How entrepreneurial is it to connect students to university technology transfer?

Mats Lundqvist and Karen Williams Middleton.
Chalmers School of Entrepreneurship
Technology Management and Economics
Chalmers University of Technology, Gothenburg, Sweden
mats.lundqvist@chalmers.se, karen.williams@chalmers.se

ABSTRACT

Questions we care about: This paper asks the following question "How entrepreneurial is it to connect students to technology transfer?". The answer is non-obvious in at least two ways. Firstly, university technology transfer is mostly assumed to be about research, patents, licensing and occasional academic entrepreneurs starting ventures, but not being a space for students to make entrepreneurial impact. Secondly, if students were connected to early technology transfer inventions, what, if any, entrepreneurial learning could that then offer?

Approach: The paper investigates a 7,5 HEC, eight-week course running annually since 2008 which connects student teams with early-stage invention disclosures. Under a secrecy agreement, the teams are asked to explore the viability of an idea. The outcomes of this course are investigated in two ways: how ideas have progressed (or not) after the course (indicating entrepreneurial impact), and how students experience learning outcomes (indicating entrepreneurial learning). A case study of one of the ideas transforming into a venture is also offered to help identify ways student-involvement can be entrepreneurial.

Results: Over ten years, altogether 211 ideas have been evaluated by the student teams within the course. 27 ideas have progressed into an incubator where idea owners have been matched with student teams. Of these 27 incubated ideas, twelve have become incorporated firms which are all (with one exception) operational to date. These descriptive findings along with the case Swedish Algae Factory indicate in what ways student involvement in technology transfer can be seen as 'being entrepreneurial'.

The idea evaluations do not contain typical entrepreneurial learning outcomes, such as business plan writing or testing value propositions on customers (Lean Startup method). Instead, skills are obtained through analyzing technical ideas into multiple directions, exploring future value visions, determining next steps, and organizational dynamics including teamwork and stakeholders (e.g. idea provider).

Implications: The findings strongly suggest that we need to revise our view of university technology transfer and what is entrepreneurial or not. Connecting students to technology transfer, makes entrepreneurial sense not only from an impact and progress perspective, but also from an entrepreneurial learning point of view.

Value/Originality: This study can help universities revise what is meant by technology transfer and entrepreneurship education and how the two can connect.

Introduction

Entrepreneurship at universities involving student engagement is often far detached from university research and technology transfer. Many would emphasize extracurricular startup-communities, Lean Startup camps or perhaps social entrepreneurship when associating students to entrepreneurship. This paper instead asks whether connecting students to technology transfer would imply 'being entrepreneurial'. The question is non-obvious in at least two ways. Firstly, while many universities have a technology transfer unit (or an equivalent function) there is normally not much connectivity between this operation and students, whether curricular or extra-curricular. The technology transfer office might offer some internships where students help analyze invention disclosures, but what then is entrepreneurial about this?

Traditionally, technology transfer is assumed to be about research results packaged as invention disclosures, to be occasionally patented and licensed. In more specific cases, it is also about professors becoming academic entrepreneurs who then start ventures. It is not seen as a space for students to make entrepreneurial impact. Furthermore, if students were to be more connected with technology transfer, how entrepreneurial could such an engagement be as a learning experience for students? Could it be carried out under the format of an entrepreneurship course, and if so, what types of entrepreneurial learning outcomes could be achieved?

This paper investigates these aspects of students being entrepreneurial when connected to technology transfer by addressing the following questions: what entrepreneurial impact can they make and what entrepreneurial learning can they gain? Ten years of evidence from a 7,5 HEC idea evaluation course, in which students are connected to early-stage inventions, is analyzed. The results challenge dominating views of how to conduct technology transfer as well as what actually enables students to develop entrepreneurial competence.

The paper proceeds as follows. Firstly, our main understandings of university technology transfer are accounted for, including more recent developments emphasizing inclusion of students, alumni and accelerators. Secondly, what we mean by entrepreneurial, both in terms of outcome and learning, is discussed. The method section describes how ten years of connecting students to technology transfer within a course format has been investigated. Results are displayed and analyzed in regards to impact of the students on transferring technology and what entrepreneurial competence they develop, thus addressing the two research questions.

Theory

The traditional roles of the university – research and education – have failed to "… ensure that knowledge would spill over for commercialization driving innovative activity and economic growth. The emergence of the entrepreneurial university gave universities a dual mandate—to produce new knowledge but also to alter its activities and values in such a way as to facilitate the transfer of technology and knowledge spillovers." (Audretsch, 2014, p. 314). In the United States, the mechanism for knowledge spillover and technology transfer came through the University and Small Business Patent Procedures Act, better known as the Bayh-Dole Act (1980), which aims to "use the patent system to promote the utilization of inventions arising from federally supported research or development; … to promote collaboration between commercial concerns and nonprofit organizations, including universities; …used in a manner to promote free competition and enterprise without unduly encumbering future research and discovery; to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; … [and] to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions" (1980, p. 3).

