

Developing and Conducting Entrepreneurship Education for Engineering Students - Lessons learned while educating students through entrepreneurship

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INTRODUCTION

In the wake of the second academic revolution [1] higher educational institutes in most of Western Europe are met with a new demand. It is no longer enough to solely focus on research and education; educational institutes are now expected to fill a new role in society as a contributor to the social and economic growth. As an extension of this universities are met with a more or less explicit governmental demand to foster innovative and entrepreneurial graduates. This has a top down effect on the strategy of many higher educational institutes where the fostering of entrepreneurial graduates has become a goal. But how can it be achieved?

1 PURPOSE

As a natural reaction to the increased societal and governmental interest in entrepreneurship, the offering, conducting and research of entrepreneurship education has become a focal point in a large number of higher educational institutes.

The purpose of the paper at hand is to put the topic of entrepreneurship education into an engineering educational context and propose an answer the question "How can entrepreneurship be taught to engineering students?" which unfolds the following sub-questions:

- What characterizes engineering students?
- What is the purpose of entrepreneurship education?
- Which frames are set by the higher educational institutes?
- How is it currently done and what lessons have been learned?

This paper is primarily written for other lectures with the purpose of sharing experiences in an attempt to further develop the field of entrepreneurship education in engineering departments and secondary as food for thought for decision makers regarding curriculum content in the aforementioned departments.

2 THEORY

There is an ongoing academic debate of what entrepreneurship is. The understanding of what entrepreneurship is covers a wide spectrum, from the traditional perception of the founding of a company to an entrepreneurial mind-set [2]. One of the reasons for the absence of an unambiguous definition of the concept of entrepreneurship may well be that entrepreneurship has been studied from many different angles, including psychology, sociology and economics. The following paper is based

on the understanding of entrepreneurship as behaviour, behaviour relating to opportunities [3] more specifically the behaviour related to going through the process of discovering or creating opportunities, that can be broken down to need recognition and solution generation, qualifying and evaluating the opportunity and exploitation of it, value creation being a key part of the process and in this context either in the form of new venture creation for profit or non-profit social entrepreneurship projects. Entrepreneurial opportunities are believed to be highly individual dependent, exiting or created in a nexus between process (a series of actions), individual (skills, competences, motivation) and opportunity (unfulfilled need) [4]. Furthermore what characterises the entrepreneurial process is effectuation [5], the entrepreneurial process is mean-driven as opposed to goal driven.

As an extension of the debate of what entrepreneurship is, entrepreneurship education is conducted in many different forms with various scopes [6]. Hannon divides entrepreneurship education into 3 categories; education *About, For* and *Through* entrepreneurship [7], providing a tool to categorise the education form. Currently the value of educating through entrepreneurship is of great interest, documenting effects of individual development positively influencing the student's self-efficacy, a person's extent of belief in own ability to complete tasks and reach goal[8], and behavioural intent in relation to entrepreneurship[9].

Different frameworks for structuring and conducting entrepreneurship education have been developed, on a general level the ME2 model [10] divides the entrepreneurship education process into four steps, understanding means, disclosing disharmonies, qualifying opportunities and realising value and Bager et al provides a more operational description of entrepreneurship education [11].

In terms of didactic strategies that can be applied in entrepreneurship education the "push"-method [12] incorporate seven enterprise-didactic strategies(Change of habits, role models, reward for action, courage to fail, mean driven, self-awareness and reflection, experiences of success) with the purpose of increasing the student's self-efficacy [13] and there by the likelihood of students behaving entrepreneurial in the future.

Handscombe et al [14] argue that in order for entrepreneurship education to be most effective it needs to be an integrated part of the engineering education programmes taught by faculty members as opposed to existing as an entity in itself or as an elective offered by a business school.

Ergo a lot of research and development have been done relating to entrepreneurship education, but little attention has been given to the challenges relating to educating engineering students through entrepreneurship, leading to the following question "How can entrepreneurship be taught to engineering students?"

3 METHODOLOGY

In order to investigate the research question "How can entrepreneurship be taught to engineering students?" a literature review is done combined with an prospective case study, currently only a single case study of the course "Entrepreneurship- from innovation to realisation" (EIR) that was developed and taught as a summer school elective for international bachelor degree students with either a business or engineering background. Data is collected from public documents i.e. course description and lecture plans, hand-in assignments, grades, video footage of episodic interviews, questioners and statements from a theme meeting (about the integration of entrepreneurship in the educations) with the heads of the engineering departments.

