# Assessment Tools for the Evaluation of the Level of Attainment of a Student Outcome Related to Entrepreneurial Activities

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## Abstract

*Mechanical engineering department at the United Arab Emirates University has added to the ABET student outcomes an additional outcome - "l: a recognition of the need for and an ability to engage in entrepreneurial activities". This paper details the assessment tools employed in measuring the level of attainment of this student outcome as well as implementation approach. Several direct and indirect assessment tools are developed for measuring the level of attainment of this additional outcome. Direct assessment is carried out through courses, graduation project, and industrial training while indirect assessment is executed through student exit survey, employer survey, alumni survey, and faculty opinion. The average achievement level of this additional outcome, between 2011 to 2014, among graduates is 3.8/5.*

**Keywords:** ABET; assessment tools; entrepreneurship; mechanical engineering; student outcomes

## 1. Introduction

Per ABET, student outcomes *a-k* of an engineering program are related to the skills, knowledge, and behavior amassed by students during their progression through the same. ABET also allows for applying additional outcomes to a program based on the specific needs dedicated by the constituents of the program, particularly the community and industry (ABET, 2016). To that end, the Department of Mechanical Engineering (ME) at the **U**nited **A**rab **E**mirates **U**niversity (UAEU) has applied an additional

outcome to its program and it is assigned the alphabet number '*l*' for obvious reasons. This outcome can be stated like other outcomes, as "*a recognition of the need for and an ability to engage in entrepreneurial activities*". The basis of creating this outcome, by the ME department at UAEU, are the need to create awareness among our graduates of the opportunities of technology-based-entrepreneurship as well as for preparing them to engage in the same without reservations.

ABET defines engineering as the profession in which knowledge of the mathematics and natural sciences, gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces in nature for the benefit of mankind [1]. This definition encompasses the need of engineering students to understand and gain the ability to perform economic analysis of entrepreneurial ventures. Various definitions of entrepreneurship, can be found in literature, with multiple similarities and distinctive differences among them. Churchill defined entrepreneurship as the "process of uncovering or developing an opportunity to create value through innovation and seizing that opportunity…" (Churchill, 1992). Kriewall reported that entrepreneurship can be defined as self-employment through business ownership that has significant elements of risk, control, and reward (Kriewall, 2010; Reeves, Zappe, Kisenwether, Follmer, & Menold, 2015).

Nowadays, more and more engineering graduates end up working in smaller but more entrepreneurial environments which demands "a broad range of skills and knowledge beyond a strong science and engineering background" (Creed, Suuberg, & Crawford, 2002). Entrepreneurial Engineer is the term used by Creed *et al.* (2002) to define the engineering graduate who possesses the ability to effectively communicate and work in a multi-disciplinary team in addition to having strong technical and engineering background (Creed et al., 2002). An in-depth look of engineering curricula reveals characteristics that provide a strong foundation as entrepreneurs. Wadhwa *et al*. reported that enterprise founders with engineering degrees have proven to be successful entrepreneurs. The study illustrated that 28% of US born tech founders of successful companies held engineering degrees (Wadhwa, Freeman, & Rissing, 2010).

### *1.1 Need for Entrepreneurship Education for Engineers*

It is well established that entrepreneurship is key to enhancing economic growth and innovation; empirical data supports the relationship between entrepreneurial activity and economic growth and innovation. This global economic and workforce shift towards entrepreneurship and innovation demands instilling entrepreneurial mindset in engineering graduate students (Sander, 2011). Fortunately, entrepreneurial skills can be taught as these are not necessarily personal traits (Welsh, Tullar & Nemati, 2016; Maresch, Harms, Kailer & Wimmer-Wurm, 2016). The challenges that engineers face in transitioning to the world of entrepreneurial activities and innovation, after spending a considerable amount of time receiving technical education, are due to lack of relevant knowledge and skills such as business practice, accounting and finance, operations management, team building, crisis management, and other skills (Sander, 2011). These additional skills desired in engineering graduates can taught as part of entrepreneurship education (Welsh, Tullar & Nemati, 2016; Maresch, Harms, Kailer & Wimmer-Wurm, 2016).

