Entrepreneurship Education in Engineering: A Literature Review, and an Integrated Embedment Proposal

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Abstract: - Entrepreneurship education in engineering and technology is lacking in majority of Universities worldwide. More attention to engineering entrepreneurship education has been emerging recently. In this paper, a literature review on entrepreneurship and engineering entrepreneurship education is provided. The main findings of the review indicate the very new history of systematic integration of entrepreneurship education in engineering and technology curriculum, the positive impact on entrepreneurial attitude and intentions, and challenges faced in robust assessment of engineering entrepreneurship outcomes. Finally a proposal for embedding entrepreneurship in engineering education at various under- and post-graduate levels at the college of engineering, Qatar University is provided.

Key-Words: - Entrepreneurship, Engineering and Technology Entrepreneurship Education, Assessment, Entrepreneurial Skills and Attributes.

1 Introduction

Entrepreneurship has gained a significant attention worldwide. Many factors have contributed to the growing interest in entrepreneurship. In developed economics, entrepreneurial activities initiating formation of new enterprises reenergize weakening economics [1][2]. For both developed and developing economics, entrepreneurship has an essential role in job creation [1][3][4].

Several attempts have been identified in the literature to explain what entrepreneurship is. For instance, entrepreneurship is known as the creative destruction which leads to innovation [5]. It is also known as the mind-set and process to create and develop economic activity [6]. Liñán [7] adds, entrepreneurship is considered as a process where the entrepreneur interacts with his/her environment to identify an opportunity and, eventually, start a new venture. Tung [8] also defined entrepreneurship as an innovation process to exploit a business opportunity by applying entrepreneurial learning (knowledge and skills). From the social aspect, entrepreneurship is defined as the process of doing new and or something different for the purpose of creating wealth for the individual and adding values to society[9][8].

Therefore, entrepreneurial activities ruin the equilibrium of a country’s economy and create a new one [9]. According to Mueller, entrepreneurial behaviour has its clear effect in increasing the economic wealth of a nation [5].

A main focus is given to introducing entrepreneurship training and skills development in higher education as a way for instilling entrepreneurial activities and emergence of entrepreneurial SMEs. Furthermore, more attention has been given to the commercialization of university research as an additional way for entrepreneurial activities enrichment [11].

This paper provides a review on entrepreneurship and entrepreneurship education in engineering and technology. At first profiling an entrepreneur is provided. Main attributes and skills needed for an individual to become an entrepreneur are provided. Furthermore, models that identify an entrepreneur (intention, trait and other models) and the effect of environment on entrepreneurial inclination are detailed. This is followed by definition of entrepreneurial education and its importance. The controversy of “whether entrepreneurship can be taught or not” is discussed, and the effect of entrepreneurship education on development of entrepreneurship related skills and intention are outlined. Highlights of assessment practices in engineering entrepreneurship education, including examples of existing instruments, are provided.

2 Entrepreneurs Profiling

Attributes of an entrepreneur, various models that identify an entrepreneur, and the effect of the
surrounding environment on entrepreneurial inclination are discussed in the subsections below.

2.1 Skills and Personal Attributes of an Entrepreneur
The successful development of innovative firms, businesses, products and processes implies an entrepreneur to possess explicit skills and attributes that enable him/her to emerge in the entrepreneurial world [12][5].

To become an entrepreneur who is able to tackle dynamic, economic, social and potential challenges; one must possess entrepreneurial attributes such as risk-taking, innovation, self-confidence, creativity, problem solving skills, management skills, professional business skills, and readiness for change [8]. In addition to these skills, and based upon the review conducted by Ryan [13], a potential entrepreneur should have personal characteristics such as teamwork, sociability, flexibility, growth orientation [14], desirability, intention [15], locus of control, and innovativeness [16].

Another set of critical attributes mentioned by Sánchez [17] includes self-efficacy and pro-activeness. To become a triumphant entrepreneur, there are three “needs” identified by Oosterbeek [9]. The first is the need for achievement in which an individual sets high targets and puts the necessary efforts and action to reach such target levels. The second one is the need for power which refers to the person’s ability to control others and have a direct influence on their actions and behaviors. Finally, the need of autonomy which is usually a subconscious motive behind the choice of entrepreneurship activity.

Since the road of entrepreneurship is full of obstacles and hindrances, an entrepreneur should have a high level of endurance to continue willfully despite of difficulties [9]. In addition, the entrepreneurship world is a market which is based on continuous changes and social interactions. Therefore, social orientation and market awareness are two important aspects an entrepreneur should own [9].

2.2 Effect of Environment on Entrepreneurial Inclination
The environment surrounding potential entrepreneurs, graduates and undergraduates, has its clear and obvious effect on the entrepreneurial inclination. Environment in this context refers to the school culture, campus life, economical status and job satisfaction. Beginning with the school environment, Wang & Verza [18] mentioned that school culture, cultural orientation and the university environment effects students’ commitment to an entrepreneurial career [18]. The better these environments are and the more comfortable they are; the higher the entrepreneurial commitment.