The research question is broken down into 4 sub-questions:

1. What characterizes engineering students?
2. What is the purpose of entrepreneurship education?
3. Which frames are set by the higher educational institutes?
4. How is it currently done and what lessons have been learned?

In order to answer the first three sub-questions a study of public documents and academic literature is done and quotes from the theme meeting and from students are used to give a more subjective description of the engineering education and the engineering students. For the fourth question a case study is used to illustrate how an entrepreneurship course can be formed and to shed light on lessons learned.

The following research is based on the preliminary results of a single case study, for further data triangulation and course improvement, data is currently being collected from a second entrepreneurship course.

4 FINDINGS

In order to come up with an answer for the main question of interest “How can entrepreneurship be taught to engineering students?” the sub questions, what characterizes engineering students, what is the purpose of entrepreneurship education, what frames are set by the higher educational institutes and how is it currently done, are explored

4.1 What characterizes engineering students?

Felder and Brent [15] argue that all students are different and thereby have different needs and preferences in a learning situation. They differ in motivation, attitudes towards teaching and learning, response to specific classroom environments and instructional practices. Furthermore they differ in national and cultural background, age, gender, family-life cycle and the list goes on. But what brings them together is the choice to study an engineering education. They chose to spend between 3,5 to 5,5 years on studying high levels of math and physics plus a technical specialization i.e. ICT, mechanical, construction, chemistry, nanotechnology or other. This implies they are drawn to positivism and during their education trained in causal thinking, mathematical logic and reasoning. As it was put by the head of one of the engineering departments “Our students are trained to be good employees”, which on one hand is fortunate giving the existing company solid applicable state of the art knowledge when hiring engineers, but on the other hand it reduces the students, narrows their perspective, educating them into only fitting the role of an employee. Students are trained to solve given problems using causal thinking, which works counterproductively in terms of engaging in an effectuation process. This engineering student’s statement in a written report, reflecting on learning outcome of the EIR course, underlines the difficulty of being causal thinking in an effectuation process: “I think it was a bit difficult to get a clear overview of what exactly was required.” Instead of taking the opportunity to imagine her own goals and using her means to achieve it, she is looking to the lecturer to define the means and the end providing a comforting structure as she is used to.

This is not advocating an either or solution, causation versus effectuation, rather an observation raising the question if training in effectuation in general can and should be implemented in a broader sense in engineering education.

4.2 What is the purpose of entrepreneurship education?

There can be numerous purposes of entrepreneurship education, but given the new role in society imposed on higher educational institutes, entrepreneurship education should support the fostering of innovative and entrepreneurial graduates and it does make sense to foster graduates that are able to spot and act on opportunities resulting in value creation benefitting the society at large.

Given the above stated understanding of entrepreneurship as behaviour related to opportunities and value creation, entrepreneurship education should enable and stimulate entrepreneurial behaviour raising the question of what the determinants of entrepreneurial behaviour are.

According to Poiesz [16] there are three key behavioural determinants, motivation, capacity and opportunity and it is the combination of the three that will determine the likelihood of a given behaviour ($F(x)$ for Behaviour X), Motivation (M) is the extent to which a person is attracted to the outcome of behaviour x . Motivation is a summery term in theory there are more motivation related concepts influencing M .

Capacity (C) is the extent to which a person has the personal qualities, competencies, characteristics and means to engage in behaviour x , from an educational perspective this is highly influenced by the solidity of the basic training in the educational programme. Opportunity (O) is the extent to which external conditions facilitate or hamper the engagement of behaviour x , advocating the importance of curricular activities providing the students with opportunities to behave entrepreneurially.

The determinants are equally important and conceptually independent. Illustrated in figure 1 the determinants are represented on the three axes, each can be viewed as a continuum ranging from completely absent (0) to completely present (1). Multiplication of the three scores indicate the likelihood of the occurrence of behaviour x ($F(x)=MxCxO$). The volume of the figure represents the likelihood of behaviour X occurring (the larger the volume the higher the likelihood).

