Incubating Engineers: Entrepreneur-student collaboration in the teaching of entrepreneurship to Mechanical Engineers

Gabriel J. Costello
Galway-Mayo Institute of Technology
Galway, Ireland
gabrielj.costello@gmit.ie

Abstract

This paper will provide an example of using student-entrepreneur collaboration in the teaching of a module on entrepreneurship to Mechanical Engineering final year students at the Galway-Mayo Institute of Technology (GMIT) based in Ireland. Problem-based learning is one of the most significant recent innovations in the area of education for the professions. The focus in this type of learning is to provide the students with problem scenarios so that they can learn through a process of action and reflection. The purpose of this paper is to contribute to the debate on the best pedagogical approach to developing engineering undergraduate skills to meet the requirements of contemporary complex working environments. The work proposes to make an original contribution by directly interfacing with industry in order to simulate a real-life entrepreneur interaction for the students. Finally I argue that this work contributes new insights to the debate on "pedagogies of engagement".

INTRODUCTION

This paper will provide an example of using student-entrepreneur collaboration in the teaching of a module "Innovation and Enterprise" to Mechanical Engineering Level 8 final year students at the Galway-Mayo Institute of Technology (GMIT). The Accelerating Campus Entrepreneurship Initiative (ACE 2014) is a partnership between a number of Institutes of Technology and Universities in Ireland. The aim of the ACE project is to create entrepreneurial graduates through a collaborative approach. This work addresses one of the main objectives of the program.

> Targeted Action 3: Embedding Technology Entrepreneurship into Engineering Education, leveraging of non-curriculum activities from incubation/technology transfer offices.

According to Boud and Feletti (1998) "problem-based learning is the most significant innovation in the area of education for the professions in many years" (p. 1). The focus in this type of learning is to provide the students with problem scenarios so that they can learn through a process of action and reflection (Savin-Baden 2003). However some scholars argue that design "is hard to learn and harder still to teach"(Dym et al. 2005). Furthermore organizations, such as Engineers Ireland, are calling for graduate engineers to have more rounded skills in the areas of presentation, communication and team-working (Engineers Ireland 2013). This paper builds on design thinking (Cross 2000, Otto and Wood 2001, Ulrich and Eppinger 2000) and brings it to a new level by directly interfacing with an entrepreneur and simulating a real-life entrepreneur interaction for the students. The purpose of the work is to contribute to the debate on the best pedagogical approach to developing undergraduate skills to meet the requirements of contemporary complex working environments. The study is being carried out in the second semester 2013/2014 with twenty five students in the Mechanical Engineering level 8 *Product Design* stream. Ms Laura Taylor, entrepreneur and founder of Adventure Sports Innovations Limited (ASI 2014) challenged the class with a design problem and met with the student teams in January 2014 at the beginning of the semester. The students will present their solution and business plan to Laura and their Lecturer at the end of the semester. Figure 1 shows a high level view of the project life-cycle.

Figure 1: High level assignment structure

The paper proceeds as follows. Firstly the background to the study in GMIT is provided followed by a literature review of entrepreneurship publications in engineering education journals. Then the theoretical framework of reflective practice is outlined. Following this the methodology and the research approach is presented. Finally conclusions and recommendation for future work are proposed.

Background

GMIT opened two Innovation in Business Centers (IiBC) in late 2005 and mid-2006. These Innovation Centers were established with the support of Enterprise Ireland, and have a twofold objective; to support and facilitate the emergence of new market-led and knowledge-based companies in the region and, forge strategic links between the college and the world of industry and commerce. The Innovation in Business Centers, at GMIT Mayo campus and Galway campus, offer incubation facilities and a supportive environment to potential entrepreneurs in order to assist them in taking their ideas from concept to full commercialization (IiBC 2013). The students from the academic year 2013/2014 collaborated with Adventure Sports Innovations Limited, a start-up company in the IiBC. Figure 2 provides the design problem presented by the CEO Laura Taylor to the B.Eng (Hons) Mechanical Engineering class.

