Becoming a sustainable techno-entrepreneur

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INTRODUCTION

At the dawn of this century, the European Commission launched the Lisbon Strategy, which was revisited in 2010 with the Europe 2020 Strategy for a smart, sustainable and inclusive economy. In order to put the strategy into a more concrete form, the concept of the ‘Knowledge Triangle (KT)’ has been introduced. It links together Research, Education and Innovation and sheds some new light on the Industry and University Collaboration (see figure 1).

![Figure 1 – The Knowledge Triangle (Sjoer et al. 2013)]
Start-up companies around universities are traditionally classified as a group that is critical for innovation because they can challenge the status quo. They are a breeding ground for new talent and they can come up with new ideas to enhance Europe's competitiveness and the well-being of its inhabitants. These new ventures in particular will benefit if the three corners of the Knowledge Triangle work well together. The entrepreneurs are higher education graduates that want to start their own company. They conduct research since they are aiming for (sustainable) technological solutions – often together with the university – which they try to bring to the market ('innovation'). Besides research, 'education' is also involved since a university-supported incubator offers a training programme that helps these entrepreneurial engineers to become techno-innovators. For this paper we have selected start-ups that have sustainability in their focus; their company strategy focuses on responsible innovation.

The question is: what problems do these entrepreneurs encounter while becoming a sustainable techno-entrepreneur and how do we educate them and facilitate their emergence?

**METHODOLOGY**

We selected four start-ups from the incubator of a technical university in the Netherlands. They serve as case studies. The ultimate goal of this research is to make recommendations to enhance the synergy of the three corners of the Knowledge Triangle, with a focus on the educational corner of the triangle. In short, to enhance the learning environment for sustainable techno-entrepreneurs. The aim of this paper is to explore the relevant concepts for further research.

Characteristics of the respondents: they are all part of the cleantech track of the incubator, hence they have sustainability in their strategy. The interviewees come from four different companies, ranging from a start-up that has recently begun, to start-ups that have been part of the university-supported incubator for 3 to 5 years. Two respondents are Dutch entrepreneurs, one respondent is a non-European entrepreneur and one is from another European country. The backgrounds of these engineers vary: mechanical engineering, aerospace engineering, management of technology and system engineering, policy analysis and management. The respondents are no solitary entrepreneurs; everyone is part of a team.

All respondents are alumni of the technical university, and alumni of courses from a centre in one of the faculties of the university that provides entrepreneurship education. As part of their Bachelor's and/or Master's degree programme, they chose to follow a minor or elective courses in entrepreneurship. Three entrepreneurs are already graduated, one of them has also obtained his PhD and one entrepreneur is not graduated yet. They are all male respondents.

The founders of the start-ups are interviewed for one and a half to two hours. These interviews are transcribed. This transcription is then tagged in two rounds. In the first round, the enablers and barriers to discover and develop entrepreneurs' competencies are identified. 'What has helped you?' 'What problems did you encounter?' The listed drivers and barriers are clustered and then placed on the Knowledge Triangle. The items are located at the side of the triangle that represents either the connection between research and innovation, or innovation and education, or education and research. By placing the drivers and barriers on the Knowledge Triangle it became clear what has been working well for
entrepreneurs and what side of the triangle can be improved. Each barrier can also be a driver if you turn it around. We will classify the item as a driver or barrier depending on the way the respondent has presented the item, as something that has inhibited or helped his development.

**DRivers and barriers of sustainable techno-entrepreneurs**

Entrepreneurship in this paper is defined as 'a process that involves the discovery, evaluation, and exploitation of opportunities to introduce new products, services, processes, ways of organising, or markets' (Shane and Venkataraman 2000). We mainly focus on the pre-launch stage, since that coincides with the study period of the respondents at the university. The respondents look back on their studies. In addition, we have studied the launch phase when they joined the incubator of the university, generally defined as the period from establishment of a new venture until 12-18 months later. At that stage their education can be regarded as continuing (entrepreneurial) engineering education.

**Pre-launch phase**

The different stage models presented in the literature are also apparent in the narratives of the entrepreneurs: opportunity search, resource gathering and exploitation (Baron 2012). In the pre-launch phase, students recognise and evaluate opportunities and they develop intentions to proceed further along the road leading to the launching of a new venture (Mitchell et al., 2002 in Baron 2012). Many enablers and barriers could be placed in these clusters of activities.