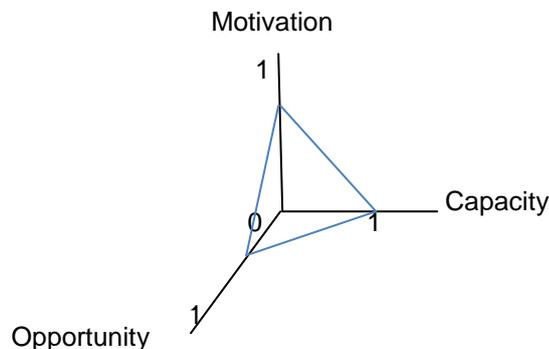


Fig. 1. The triad model (Source Poiesz [16])

If we apply this model to entrepreneurship education as Drabbe [17] suggests, the purpose of entrepreneurship education becomes to ensure that all three determinants are present and to such a degree that the likelihood of students acting entrepreneurial is maximised.

This means that entrepreneurship education should facilitate motivation of students. According to McClelland [18] there are three drivers of motivation: achievement, affiliation and power, but it varies between individuals which are the dominant motivator, this means that entrepreneurship education should accommodate all three. Bandura [19] believes that human behaviour and motivation is determined by our self-efficacy, the extent of belief in our own ability to complete tasks and reach goal. This suggests that entrepreneurship education should evolve around strengthening the student's self-efficacy in relation to entrepreneurial behaviour.

In terms of capacity one could argue whether the purpose of an entrepreneurship course should be to develop skills and competences for entrepreneurship or exploit the existing skills of the students as Sarasvathy's bird in hand principle suggests. Either way students need to be able to recognize their capabilities and utilize them giving entrepreneurship education a purpose relating to self-awareness.

Opportunity is a key in relation to entrepreneurship as sated earlier. Therefore one could argue that the primary purpose of entrepreneurship education should be to give students the opportunity to discover or create their own opportunity which they are motivated to and capable of exploring.

According to Shane and Venkataraman [20] entrepreneurial opportunities are highly individual, meaning that an opportunity for one person is not an opportunity for everybody, therefore entrepreneurship happens in a nexus between individual, opportunity and process (a series of actions) (Figure 2).

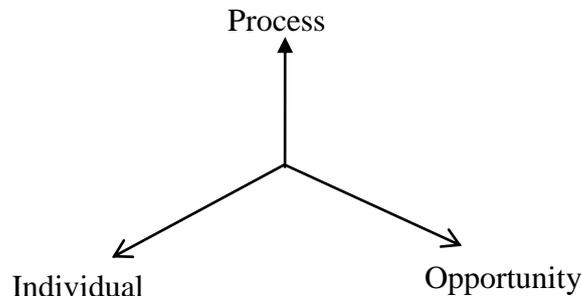


Figure 2: Individual – opportunity nexus

If so, entrepreneurship education must accommodate all the student's individual opportunities. This does not rule out the importance of teamwork in entrepreneurship, but it stresses the importance of setting the right team where the entrepreneurial opportunity is in all of the member's nexus of opportunity, which render most team building tools like Belbin useless given the lack of focus on motivation and opportunity qualification.

In conclusion entrepreneurship education need to provide opportunity, utilize capabilities, promote motivation and strengthen the student's self-efficacy all at once to maximise the likelihood of students behaving entrepreneurial also in the future.