However, decades of university technology transfer activities have illustrated that university-industry transactions are still mostly about the 'low hanging fruits' – the transfer of research results which easily fit into established industries and supply chains (Mowery and Sampat, 2005, Siegel and Phan, 2008). This established perspective on technology transfer has placed emphasis on financial return, promoting the collection and measurement of invention disclosures leading primarily to transaction of licensing deals or material transfer agreements, with only a small portion of disclosures resulting in academic spin-offs (Louis et al., 1989, Lundqvist and Williams Middleton, 2013).

For example, the annual reporting from the Association of University Technology Managers (AUTM) showed that, in 2016 in the U.S. and Canada, a basis of 66.9 Billion USD of research expenditure contributed to 25,825 reported invention disclosures. Of these reported disclosures, 30% were transferred into license deals, and only 4% ultimately ended up as start-ups[1]. In this space, the academic entrepreneur, capable of transforming from the role of academic to entrepreneur, is much sought after in innovation policy but nonetheless remains a scarcity (Grimaldi et al., 2011). The lack of academics opting to take on the entrepreneurial role is perhaps not surprising when considering that faculty are trained to fulfill a specific professional role addressing primarily the delivery of research and education (Fogelberg and Lundqvist, 2013, Obschonka et al., 2012).

Given the reluctance or inability of academics to take on the entrepreneurial role, there is both a need and space for new actors to engage entrepreneurially within the university, ensuring that key ideas and innovations reach society (Boh et al., 2012, Hayter et al., 2016, Siegel and Wright, 2015). Internal technology transfer officers or external industry partners are seemingly not sufficient when it comes to less low-hanging fruits. Appointing an experienced surrogate entrepreneur has therefore become customary within more experienced universities (Franklin et al., 2001, Lundqvist, 2014, Würmseher, in press), but this also presents challenges. The surrogate often comes in too late to make an impact, or ends up having non-constructive tensions trying to bridge technical perspectives of inventors with business perspectives (Siegel and Wright, 2015, Würmseher, in press). In essence, these alternative roles (to the academic entrepreneur) lack the incentive to take new knowledge into new unexplored contexts (Siegel et al., 2003, Tello et al., 2011, Würmseher, in press). Consequently, there is still a large amount of promising knowledge to be realized into new contexts, requiring entrepreneurial venturing by someone.

The traditional perspective around university technology transfer, outlined so far, is depicted in Table 1 and contrasted to an emerging perspective (Siegel and Wright, 2015). Instead of focusing on research and faculty, the emerging perspective focuses on students and alumni. This is in line with the current (global) movement around Lean Startup camps, accelerators and

[1] www.autm.net/STATT

other types of entrepreneurial activities around universities (Wright et al., 2017). However, the emerging perspective also loses the old focus on research and knowledge productions, as if to emphasize entrepreneurship as only about ideating and effectuating upon your own idea. So, the question thus remains: how entrepreneurial is it to connect students to university technology transfer?

Theme	**Traditional perspective**	**Emerging perspective**
Why	To generate direct financial returns	To provide a wider social and economic benefit to the university ecosystem
What	Academic spin-offs; licensing; patents	Students and alumni start-ups; entrepreneurially equipped students; job creation in the local region or state
Who	Academic faculty and post-docs	Students; alumni; on-campus industry collaborations; surrogate entrepreneurs
How	Technology Transfer Offices; science parks	Accelerators; Entrepreneurship garages; student business plan competitions; collaborative networks with industry and alumni; employee mobility; public-private 'incubators'

Table 1. Traditional and emerging perspectives on how the university takes on entrepreneurial roles (Source: (Siegel and Wright, 2015))

Arguments for the role of entrepreneurship education in technology transfer

The emergent perspective depicted by Siegel and Wright (2015) indirectly helps to illustrate the potential role of entrepreneurship education in supporting or facilitating technology transfer. Successful startups require key competencies in regard to organizational management, resource attraction, sales and marketing, etc. The venturing of students and alumni points at such skills, and thus widens a view of technology transfer primarily being about technology verification, patenting and licensing. Although much student entrepreneurship at universities is extra-curricular, the emerging perspective should and could create space for more curricular approaches as well. Courses and programs could then potentially benefit from linking to technology transfer, constituting a largely unrealized potential identified by Nelson and Byers (2010).

There are identified challenges in making technology transfer more entrepreneurial: "Institutions that choose to stress the entrepreneurial dimension of technology transfer need to address skill deficiencies in technology transfer offices (TTOs), reward systems that are inconsistent with enhanced entrepreneurial activity, and education/training for faculty members, post-docs, and graduate students relating to interactions with entrepreneurs" (Siegel and Phan, 2008, p. 2). Interestingly, education is proposed as a tool to develop not only students but all university employees, from senior and junior faculty to technology transfer officers. Students, however, are apparently seen as just students and the important role student entrepreneurship could play in the technology transfer process has thus been neglected (Grimaldi et al., 2011).