Project Specification

A wetsuit needs to be rinsed with fresh water and hung to dry between uses. It can take up to 12 hours for a wetsuit to drip dry. Teams are to come up with a better way to rinse and dry a wetsuit than is currently available and to develop a business plan for the new product. Keep in mind that UV light can damage the neoprene and hanging a wetsuit with thin hangers

Figure 2: The task presented by the entrepreneur to the students

Adventure Sports Innovations Limited (ASI) is a young Irish company that makes innovative products for the wetsuit accessory market. ASI's founder and CEO, Laura Taylor is the Irish National Snorkelling Development Officer. She is also a qualified instructor in many water sports including sea kayaking and is a beach lifeguard. Over many years of experience in the industry, Laura noticed water sport participants experiencing difficulty removing wetsuits after sporting activity. This led her to develop the Off'n'Up^{TM}, the world's first patent pending wetsuit removal tool. The company proposes to supply a range of other wetsuit accessories designed to make participating in water sports easier and more fun for all enthusiasts.

Literature Review

According to Luryi et al. (2007), engineering programs increasingly endeavor to include entrepreneurship and innovation in their curriculum. The environment of engineering they contend has radically changed in the last decade driven by advances in information and communications technology. Furthermore, globalization of manufacturing and R&D (research and development) has had a significant impact on how engineers work. Among their recommendations is that engineering programs "should involve hand-on business experience based on innovating engineering projects" (p. T2E-15). A review of major journals in the area of engineering education using the search word entrepreneurship yielded the following results. The Journal of Engineering Education (JEE) had fourteen publications on the subject of entrepreneurship from 2001 to 2009 while the European Journal of Engineering Education (EJEE) had ten publications on entrepreneurship from 2000 to 2012. Table 1 outlines the main contributions from a number of publications that are relevant for this study.

Table 1: A summary of relevant papers from the literature

Authors	**Journal**	**Summary of the main argument from the paper**
(Ohland et al. 2004)	JEE	Entrepreneurship programs add value to students
(Creed et al. 2002)	JEE	Paradigm Shift required: merger of classroom learning and industry participation
(Mendelson 2001).	JEE	Proposes joint projects between engineering and business students
(Silva et al. 2009).	EJEE	Teaching product development in an entrepreneurship framework promotes students skills
(Papayannakis et al. 2008)	EJEE	Entrepreneurship teaching should be part of a more general discussion related to educational priorities
(Casar 2000).	EJEE	Proposes a synergy between research and education

The literature summary in table 1 supports the argument of this paper that direct collaboration between an entrepreneur and students has a strong pedagogical basis. However any review of the literature must be cognisant of the words of Cooney and Murray (2008) that the debate continues on "whether or not entrepreneurship can be taught" (p. 19)

Now we will argue that the work of Donald Schön can provide a theoretical framework in which to position this study.

Theoretical Framework: reflective practice

Donald Schön's (1983) publication of The Reflective Practitioner is regarded as a seminal work in the debate on the benefits of reflection for practice and research. In the book he criticises the prevailing academic epistemology as having nothing to offer either practitioners "who wish to gain a better understanding of the practical uses and limits of research-based knowledge" or scholars "who wish to take a new view of professional action". Schön begins with the assumption that "competent practitioners usually know more than they can say" and that they exhibit "a kind of knowing in practice, most of which is tacit". Furthermore in disciplines such as medicine, management, and engineering, his experience was that professionals were exhibiting "a new awareness of a complexity which resists the skills and techniques of traditional expertise". Schön laments that the seeds of Positivism were firmly planted in the curricula of American universities and professional schools; a factor which he argues has contributed significantly to the contemporary fissure between research and practice. Furthermore he concludes that the present difficulty in accommodating contemporary phenomena such as "complexity, uncertainty, instability, uniqueness, and value conflict" stems from the positivist origins of technical rationality. He proposes the primacy of problem-setting over problem-solving for practitioners. Problems-setting he defines as an interactive process in which "we name the things to which we will attend and frame the context in which we will attend to them". The perennial dilemma of rigour and relevance is presented using the analogy of a hilly landscape. He describes the "high hard ground" as the place where practitioners can effectively apply research-based theories and methods. However the important and challenging problems exist in the "swampy lowland" of messy situations that do not respond to neat technical solutions. Furthermore according to Schön the earlier models of technical rationality have in general "failed to yield effective results" when dealing with the complex and fuzzy problems of technology management. In order to fit practice into the models of technical rationality and deal with the tension of rigour versus relevance, practitioners become "selectively inattentive" to data that do not fit neatly into their pre-defined categories. In addition, the following comment by Schön seems pertinent to the philosophical debate within the technical disciplines: "among philosophers of science no one wants any longer to be called a Positivist". Furthermore he observes that the growing rebirth of many areas recently consigned to the positivist graveyard such as craft, artistry and myth is further evidence of the failure of the positivist program. However he is at pains to point out that his problem is not with science *per se* but on the view of science portrayed by positivism. As an antidote to technical rationality, Schön proposes reflection-in-action built on the idea of knowing-in-action which he explains as:

> Our knowing is ordinarily tacit, implicit in our patterns of action and in our feel for the stuff with which we are dealing. It seems right to say that our knowing is in our action.

Furthermore, the "common sense" that reveals knowing-in-action to us also reveals that sometimes we "think about what we are doing". Schön believes that reflection-in-action is still not generally accepted in professional practice, even by those who actually carry it out, due to the professions still being viewed solely in terms of their technical expertise. He begins to describe an epistemology of reflection-in-action that "accounts for artistry in situations of uniqueness and uncertainty" to deal with conditions where the model of technical rationality "appears as radically incomplete". This section has outlined a theoretical framework to present my reflection as an educational practitioner on the teaching of this module. I argue, following Schön, that the pedagogical approach requires the practitioner to offer his or her tacit knowledge to the classroom experience rather than using a formal lecturing environment. Two forms of reflection are proposed in this study: reflection by the students on the project and self-reflection by both the lecturer and the entrepreneur.

Methodology and report of work

The product design modules taught to the mechanical engineering students can be described in a number of steps which are presented in figure 2 together with the high-level timeline.

Step 1: The lecturer makes contact with the IiBC management to established possible projects in advance of the commencement of the term. The center administrator contacts all the companies in the IiBC by email outlining the proposed format of the module and enquiring if any company would be willing to take part in the exercise. Another method of engaging with the start-ups was through a networking lunch organized twice per year by the IiBC and attended by the lecturer.

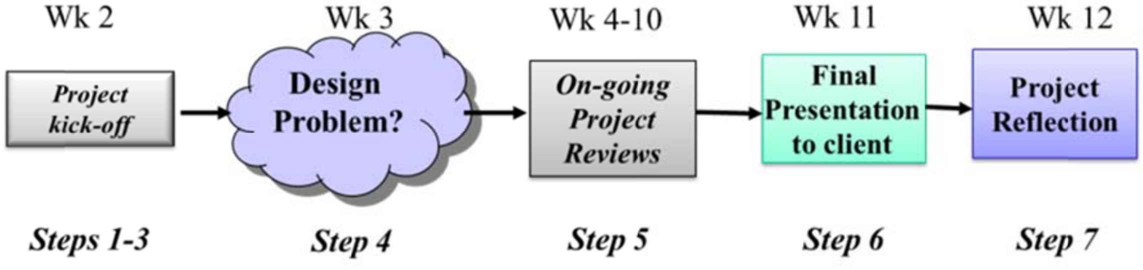

Figure 3: High Level Module Roadmap

Step 2: The lecturer meets with the client to further explain the pedagogical approach and to clarify requirements and deliverables. This is an important stage in developing a relationship with the entrepreneur at the beginning of the three month interaction. However it is worth stressing that work for the entrepreneur is kept at a very reasonable amount given the busy workload associated with start-up of a new venture.

Step 3: The entrepreneur completes a short description of the design problem (see figure 2) and sends it to the lecturer to review. This draft design brief is made available to the students via Moodle (an on-line eLearning application). The lecturer meets with the class and presents an overview of the module learning outcomes and the structure of the project as well as assessment criteria and expected project logistics. Then the class is divided into project teams (normally three students per team) and they review the draft design problem and prepare for a meeting with the entrepreneur on the following week.

Step 4: The class project teams meet the entrepreneur face-to face (see figure 4). The entrepreneur presents the design problem to the class verbally with more detailed description than in the design brief. This provides an opportunity for the class to get a more in-depth view of the clients thinking and to put themselves in the entrepreneur's shoes (Leonard and Rayport 1997). Also the project teams have time to question the entrepreneur based on their initial week long research into the problem domain. At this stage a date will be set on which each project team will present their design solution to the client at the end of the semester (Week 12). Also issues like Intellectual Property (IP) are discussed at this point and in some cases the students are asked to sign a non-disclosure agreement (NDA).