4.3 Which frames are set by the higher educational institutes?

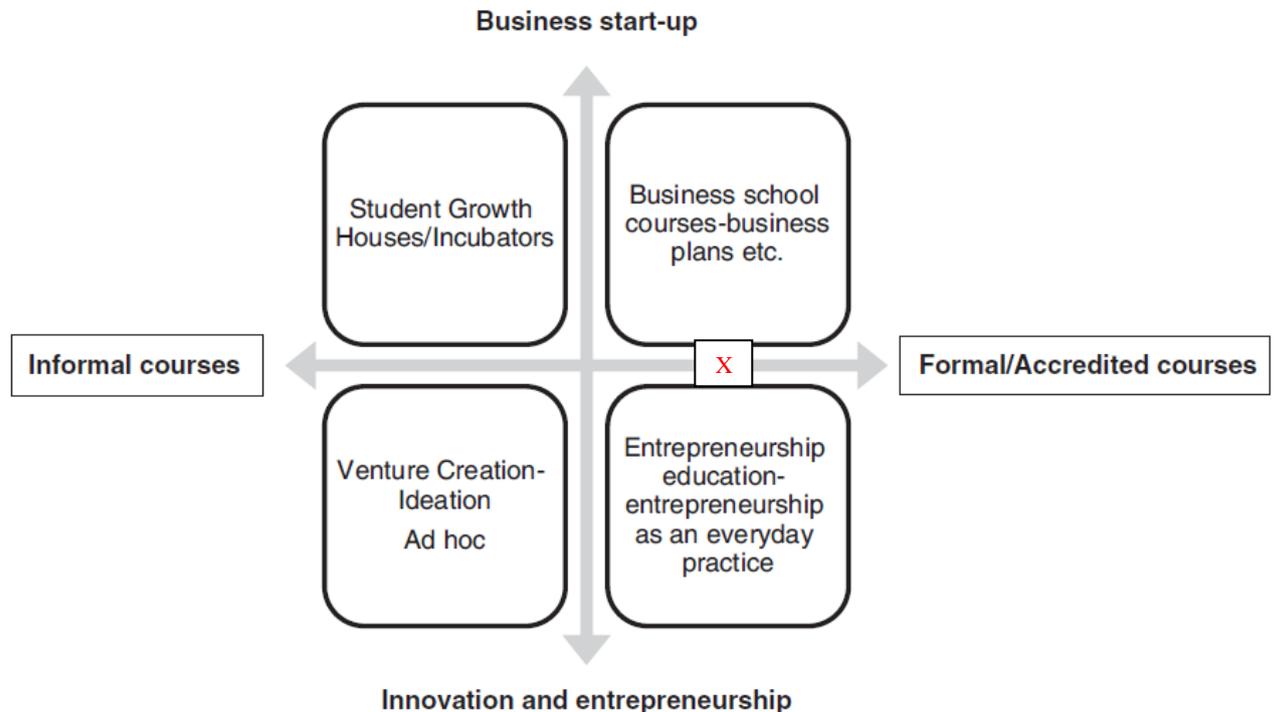
The framing of education can vary from one educational institute to another, there can be different strategic focal points or different traditions relating educational practices i.e. problem based learning. With the Bologna processes [21] a certain level of standardisation is introduced across Europe with the purpose of making it easy to compare. All courses are assigned ECTS points depending on the expected amount of time students should use on the course. All curricular courses are time limited and students are evaluated and graded based on the observed learning outcome measured up against formulated learning goals, utilising either Bloom's or SOLO taxonomy in order to define the expected level of cognitive learning.

4.4 How is it currently done and what lessons have been learned?

Paul Hannon [22] divides entrepreneurship education into education *About*, *For* and *Through* Entrepreneurship, where *about* deals with studying the question of what is entrepreneurship. Education *for* entrepreneurship focuses on teaching students skills and competences that are perceived to be useful in the entrepreneurial process very commonly the focus is on new venture creations and various business skills and competences such as marketing, management, accounting and business plan writing are taught. When educating *through* entrepreneurship students learn by acting on opportunities. Handscombe et al. [23] found that in order for entrepreneurship education to be most effectfull it should be embedded in the engineering education and taught by faculty members not exist as an entity in itself or as an elective offered from a business school.

Robinson and Blenker[24] have looked at the development of entrepreneurship education and found that the entrepreneurship discipline has a number of paradigmatic positions struggling with each other but united around to two central elements; entrepreneurship is about value creation and explores the opportunity nexus (figure 2). Furthermore Robinson and Blenker have looked at entrepreneurship courses and their aims discovering that they can be located in a matrix (Figure 3), where the horizontal axis categorises activities as extracurricular (left side of axis) or curricular (right hand of

axis) and the vertical axis categories the focus of the course on a scale from business start-up to innovation and entrepreneurship as an everyday practice.



Figur 3: Scope of courses in entrepreneurship education (source Robinson and Blenker [24]).

Based on the literature review above it is concluding that entrepreneurship education is conducted *about*, *for* and *through* entrepreneurship, both as curricular and extracurricular activities and with scopes ranging between the traditional new venture creation and entrepreneurship as a mind-set used in everyday practices.