The few studies that exist on student involvement into entrepreneurship, suggest that graduate and post-doctoral students are critical participants in university spinoffs (Boh et al., 2012, Hayter et al., 2016). Four pathways have been identified that can lead to successful spinoff creation, based on the varying functions of faculty, experienced entrepreneurs, PhD/post-doctoral students, and business students, and the relative strengths and weaknesses of each arrangement (Boh et al., 2012). Students taking on entrepreneurial roles, while at the university, have become increasingly common (Kolvereid and Åmo, 2007). The evolution of entrepreneurship education (Finkle et al., 2006, Solomon, 2007) has led to the development of courses and programs which focus on engaging the student in entrepreneurial practice (Lundqvist, 2014, Neck and Greene, 2011, Neck et al., 2014) or build upon students own independent (extra-curricular) entrepreneurial activity (Pittaway et al., 2015).

Connecting students to early-stage ideas could potentially train them through learning by doing (Cope and Watts, 2000) and take on the role of entrepreneur to provide experiential learning of the entrepreneurial process (Gondim and Mutti, 2011, Lackéus and Williams Middleton, 2015, Ramsgaard and Christensen, 2016, Rasmussen and Sørheim, 2006). This then, arguably, would require the student being given relatively free hands to explore any idea and take it to new unforeseen places. Evidence of students being connected to unrealized ideas from public or private R&D is, however, very scarce. Even the most extreme forms of action-based venture creating entrepreneurship programs primarily rely on students as the idea generators for the future ventures (Lackéus and Williams Middleton, 2015, Lockyer and Adams, 2014). Only rare examples source early-stage innovative ideas from the broad entrepreneurial ecosystem associated to the university (Lundqvist, 2015, Lundqvist and Williams Middleton, 2008, Moroz et al., 2007, Wright et al., 2017).

If the educational objective is to become entrepreneurial, research argues that critical components should be incorporated into the learning process, such as identity construction (Donnellon et al., 2014, Nielsen and Gartner, 2017), alertness, shrewdness and prudence in the context of action (Johannisson, 2016), and the creation of value as perceived by others (Lackéus, 2016a, Lackéus, 2016b). For entrepreneurial education to provide these competencies, students need to break out of the boundaries the classroom, and arguably outside the boundary of 'being a student'. The question is, can this be done if students are connected to the ideas of others, as much, or perhaps even more, than when asked to pursue ideas of their own?

If students are entrusted to deal with others idea and break out of the boundaries of both the classroom and the technology transfer office, then the role they take is comparable to the surrogate entrepreneur. The term surrogate entrepreneur was introduced specifically to the context of commercializing public research and was a reaction to the challenge of asking individuals established in one professional career, to take on a secondary career identity as entrepreneur. Surrogacy has both benefits and limitations (Franklin et al., 2001, Lundqvist, 2014, Radosevich, 1995). To be beneficial, surrogate entrepreneurs should be seen as a complement rather than replacement to the inventors and technological experts. Timing is important – studies have shown that surrogates need to be engaged in the early formation of the venture if they are to have impact in the venture development. Perhaps students are more willing to engage in early risky stages than more experienced surrogate entrepreneurs allowing them to affect an early venture more than more experienced surrogate entrepreneurs can when engaged in later stages?

Surrogate entrepreneurship also draws attention to the importance of being relational and team-based. It emphasizes an intersubjective perspective on value creation from day one, and not only as something potentially important more downstream. This might be an important distinction, since it emphasizes a professional quality (to serve others), differentiating quite a lot from the image of the "self-made" more or less "lone" entrepreneur – starting a business to become independent.

There is currently a shift of perspective around university technology transfer, from professors and established industry partners, to students, alumni and surrogate entrepreneurs to play key entrepreneurial roles (Siegel and Wright, 2015). However, there is still little evidence around these actors and especially students taking on what used to be left to professors and R&D professionals, i.e. evaluating and propagating potential spillover R&D findings through technology transfer – lacking recipients but still having potential for society.

Method

Student entrepreneurial impact and entrepreneurial learning relative to technology transfer is investigated through a 7,5 HEC, eight-week, elective course in Idea Evaluation which has run from January to March annually since 2008. Each year, approximately 50 students (mainly engineering disciplines) are placed in teams of four/five, and connected with early-stage technical ideas (presented in the form of invention disclosures). Under a secrecy agreement, the teams are asked to explore the viability of the idea in regards to three main areas: 1) functionality, novelty and freedom to operate; 2) potential future value in terms of societal-, customer/end-user- and business utilities; and 3) next steps required to further develop the idea. Tools, perspectives, counseling and feedback are offered through lectures, workshops and presentation events. Societal utility (including principles of sustainability) is emphasized as a key evaluation aspect, building upon identified situations of use.