Established enterprises are in high demand of engineers with entrepreneurial skills and mindset to participate in the company's advancement as well as enhancement of the firm's ability to compete with international and global peers and adapt to technological changes (Antoncic & Hisrich, 2001; Menzel, Aaltio, & Ulijn, 2007). Renewal and revitalization of large companies can involve mergers and consolidation, spin offs, acquisitions, outsourcing, and adopting innovative practices to decrease product time-to-market (Creed et al., 2002). Involvement in these activities require engineers with a unique set of leadership and management skills, including individual initiative, visionary thinking, opportunity seeking, flexibility, teamwork, and network building (Menzel et al., 2007).

### *1.2 Examples of Entrepreneurship in University Education*

Over the years, researchers developed an educational explanation for including entrepreneurial activities in engineering curriculum. The year 1983 saw entrepreneurship being introduced as a course in the engineering school of University of Mexico and since then several engineering schools have included entrepreneurship courses as part of their curriculum (Katz, 2003). A few examples of how entrepreneurship-related activities have been used within engineering courses to meet ABET outcomes are presented below.

Lehigh University, Washington State University, and Stevens Institute of technology have integrated the entrepreneurship mindset into their capstone design courses (Davis & Rose, 2007; Hazelwood, Valdevit, & Ritter, 2010; Watkins, 2006). Lehigh University offers engineering capstone design courses that align with the campus-wide entrepreneurship minor, and meets or exceeds ABET requirements. The courses provided examples of criterions and how they were aligned with Lehigh's Integrated Product Development Model (IPDM). The model is designed to analyze customer needs and to create wealth for the company stakeholders including owners, employees, the community, and nation.

Hazelwood *et al.* described a two semester course at Stevens Institute of Technology in New Jersey, United States (Hazelwood et al., 2010). The course enabled students to work with a physician to address real world clinical needs and develop basic product development and project management skills while working in small teams of 3 or 4. The authors reported that the course had resulted in a startup company.

Gassert *et al.* illustrated the integration of entrepreneurship into the undergraduate biomedical engineering curriculum at the Milwaukee School of Engineering (Gassert, Blessing, Schmedeman, & Fennigkoh, 2007). The faculty members were introduced to a model describing how entrepreneurship can be integrated into an already overcrowded engineering curriculum. The faculty learned how graduates who understand entrepreneurship are immediate strategic assets to an employer.

Sullivan *et al.* discussed an engineering course at the University of Colorado at Boulder which was described as being a team-based product design and development course designed to teach students the processes of invention and product innovation (Sullivan, Carlson, & Carlson, 2001). The course introduced students to the invention process through hands-on doing, while learning valuable engineering skills such as communication skills, feasibility study development, use of design software, and tools for exploring product invention and innovation.

Wise *et al.* discussed the finding of an assessment plan, lessons learned, and recent improvement applied

to the curriculum of a minor in engineering entrepreneurship at the Pennsylvania State University (Wise, Kisenwether, & Rzasa, 2003). The problem-based curriculum of the course is designed to encourage creativity, customer-oriented design, and foster understanding of the entrepreneurial business world. The authors used an online form that is completed by the students on their intention to continue in the entrepreneurship minor and to help improve the curriculum of the course he/she just had completed.

These studies clearly indicate that engineering faculty must value entrepreneurship education and understand how to address it in their courses for true transformation from pure technical courses to those that have components of entrepreneurship integrated within them.

### *1.3 Challenges in Entrepreneurship Education*

Many universities and colleges around the world are developing entrepreneurship programs. Due to the variation in the definition of entrepreneurship, there are considerable differences in the education curriculum and the associated outcomes (Duval-Couetil, 2013). Gorman *et al.* carried out a survey of the literature on entrepreneurship education and concluded extreme diversity in teaching strategies and curriculum designs (Gorman, Hanlon, & King, 1997). Other challenges include the multidisciplinary nature of the field of entrepreneurship, the various program models that exist, and the numerus academic and professional backgrounds of those involved in teaching the same (Duval-Couetil, 2013; Zappe, Hochstedt, Kisenwether, & Shartrand, 2013).

Multiple barriers exist in the educational curriculum that limit the students' participation in entrepreneurship courses. Standish-Kuon and Rice illustrated that many engineering students face the dilemma of the limited availability of approved electives that specifically teach entrepreneurship (Standish-Kuon & Rice, 2002). Acquiring the accreditation of ABET forces many institutions to design their academic programs in a very structured and sequenced manner which bounds the students' ability to enroll in elective courses outside the immediate scope of the engineering discipline. A major barrier stated by Zappe *et al.* is the limited experience or interest of the engineering faculty members in delivering entrepreneurship courses or activities (Zappe et al., 2013). This led to relying greatly on non-faculty members (non-tenure track) or practitioners to teach entrepreneurship. Furthermore, many institutions that are willing to offer and integrate entrepreneurship programs face the difficulty with funding especially when the course is offered in multi-disciplinary college.