As mentioned, all respondents obtained (or are in the process of obtaining) a degree at a technical university and were also alumni of a number of courses on entrepreneurship. These courses range from experiencing entrepreneurship, writing a business plan, turning technology into business, to launching a new venture. To give an example, as part of these courses students can compose a feasibility study for an external client or they can get started with their own idea. Sometimes the latter is a requirement for submission, as well as enrolment with a team. If students take 15 ECTS on entrepreneurship courses and combine their graduation project with entrepreneurship, they can achieve an entrepreneurship annotation. The remarks of the respondents are related to their regular study (e.g. mechanical engineering), and to the courses on entrepreneurship.

The drivers and barriers the respondents mentioned are linked to three categories: individual level factors relating to personal skills, abilities and motives (e.g. risk-taking, self-efficacy), group level factors relating to relations with others, and macro level factors relating to the economic, political and social environment.

Individual factors can serve as both enablers and barriers. Respondents mentioned personal traits as 'positive outlook', and errors classified in the literature as 'overconfidence' and 'illusion of control' (Baron 2012). We are, however, not delving into personal traits; for that we refer to another article (Hensel et al.). We also left out a remark of one of the respondents: ‘It is in our genes, our parents are also entrepreneurs’. Although we assume that family is an important factor, we want to elaborate on two individual factors: ‘want to have impact’, and ‘the perception of originality’.
Respondents explained that they want to have impact. They want to change something fundamentally. For these entrepreneurs, their motive is connected with sustainability. ‘I always wanted to do something with renewable energy […] Then I can work here at some office and give the “Average Joe” two solar panels. However, if I was able to do the same trick somewhere in Africa, then instead of saving €20 on someone’s energy bill, I can give someone energy that he didn’t have before.’ A second example comes closer to home: ‘Today, the European Parliament voted for a new legislation […] cool that you can contribute to society, industry […] which means less fuel or less energy consumption […] building up knowledge and also educating people and starting a whole movement of believers.’

Another individual factor is connected with evaluating opportunities. Some students believe that you must have an exceptionally good idea to start a company: something that no one else has done before. The stories they hear at the university are often success stories, such as Facebook: ‘But you cannot really relate to it’. Only when they come into contact with start-ups at the incubator, which is what happened in a number of entrepreneurial courses, they discover that most ideas are not ground-breaking. They apparently have a wrong picture of what opportunities can lead to a new venture. The link between education and innovation can be strengthened when realising that students with these career perspectives also need role models, especially in the area of responsible innovation.

Many drivers and barriers are related to group factors, partly because of the interview questions about education, but also because entrepreneurship is teamwork. As Bill Gates mentioned: ‘Our success has really been based on partnerships from the very beginning.’ All entrepreneurs at the incubator are operating in a team. One of the issues is meeting your business partner. According to the respondents it is helpful to meet one another at an early stage, preferably students with additional qualities. Students from aerospace engineering possess knowledge on (light) materials, and industrial design students on design and user-friendliness. Students of different disciplines and personalities (also from different universities) should be able to get to know each other during their studies. Two of the four respondents met their business partner via LinkedIn or an article about their idea in a popular magazine.

Another barrier mentioned in that perspective is the lack of mixing international and local students in group assignments in many courses. According to the non-European entrepreneur, it is very convenient to have a ‘local’ in your business team. Local students know the way and create confidence among local stakeholders and partners (even though the market is ‘global’). During your studies, much can be learnt from ‘the local way’ in a mixed team (and the other way around).

These start-ups are techno-entrepreneurs, and technology is subject to rapid changes. The respondents mentioned as a barrier that they did not come into contact with the very latest technologies that are described in magazines and on the internet. The respondents indicated that occasionally there was a match between an idea or a problem that they as a student wanted to resolve, and the technology which they came across. In many regular courses at the university though, the technology which is taught, exists for years and usually in established companies. That, however, is changing; technical universities in the Netherlands have fantastic, world-famous examples, but, for instance, oil and gas are still more dominant in the regular courses than offshore wind. ‘So basically you will be educated to work for Shell. That’s a pity.’ In the phase of opportunity search, this might be an important barrier.

The entrepreneurial courses they obtained have made the former students enthusiastic. They have made them aware of their capability to accomplish something and subsequently
that starting a business is a real option. Moreover, the courses have helped them with the (further) development of the idea and resource-gathering.