The curricular learning gained by students is captured through two main assessments: a seven-page idea evaluation report (a group deliverable) and associated oral presentation, and an individual exam testing knowledge and skill acquisition. Since the ideas connected to the student teams are unique, the teams must figure out their own way to develop and evaluate the potential innovation, as there is no common standard beyond the three area framework outlined in the previous paragraph. Hence, students are faced with the entrepreneurial method of effectuation (Sarasvathy, 2008) where they embrace uncertainty through drawing from what they have at hand and can access (competencies, networks, relationship to idea provider, etc.) in order to create solutions, which in turn then can be re-examined to iterate even better solutions (Agogué et al., 2015). The relatively short course format utilizes a substantiated argument-based packaging of the evaluated case with limitations on the technical verification of any claimed functionality or utility. However, the delivered idea evaluation provides a basis for university technology transfer office and incubator to, in dialogue with the idea providers, find ways to take the idea forward. In certain instances, this includes offering it back to students to continue as surrogate entrepreneurs through a specialized venture creation program (Lundqvist, 2015).

The course format has evolved over the years but within the same overall structure. Key features have been the following:

1. One or two real-life recruited ideas appointed to the student teams to evaluate under secrecy agreement.
2. Non-mandatory classroom half-days, twice a week, with a blend of lecturing faculty, guest lectures, workshops, consultations, and peer-learning around the progress of the idea evaluations.
3. Written exams at the end of the course, having questions that address theory, tools and how these have been applied.
4. Mandatory presentations and oppositions of final idea evaluation reports, including submitting a written seven-page report plus greater or less extensive appendices for grading.
5. Grading based upon individual exam (60%) and grading of the idea evaluations done in teams (40%)
6. From 2010, the course has had the anthology Sustainable Business Development (see the more recent version, Alänge and Lundqvist, 2014), written by faculty and alumni around the entrepreneurship program as the main literature.

Entrepreneurial impact from the students engaged into technology transfer is assessed in two ways. Firstly, a database of all ideas evaluated through the school and how they progress has been established and accounted for. While on a higher descriptive level, such an account indicates the extent to which there is entrepreneurial impact beyond the early-stage idea evaluations conducted within course-setting, as the progression from the course to, for example a venture incubator is shown. Secondly, a detailed case is offered – Swedish Algae Factory – as illustration of an idea evaluation which evolved into an entrepreneurial venture with a variety of entrepreneurial attributes, such as pivoting between different business models, attracting different type of financing, pushing new and more sustainable technology into the market-place, etc. The case is selected due to its richness as regards entrepreneurial dimensions rather than as a typical example of what comes out of the course-setting.

Entrepreneurial learning from the course is mainly assessed through the course examination process, where not only declarative knowledge is examined but even more so skills and reflexivity around the project-work students conduct. Although, students experience such project work differently, the examination does give a generalizable picture over the years around key learning outcomes that students relate to.

Findings

First, a descriptive overview of how ten years of idea evaluation has progressed is given. Then, the Swedish Algae Factory case is offered. Finally, evidence around the entrepreneurial learning outcomes is provided.

Progress of Student Evaluated Ideas

Since 2008, 211 ideas have been evaluated by the student teams within the Idea Evaluation course. Ideas are mainly sourced from university research/university associated organizations (41%), research institutes (3%), private companies (30%), private individuals (21%) or other environments (5%).

Table 2. Incubated Ideas

IE course year	CSE Company	Incubation Year	Idea Provider Category	Notes
2008	Acousense	2009	Company	Incorporated 2009 – ongoing
2008	Cereduce	2009	Company	Picked up by GU Ventures post incubation year
2008	LineRobot	2009	Company	shutdown during incubation year
2008	Timaging	2009	University	shutdown during incubation year
2008	T-Sort	2009	University	
2008	Microfield Technologies	2009	University	shutdown during incubation year
2009	Breathsensor aka Tibria	2010	Inventor	not incorporated
2009	Seaceron	2010	Inventor	not incorporated
2010	Hydrock	2011	University	shutdown during incubation year
2010	Plasmid	2011	University	not incorporated
2010	Qascade Lasers	2011	University	not incorporated
2011	Previsco	2015	Inventor	Incorporated
2011	Flocazur	2012	Inventor	not incorporated
2012	Eviwave	2013	Company	Incorporated 2012 – shut down 2017
2012	ModMide	2013	University	not incorporated
2013	Agropaper	2014	Company	not incorporated
2013	Swedish Algae Factory	2014	University	Incorporated 2014 – ongoing
2013	ReVibe	2014	Company	Incorporated 2014 – ongoing
2013	Simplex Motion	2014	Company	Incorporated 2013 – ongoing
2013	Imnus	2014	Company	not incorporated
2013	Melvitas	2014	University	not incorporated
2014	Biopetrolia (aka Cetect)	2016	University	ongoing project
2014	Profoto	Corp 2015	Company	new project started at company
2015	ETON	Corp 2016	Company	new project started at company
2015	Epishine	2016	University	Incorporated 2016 – ongoing
2015	Waste2Energy	2016	Inventor	shutdown during incubation year
2017	Atium	2017	University	Currently being incubated

