues associated with conflict management, faculty are informed of the potential conflicts in their contract and the remediation methods.

A digital security workshop is conducted each semester to remind student of the intent and ramifications of storing sensitive information. All IRE computers require personal authentication to log in, with wireless access secured with 192 bit encryption. Locally stored files are kept on a password protected drive accessible through the local network only. Portable storage device content is encouraged to be encrypted to prevent access if lost or stolen. All written design work is recorded in hard-bound and page-numbered notebooks which are stored behind locked doors when students are not working. At present IRE is working on developing a secure local email system to allow confidential communications with clients over email.

The use of academic licensed software, instead of commercially licensed software, also becomes an important issue when working on projects for entrepreneurial activities. Some vendors allow use for design projects if done in the context of education by students. Others do not allow any use of the academic licensed software for potentially commercial design no matter if educational, or if used by students for educational purposes. In this latter case, sometimes comparable, if not superior, software can be found in the open source marketplace without encumbrance by closed source licensing issues. An example of such is Octave, an open source program comparable to MATLAB®. In other cases the commercially licensed software can be purchased by the academic institution for a reduced cost for use by the project. But in any event, it is critical for faculty and students to know and understand the professional and ethical considerations of design software licensing for commercial activities.

Outcomes:

The IRE program began in January 2010, therefore we have only one semester of results to report. A new student outcome was added to the ABET a-k. The new outcome has students develop an ability to engage in entrepreneurial activities. The objectives of which are to have students learn and apply the principles of entrepreneurialism to real world situations to develop an understanding of how business and economic factors influence engineering designs.

One measure that demonstrates a student's ability to engage in entrepreneurial activities is competition in large-scale business plan competitions (eg. Minnesota Cup). The first Minnesota Cup competition was summer of 2010, to which four IRE projects were submitted. Three were submitted in the Student division and one submitted in the Biosciences division. The Minnesota Cup had over 1000 overall entries in all divisions and three of the four IRE projects made the top 10 of their respective divisions, with only one project failing to make the top ten. In round two of the competition, those in the top 10 submit a full business plan which is evaluated by a team of experienced business and technical professionals and three plans are selected as semi-finalists. One IRE team made the top three, two did not. In round three, each semi-finalist, those in the top 3, present their business plan to a panel of business and technical experts and a division winner is selected. The winner is presented with a monetary award which can be used to help start the company as presented. Although the IRE team did not win the division, but the product is currently under commercialization efforts by a local company.

A secondary measure of student outcome success is student self-assessment. In evaluation of the students' self-assessed experiences, it was clear that the IRE students felt they did not have sufficient business background to answer some of the questions during the final round. As first semester junior engineering students, this is understandable. The student teams also participated in several professional workshops sponsored by the MN Cup organization on various aspects of the business plan process. These workshops provided valuable information which the students have shared with other students in IRE workshops.

Future developments:

In response to the self-assessments of the engineering students, a pilot project has begun with Minnesota State University – Mankato College of Business. Business students are now placed on the engineering entrepreneurial teams and will become part of the overall design and business plan process. Partnering business and engineering students together will provide engineers with deeper insight into the business concepts and strategies that go into marketing an idea. In an effort to expose the IRE engineering students to the impact of the manufacturing process on design and commercialization, trades students from the local community and technical college will be incorporated onto the engineering and business student teams to help manufacture the prototypes. The incorporation of business, trade, and engineering produces a multidisciplinary team that creates a spirit of entrepreneurship and broadens the students' experience[17].

A future development under consideration in the entrepreneurial process is the idea of a "superteam". A "superteam" involves the entrepreneurial team as already described but with the addition of external experts in technology, business, investment, and government. By bringing these experts on to the entrepreneurial teams, a more cohesive and coordinated approach to commercialization may be realized. However, the amount of oversight and other legal issues grows considerably specifically intellectual property rights and ownership will be determined on a case by case basis. In one pilot project, a superteam developed a medical device that is now under consideration for venture funding with a private investment company. Diversity, talent, teamwork and a good idea were found to be the key components for this modestly successful pilot effort.

Conclusion:

A new engineering education paradigm based on significant PjBL was described. Leveraging this new engineering model together with entrepreneurial activities improves both the educational value and experience of the students and helps create wealth in the region by developing IP and regional startup companies, which should prove to be globally competitive. . It is desired to recoup the intellectual capital developed in our students and provide opportunities for these talented young people to stay in our region. Our immediate goal is to continue developing a hybrid educational/economic development program that converts state tax dollars into regional and state-wide wealth.

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