Lange [19] refers that the higher the income of an individual, the lower their intention to become an entrepreneur. Another distinguished finding by Lange suggests that job dissatisfaction has its effect on the intentions of the alumni to become entrepreneurs. The higher the dissatisfaction, the higher the intention to become an entrepreneur [19].

3 Entrepreneurship Education
One way to grow entrepreneurial skills is through entrepreneurship education and training. The following sections begin with the definition of entrepreneurship education and its importance followed by the debatable views of the effectiveness of such education, that is, can entrepreneurship be taught? Finally, a discussion on the effect of entrepreneurship education on the development of entrepreneurship intentions and related skills is provided.

3.1 The Importance of Entrepreneurship Education
Entrepreneurship education is explained as the methods and approaches used to teach people to start new businesses successfully and operate such businesses profitably [8], [21]. Entrepreneurship education is defined as the “process of transmitting entrepreneurial knowledge and skills to students to help them exploit a business opportunity” [8].

Entrepreneurship education has an impact on increasing start-up rates [8]. Entrepreneurship education leads to the improvement of the level of knowledge about how to launch and manage a new business venture [22], enables students to gain experience in a real business context, foster favourable attitudes towards entrepreneurial activities [23][24][25][26], develops perception of self-efficacy of students [21], raises the level of students’ entrepreneurial intentions [27][28][20], and stimulates students to choose an entrepreneurial career [29].

Both Tung [8] and Liñán [7] agree that entrepreneurship education is considered as one of the main elements that contribute in the increase of entrepreneurial attitudes (potential and nascent). Entrepreneurship education is considered a vital component in the development and creation of such attitudes [23][24]. Lange [19] adds that students
who took one course on entrepreneurship explored entrepreneurship as a career. While students who took two or more courses, their intention to become an entrepreneur was influenced and the likelihood of actually becoming one was also increased.

This concludes that the development of positive attitudes towards entrepreneurship is significantly dependent on the awareness of entrepreneurship as an alternative which is achieved through entrepreneurship education.

3.2 Effect of entrepreneurship education on development of related skills and intention

It is clear from any successful educational process that it influences the students’ intentions and skills towards a desired outcome. Entrepreneurship education is no different. It affects the intention of students taking such education, either positively or negatively. It provides guidance and clarifies the unclear parts of entrepreneurship. Students majoring in entrepreneurship possess a higher level of intention to become an entrepreneur. Therefore, they are more likely to found companies. By majoring in entrepreneurship, the entrepreneurial intention and self-efficacy of the students’ increases to high levels compared with students majoring in other disciplines [5]. Furthermore, entrepreneurial intention is promoted by entrepreneurial education. This is so because entrepreneurial education equips students with the knowledge and skills that stirs up their interest, intention and motivation towards entrepreneurship [8].

By reviewing Mueller’s [5] paper, it is concluded that self-efficacy perceptions and attitudes are changed and learning is enabled by the following three main concepts of educational science: experimental learning. Emotion addressing, and student-oriented learning. Entrepreneurship education surely has its impact on entrepreneurial intention [8]. This statement is supported by Clark in which he “investigated the university students who studied an entrepreneurship course and reported that most of the students (80%) had entrepreneurial intentions which significantly predicted actual entrepreneurial actions. According to the authors, 75% of the students who had entrepreneurial intention subsequently started their own businesses after graduation” [30]. Entrepreneurship education also improves the students’ decision-making skills especially in the start-up process of a new business. This is accomplished by enhancing personality traits such as locus of control, need for achievement and self-efficacy [8].

3.3 Assessment of Entrepreneurship Education

In general, little literature has been developed on assessment of engineering entrepreneurship educational programs and courses [32][33]. Even less research has been conducted investigating the learning outcomes and the influence of engineering entrepreneurship courses and programs on students’ behaviors and attitudes exist [34]. One main reason for the lack of valid instruments to assess engineering entrepreneurship education (EEE) is that the efforts to incorporate entrepreneurship into engineering education curriculums are still relatively new [34]. One other reason of the scarcity of EEE assessment tools is the inconsistency of developed entrepreneurship educational programs [35], and hence the lower validity of global EEE instruments for different types of programs [36]. Duval-Couetil et al. [34] discussed three levels based on their literature review of assessment practices in EEE; those levels are: 1- course-level assessment, 2- focused instruments, and 3- program-level assessment. The main differences in between these levels are summarized in Table 1.