Overall, verbal feedback from idea providers has been appreciative or very appreciative of the idea evaluations conducted by the student teams. This further evidenced by idea providers choosing to enact the suggested next steps presented by the students in the evaluations, with exemplary cases being the choice to engage in venture incubation (see Table 2 and the following paragraph). There is no systematic record of how the ideas not continuing into the incubator have progressed. In some but not all cases, the idea owner or technology transfer officer have taken measures to progress an evaluated idea. And for nearly all the 211 ideas, value has been given to the idea providers through insight and knowledge of what to do next, including patentability options and identification of more sustainable areas of use for the early-stage idea. Some idea providers have then been able to take steps themselves or in collaboration others, thus helping such ideas forward. Examples of this kind of continuation include: a university researcher connecting to an incubation advisor, eventually incorporating the evaluated idea; a researcher building upon the student evaluation to develop an IT platform; and a private company continuing collaboration with the students to develop the evaluated idea as part of their business. In the few cases where idea providers raised concerns, faculty or TTO/Incubator actors were able settle and resolve any issues.

Of the 211 ideas evaluated, 27 have progressed into an incubator where master-level students pursue the idea as a project for one year, with the potential to incorporate upon graduation. Table 2 depicts these projects and also accounts for which have progressed into incorporated ventures. Twelve of these 27 stem from university research, and therefore also involved continued collaboration with research development to progress the venture. Of the 27 incubated projects, twelve were based from university research, ten were R&D transferred from a company, and five were ideas that came from independent inventors. Of those incorporated, two were from a university research, four from a company and one from an independent inventor. So far, only one of the incorporated ventures has been terminated.

Swedish Algae Factory

The start-up Swedish Algae Factory today enables an energy efficient algae biomass production in cold and dark climates. Swedish Algae Factory was incorporated 2015 and has since then been run by Sofie Allert as the lead entrepreneur. She was also in the team evaluating the idea disclosure in the 2013 iteration of the Idea Evaluation course (see Figure 1).

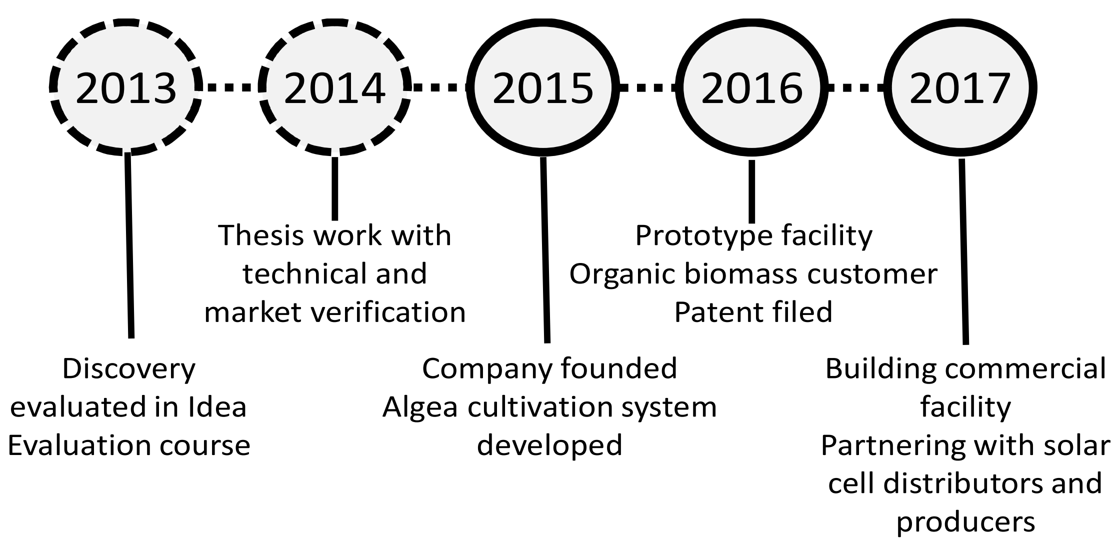

Figure 1. Key events in Swedish Algae Factory.

Sofie came to the Idea Evaluation course with a background in biochemistry and having done her bachelor thesis in biofuels. When engaging into the Idea Evaluation course, she was doing her second semester in the two year MSc program at Chalmers School of Entrepreneurship, where this course has been mandatory. The idea (disclosure) provided was a research discovery of a professor at University of Gothenburg regarding a specialized algae with promising properties for application in e.g. biofuel, and able to thrive in harsh conditions of colder temperatures and limited sunlight. Algae production for multiple of sustainable uses could, through this discovery, potentially be brought to new contexts, outside the mainly sunny and warm sites commonly used.