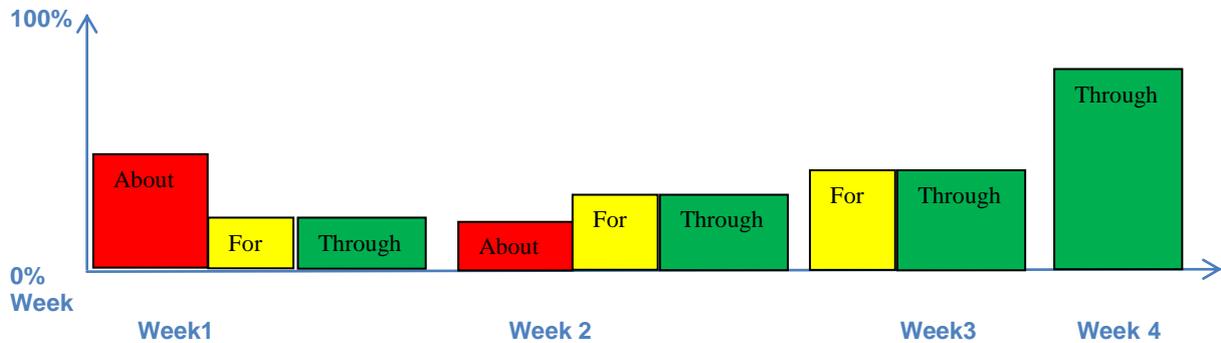
Ergo depending on which paradigmatic position the educational institute allows and the lectures presume entrepreneurship education can have different scopes but evolving around value creation and opportunities. In order to make entrepreneurship education more tangible in an engineering context an example of an entrepreneurship course that would be placed between the first and second quadrant (marked X) of Robinson's and Blenker's matrix, is given in the following.

4.4.1 Entrepreneurship-from innovation to realization

The development of the summer school elective course, Entrepreneurship -from innovation to realization (EIR) [25] is based on an understanding of entrepreneurship as "The process of identifying and creating entrepreneurial opportunities and the exploitation of these." inspired Sarasvathy [26], Shane & Venkataraman [27] and Spinoza Flores and Drefus [28]. The EIR course is based on the ME2 model of entrepreneurship education [29], in which the entrepreneurial process is broken down to four stages; understanding means, disclosing disharmonies, qualifying opportunities and realizing the value. In the operationalization process of the model, Bager et al's book on entrepreneurship education [30] is used.

The primary aim of the course is to increase the likelihood of students displaying entrepreneurial behaviour in the future by developing and strengthening the students' self-efficacy [31], in a learning by doing process where the focus is on teaching *for* and *through* entrepreneurship (figure 4) rather than *about*.

Weight



Source: Own design based on course description

Figure 4: Weighted course focus for EIR, divided by week and focus divided into: *about*, *for* or *through* entrepreneurship

A strong source of inspiration for the didactic methodologies applied in the course and the activities in the course is the “push-method” [32], which seeks to apply the seven enterprise-didactic strategies (Change of habits, role models, reward for action, courage to fail, mean driven, self-awareness and reflection, experiences of success), to train the students to achieve a transformation from thoughts to action.

The education about entrepreneurship is in this case based on Bessant and Tidd's book innovation and entrepreneurship [Tidd and Bessant], Sarasvathy's own article from 2001 [34] and Sarasvathy & Venkataraman's article from 2011[35], Shane & Venkataraman's article from 2000 [36] and Spinosa et al's article from 1997[37], combined offering the students an understanding of entrepreneurship as a self-initiated, internal-motivated, action-oriented, effectuation process in which the individual, based on disharmonies, defined by its nexus of opportunities, identifies and creates entrepreneurial opportunities and exploit these in a value creation for others, rather than the mere process of founding a company.

In terms of educating for entrepreneurship, the students are introduced to potential issues relating to intercultural, inter-professional, entrepreneurship centred teamwork, based on a cultural readiness test [38], Jung's Typology test and a self-efficacy test. Furthermore the students are given lectures in the use of Osterwalder's Business Model Canvas [39] and Sharmer's early prototype thinking [40]. In addition to this four workshops were held during the course where the students were educated for entrepreneurship in relation to the topics of: Intellectual property, micro economics (primarily focusing on accounting), negotiations and marketing & communications.

In terms of educating through entrepreneurship this process, for EIR, includes idea generation based on disharmonies in the student's every day practises, idea qualification using the business model canvas as a process tool for generating hypotheses and testing them, idea conceptualisation, early prototyping and gaining buy-in from external stakeholders through pitching.