What are the respondents so excited about? Here is a quote that mentions a number of elements that occurred more frequently, such as interdisciplinary and open assignments. ‘If there is anything that has made me excited, then it is this entrepreneurial course. Because you are in a team with others, a management student, a chemical engineering student and an aerospace guy. Super innovative subject, very big, a lot of impact, without barriers, no set deliverable. You don’t know where it ends and you gain the most out of it. This course has a very entrepreneurial attitude.’ Apparently it teaches him to look beyond his own Master’s study programme – also outside of the box, and to collaborate with students from other disciplines.

Enablers for ‘gradually developing the idea of starting a new venture’ were according to the respondents: meeting your business partner, presenting your idea to investors and consultants who are taking it seriously, considering role models in the incubator, and later entering contests and winning these contests. ‘I had the intention of becoming an entrepreneur, but with this course I think I truly became one.’ […] We won the Philips Innovation Award and that gave us some funds but also the motivation to make it real.’

For the further development of their idea and resource gathering, the courses in which you can bring in your own idea contributed the most. Students are required to read (entrepreneurship) literature and follow workshops which can be translated immediately to their own practice. In addition, they mentioned as enabler for the (further) development of their idea that they are encouraged to go outside and meet their potential customers. Moreover, respondents have experienced that a large assignment such as ‘writing a business plan’ is fundamentally different from a university assignment. ‘Because you were treated as if you were an entrepreneur already, you had to teach yourself to behave like one and start building on your professional skills. […] It also gives you more confidence. When you are explaining your business idea and everyone is listening to you, and when you’re presenting your business plan and everybody takes it seriously, and asks serious questions. That gives you confidence on the one hand, but also adds a lot of pressure and accountability because it is not just a university assignment any more. You have to be more realistic and it has a direct impact on what you do [while] in a university environment, you are with a group of students; they are your friends […] The lectures… you listen to them, and you take notes.’

Respondents indicate further that a company also responds to their work in another way. ‘[Working] with a company is also very educational. A company reacts different from a university. They are much more into deliverables. A company knows exactly what is going on in the market, what works and what doesn’t. A university reacts like “Oh yes, interesting” and has no further considerations. While a company cuts it off immediately, if it is not in the right direction. That was very instructive.’

In addition, for the development of a product detailed and operational knowledge is needed from the industry. For example, how users interact with cars, how many claims they get and what type of damages they encounter etc. Finally, the reality is often different from testing in, for instance, a wind tunnel.

Communicating with industry is also something respondents have learned by doing: ‘If you want to work with industry, you have to reduce things to the core and throw away everything else.’

Finally, for their final thesis project on, for example, aerospace engineering, it helps to involve relevant stakeholders at an early stage. One of the respondents has set up a working group during graduation around a particular theme, with people from the government and the
industry. 'We were testing and building prototypes together. [...] So, if I wanted to test something, I simply had to call someone. [...] They gave all the information I wanted, and they also received all information from us; as a result we became better and smarter together. [...] They also like the attention we generated: press releases and even television.'

Setting up a working group at this scale is not realistic without the support of the academic staff of the university. One great enabler or barrier, therefore, is the cooperation and network of the academic staff. One respondent says of his former supervisor at the university: 'He is very good, very clever. He juggles many things at once, is creative, organises everything well, also financially. [...] "Let's do it," he goes, "give it a chance". That is what you need: because if you take it too tightly, then you eliminate each chance.' Unfortunately, not all experiences of the respondents are positive. There are also members of academic staff who do not want (or are less able) to take any risk or think 'out of the box'. For example a potential supervisor at the faculty of aerospace engineering responded: 'I don't find cars that interesting'. One respondent stated that the dean of the faculty plays a central role; he can influence an entrepreneurial culture.

Finally, the choice for entrepreneurship is also influenced by the social, political and economic climate. For instance, in society the choice for starting a company is no longer seen as a stupid choice, but an attractive career option. 'No one reacts oddly. [instead] they say that it is interesting, much more fun than working at a big company. So that has already changed a lot.'

**Launch phase at the incubator**

All respondents have joined the incubator after graduation. The start-up phase includes activities aimed towards the actual launch of the new venture and its initial period of operation. Entrepreneurs shift their attention to tasks such as choosing a legal form for their company, developing initial marketing plans and a strategy for exploiting the recognised opportunities. Two of the four entrepreneurs are close to the post-launch phase; in this phase, entrepreneurs shift from dealing mainly with ideas and plans to running a company in which the retention of employees and return of investment is important (Baron 2012). We did not include the post-launch phase in our study.