This paper discusses the method and techniques used to evaluate the entrepreneurship skills gained by students in the enrolled in the mechanical engineering undergraduate program at the UAEU. The main outcomes of the methods employed are illustrated and the effectiveness of each method is evaluated for future development and enhancement.

## 2. Entrepreneurship Education in Engineering at UAEU

Starting in 2005, the College of Engineering at UAEU has developed a general engineering course titled "*Engineering practice and entrepreneurship*". Students enrolled in the engineering programs of the College of Engineering must attend this course as a part of their study. The goal of this course is to familiarize the students with economics and entrepreneurial activities that can prove to be beneficial to

them after their graduation. The course combines lectures and projects in which a business plan is developed and presented at the end of the semester.

Recently, the ME department at UAEU integrated the concept of entrepreneurship in the mechanical engineering curriculum in the form of different projects to be executed by student groups. This approach allows educating ME students about entrepreneurship without having to restructure the curriculum. Also, this approach at entrepreneurship education is action based as traditional teaching alone is not sufficient for training students on the concepts of entrepreneurship.

### *2.1 Assessment of the Entrepreneurial Education at the ME Department with UAEU*

The ME department has developed several assessment tools to evaluate the achievement levels of the student outcomes (*a-k+l*). There are twelve outcomes, including SO *l* which is the outcome pertaining the recognition for the need for the entrepreneurial activates. Outcome *l* statement is "*a recognition of the need for and an ability to engage in entrepreneurial activities*".

### *2.2 Assessment Tools considered for Attainment Level of SO l*

Direct and indirect assessment tools are used for evaluating SO *l*. Direct here means there is a quantitative measure set for student activities that are related to SO *l*. However, indirect means an opinion is drawn about the students' performance towards the achievement of this student outcome. Table 1 presents the tools used for assessing SO *l*, including frequency and assessment criterion. A brief description of the assessment tools is presented next.

**Table 1:** Assessment Tools Considered for the Attainment Level of SO *l*

| Type | Assessment Tool | Required task | Frequency | Assessment criterion |
|---|---|---|---|---|
| Direct | Course assessment | Presentation or term paper | Every offering | Instructor evaluation |
| Direct | ME direct measures of GP | Answer of oral questions | Every term | ME faculty examiner evaluation |
| Direct | ME Direct measure of IT | Answer of oral questions | Every term | ME faculty examiner evaluation |
| Indirect | Student survey | Student opinion of SO *l* | Every time course is offered | 5 points scale |
| Indirect | Student exit survey | Student opinion of SO *l* | Every term | 5 points scale |
| Indirect | Employer survey | Opinion of SO *l* achievement | Every two years | 5 points scale |
| Indirect | Alumni survey | Opinion of SO *l* achievement | Every two years | 5 points scale |
| Indirect | Faculty opinion | Opinion of SO *l* achievement | Every year | 5 points scale |

### 2.2.1 Course Assessment

The entrepreneurial education and skills are first introduced as a part of the general engineering course of *Engineering Practice and Entrepreneurship*. The ME department has selected several courses that focus on strengthening student entrepreneurial awareness in the related course subject. These courses are Manufacturing Processes, Introduction to CAM, Thermofluid System Design and Analysis, Machine Design II, Thermal Engineering Lab, and Design and Manufacturing Lab. Each course has a dedicated course outcome that is mapped directly to SO *l*. Several activities within the course are used to evaluate the student achievement level of the related course outcomes which reflect the attainment of SO *l* within that course. The achievement level of the course assessment tool is simply the average of the achievement levels for all considered courses. For instance, in the "Thermal Engineering Lab" an outcome states "inspiring the student and enhancing his/her entrepreneurial skills as relevant to the area of thermal engineering" is set. To satisfy this outcome, students need to propose a simple entrepreneurial idea for a cost-effective method of a cooling system. In most relevant courses, no additional material needs to be delivered to the student but rather students rely on their information and knowledge gained in the general engineering course of "*Engineering practice and Entrepreneurship*" and build on it to the specific area of the given course or lab. Typically, the student is required to submit a report or give a presentation which is then evaluated by the course instructor.