Figure 4: A photograph of the 2013/2014 class with the entrepreneur Ms Laura Taylor

Step 5: Each week the project teams present a status of their work to the lecturer who in this type of pedagogy acts as a coach and advisor rather than the conventional lecturing mode. The project teams work on the design problem during the semester using academic and industry standard product design methodologies (Cooper 2001, Eppinger 2001, Ulrich and Eppinger 2000) and with reference to suitable entrepreneurship publications (Burns 2001, Drucker 1993, O'Gorman and Cunningham 2007). The project teams initially complete a detailed project plan in the form of a Gantt chart before undertaking the main task of compiling a business plan.

Step 6: The class project teams present their design solutions and business plans to the entrepreneur and lecturer through oral presentation and a project report (in the form of a business case). Distribution of marks is the responsibility of the lecturer who, however, takes into account feedback from the entrepreneur on the quality and relevance of each project. The project deliverables include such items as: a set of working drawings, computer-aided design (CAD) models and/or renderings. An artifact such as a mock-up of the design in cardboard or other materials is encouraged but not mandatory. This early development of an artifact is now sometimes called preto-typing in the literature and also referred to as “fake it before you make it”. The business case will cover expected areas such as industry analysis, marketing plan, supply chain plan, financial plan and assessment of risk.

Step 7: Reflection and feedback from the students is built into the module review process. In the week 12 class of the module each student is required to do an assessment of their own contribution to the project. The rationale used for this is based on the lecturer’s experience (twenty years as an engineering practitioner) of having to complete end of year reviews. This feedback is important for the lecturer who is continually endeavouring to improve the module content and process year-on-year. Each team project is assessed and the same mark given to all students in a project team with 10% of the module marks for the presentation and 30% for the business plan. Typical project assessment criteria are outlined in table 2.

Table 2: typical project assessment criteria

Presentation: is the idea presented clearly, in an easy-to-understand format?
Innovation: What is unique about your product/service?
Market: Is there evidence of a substantial market?
Feasibility: Can the market be “won”. What level of investment is required?
Technical Content : level of technical detail or unique knowledge in case of service

Other factors which are taken into account include and may affect individual student’s grade.

- Attendance at weekly lecture/lab /team meetings
- Teamwork and contribution
- Construction of an Artifact (alpha model)

This section has outlined the seven step process used to simulate a real-life entrepreneurial experience for undergraduate mechanical engineers in their final year product design stream. Now I will describe some of the conclusions resulting from the work.

Conclusions

There were a number of learning experiences in this study: primarily by the students but also by the lecturer and the industry partner. Furthermore the project demonstrated the following learning outcomes:

- The module structure, described in this paper, has embedded entrepreneurial learning in the department of mechanical/industrial engineering.
- Working with the entrepreneur is a novel pedagogical approach that fosters entrepreneurial thinking and behavior among the students.
- Key stakeholders (in this case the manager and staff of the IiBC) have been persuaded to engage in the learning process. The manager has been very supportive of the process as it meets one of his remits: to involve the IiBC with the main GMIT campus.
- The project meets Targeted Action 3 of the ACE program as outlined in the introduction above.

This paper has limitations as it reports briefly on the students experience but future work intends to expand this and focus on the practitioner learning as well. Furthermore, as this paper was completed before the end of the semester there was not enough time for important data to be analyzed. From an initial analysis of the feedback in step 7, reaction to the project was positive as the students appreciated the opportunity to work in a *simulated* environment similar to what they would encounter in industry. Students were particularly pleased that their work might be implemented in a real-world product and not just be archived as another class project. The author intends to develop the concept of *simulation-based learning* as an enhancement of problem-based learning and this paper aims to support this objective. Comments and constructive criticism will be welcomed. Finally we argue that this work contributes new insights to the debate on “pedagogies of engagement” (Smith et al. 2005).

Nomenclature

ACE Accelerating Campus Entrepreneurship
CAD Computer Aided Design
GMIT Galway-Mayo Institute of Technology
IiBC Innovation in Business Centre
NDA Non-disclosure Agreement
PBL Problem-based Learning

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