All start-ups of the incubator are located in an interesting building nearby the campus of the university. Respondents were united in the fact that the joint housing in this building was an enabler. 'The biggest advantage is that you are part of this community. Every day you come in and you feel the energy. In addition, if you invite people, they become excited, which makes us more credible, situated in this building and that we are part of this incubator.'

The founders have access to an incubation programme, consisting of coaches, master classes etc. The satisfaction regarding the coaching varies. 'The coach has a background in IT, and wants to put something on the market quickly, which is not so suitable for a long-term project.' 'We did not have a personal match and we have an experienced entrepreneur in our company who is our coach.' 'A lot of coaching is about business development, which is useful, but we also need support in the process of (technical) product development. We have questions such as: how to select the right supplier?' And, following one of the entrepreneurs who is very satisfied: 'We always go to him if we have a strategic decision to make when we are unsure.'
At the incubator, many activities that are organised were considered enablers. Network events, competitions and government funding (for which proposals are prepared together with the valorisation centre of the university) helped for arranging successive waves of financing and provided them with feedback. Publications in widely read magazines added exposure and generated new partners, team members and (potential) customers. Conferences with the industry revealed information about the competition. Respondents indicated further that they can use each other much more, for instance, by sharing more knowledge. Since sustainability is on the political agenda, there is also an additional programme for cleantech companies.

Because of the restricted size of this paper we are not able to report all enablers and barriers in the launch phase. We would like to put forward two important enablers or barriers (depending on whether one had succeeded to generate it easily). These two factors were mentioned as a driver or as a barrier by almost all respondents: the access to testing facilities, and the moving forward together with the university.

The start-ups require test facilities that are affordable, and academic staff that can help them. 'I still have crazy ideas that I want to try out.' And: 'It also gives you that first reference. It is not just anyone. It is a professor at a famous technical university. It is an internationally-renowned person in the solar industry.' At this point, however, the involvement of the university, differed significantly in the stories of the entrepreneurs. Respondents also reported negative experiences: 'It's always a fight for us to involve people from the university. They have their own budgets. There are individuals within the university who care for us, but there is no foundation.' The respondents, in contrast, think of a model where education (using students and PhDs, and giving guidance and useful guest lectures in return) can grow parallel with the company.

CONCLUSION

The research question is: what problems do start-ups encounter in their way to becoming a sustainable techno-entrepreneur and how to educate them and facilitate their emergence? In this paper we studied a process approach of entrepreneurship which assumes that entrepreneurs execute different activities and accomplish different tasks in the distinctive phases of the emergence of their company. They have to obtain different competencies in each stage. We know the limitations of phase models and do not want to deal with these too strictly. In our case, however, there are good reasons to split the drivers and barriers in a pre-launch phase, which more or less corresponds with their regular Bachelor's and Master's study, and the launch or start-up phase which coincides with the accession at the incubator.

All drivers and barriers are put in a matrix and are clustered around the activities that entrepreneurs carry out and the perceptions they have on these activities. The enablers and barriers are individual level, group level and macro level factors. For example: cluster: perception of what it means, starting your own company: I(individual factor), b(barrier), 'exceptionally good idea'. Most drivers and barriers were group level factors, concerning the relationship with others. All drivers and barriers are placed on the sides of the Knowledge Triangle.
Most barriers in the pre-launch phase can be found along the side research-education. The (technical) research in regular courses is not innovative enough. Even for the graduation thesis, some members of the academic staff don’t want to participate in something really new. They are also not very aware of a (potential) market for the technology they are working on. Furthermore, research that involves students lacks the possibility to work on the same problem with different disciplines (also from another university), and while doing that, meeting potential business partners. These courses are less interdisciplinary than they should be to resolve societal problems. In sum, the link between research and education is not well-developed for the entrepreneurial student in the pre-launch phase. Students are not receiving the opportunity to discover and evaluate opportunities. That is not the case in all entrepreneurial stories. In the same cluster on the research-education side, a big enabler is the academic staff who cooperated very well or even took the lead. The academic staff is therefore a crucial factor – positively or negatively. We can conclude also, that research and education disengaged of innovation does not work well in the learning process of an entrepreneurial student. The question remains whether the lack of ‘cutting-edge’ technology that might be of interest for the market, is indicating that the link between research and innovation is not active at the university, or that although there is a strong link, education is not involved (yet). To achieve the latter, it is for instance necessary that courses will be thoroughly updated every year, and new stakeholders be asked to participate.