Sofie and her team in the Idea Evaluation course were able to build a strong case around key issues such as patentability (including novelty and freedom to operate); situations of use with strong potential for societal, customer and business utility; and point a critical next steps for the discovery to be more verified. After the course, Sofie was matched with another student in her master program and together they continued to develop the business application areas of the algae and business potential of using the algae as a biofuel during their entrepreneurial thesis work. Among other things, they applied for and received verification grants from a Swedish innovation agency. Additional grants required that they obtain co-applicants from industry, which they found. After some time, one of these partners was exchanged for a new industry actor partner providing a wastewater source to facilitate the algae production – a fish production site on the Swedish west coast. This sector was a new area of use for the organic biomass.

After some development attempts within the wastewater and crude oil sectors, Swedish Algae Factory ended up going back to some of the earlier identified application, re-evaluating the silica aspect of the algae. Building from knowledge about the algae's silica structure, Swedish Algae Factory could prove an ability to increase a particular performance criteria of solar cells by 4%. It was not clear until attending an industry fair, that this was a drastic improvement on existing industry standards. Based on this, Swedish Algae Factory currently explores solar panel applications, while over the years, having explored a variety of interesting situations of use, many of which were identified already back in the Idea Evaluation course as evidenced in the student report. Key events of the venture are indicated in Figure 1.

In the case of Swedish Algae Factory, the idea provider has, in interviews, clearly stated that the engagement of Sofie to the project was critical to her research being transformed into an incorporated venture, and that the venture has then continued to explore new application areas beyond the initial intention of biofuel. In her view, there is a clear impact of engaging students in a leading entrepreneurial role in a technology transfer process. Sofie has in turn, in different interviews, acknowledged the specific motivation she gained from engaging in the creation of a venture that linked to research related to her bachelor studies, but that the learning also stemmed from the masters-program and specific environment that allowed her to experience incubation of a real-idea based venture.

Entrepreneurial Learning Outcomes

The aim of the course is allow students to be skilled in carrying out idea evaluations of early-stage ideas as well as become aware of the critical role that idea evaluations play for economic, environmental and social sustainable development.

Apart from being examined on declarative knowledge around idea evaluation tools and terminology, the course also assesses the following skills:

1. Ability to analyze a technical idea as regards e.g. freedom to operate and novelty, through the use of patent databases and other means
2. Determine value visions around future areas of use, including customer, societal, business utility, market potential, etc.
3. Formulate needs for further verification, including risk analysis, competence requirements, and financing needs
4. Skills in communication and presentation of idea feasibility.

In essence, all students attending the course gain entrepreneurial experiences in terms of having to effectuate under uncertainty and develop skills in how to package early-stage technical ideas in ways more attractive to existing (the idea provider) as well as new and potential stakeholders. They also gain skills in taking entrepreneurial action as well as express and perhaps develop attitudes towards how they want to contribute to sustainable development through early-stage idea evaluation, while relating to project experiences as well as to an anthology with frameworks and perspective offered faculty and alumni entrepreneurs (Alänge and Lundqvist, 2014).

Conclusions and Future Research

The purpose of this paper is to explore how entrepreneurial it is to connect students to technology transfer ideas. This purpose has been investigated through investigating outcome from a 7,5 HEC Idea Evaluation course, where students every year have been connected to inventions disclosures during eight weeks. The findings display clear entrepreneurial progress in more than 10% of the evaluated ideas into technology ventures, where many still are operating. In all these cases, students being part of the idea evaluation course, also were the ones venturing the ideas further, such as in the Swedish Algae Factory case. For almost all the other ideas evaluated, the idea providers have expressed content around what the students delivered. Hence, connecting students to technology transfer has had positive and often value-creating entrepreneurial outcomes, while resulting in very few negative effects.

From an entrepreneurial learning perspective, the students engaging with technology transfer, accomplish important learning outcomes. These are not reflected in business plans or intense (Lean Startup) interactions with potential customers, but rather involve analyzing technical ideas into multiple directions, exploring future value visions, and determining next steps and handling teamwork and stakeholders (e.g. idea providers). All these skills arguably result in important entrepreneurial learnings for the students, as they must translate the potential value of underlying function and utility, as well as illustrate how value propositions can be enacted.

The main conclusion of this study, hence, is that students can gain important entrepreneurial learning while also enable technology transfer inventions to progress. The implications from this is twofold. Firstly, universities need to recognize connecting students to early-stage ideas in need of evaluation as an important source for entrepreneurial learning. Policies and management need to take this opportunity into consideration and not just settle with students being entrepreneurial in the more established ways through startup communities or lean startup camps. Secondly, policies and management also need make clear that technology transfer is not just about researchers, technology transfer officers and close at hand industry contacts. Technology transfer at universities need to evolve into something more explorative, reaching not only for low-hanging fruits, and caring about impact in a variety of ways. Evidently, students can and want to play a major role in this expansion of technology transfer into the realm of entrepreneurship, if only they are clearly invited and connected to these opportunities.