### 2.2.2 ME Direct Measures of Graduation Projects and Industrial Training

To gain a more direct way of evaluating the achievements of the SOs of the ME engineering curriculum from students, the ME department has developed a tool for assessing student performance in graduation project (capstone project) and industrial training (IT). It is a form of an evaluation performed by ME faculty present in the oral exam jury of ME students defending theses of their graduation projects or their industrial training reports. During the exam, the departmental representative asks relevant questions on the skill based outcomes and provides the appropriate mark. The marks are rated from 1 to 5 such that 1 implies poorly correlated answer and 5 meaning strongly correlated answer. The questions are listed below.

1. *"If you were to turn this project into a business venture, what steps would you need to take and what aspects should you consider?";*
2. *"Do you think your system can be marketed and if yes, how would you go about marketing it?";*
3. *"If you were to do this project again, how would you reduce the budget that you spent?";*
4. *"Does your project exist commercially and if yes, how does it compare, from a technical and financial point and what would you do to give yourself an advantage over the competition?".*

### 2.2.3 Student Surveys

Two types of student surveys are conducted for SO *l*. Along with the direct course assessment tool, there is a student course survey conducted at the end of each term for each course. The survey is a feedback on the level of attainment of the course outcomes as perceived and judged by the students themselves. The second survey is called "student exit survey" which is conducted at the end of student study in the ME

department and it provides input to the level of achievement of each of the twelve SOs including SO *l*. Each survey consists of multiple questions with score of each question varying between 1 (lowest satisfaction) and 5 (highest satisfaction). The questions asked to students, in different UAEU's ME courses, are listed below.

**Introduction to Computer Aided Manufacturing:** *"Students will be able to suggest entrepreneurial opportunities existing in UAE in computer integrated manufacturing"*

**Thermofluid System Design and Analysis:** *"Able to practice imagination and unlimited way of thinking and carry out discussions about examples that may help identify entrepreneurial opportunities"*

**Thermal Engineering Lab:** *"Inspiring the student and enhancing his/her entrepreneurial skills as relevant to the area of thermal engineering"*

**Design and Manufacturing Lab:** *"Students demonstrate an appreciation for entrepreneurial opportunities relevant to design and manufacturing"*

### 2.2.4 Employer Surveys

The opinion of the managers of our graduate achievement is very important. A survey is collected from our graduate employers regarding their opinion of the level of attainment of the student outcomes and the program objectives. These surveys are typically collected every two years. Each survey contains multiple questions where each question can be assigned a score between 1 and 5; 1 and 5 represents the lowest and highest satisfaction, respectively. The question is listed below.

*"How well the UAEU graduate recognize the need for and an ability to engage in entrepreneurial activities"*

### 2.2.5 Alumni Surveys

Like the student exit survey, an alumni survey is conducted seeking graduate opinion of their achievement of the student outcomes and program objectives of the ME department. Each of the participants need to select a score from 1 to 5 for each question of the survey, with 1 being the lowest and 5 being the highest. The question pertaining to entrepreneurship is listed below.

*"A recognition of the need for and an ability to engage in entrepreneurial activities"*

### 2.2.5 Faculty Opinion

Faculty members are requested to complete a survey similar to the student exit survey which requires faculty opinion on the performance in the achievement of each student outcome including SO *l*. They are required to provide a score from 1 to 5 (1 = lowest satisfaction and 5 = highest satisfaction).

## 3. Results of Achievement of SO *l* and Discussions and Plans for Future Work

Figure 1 shows the scores of the achievement levels of SO *l* using all considered assessment tools. It shows a somewhat consistent average of about 3.8 over seven terms between 2011 and 2014. It is noticeable that faculty opinion and their direct assessment of student achievement in their senior projects are rather low compared to the scores of the other tools. This is related to the nature of SO *l* where it is

quite hard to measure student achievement in the need and awareness of entrepreneurial by just asking them certain questions. The surveys on the other hand indicate higher score levels. It is very evident that there is some sort of discrepancies among the used tools and more systematic approach is required.