The students were evaluated based on 4 individual assignments, where they were asked to describe and reflect including theory on specific exercises or processes they have gone through and on their final presentation.

4.4.2 Lessons learned during and after developing and conducting EIR

In the development process of EIR one of the main challenges was to figure out how to design a course where students are supposed to be facilitated through an effectuation process which by nature is a very individual process but taught to a group with-in the frames of higher education. The further

into the course we get the harder it is to predict in which direction the students are going and finding communalities between the projects, increasing the importance of an individual focus. Adding on top of this challenge, causes are time limited and entrepreneurial processes are not easily fit into fixed time schedules, for example some groups of students found it hard to get in contact with the right stakeholder and on that account wished they had had more time. Other students felt pressed on time in relation to making a prototype. Common for all project were that they never made it into the realisation face, advocating the importance of having student incubators or the like, where students can go, seek advice, realise their projects and start creating value, instead of being abandoned in a critical face of their entrepreneurial process.

Evaluation proved to be a challenge as well not in relation to the education about or for entrepreneurship where the level of cognitive learning is evaluated based on observed learning outcome relating to specific learning goals formulated based on John Biggs SOLO taxonomy. But when the main purpose of the course is to educate students through entrepreneurship strengthening the student's self-efficacy in a learning-by-doing process, how can learning goals be formulated? At higher educational institutes there are in terms of grading a focus on cognitive learning, not on behaviour or changed behaviour. In an entrepreneurial process for educational purposes it is not purposeful solely to measure the outcome of the process for many reasons. First of all it is not desirable that students become too focused on their final output since the process then becomes goal-driven. Secondly who is to evaluate if an idea is good or bad if it is not in the realization phase yet and thirdly it is not purposeful to have students afraid of failing because failing is an important part of the entrepreneurial learning process "fail fast and fail forward", as Einstein put it "Anyone who has never made mistakes has never tried something new". Therefore it is preferred to focus on the process rather than the result, challenging the formulation of learning goals. How can we set up goals for highly individual effectuation processes? The way this is circumvented is by formulation learning goals about students ability to theoretically reflect on their "through" process, going back to measuring cognitive learning rather than the behaviour itself, thus being a bit problematic in relation to the scope of the course, entrepreneurial behaviour, and the notion "you get what you measure" in this case cognition.

Though proven hard to evaluate there is value in teaching through entrepreneurship. In an analysis of the student's (participating in EIR) filmed narratives in the form of episodic interviews, answers and written statements in the questionnaires, an ethnomethodological approach is used to understand what the students perceive to be valuable in this entrepreneurship course, to identify signs of change in the individuals and to determine if the change affects the likelihood of students displaying entrepreneurial behaviour in the future. Initially the statements are categorized, inspired by symbolic interactionism, presented by George Herbert's understanding of the individual as a social product, purposive and creative and ethnomethodology represented by Harold Garfinkle's description of the individual as reflected, improvising, practical orientated and negotiating, plus added three dimensions of; signs of students taking action, which is the purpose of the applied enterprise didactics, signs of boosting of self-efficacy and signs of intentions of transferring the learned knowledge into a new situation after the course, all aiding to the identification of a development of the individual, and by method of collecting data, serving the purpose of data triangulation. Afterwards in order to render probable that this development is likely to result in entrepreneurial behaviour in the future, and there by fulfil the purpose of education through entrepreneurship contributing to create value on a macro-level, the statements are rearranged according to the theory of the seven didactic strategies that contributes to the likelihood of thoughts being transferred into action

Evidence was found of individual development and not any development but a development that rendered probable to be likely to result in enterprise behaviour in the future, and there by fulfil the purpose of entrepreneurship education.

Table 1 shows selected statements from the study which shows signs of boosting the student's self-efficacy and signs of intentions of transferring the learned knowledge into a new situation after the course.

Table 1: Statements reflecting the perceived value of education through entrepreneurship, categorised based on signs of students taking action, which is the purpose of the applied enterprise didactics, signs of boosting of self-efficacy, and signs of intentions of transferring the learned knowledge into a new situation after the course and method of collecting data.