The current paper draws from one setting and only provides one more descriptive example of a startup enabled by a specific educational format. There is reason to study more broad and systematic attempts by universities to position students into entrepreneurial roles under curricular or extra-curricular formats. Such further studies should apply a broader view of what being entrepreneurial entails, allowing all types of assignments where there is no clear solution but rather a potentially interesting starting point (such as an early-stage research results) to allow for some type of learning-by-creating-value-for-others approach.

References

(1980), University and Small Busines Patent Procedures Act. *In:* Congress, U. S. (ed.) *35 U.S.C. § 200-212 (37 C.F.R. 401).* United States: U.S. Code.

Agogué, M., Lundqvist, M. & Williams Middleton, K. (2015), Mindful Deviation through Combining Causation and Effectuation: A Design Theory-Based Study of Technology Entrepreneurship. *Creativity and Innovation Management,* Vol.24, No.4, pp.629-644.

Alänge, S. & Lundqvist, M. (2014), *Sustainable Business Development: Frameworks for Idea Evaluation and Cases of Realized Ideas,* Chalmers University of Technology, Göteborg, Sweden.

Audretsch, D. B. (2014), From the entrepreneurial university to the university for the entrepreneurial society. *Journal of Technology Transfer,* Vol.39, No.3, pp.313-321.

Boh, W. F., De-Haan, U. & Strom, R. (2012), University Technology Transfer Through Entrepreneurship: Faculty and Students in Spinoffs. Available at SSRN.

Cope, J. & Watts, G. (2000), Learning by doing: An exploration of experience, critical incidents and reflection in entrepreneurial learning. *International Journal of Entrepreneurial Behaviour & Research,* Vol.6, No.3, pp.104-124.

Donnellon, A., Ollila, S. & Williams Middleton, K. (2014), Constructing Entrepreneurial Identity in Entrepreneurship Education. *International Journal of Management Education,* Vol.12, No.3, pp.490-499.

Finkle, T. A., Kuratko, D. F. & Goldsby, M. G. (2006), An Examination of Entrepreneurship Centers in the United States: A National Survey. *Journal of Small Business Management,* Vol.44, No.2, pp.184-206.

Fogelberg, H. & Lundqvist, M. A. (2013), Integration of academic and entrepreneurial roles: The case of nanotechnology research at Chalmers University of Technology. *Science and Public Policy,* Vol.40, No.1, pp.127-139.

Franklin, S., Wright, M. & Lockett, A. (2001), Academic and surrogate entrepreneurs in university spinout companies. *Journal of Technology Transfer,* Vol.26, No.1-2, pp.127-141.

Gondim, S. M. G. & Mutti, C. (2011), Affections in learning situations: a study of an entrepreneurship skills development course. *Journal of Workplace Learning,* Vol.23, No.3, pp.195-208.

Grimaldi, R., Kenney, M., Siegel, D. & Wright, M. (2011), 30 years after Bayh-Dole: Reassessing academic entrepreneurship. *Research Policy,* Vol.40, No.8, pp.1045-1057.

Hayter, C. S., Lubynsky, R. & Maroulis, S. (2016), Who is the academic entrepreneur? The role of graduate students in the development of university spinoffs. *The Journal of Technology Transfer*, pp.1-18.

Johannisson, B. (2016), Limits to and prospects of entrepreneurship education in the academic context. *Entrepreneurship & Regional Development,* Vol.28, No.5/6, pp.403-423.

Kolvereid, L. & Åmo, B. W. (2007), Entrepreneurship among graduates from business schools: A Norwegian case. *In:* Fayolle, A. (ed.) *Handbook of Research in Entrepreneurship Education Vol 2: Contextual perspetives.* Edward Elgar, Cheltenham, UK, pp.207-218.

Lackéus, M. (2016a), A 'value' and 'economics' grounded analysis of six value creation based entrepreneurial education initiatives. *ECSB Entrepreneurship Education (3E) Conference.* Leeds, UK.

Lackéus, M. (2016b), *Value Creation as Educational Practice - Towards a new Educational Philosopy grounded in Entrepreneurship?* PhD Kappa, Chalmers University of Technology.

Lackéus, M. & Williams Middleton, K. (2015), Venture creation programs: bridging entrepreneurship education and technology transfer. *Education and Training,* Vol.57, No.1, pp.48-73.

Lockyer, J. & Adams, N. Venture Creation Programmes: Causation or Effectuation? *European Conference on Innovation and Entrepreneurship, 2014*, Academic Conferences International Limited, pp.287.