Most enablers can be found in education that focuses on entrepreneurship and innovation. That is especially successful if it is associated with authentic assignments with companies. Furthermore, exposure to role models is important. Our analysis of limited cases suggests that it makes a difference where the idea is coming from. If the (business) idea derives from a graduation project at one of the faculties of the university, the link between research and education of the KT has already been established and students can build upon the acquired knowledge and other available resources. If students take their own mainly immature idea to one of the entrepreneurship courses, the entire infrastructure around the (technical) inquiry must be set up. The university, however, has a limited provision to facilitate a potential entrepreneur with an idea that does not originate from its own research. Further, if it is also not a sustainable idea, then the resources are probably even more limited. So activities linking education to innovation, disengaged from the link research-innovation and research-education, also work less effectively. Not so clear in the literature, but very clear to a technology-advanced start-up, test facilities are crucial for the development of the idea and product. Academic staff can serve as an important sparring partner and can also bring into their network. In the launch phase these factors remain.

In becoming a sustainable techno-entrepreneur, sustainability affects all three levels factors. It can be part of the personal motives of the entrepreneur; it can be a shared ambition, and part of the value proposition to customers, and partners. Furthermore, on macro level, sustainability is currently high on the European political agenda, which means that funds are available for programmes and competitions.

In the light of an earlier paper, in which one of us composed possible models of entrepreneurship that showed the transition of the classic entrepreneur focused on risk-taking and competition to an entrepreneur who tackles social problems using the market mechanism as a means to accomplish change in the direction of a stable growth-economy and society (Ravesteijn and Sjoer 2010), we can conclude that although our four entrepreneurs consider people and planet, besides profit, there are still issues such as increasing resource productivity and system building. The knowledge of sustainable materials, cradle to cradle concepts applied to their product (and service), was there,
however not fully capitalised. In a subsequent article, we want to delve deeper into what it takes to be a sustainable techno-entrepreneur and what is helpful to operate in that direction.

Limitations of the research
A major limitation of this study is that only four cases were analysed. In addition, none of the other stakeholders, such as academic staff, incubator staff, industry partners or governmental actors are interviewed. Nevertheless, we learned a lot from the way the entrepreneurs perceived their learning process in retrospective. A second imperfection is that only students who have become an entrepreneur were questioned, not the students who also obtained a degree at the technical university and took courses on entrepreneurship, and decided on another career option. It is very likely that they can come up with some barriers that are not mentioned in the four cases. Finally, we would like to mention that the concept of KT, which is the interaction of research, education and innovation (‘to invent the future’), strongly depicts the interpretation of the results, and, for instance, the meaning of innovation. That is why the barriers and enablers mentioned by the respondents are described extensively and are often supported with quotes.

Recommendations
In line with a paper on entrepreneurship we come up with possible directions of solutions. In accordance with our MAU-approach, which we presented at IACEE 2012 (Goossens and Sjoer 2012), we can address the issues mentioned, in terms of a mindset (M), activities (A) and the way we evaluate the results of the activities (Utility). In terms of mindset, you can consider the idea that facilitating entrepreneurial engineering education is not only a task of the university. To make it even stronger, the results of this small study indicate that that is not leading to the best possible (learning) environment. In addition, the idea of distinguishing between science and design might not be desirable or, to even put it further, to continue with separate mono-disciplinary studies and universities is not an ideal situation for becoming a techno-entrepreneur. Having said that, we could think about all kinds of cross-border activities, addressing global problems, for instance living labs, ‘hybrid’ professors (who work both at the university and in industry). The question is always how do we evaluate the results; when are we satisfied with the quality of the acquired knowledge, skills and abilities of our engineers? Perhaps the university is not the only partner that will assess these competencies (any more). Sustainability can be a significant value driver in the context of the transition towards what we could call responsible innovation. However, such a transition can only be realised through a combination of innovative entrepreneurship and a favourable (learning) environment, in which a number of conditions are fulfilled. The recently-launched Horizon 2020 programme of the European Union can be an enabler because of the requirement of newborn international consortia that will shape the corporation between parties in a new way.

In conclusion, facilitating entrepreneurship education is a co-creation and co-production of all kind of actors from the university and the market, involving all sides of the Knowledge Triangle.

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Conference track: Industry and University Collaboration