Category/Tool for data collection	Filmed interviews (Statement number= S#) (respondent number = R #)* (Clip XXXMOV)	Questioners (Statement number= S#) (respondent number = ur #)**
Signs of boosting of self-efficacy	S:15 r#10: I will not feel as intimidated next time (relating to pitching ideas to external stakeholders) (018MOV) S16: R#8: I feel more confident now to realize something...I know what to do...how to develop the next best step. (014Mov) S17: R#1 ... through practical experiences and little games that Mette did, we learned that we are capable to do something, and we can learn something from it and use it in the future.(023 MOV)	S29 Q5: The student-entrepreneur business presentations were inspiring: 6/9 agreed or strongly agreed. S 30: Q7: After having completed EIR I feel better qualified to start my own business venture: 8/9 agree or strongly agree
Signs of intentions of transferring the learned knowledge into a new situation after the course.	S18: R#4: to me the course was very useful...I learned a lot of new things...and back home I will try to run my own company (008MOV)...I feel very motivated to start my own business back at home. I learned many techniques that are very useful (014 MOV) S20: r#10: I'm not the kind of open person, but now I think I'm really into it and I could run a business at home, maybe, (021 MOV) S21: R#11: I think the best part of the course was going through the whole process of starting a new business....it is really useful because it will not be new to us. (021MOV)	S 31: Q8: After having completed EIR I feel more inspired to start my own business venture. 7/9 agree or strongly agree

* The respondents' identity is known

** The respondents' identity is unknown

The statements in table 1 shows that the students, in their own perception, have learned valuable lessons through entrepreneurship and it is likely to have an effect on their future behaviour relating to entrepreneurial opportunities.

Currently the EIR summer school elective course has been adapted to fit in as an elective course during the semester, giving the advantage of having more time to go through the entrepreneurial process but in terms motivation, which is a key contributor to entrepreneurial behaviour according to Poizes, it is experienced that the students in general are less motivated to really engage in the entrepreneurial process during the semester, this is reflected in the student's reluctances to actively participating in activities during class and in between classes, compared to the summer school students, and also in a lower grade average from the class taught during the semester. Speculations can be put into why this is observed, but a likely explanation is that the student's attention is divided

between numerous courses and secondly students who choose to spend their summer time studying, often traveling abroad for this purpose, may generally be more motivated to engage and learn. Another observation made is the number of students enrolled in the course can pose as a challenge with increasing numbers of students. Working in effectuation processes is challenging for the students [41], especially students prone to causal thinking, and in order to ensure progression in the process individual sparring is found purposeful, and with an increasing number of students this becomes more resource intensive.

Lastly it is found that the role of the lecturer is challenged when working with students from different professions who engage in highly individual and unpredictable entrepreneurial processes. As a lecturer teaching through entrepreneurship you do not have full control of the direction the students move, often they move in different directions, face different challenges and they might move away from your field of expertise, giving the lectures a role as a facilitator of a process rather than an expert of a certain field potentially evoking a need of other project specific sparring partners.

4.5 Conclusion

To answer the question of “How can entrepreneurship be taught to engineering students?” there are many ways to conduct entrepreneurship education and different positions can be taken in relation to the purpose of the course. An example is given where engineering students are taught entrepreneurship, following the ME2 model's first 3 quadrants. But in more general terms it is possible to teach about, for and through entrepreneurship, the latter with a proven positive effect on the student's self-efficacy and intent of acting entrepreneurial. Though valuable, educating through entrepreneurship has proven difficult in terms of fitting the student's individual effectuation processes into a limited time span and evaluating when focusing on behaviour rather than cognition. When teaching engineering students, argued to be positivistic, one should be aware of the fact that they are trained in causation and might very possibly prefer that, causing frustration when going through an effectuation process. More over the role of the lectures takes the form as a facilitator of active learning, in which he or she needs to be comfortable, rather than the familiar role as an expert educating students in a didactic lecture form.

In order to achieve the goal of fostering innovative and entrepreneurial graduates there are some implications for engineering departments. Handscombe et al stresses the importance of entrepreneurship as an everyday practice being implemented to some degree in the entire curriculum, calling for a development and implementation of entrepreneurship strategies at departmental levels of higher educational institutes, where the form and scope of entrepreneurship education should be formulated to align entrepreneurship educational efforts. For lectures in general this leads to an opportunity to explore how their topics can promote and support entrepreneurial behaviour by students. For lectures planning and developing entrepreneurship courses this article support educating through entrepreneurship, gives an example of how it can be done and exhibit some of the challenges of educating engineering students through entrepreneurship, in conclusion raising the question of how to best solve the problems?

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