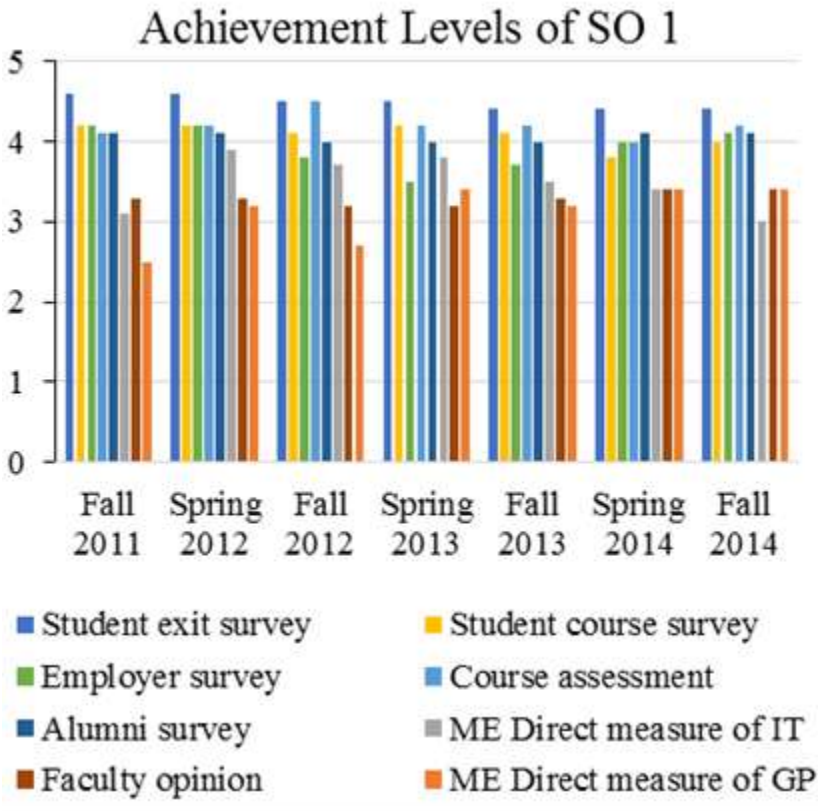


Figure 1. Achievement levels of SO *1* using all considered assessment tools

ABET has long been a major driver of change in engineering curricula as it accredits over 3,400 programs at more than 700 colleges and universities in 28 countries (ABET, 2016). Per ABET, accreditation has value and matters because it is "proof that a collegiate program has met certain standards necessary to produce graduates who are ready to enter their professions". Students who graduated from accredited programs have better opportunities at employment, licensure and certification, graduate education and global movement." Further, "accreditation is an assurance that the professionals who serve us have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and in anticipating the welfare and safety needs of the public." The accreditation process provides a structured method to develop, assess, evaluate and improve the quality of the academic programs.

The integration of entrepreneurship in engineering courses is a challenging task. The following represents some of the noticed challenges and observations:

Final grading of the projects is challenging as they are usually qualitative and the instructor must balance the students' lack of any experience in entrepreneurship with the high expectations of the course;

Typically, students tend to form their companies around relatively simple ideas (e.g. limited services, simple products) rather than bigger ideas that can make them successful entrepreneurs;

Teams of students from diverse cultures help stimulate learning. This is most beneficial to this type of courses as the diversity helps to bring broader range of experiences, ideas, and ideologies in making the virtual enterprises. In addition, it improves the level of discussion, risk taking, product features and marketing plans; and

The number of students enrolled in one class and assigned one instructor must be maintained adequately as the optimal size of a company executive team is 4-5 students. Individual discussion with teams and team presentation have to be taken into consideration in setting the class capacity.

Studies have shown that combinations of classical teaching and hands-on-approaches such as business plans, consultations with start-up entrepreneurs, computer and behavioral simulations, and published or live case studies are effective in entrepreneurship education (Beaury, Boyer, & Kisenwether, 2010; Kuratko, 2005; Neck & Greene, 2011). To this end, the ME department at UAEU is seeking to broaden the entrepreneurship projects to include visits from external investors and successful entrepreneurs who were once students in the same university. The evaluation process and methodology of integrating problems of entrepreneurship would still need further improvements.

## 5. Conclusion

Entrepreneurship education is becoming increasingly relevant in today's world. In light of this fact the mechanical engineering department at United Arab Emirates University is attempting at educating its graduates regarding entrepreneurship through existing courses without having to restructure the curriculum. Several barriers and challenges that are specific to the engineering programs and engineering faculty, are limiting the adoption and integration of entrepreneurship education in the engineering curriculum. One of these challenges is the condensed curriculum of engineering courses with technical material with no space for the addition of entrepreneurial activities. The lack of a unified and certified model for integration of entrepreneurship in all engineering disciplines need the attention of the faculty members to develop such model. The increased awareness of entrepreneurship among engineering graduates is the road to build a contemporary economy that is sustainable and innovative.

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