Louis, K. S., Blumenthal, D., Gluck, M. E. & Stoto, M. A. (1989), Entrepreneurs in academe: an exploration of behaviors among life scientists. *Administrative Science Quarterly,* Vol.34, No.1, pp.110–131.

Lundqvist, M. (2015), Chalmers. An entrepreneurial university institutionalizing the entrepreneurial?, *In:* Foss, L. & Gibson, D. (eds.) *The Entrepreneurial University: Context and Institutional Change.* Routledge, New York, NY USA, pp.113-130.

Lundqvist, M. & Williams Middleton, K. (2008), Sustainable Wealth Creation beyond Shareholder Value. *In:* Wankel, C. & Stoner, J. (eds.) *Innovative Approaches to Global Sustainability.* Palgrave MacMillan, New York, NY, pp.39-62.

Lundqvist, M. & Williams Middleton, K. (2013), Academic entrepreneurship revisited: university scientists and venture creation. *Journal of Small Business and Enterprise Development,* Vol.20, No.3, pp.603-617.

Lundqvist, M. A. (2014), The importance of surrogate entrepreneurship for incubated Swedish technology ventures. *Technovation,* Vol.34, No.2, pp.93-100.

Moroz, P., Hindle, K. & Anderson, R. B. (2007), Exploring the linkages between university technology transfer and entrepreneurship education programs: attitudes and perceptions amongst entrepreneurship academics. *International AGSE Entrepreneurship Research Exchange.* Brisbane, Australia.

Mowery, D. C. & Sampat, B. N. (2005), The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Governments? *Journal of Technology Transfer,* Vol.30, No.1/2, pp.115-127.

Neck, H. M. & Greene, P. G. (2011), Entrepreneurship Education: Known Worlds and New Frontiers. *Journal of Small Business Management,* Vol.49, No.1, pp.55-70.

Neck, H. M., Greene, P. G. & Brush, C. G. (2014), *Teaching entrepreneurship: A practice-based approach,* Edward Elgar Publishing, Cheltenham, UK.

Nelson, A. & Byers, T. (2010), Challenges in university technology transfer and the promising role of entrepreneurship education. *Kauffman: Emerging Scholars Initiatives*.

Nielsen, S. L. & Gartner, W. B. (2017), Am I a student and/or entrepreneur? Multiple identities in student entrepreneurship. *Education + Training,* Vol.59, No.2, pp.135-154.

Obschonka, M., Goethner, M., Silbereisen, R. K. & Cantner, U. (2012), Social identity and the transition to entrepreneurship: The role of group identification with workplace peers. *Journal of Vocational Behavior,* Vol.80, No.1, pp.137-147.

Pittaway, L. A., Gazzard, J., Shore, A. & Williamson, T. (2015), Student clubs: experiences in entrepreneurial learning. *Entrepreneurship & Regional Development,* Vol.27, No.3/4, pp.127-153.

Radosevich, R. (1995), A model for entrepreneurial spin-offs from public technology sources. *International Journal of Technology Management,* Vol.10, No.7/8, pp.879-893.

Ramsgaard, M. B. & Christensen, M. E. (2016), Interplay of entrepreneurial learning forms: a case study of experiential learning settings. *Innovations in Education and Teaching International*, pp.1-10.

Rasmussen, E. & Sørheim, R. (2006), Action-based entrepreneurship education. *Technovation,* Vol.26, No.2, pp.185-194.

Sarasvathy, S. D. (2008), *Effectuation: Elements of Entrepreneurial Expertise,* Edward Elgar, Cheltenham, UK.

Siegel, D., Waldman, D. & Link, A. (2003), Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy,* Vol.32, No.1, pp.27-48.

Siegel, D. & Wright, M. (2015), Academic Entrepreneurship: Time for a Rethink? *British Journal of Management,* Vol.26, No.4, pp.582-595.

Siegel, D. S. & Phan, P. H. (2008), Analyzing the Effectiveness of University Technology Transfer: Implications for Entrepreneurship Education. *In:* Libecap, G. D. (ed.) *University Entrepreneurship and Technology Transfer: Process, Design, and Intellectual Property.* Emerald Group Publishing Limited, Bingley, UK, pp.1-38.

Solomon, G. (2007), An examination of entrepreneurship education in the United States. *Journal of Small Business and Enterprise Development,* Vol.14, No.2, pp.168-182.

Tello, S., Latham, S. & Kijewski, V. (2011), Assessing differences between technology transfer officers and institutions in the decision to commercialise new technologies. *International Journal of Technology Transfer and Commercialisation,* Vol.10, No.1, pp.93-111.
Wright, M., Siegel, D. S. & Mustar, P. (2017), An emerging ecosystem for student start-ups. *Journal of Technology Transfer,* Vol.42, No.4, pp.909-922.
Würmseher, M. (in press), To each his own: Matching different entrepreneurial models to the academic scientist's individual needs. *Technovation,* Vol.59, pp.1-17.