| Table 1. Types of Utilized Assessments in EEE |
|-----------------|--------------------------------------------------|
| **Level**       | **Description**                                  |
| Course-level assessment | Measures students’ reactions toward certain classes or activates within them (defined by [37] as student work grading, assessing learning outcomes, evaluation of the course) |
| Focused instruments | Present short-term measures of entrepreneurship learning, the methods used in these instruments targets specific objectives and used to collect quantitative data (Examples includes: Knowledge of entrepreneurship principles, Self-efficacy, Attitudes toward entrepreneurship and entrepreneurship education and Others). |
| Program-level assessment | Measures can cover targets of the previous levels but a much wider spectrum of outcomes and attitudes are covered. |

Some efforts identified in literature provide key considerations to aid the development of effective assessment approaches of enterprise education in general which can be adapted into assessment of EEE. An example on that would be considerations reported by[36], and adopted from[38][39]: 1-
“Assessment should be valid, reliable and consistent.”; 2- “The purpose of assessment should be clearly explained.”; 3- “The amount should be appropriate.”; 4- “The criteria should be understandable, explicit and transparent.”; 5- “Assessment should be based on understanding of how students learn.”; 6- “It should accommodate individual differences in students.”; 7- “Assessment procedures should allow students to receive feedback on their learning.”; 8- “Assessment should provide staff and students with opportunities to reflect on their practice and their learning.”; 9- “Assessment should be an integral component of course design.”.

4 Model Proposal for Engineering Entrepreneurship Education in Qatar

A progressive and contextualized conceptual model for engineering and technology entrepreneurship education and training in engineering under- and post-graduate studies in Qatar University is proposed in this section.

4.1 Undergraduate Education

Implementation will be through the following: 1-) Independent course, 2-) Embedded approach in other courses, 3-) Extra-curricular.

**Independent Course(s):** CMPS Project Management and Entrepreneurship (for Computer Science and Computer Engineering Students); New GENG 400 Technology and Innovation Entrepreneurship (Optional for all Engineering Students).

**Embedded approach in other courses and projects:** General Engineering Courses- GENG: GENG 107 Engineering Skills and Ethics, GENG 360 Engineering Economy, and Capstone Design/Senior Projects for all engineering students (Computer Science, Computer Engineering, Electrical Engineering, Mechanical Engineering, Industrial and Systems Engineering, Civil Engineering, and Architecture)

**Extra-Curricular Activities:** Extra curriculum activities will be planned via different activities:

1- Crash entrepreneurship introductory training courses offered by local organizations, namely Bedayah, Injaz, and Enterprise Qatar.
2- Entrepreneurship Competitions: Encouraging students to participate in local, regional, and international entrepreneurship (general and technical) competitions, such as: Injaz Al-Arab annual competition, Google Startup weekend, MIT.

4.2 Postgraduate Education:

A major part of embedding entrepreneurship in engineering in Qatar will be through postgraduate education at the college of engineering, Qatar University. A Minor in Technology Innovation and Entrepreneurship (9 credits, equivalent to 1 semester) will be introduced in the MSc in Computing Program, the MSc in Electrical Engineering, the MSc in Mechanical Engineering, the MSc in Civil Engineering, and the Engineering PhD Programs (11 specializations: Architecture, Urban Planning, Chemical Engineering, Computer Science, Computer Engineering, Civil Engineering, Electrical Engineering, Industrial and Systems Engineering, Mechanical Engineering, Environmental Engineering, Material Science and Engineering); Master programs are 4 semesters, and PhD programs are 6 semesters long. The following courses will be offered:

1- GENG 500 Principles of Technology and Innovation Analysis, Market Research, and Entrepreneurship (3 Credits)
2- GENG 520 Project in Technology and Innovation Entrepreneurship (3 Credits)
3- GENG 540 Advanced Technology Innovation and Entrepreneurship (3 Credits)

A Major in Technology Innovation and Entrepreneurship will be introduced in the MSc program in Engineering Management. A new track in Technology Innovation and Entrepreneurship (18 Credits) will be introduced in addition to the current three tracks (Logistics & Supply Chain, Operations, and Constructions Management). Out of these 18 credits, 6 credits are dedicated for Master Thesis. The following are the planned courses:

1- GENG 500 Principles of Technology and Innovation Analysis, Market Research, and Entrepreneurship (3 Credits)
2- GENG 540 Advanced Technology Innovation and Entrepreneurship (3 Credits)
3- EMP 560 XXXXX (3 Credits)
4- EMP 580 XXXXX (3 Credits)
5- EMP 595 Master Thesis I (3 Credits)
6- EMP 596 Master Thesis II (3 Credits)
5 Conclusion
The main aim of the paper is to provide an overview of the emerging area of engineering entrepreneurship education. A literature review on entrepreneurship, engineering entrepreneurship education, and the attributes of the entrepreneurs has been provided. A proposal for integrated and systematic implementation for engineering entrepreneurship education at the College of Engineering in Qatar University has been detailed.

References:


