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Science-based entrepreneurship education as a means for university-industry technology transfer

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Abstract

This paper explores the potential of university-industry technology transfer through science-based entrepreneurship education (SBEE). The scientific literature focuses mostly on enabling university-industry technology transfer via university-industry collaboration in research, and not so much in (science) education. The paper identifies four strands of relevant literature for further theorizing SBEE principles to research its contribution to industry-technology transfer: 1. Embedding entrepreneurship education in universities; 2. Balancing theory and practice of entrepreneurship education; 3. Cultivating an entrepreneurial mindset through entrepreneurship education; and 4. Creating spin-offs through entrepreneurship education. One of the main theoretical contributions of this paper is, that SBEE is different from regular entrepreneurship education in its need for being firmly embedded in a science, technology and R&D environment, both within and outside the university. This is important in order to give SBEE students the opportunity to gain experience with handling the hurdles for successful university-industry technology transfer. The main empirical finding is that elements in the program, related to for example the balance between teaching entrepreneurship through theory and experiential learning, are not systematically covered. It means that fundamental questions such as: Can entrepreneurship be indeed taught? Which elements of entrepreneurship can be taught through theory, and which ones must be experienced in practice? are currently left unanswered. Systematic coverage of these questions enables a better exploitation of the possibilities that SBEE offers for university-industry technology transfer.

Keywords University-industry technology transfer · Science-based entrepreneurship education · Entrepreneurship education · Technology based entrepreneurship · Innovation · Innovation policy

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Introduction

University-industry technology transfer has long been perceived as the holy grail in science and innovation policy. Governments support universities and companies to collaborate in research projects, and thus, as is generally thought, to enhance their mutual innovative potential (De Jong et al. 2015). Innovation policies often implicitly assume, that a lack of university-industry technology transfer is related to a lack of collaboration between scientists and external parties.

Problems with university-industry technology transfer however have more underlying causes than this single one. Warren et al. (2008) for example point out the importance of a supportive regional innovation system, in order for a university to be successful in university-industry technology transfer. Anderson et al. (2007) question the efficiency of university-industry technology transfer through current organizational arrangements such as Technology Transfer Offices. They develop a model to quantitatively assess the efficiency of such transfers through current organizational arrangements. Audretsch et al. (2005) discuss the role of firm location for university-industry technology transfer.

Related to the above mentioned difficulties in creating effective university-industry technology transfer, a still remaining question is how university-industry technology transfer can be stimulated through entrepreneurship education in science, engineering and technology faculties: by means of science-based entrepreneurship education (SBEE). Universities have, in the last decades, started to reposition themselves in society. Keywords in their endeavors to do so are 'valorization' and 'entrepreneurship' (Blankesteijn et al. 2019; van de Burgwal et al. 2019). In order to 'valorize' their findings - turning scientific knowledge and technological inventions into commercial and societal value - academic researchers in a growing number of universities increasingly develop a new identity as academic entrepreneurs (Rothaermel et al. 2007; Morales-Gualdrón et al. 2009; Philpott et al. 2011; Leloux et al. 2013; Audretsch 2014; Sam and van der Sijde 2014; Wright 2014; Schmitz et al. 2017).

Next to university-industry technology transfer through research, universities currently also *teach* entrepreneurship to cultivate an entrepreneurial attitude in the mindset of their students (Davey et al. 2016a). Next to the more traditional entrepreneurship education through business administration programs, this increasingly takes place also in faculties of science, engineering and technology. Yet, to date, research that discusses the content of, and effect of SBEE, on university-industry technology transfer is scarce (Maresch et al. 2016; Barr et al. 2009; Lackeus and Middleton 2015; Souitaris et al. 2007; Standish-Kuon and Rice 2002; Blake Hylton et al. 2019). Further insight in this would help to asses why and how SBEE can support university-industry technology transfer.

To gain further insight in this area, the research question this paper addresses is: How does science-based entrepreneurship education (SBEE) contribute to university-industry technology transfer?

This paper is structured as follows. Firstly, the literature on university-industry technology transfer will be reviewed. The review shows that university-industry technology transfer via university-industry collaboration on the level of *research* is well-researched. However, the role of education – in particular SBEE, whereby a particular type of academic *education* is seen as a means for university-industry technology transfer, is a relatively under researched topic (see Barr et al. 2009; Lackeus and Middleton 2015; Maresch et al. 2016; Souitaris et al. 2007; Standish-Kuon and Rice 2002; Blake Hylton et al. 2019).

The contribution of this article is, that is focuses on an analysis of SBEE as a means for university-technology transfer, especially from the viewpoint of 1. Academic education and teaching instead of research; 2. the insides of an educational program itself instead of, for example, innovation policy or academic entrepreneurship more generically; and 3. *science*-based entrepreneurship in particular instead of generic science and engineering entrepreneurship education. We develop four analytical categories based upon the literature review, to systematically explore the potential of SBEE as a means for university-industry technology transfer. Secondly, methodology and data gathering is elaborated upon. Thirdly, an empirical case study is introduced. The case study researches ways to stimulate university-industry technology transfer through SBEE, via an in-depth study of a particular educational program representative of SBEE, namely Science, Business & Innovation (SBI) at VU University Amsterdam. Fourthly, the results are discussed whereby the potential of SBEE in contributing to university-industry technology transfer is assessed critically in the light of the literature. Based on the discussion, avenues for further research are identified. The conclusion section highlights the most relevant findings of this paper and formulates a set of recommendations.

Science based entrepreneurship education

Studies on university-industry collaboration often find their starting point in the research task of universities. Academic entrepreneurship is a central theme in the literature that identifies the increased importance attached at universities to university-industry collaboration (Audretsch 2014; Sam and van der Sijde 2014; Wright 2014). Rothaermel et al. (2007) give a comprehensive overview of the state of the literature on academic entrepreneurship as a means for university-industry technology transfer and Schmitz et al. (2017) recently updated this literature review. Three topics in this research field that receive considerable attention are the role of technology transfer offices (TTOs) in transferring universities' knowledge to business (Mazdeh et al. 2013), product innovation trajectories of university-business partnerships (Un et al. 2010), and intellectual property arrangements between universities and firms (Forti et al. 2013; Siegel et al. 2007).

Next to a research task, universities have an educational task and a societal mission. Their educational task is clear. Their societal mission has received more emphasis in the last decades. It is translated, amongst others, as the university having a role in university-industry technology transfer. How does the emphasis put on university-industry collaboration, one of the main goals of science and innovation policy, precipitate in the context of academic education?

Some studies, such as Boocock et al. (2009) mention the role of technology based entrepreneurship education, facilitating university-industry technology transfer as well. They research its role from the perspective of national innovation policy schemes. Other studies review the role of entrepreneurial attitudes at universities for technology transfer, giving a broad overview of mechanisms, organizations and actors engaged in entrepreneurial activities in Academia and in facilitating technology transfer (Morales-

Gualdrón et al. 2009; Siegel and Wright 2015). Boh et al. (2016) research the role of general academic education, specifically with regard to teaching entrepreneurial knowledge, skills and attitudes in university-industry technology transfer.

Although a growing body of literature emerges in this area, a limited number of studies specifically focusses on the role of SBEE for university-industry technology transfer. These studies signal a research gap in the literature with regard to the contribution of entrepreneurship education in science and engineering programs to university-industry technology transfer. They address this research gap as follows. Barr et al. (2009) draw lessons on developing a "commercialization of technology" pedagogy – such as the importance of putting an epistemological perspective central in the curriculum whereby the assumption is that entrepreneurial opportunities are 'created', and hence not 'discovered'. And Lackeus and Middleton (2015) study a program in which science and engineering students, through real life experience with creating a new venture, learn about entrepreneurship. Maresch et al. (2016) compare the effect of entrepreneurship education on entrepreneurial intentions of students in business administration and students in science and engineering. Their study finds that science and engineering students are negatively affected in their entrepreneurial intentions by subjective norms in their surroundings, whereas business administration students are not.

Some previous studies specifically concentrate on the effects of entrepreneurship education for a generic group of science and engineering students. Blake Hylton et al. (2019) focus on curricular, cocurricular and extracurriculur activities developed to create an entrepreneurial mindset in a mechanical engineering program at Ohio Northern University. Souitaris et al. (2007) study the effects of entrepreneurship education on entrepreneurial attitudes and intentions of students. Based on statistical analysis of data taken from a generic sample of science and engineering students, they found a positive effect of such education on entrepreneurial intentions of students. They also found that inspiration is pivotal in creating entrepreneurial intents through education and recommend to focus on creating such inspirational effects in science and engineering curricula. Standish-Kuon and Rice (2002) found, based on six case studies at American universities, that promoting the work and practices of succesful entrepreneurial students, alumni, and other entrepreneurial champions in science and engineering programs, is highly stimulating for science and engineering students to become entrepreneurs themselves.

Other papers report on research on the effect of entrepreneurship education on *engineering* students only, such as Blessing et al. (2008), Duval-Couetil et al. (2012), Duval-Couetil et al. (2016), Gilmartin et al. (2016), Hixon and Paretti (2018), Huang-Saad et al. (2018), Kriewall and Mekemson (2010), London et al. (2018), Nichols and Armstrong (2003), Rae and Melton (2017). These studies use a generic sample of science and engineering education, not specifying for traditional science areas as physics and chemistry; or focus solely on engineering faculties and education. The studies lack a specific focus on the contribution from fundamental natural sciences such as physics and chemistry to technology development and technology transfer to the market. Thus, these studies do not specifically highlight the contribution of SBEE for university-industry technology transfer. However, the natural sciences such as physics and chemistry, and their concurrent educational programs, harbor a huge potential in developing instruments, applications and technologies which are interesting, not only from a scientific perspective, but from a commercial viewpoint as well – thereby enabling coverage of the whole science-to-business-to-market innovation process, from the research phase to full commercialization. Technology transfer in case of engineering, focusses mainly on the phase from development towards commercialization and thus does not cover the preceding phase of research.

We aim to contribute to this literature by adding a perspective on the contribution of science based entrepreneurship *education* (SBEE) (thus: not research-based academic entrepreneurship) to university-industry technology transfer (thus: not entrepreneurship education in *engineering* faculties), researched from the perspective of the insides of an educational program itself (instead of, for example, from the viewpoint of innovation policy schemes or, an overall assessment of entrepreneurship stimuli at universities).

Compared to the role of university-industry collaborative research, SBEE and its contribution to university-industry technology transfer are thus relatively under researched. However, a multitude of studies on either technology based entrepreneurship or entrepreneurship education, as core components of SBEE, without an emphasis on its influence on university-industry technology transfer, have been conducted. The coming paragraphs discuss this literature based on our identification of four streams of research on these topics: 1. embedment of entrepreneurship education in a university context 2. balancing in entrepreneurship education between theory and practice 3. cultivating an entrepreneurial mindset through entrepreneurship education, and 4. creating spin-offs through entrepreneurship education.

Embedment of entrepreneurship education in a university context

One research stream on entrepreneurship education discusses the embedment of entrepreneurship education at universities. Embedment of high tech entrepreneurship in universities has consequences for the positioning of universities in society, as Huffman and Quigley (2002) signal. Schmitz et al. (2017) give an overview of innovation and entrepreneurship in an academic setting. Embedment of entrepreneurship education in universities has, as a theme in a general sense been discussed by Abreu and Grinevich (2014). The effect of entrepreneurship education at universities on regional innovation systems has been researched by Aldianto et al. (2018). An approach to identify different intensities of knowledge transfer activities at universities is developed by Berbegal-Mirabent et al. (2013). Cultural perceptions and practices play a significant role in the successful development of entrepreneurship in doctoral education (Brush et al. 2003). Audretsch et al. (2015), Audretsch et al. 2005) highlight knowledge spillovers from entrepreneurship education on regional innovation systems. From a broader perspective, Clarysse et al. (2009) identify trends in technology management education, such as a transition from a case-based approach towards a mentoring approach with regard to developing entrepreneurial skills. St-Jean et al. (2017) also emphasize the value of a mentor in entrepreneurship education. Davey et al. (2016b) discuss academic entrepreneurship, both in research as well as in teaching, as a function of regional innovation systems. For entrepreneurship education, a multi- and sometimes even interdisciplinary scientific approach is needed in order to bring innovation to the market, as Rosenberg (2009) shows for innovation in the life sciences. Mustar (2009) discusses, amongst others, how to develop a highly selective technology management and entrepreneurship specialization for students in a university environment traditionally resistant to the notion of entrepreneurship. Morales-Gualdrón et al. (2009) study the motivation of academic entrepreneurs and develop a six-dimensional model to analyze this in a real-life context. Siegel and Wright (2015) analyze how the fact that entrepreneurship has become part of the strategic agenda of universities, requires rethinking academic entrepreneurship as a topic of research.

Balancing in entrepreneurship education between theory and practice

A major issue is how to teach entrepreneurship, as a combination of theoretical knowledge and practical skills and expericence. Mars et al. (2008) mention the 'teachability dilemma' – a dilemma that often presents itself in designing entrepreneurship education. Also Haase and Lautenschlager (2011) mention the importance in entrepreneurship education of developing a vision on this dilemma within programs that aim to teach entrepreneurship. The dilemma frequently appears, implicitly or explicitly, in the literature that discusses entrepreneurship education in terms of content of the program. Should entrepreneurship education put emphasis on theory of entrepreneurship, or on offering opportunities for practical experience: as being entrepreneurial has not so much to do with 'knowing about' and more with 'doing' entrepreneurship? Entrepreneurship education often puts relatively much emphasis on practice oriented learning modules, as is shown by reviewing the literature on the content and technique of entrepreneurship education (Abreu et al. 2016; Arias et al. 2018; Arpiainen and Kurczewska 2017). A good balance between practice- and theory oriented learning in educational programs is hard to strike. Innovative forms of education are developed, in which this balance is guiding the curricular choices that are made (Chang et al. 2018; Ratinho and Henriques 2010; Yi 2018). The dilemma relates to the question that has guided entrepreneurship research for a long time (Fiet 2001), namely if entrepreneurship is an inborn quality that can be further cultivated through education, or if it can be taught as well, with not so much entrepreneurial talent naturally being present (Henry et al. 2005).

Cultivating an entrepreneurial mindset through entrepreneurship education

A third theme identified is how student entrepreneurship can be stimulated by means of entrepreneurship education. Mars et al. (2008) also discuss the role of student entrepreneurship at universities. Dabbagh and Menasce (2006) analyze the effect of regular confrontations of students with examples of entrepreneurship in engineering. Shirokova et al. (2016) map which circumstances in university environments prevent students to become a student entrepreneur. Botha and Ras (2016) study the role of entrepreneurship education in enhancing the number of students that establish a start-up, during or after their studies. Hahn et al. (2017) research the critical question if entrepreneurship education really contributes to cultivating an entrepreneurial mindset. Their outcomes point out that, although not contributing to students' actually starting their own business, such education does succeed in teaching them an entrepreneurial attitude. Based on theory of planned behavior, Jie and Harms (2017) research what stimulates international entrepreneurial intentions of students. Secundo et al. (2016) study trends at European universities and Faculties of Science and Engineering that aim to cultivate an entrepreneurial mindset in their students through education. Taks et al. (2016)

distinguish four conceptions of entrepreneurial learning in the minds of students, based on studying an entrepreneurship course in Estonia. And Wach and Wojciechowski (2016) studied the role of risk assessment as a mediating variable in the development of an entrepreneurial mindset in students in entrepreneurship education, based upon a Polish case. They found that attitude towards entrepreneurship, subjective norms and perceived behavioral control determine the entrepreneurial intentions of the investigated students.

Creating spin-offs through entrepreneurship education

Fourthly, the role of entrepreneurship education and students in the creation of spin-offs in universities is addressed in the literature. Science- and technology based entrepreneurship is important for regional innovative capacity, as Sarfraz (2011) shows. Rasmussen and Wright (2015) state that the role of students in creating spin-offs is an under researched topic in the academic entrepreneurship literature. However, students do contribute to spin-off development, for instance through theses and projects related to the spin-off, and as founding team members or early employees (Blankesteijn et al. 2019). Moreover, alumni often represent a strong industry network that can be drawn upon by universities and their academic entrepreneurs. This category thus refers to a relatively small body of literature on how university-industry technology transfer is enabled via spin-offs as an outcome of entrepreneurship education. In the wider sense, thus, apart from entrepreneurship education, university spin-offs often result from academic, technology based entrepreneurship (Kroll and Liefner 2008; Wennberg et al. 2011). Karnani (2013) researches the role of tacit knowledge in the creation of university spin-offs, whereas usually the focus is only on explicit, research based knowledge. Tacit start-up knowledge is present in all scientific disciplines of universities; even the exploitation- and patent-oriented engineering sciences account for almost half of the start-ups.

Method

Data gathering

The empirical research in this article consists of a single, in-depth case study. The case study concerns the building (from scratch) and management of a master program for SBEE, over a time period of ten years. This research approach is adopted to explore how an academic science-based and at the same time entrepreneurship-oriented educational master program potentially contributes to university-industry technology transfer. The data represents internal and public documents that are written and/or used in the building and management activities related to the establishment of the master program.[1] These documents represent formal statements on the content and position of the educational program at VU University. They have been used in formal government ordered accreditations of the educational program, in events aimed at giving information to prospective students, and in yearly management and control cycles of

[1] An overview of the data can be found in the supplementary data appendix.

the university itself. The documents have been written and put together by key professors, directors and advisors involved in the building, implementation and management of the program. These actors have given the first author of this paper full access to their personal archives. Data has been triangulated by cross comparing these documents and/or through factual checking of different versions of this paper by these key actors and/or related academic staff members, thus enhancing the reliability of the outcomes of this study (Yin 2014; Creswell and Miller 2002).

Case description

The case study concentrates on the Master program 'Science, Business & Innovation' (SBI) at the Faculty of Science at VU University Amsterdam. Central theme of SBI is to study how (natural) science knowledge can be developed into economically, socially, and ecologically viable opportunities, which can be turned into commercially and societally valuable products, services, processes, methods and approaches. Students need to gain natural scientific knowledge in the disciplinary fields of chemistry and physics, related to topics in the energy- and the life sciences. Secondly, they learn about the social scientific fundamentals of innovation sciences, business processes and organizational sciences.

The master program SBI offers the opportunity to learn about university-industry technology transfer from both the natural sciences as well as the social sciences and business and economic perspectives.[2] The program is offered in the Faulty of Science by the Department of Physics and the Department of Chemistry, which both closely collaborate with the other university in Amsterdam, the University of Amsterdam (UvA). Until 2017, it was offered as a track within either the physics master or chemistry master program. Since its formal accreditation in 2017 by the Dutch-Flemish Accreditation Organization, SBI is offered as an autonomous and standalone study program in the Science faculty. It distinguishes itself from similar programs taught in other regions of the Netherlands by studying the innovation management on the firm level together with a strong focus on science-based, technological innovations stemming from knowledge and insights in physics and chemistry.

The basic concept of the educational program is that students can vary within their curriculum by taking elective natural science courses, social science courses or courses with an interdisciplinary character. The basic design of the program is that students have a solid to good background in natural sciences, social scientific innovation sciences, as well as experience with settings in practice in which science-based innovation though valorization takes place. At the start students choose one out of two offered specializations in the program: 'life & health', focusing on valorization of drug development, medical technology and medical treatment, or 'energy & sustainability', concentrating on valorization of clean and renewable energy technology and cyclic products and production processes. Examples of science courses are 'Materials for energy and environmental sustainability' and 'Biomedical Modelling and simulation'. Social sciences are for example covered in the course 'Business, Innovation and Value Creation in the Life Science Industry' and 'Science Project'.

[2] Nieuwe opleiding macrodoelmatigheidstoets 2014, p. 5.

Students are offered a centrally positioned ‘stream course’ (see Table 1) in which natural sciences and business and innovation sciences in their specific specialization are explicitly integrated. A major part of the program is reserved for elective courseware in both mono- as well as multidisciplinary subjects. For instance, in the past SBI master students have taken courses in engineering at tech universities, both in the Netherlands and abroad. As mentioned, students also work on projects in and for companies. Half of the SBI program – i.e. the last part of the first- and of the second and final year - is dedicated to applying natural science and business and innovation science in the empirical field: the science project of 24 European Credits (EC) in the first year, and the master project of 36 EC in the second and final year. In the last part of the first year students (from both specializations) apply the appropriated knowledge in the science project. The master project is dedicated to the study of the integration of natural sciences in commercial business trajectories in practice. The students learn about this integration in theory and practice. Practical experience is gained by them through the science project and the master project (see Table 1).

Analytical framework

Based on the literature review, an analytical framework is constructed to enable a structured and literature guided empirical study of the case. The four streams of research, as distinguished in the previous literature review in section 2, are used as a coherent framework to structure the study of the potential of SBEE for enabling university-industry technology transfer in the selected case (Yin 2014) (see Table 2). The four analytical categories in the first row of the table correspond with the titles of respectively sub sections 2.1 up until 2.4. The main topics and related core references within each of these analytical categories correspond with the topics elaborated Ion in these respective sections.

The analytical framework serves as an instrument to systematically study, categorize and discuss the findings from the empirical case (Yin 2014).

Credibility and transferability

Credibility in the research is constructed through an in-depth single case study research design. This case study generates an in-depth, fine-grained understanding

Table 1 Schematic overview of the master program SBI

	Year 1	Year 2
Sep/oct	Courses 12 EC	Courses 12 EC
Nov/dec	Courses 12 EC	Courses 12 EC
jan	Stream course 6 EC	Master project 36 EC
Feb/mar	Science project 24 EC	
Apr/may		
jun	Course 6 EC	

Overview of the program

Table 2 Analytical framework: SBEE as a means for university-industry technology transfer

Analytical categories	Topics	References
1.1.1.1. Embedment of entrepreneurship education in a university context	- academic entrepreneurship	(Huffman and Quigley 2002; Schmitz et al. 2017; Brush et al. 2003; Audretsch et al. 2015; Audretsch et al. 2005)
	- effect academic entrepreneurship students on regional innovation systems	(Abreu and Grinevich 2014; Aldianto et al. 2018; Berbegal-Mirabent et al. 2012)
	- mono-, inter- and transdisciplinarity in entrepreneurship education	(Clarysse et al. 2009; Davey et al. 2016b)
	- link between research and education in entrepreneurship education	(Rosenberg 2009; Mustar 2009)
1.1.2. Balancing entrepreneurship education between theory and practice	- entrepreneurial opportunities discovered or created?-	(Henry et al. 2005; Fiet 2001)
	‘teachability dilemma’	(Mars et al. 2008; Haase and Lautenschlager 2011)
	- educational function of internships	(Chang et al. 2018; Ratinho and Henriques 2010; Yi 2018)
1.3. Cultivating student entrepreneurship through entrepreneurship education	- role of university environment	(Mars et al. 2008; Dabbagh and Menasce 2006)
	- role different culturally influenced ideas on entrepreneurship	(Shirokova et al. 2016; Botha and Ras 2016, Hahn et al. 2017)
1.4. Creating university spin-offs through entrepreneurship education	-role of students in entrepreneurship education under researched	(Rasmussen and Wright 2015; Kroll and Liefner 2008)
	- role of SBEE in regional innovation systems	(Wennberg et al. 2011; Karnani 2013; Sarfraz 2011)

of a situation, phenomenon and/or setting (Baxter and Jack 2008). The case study is exploratory in character, since SBEE and its contribution to university-industry technology transfer are relatively under researched topics. The existing literature on technology based entrepreneurship and entrepreneurship education has been used as a starting point to develop a research framework to get an approximate idea of the contribution of SBEE to university-industry technology transfer.

To aim for transferability of the findings to comparable cases in universities, i.e. to realize analytical validity of the findings for comparable cases (Yin 2014), an educational program is chosen that fits within a relatively new and growing landscape of similar educational tracks focusing on entrepreneurship education, as shown by Audretsch and Caiazza (2016), Audretsch et al. (2015); Clarysse et al. (2009) for entrepreneurship education in general; and more specifically for SBEE, by Barr et al. (2009), Lackeus and Middleton (2015) and Maresch et al. (2016). On an empirical level, several comparable educational programs have been established for which the insights provided by this case study can be insightful.[3]

Data is analyzed using qualitative content analysis (Hsieh and Shannon 2005). The correctness of the representation of the data in the results section has been checked by key figures involved in the building and management of the master program, thus applying the principle of triangulation, which enhances the reliability of the data and internal validity of the study (Creswell and Miller 2000).

Case study findings

Embedment of entrepreneurship education in a university context

Entrepreneurship education is part of the third mission of universities – next to its first mission, research; and its second mission, education. Generally, universities have started filling in the third mission differently than before, with an increasing emphasis on relations with society and industry (Sam and van der Sijde 2014).

Pressure is exerted by the national Ministry of Education, Culture and Science, which states that science needs to aim for contributing to the grand societal challenges via developing a more entrepreneurial attitude.[4] A policy document of VU University's Science, Business & Innovation (SBI) program explicitly connects the goals of the program to this national ambition.[5]

Via its embedment at VU Amsterdam, SBI contributes to the realization of the "Topsectors Innovation Contracts" that the Dutch Universities have signed, and in which they officially declare it is their mission to contribute to university-industry technology transfer. Dutch universities, amongst which VU University Amsterdam, have materialized this not only in terms of research,[6] but also in terms of educational programs in which university-industry technology transfer is at the heart of every course that is taught within these programs.

[3] See overview 'Benchmark programs' in Appendix 1.

[4] 'Keuzes voor de toekomst van de Nederlandse wetenschap'. 'Goedemorgen Professor!'.

[5] Wetenschapsvisie 2025.

[6] 'Visie 2015–2020: Instellingsplan Vrije Universiteit Amsterdam'

Entrepreneurship is seen as a key element in these programs. Via entrepreneurship, commercialization of technologies from the perspective of societal value is aimed for.[7] Students are taught to strike a balance between economical, ecological, social and commercial aspects in science-based and technological innovation trajectories.[8]

Academic entrepreneurship

Academic entrepreneurship lies at the basis of the SBI program. SBI originates from it. SBI started by recognition of a group academics in the Faculty of Science, that doing research alone, and educating alone, does not lead to a desired repositioning of their faculty towards valorization goals. They recognized that academic entrepreneurship was fundamental given the importance currently attached to science-based innovation and needed to be given a central place in the SBI master program that was being constructed.

The SBI master program starts from the idea, that natural scientists often have difficulties, when confronted with political, societal and economic incentives to valorize their findings, to turn their insights into commercial and social value and learn from this experience. At the same time, social scientists often lack the knowledge, affinity, experience and skills to understand, interpret and valorize the findings that are being developed in the natural sciences. Students entering the SBI master program had to combine and integrate aspects of both worlds. They had to be able to understand and analyze the potential of natural scientific knowledge, findings and inventions, through natural science education. At the same time they had to be capable of searching, finding and serving market and societal needs with science-based knowledge and technology, through social science education. Ideally both educational components are actively taught and used, in all courses and projects in the SBI program.

Currently the described package of knowledge and skills is often developed by professionals in practice, after they have completed a mono disciplinary master program in either natural sciences or social sciences, and through years of professional experience and hands-on training. Special academic programs like SBI, already incorporate all the important elements of SBEE in the program, which enables alumni to integrate these perspectives from the very start, already in the student-stage of their career. A program like SBI comprises of specific educational trajectories with a focus on combining knowledge from natural science (energy & sustainability or life & health) and social science (business, entrepreneurship and innovation) together with a training program aimed at development of particular competences, of which entrepreneurial skills are among the most important.

The value of such a package is increasingly noticed and recognized as containing an important and unique mixture of knowledge and skills. It is an important reason for students to choose for the master program SBI.[9] The mixture serves a source of inspiration for educational activities in academic programs – thereby partly bypassing the otherwise existing need to be embedded as a professional in an R&D-dependent business environment for years to acquire this same package of knowledge, skills and experience.

[7] NWO maatschappelijk verantwoord innoveren.

[8] Nieuwe opleiding macrodoelmatigheidstoets 2014, p. 13.

[9] 'Enquete nieuwe master SBI in Energy & Sustainability en SBI in the Life Sciences'.

Effect of entrepreneurship students on regional innovation systems

A first manner in which students in entrepreneurship programs contribute to regional innovation systems is through internships, starting up their own companies, organizing career events and related activities. The students in the program are often conducting major parts of their studies in companies in the regional innovation system. They bring knowledge and skills with them in the field of how to introduce new products to the market. Thus, they contribute to university-industry technology transfer in the regional innovation system in the Amsterdam region. The academic staff also fulfills an important role here. In recent years, two full professors have been appointed in the SBI division to direct the development of a specific focus on science valorization. Each member of the academic staff working in this direction, consisting of associate professors and assistant professors, has a broad network of professional relations, that is put to use by them both in research and education in the SBI master program.[10]

There is a second, more implicit way in which they contribute to knowledge circulation in the regional innovation system. Within SBI, entrepreneurship is seen as being at the heart of a cyclical innovation process. In this cyclical idea of innovation, innovation is not seen as a result from a linear process in which science does presume over the market or vice versa, but as a result of an cyclic and complementary process that can have linear steps, but that also goes back and forth between the steps taken and results accomplished, following the concept of cyclical innovation processes developed by Berkhout et al. (2006). In this process, recognizing entrepreneurial opportunities is a skill that can be taught, by teaching students about the three different but also potentially connected worlds of science, innovation and markets. Students need to be involved and immersed in these worlds as well, to develop an in-depth understanding of them. By being involved, mutual learning processes are enacted.

A third way in which students contribute to regional innovation systems, begins after their graduation. SBI delivers entrepreneurial professionals who have been trained to be the linking pin between science and industry and who, by now, have proven their worth on the labor market. They fulfill functions in which they are important as translators between the worlds of science, market and society. The positions they hold directly after graduation are mainly advisory, related to sales and marketing, project preparatory and coordinating. They bring together human, economic and ecological aspects in innovative profit, not for profit and non-profit organizations.

Mono-, inter- and transdisciplinarity in entrepreneurship education

A core idea of SBI is, that, although disciplines provide an important natural scientific or social scientific knowledge base, significant university-industry technology transfer can only sprout from looking over the disciplinary fences in order to develop a transdisciplinary outlook on commercial and societal challenges. University-industry technology transfer, in the definition developed here, comprises the same challenge; namely incorporating different views from actors with very different (disciplinary determined) backgrounds.

[10] Toets nieuwe opleiding MSc-program Science Business Innovation, p. 11. Overview of External Contacts. Student-staff-ratio. Domain-specific framework.

SBEE can only be taught when mono disciplinary knowledge is transcended at particular moments in the program. VU University Amsterdam has stated as its ambition, that it teaches their students to learn to look over the fences of their disciplinary education.[11] In a similar vein, the SBI master program is based on a multi- and interdisciplinary didactical concept. Starting from the students' multidisciplinary and interdisciplinary basis, acquired in their natural scientific bachelor's degree trajectory and/or premaster program, they deepen their knowledge, capabilities and insights in management and coordination of science- and technology-based and R&D-induced innovation pathways. These pathways chart a course from natural science to commercial business. The master program provides students with courses on an advanced level in the natural sciences and in business and innovation sciences.

The SBI program is embedded in the Faculty of Science at VU University Amsterdam. This is significant because of the strong connections of the program with mono disciplinary programs – physics and chemistry. It also depends on close collaboration with the School of Business and Economics and the Faculty of Social Sciences at VU University Amsterdam, which covers business, organizational and commercial perspectives in the program.

Link between research and education in entrepreneurship education

Research based education is stated as an important competence of Vrije Universiteit Amsterdam's educational policy in each of its master programs.[12] Four pillars on which education at VU Amsterdam rests, are defined: internationalization, national position and regional embedment, continuous improvement of education, and keeping a connection between research and education. The last pillar implies that in all master programs education ties in with research conducted by lecturers and students in turn (independently) design and execute a research project.[13]

Currently, ten SBI PhD students conduct their research in the division SBI and six SBI PhD students have successfully completed their PhD.[14] The division's research is further described in the research program 'Dynamics of Valorization of Knowledge'. Central elements of the SBI field of research are both the connection between science and commercial environments, as well as the creation of value in a broader soci(et)al sense.[15]

Balancing entrepreneurship education between theory and practice

Through the embedment of entrepreneurship education in universities, and through academic entrepreneurship developed at its science faculty, adopting thereby an inter −/multidisciplinary outlook, the master program SBI, during its existence of ten years, developed particular ideas about the fundaments of the program. It starts from the viewpoint that entrepreneurial skills can indeed be taught, so that entrepreneurial opportunities can be created. Mono disciplinary trained physicists and chemists lack

[11] 'Onderwijsvisie Vrije Universiteit'.
[12] 'Onderwijsvisie Vrije Universiteit'
[13] 'Verwevenheid van onderzoek en hoger onderwijs'.
[14] SBI Research Program. SBI PhD students overview.
[15] Toets nieuwe opleiding MA-program Science Business Innovation, p. 7.

the skill set to do so, which often led in the past to an absence of the creation of entrepreneurial opportunities at most research and teaching groups.

The assumption present in the program, that entrepreneurship can be *taught*, leads to the insertion of a set of stimuli in the program for the creation of entrepreneurial opportunities. A good balance between teaching entrepreneurship in theory and teaching it through experiential learning is a precondition for entrepreneurship education and teaching on how to create entrepreneurial opportunities. Entrepreneurship is one of the key elements of the educational vision of the master program.[16] It is currently taught by a program that rests on lectures, group and individual assignments, working groups, paper discussions, interactive lectures, literature study, tutorial, consultancy sessions and presentations. These are used as teaching methods, always about, and/or in, and/or situated in the empirical context in which the valorization topic is actually situated.

The balance in the program between teaching entrepreneurship in theory and practice, is currently present as follows. The number of contact hours is about 290–350 in the first year, and, due to the practical nature of this part of the curriculum, about 160 h in the second year.[17] The first year focuses mostly on science based entrepreneurship in theory; hence, the relatively high number of contact hours. The scientific character of the program is reflected in the literature used and the research (experience) contributed by the lecturers. The program ties in with the research from the SBI division. Theory on science-based innovation and -entrepreneurship is thus currently mostly based on research-based education. In the second year, the focus is much more on experiential learning of science-based entrepreneurship. Across the master program, external experts from companies and institutes play a role in a variety of courses. This may include the handling of specific casework gleaned from the actual business and application settings in the courseware.

Entrepreneurial opportunities discovered or created?

In the master program, a starting point is the conviction that entrepreneurial opportunities can be created. Hence they are not simply discovered. The idea underlying the program is that physicists and chemists can develop fruitful ideas and concepts, but that they often lack the knowledge and skill set to create entrepreneurial opportunities for their findings. Thus, creating entrepreneurial opportunities represents a skill set, that can be taught. Students therefore receive education and training to develop such entrepreneurial skills.

Developing such a skill set starts with an understanding of the innovation chain and, more specifically, the phase in which entrepreneurial opportunities can be created. Students in the program SBI study and participate in the entire chain of technology-driven, R&D-induced, science-based innovation (Fig. 1) – whereas physicists and chemists working in science and academia mostly stop in the demonstration phase. This chain is defined by five developmental phases: research, development (R&D), demonstration, deployment and improvement.[18] Although this chain is visually presented as a linear chain, from the very beginning students are also taught that going

[16] Opleidingsvisie masteropleiding SBI, onderzoeksprogramma SBI Dynamic Valorization of Knowledge.

[17] Contact hours per year.

[18] Nieuwe opleiding macrodoelmatigheidstoets 2014, p. 12.

Fig. 1 The R&D-induced innovation chain

back and forth in this chain, with feed-back and feed-forward loops active, is a basic characteristic of this chain, which makes this innovative process in essence a cyclic process.

The basic idea behind this approach is that going through the phases of research, development, demonstration, deployment and improvement, natural scientific knowledge can develop into products, processes and services that serve society, institutions and businesses (Fig. 1). The research phase delivers the natural scientific knowledge and findings with valorization potential. In the development phase this knowledge is translated into technologies than can be potentially applied in multiple products, processes and services. In the demonstration phase these versions are improved and altered continuously, until these are ready for a market/user niche. The deployment phase then concentrates on a larger scale production, distribution, sales and use of the prototype-turned-into product/process/service. Finally, the improvement phase focuses on further amending the products, processes and services to continuously changing markets and societal demands. Although SBI-students are involved in the entire innovation chain, the development of an entrepreneurial skill set through SBI is specifically targeted at the demonstration and deployment phase.

'Teachability dilemma'

The idea that entrepreneurship is an inborn quality seems to become less dominant (Fiet 2001; Henry et al. 2005).[19] Starting from the often implicit assumption that entrepreneurship can be taught, most universities now offer entrepreneurship courses to their students - not only those who are doing business studies, but students following all types of education. Based on such entrepreneurship education, students are able to develop themselves as entrepreneurs, entrepreneurial professionals or as 'intrapreneurs' who offer their services to their employers. Entrepreneurship is often at the heart of all university-industry technology transfer activities.

Underlying this, particularly for SBI, is a focus on professionalizing the skill to bring together people who work in different parts of the innovation system (the interaction between knowledge institutes, industry and the government). As a professional, the science based entrepreneur aims to stimulate and facilitate that new scientific knowledge can be transformed into technological applications that can serve potential future markets. To do so, it is important that the science entrepreneur has both theoretical knowledge of, and an interest in (natural) science that ignites new technological applications as well as social science that provides an insight into the emergence and growth of possible future markets for these applications. And, in addition to this, the science- entrepreneur

[19] Nieuwe opleiding macrodoelmatigheidstoets 2014

Table 3 Prognosis of national increase, replacement and vacancies for SBEE relevant jobs (2015–2020) (ROA, 2015)

	National demand for expansion 2015–2020 (× 1.000)	National demand for replacement 2015–2020 (× 1.000)	Total amount job openings 2015–2020 (× 1.000)
Service- oriented jobs	49	175	224
Technical jobs	84	201	285
Total	133	376	509

should also have knowledge of, and a feel for the development and exploitation of products and services by commercial firms and public organizations, on markets and among users. They learn to contribute to 'valorization by means of developing, designing, executing, reporting and presenting academic research about valorization subjects in the empirical field'.[20] An advisory board has been established to keep a close eye on the relation between theory and practice.[21]

Yet, originally, university education is less aimed at satisfying immediate demands from the labor market.[22] As originating in academic entrepreneurship and through its recognition that entrepreneurial skills can be taught at universities, via which entrepreneurial opportunities can be *created* (see paragraph 4.2.3.), SBI is a breach with the past in this respect. Through reaching for a balance between theory and practice, the program aims to satisfy an immediate and growing demand of the labor market for professionals enabling university-industry technology transfer (Table 3).

An analysis of the Dutch national labor market shows that until 2020, 60.000 vacancies need to be filled with people in sectors confronted with a technological sustainability challenge[23] (Table 3). In addition to this, an online survey among 66 firms that worked with SBI-students, conducted by VU university shows, that 30% of the organizations that were approached expected to hire two full time equivalents of employees with SBI-skills in the next two years.[24] Students who graduate from SBI find a job on average within three months' time, mostly within the vicinity of Amsterdam (62% SBI students find jobs in both service as well as technology oriented companies and organizations (Table 4)).[25]

Educational function of internships

Via the specific learning goals within the program the need is acknowledged for the early cultivation of an entrepreneurial attitude, alongside building an actual knowledge base, to be able to successfully turn natural science into commercial and social value. This is expressed in the extensive internships students need to organize and follow, in order to

[20] Toets nieuwe opleiding MA-program Science Business Innovation, p. 1.
[21] Advisory Board, Appendix 10 Toets nieuwe opleiding MA-program Science Business Innovation.
[22] De Waarde van Weten 2015–2025.
[23] Human capital agenda Topsector Life & Health. Onderzoek alumni afstudeerrichtingen. ROA (2015). UWV (2015). CBS (2016). CBS (2015). Report: Welke beroepen bieden kansen?
[24] Onderzoek alumni afstudeerrichtingen.
[25] Onderzoek arbeidsmarktbehoefte (survey conducted by SBI).

Table 4 Type and number of jobs graduates MSc program SBI 2011–2013

	Service-oriented	Technology-oriented
Energy and sustainability	5	6
Life & health	6	3

finish the program successfully. They learn in practice, via experiential teaching combined with intensive supervision of their projects by the academic staff of the SBI division.

A heavy emphasis is therefore placed on following internships in commercial and/or public organizations for a relatively long period, in order to develop sensitivity towards the practical work of valorization. It thus involves experiential teaching via being embedded as a student in a real-world learning environment, combined with an intensive supervision trajectory offered by the SBI division. Students study and gain experience with these phenomena by research internships in empirical settings (laboratories and R&D-intensive organizations).

Internships are aimed at learning students to 'smoothly switch between theory and practice'.[26] The focus on internships ties in with a strong focus in SBI on case study research methodology,[27] whereby the internship represents a context in which a case study on a certain aspect of science based innovation can be studied. In Table 5 an overview of companies and organizations in which master students SBI conduct their internship projects, can be found.

Through internship projects, a skill set is developed for working goal- and task-oriented with, and serving others in, a differentiated and dynamic multi- and interdisciplinary, practical setting.[28]The skillset developed represents the beginning of a process of life long-learning, as indicated by the 'Dublin Descriptor' life long-learning.

Cultivating an entrepreneurial mindset through entrepreneurship education

It is assumed in the program that entrepreneurship can be taught. It is taught via, in the first year mostly theoretically and research based courses, in the second year mostly based through experiential learning. To a certain extent it rests upon a multidisciplinary theoretical approach, and to a certain extent on practical experience as well via an outspoken idea on the function of internships. Thus, students are enabled to create entrepreneurial opportunities. The role of university environments and immediate student population is also an important factor in SBI and will be discussed in the following paragraphs.

Role of university environment

By providing an academic and empirical playground for students to bring their knowledge to the world of work and practice and further develop their entrepreneurial skills. The playground is provided within the walls of university buildings themselves,

[26] Nieuwe opleiding macrodoelmatigheidstoets 2014, p. 25.
[27] Opleidingsvisie master program SBI, p. 47.
[28] Appendix 12, Intended Learning Outcomes: Toets nieuwe opleiding MA-program Science Business Innovation, p. 102.

Table 5 Type and number of companies and organizations in which students SBI do internships 2013–2015

	Service-oriented	Technology-oriented
Energy and sustainability	12	8
Life & health	7	8

via the extensive internships within leading R&D dependent companies stemming from university research, but also via science hubs related to the university. The Demo Lab at VU Amsterdam, for example, creates an environment where education, research and R&D intensive companies stemming from this research strengthen each other via their complementarity. It creates a climate in which key processes related to knowledge exchange, university-industry technology transfer and strengthening the local economy take place. Research activities are turned into commercial activities. Students can participate in these initiatives through internships. They are invited to start up their own businesses, and in some cases have actually done so. Examples in which SBI interns have participated are LUMICKS and Optics11. LUMICKS is the leading supplier of Dynamic Single-Molecule and Cell Avidity analysis instruments. Their instruments enable the analysis of complex dynamic details related to the behavior and interaction of single molecules and cells. Optics11 develops optical fibre sensing for life science and industrial sensing.

Other experience places include the laboratories from the departments of Physics and Chemistry, as well as the facilities of the VU Medical Center (one of the largest academic hospitals in the Netherlands), the facilities offered at the Science Park of University of Amsterdam, and the facilities offered by the Technology Transfer Office (IXA) of VU Amsterdam.[29]

Role of different culturally influenced ideas on entrepreneurship

Based on the overall inflow of students, which is the most culturally diverse in SBI, and based on former research (Brush et al. 2003), a certain effect on different cultural conceptions of entrepreneurship can be expected. Diverse cultural backgrounds of students bring in a broad spectre of culturally determined ideas and conceptions of entrepreneurship. Also, study trips are organized to different innovation cultures (for example in the US, India, Brazil, South Korea, Israel, and South Africa) to sensitize students on effect of culture on entrepreneurial activities. Students are, lastly, exposed to a variety of different ideas with regard to entrepreneurship via electives, (international) internships, and graduation projects. They are explicitly and implicitly confronted during the program with different culturally determined ideas and conceptions of entrepreneurship.

Creating spin-offs for enabling university-industry technology transfer

In the previous paragraph, central topics are the role of environmental factors in enabling entrepreneurship education and creation of entrepreneurial universities. The themes and issues so far primarily focus on the processes within the walls of

[29] Toets nieuwe opleiding MA-program Science Business Innovation, p. 11–12.

universities, and on their effects in the Amsterdam region. To research how SBI, as a case of SBEE, contributes to university-industry technology transfer – it is also of importance to see how SBI students directly influence the Amsterdam region, as a student or as an alumnus.

Role of students in spin-offs

Students already practice with the acquired knowledge and skillsets during their studies by starting up their own ventures, of which some are more successful than other. An example comprises a student that has, through crowd funding, been able to build his own factory in order to retrieve natural colorings and flavorings from orange peel for the food and cosmetics industry. Other examples include start-ups Findest and Qlayers, which are started by SBI alumni. Findest develops algorithms and artificial intelligence applications to allow entrepreneurs to find new technologies quickly. Qlayers develops shark skin like coatings for, for example the aviation industry to help them increase their aerodynamic qualities, thus to render the industry more cost efficient and sustainable.

Role of SBEE in regional innovation systems

Outside the university context, the internship coordination office arranges accessibility of the laboratories and R&D facilities of the companies in which students do internships, thus contributing to knowledge circulation between university and industry.

The value of experience places has been acknowledged in national science agendas. In the Dutch Vision on Science (*Wetenschapsvisie*) 2025, the importance of the Science Park Amsterdam of the University of Amsterdam is emphasized as a hub where scientists and students take their first steps as entrepreneurs, as well as a place where local entrepreneurs are explicitly invited to seek collaboration with universities.[30]

Discussion

Main findings case study

In Table 6, the main findings of the case study are summarized and subsequently assessed in terms of how the topics that were distinguished, based on the literature review, are covered in the program. Thus, insight is obtained in the extent of explicit attention paid to each topic in the building and management activities of the SBI program. These conscious and unconscious choices by the developers and managers of the program have consequences for the potential contribution of SBEE for university-industry technology transfer. The implications of these choices will be discussed in this section as well, and put in the context of the literature that was reviewed in section 2. They underpin a set of practical recommendations for SBEE curricula.

[30] Wetenschapsvisie 2025.

Table 6 Main case study findings

Analytical categories	Topics	References	Main findings case study	Covered in program building and management activities of SBI? Yes	No
1. Embedment of entrepreneurship education in a university context	- academic entrepreneurship	(Huffman and Quigley 2002; Schmitz et al. 2017; Brush et al. 2003; Audretsch et al. 2015; Audretsch et al. 2005)	-Entrepreneurship education part of 3rd mission universities -Pressure from national government to develop entrepreneurial attitude in Academia -Topsectors innovation contracts -Developing academic entrepreneurship as well through education	x	
	- effect academic entrepreneurship students on regional innovation systems	(Abreu and Grinevich 2014; Aldianto et al. 2018; Berbegal-Mirabent et al. 2012)	- Important role for internships in program - Immersion in different worlds during study program for being able to connect different phases of cyclic innovation process - After graduation students are linking pins betweens science and market		x
	- mono-, inter- and transdisciplinarity in entrepreneurship education	(Clarysse et al. 2009; Davey et al. 2016b)	-Emphasis on transdisciplinary outlook for university-industry technology transfer -Transdisciplinary outlook part of university ambition -Strong ties to monodisciplines chemistry and physics	x	
	- link between research and education in entrepreneurship education	(Rosenberg 2009; Mustar 2009)	-research-based education is one of the four pillars of Educational Vision VU University −10 PhD students perform research on innovation processes -research program 'Dynamics of Valorization of Knowledge'	x	
2. Balancing entrepreneurship education between theory and practice	-entrepreneurial opportunities discovered or created?	(Henry et al. 2005; Fiet 2001)	-Opportunities are created - is the basic idea behind the SBEE program -Innovation chain suggests belief in creation of entrepreneurial opportunities, hence not discovery -involvement of students in entire chain leads them to *create* entrepreneurial opportunities		x

Table 6 (continued)

Analytical categories	Topics	References	Main findings case study	Covered in program building and management activities of SBI? Yes	No
	'teachability dilemma'	(Mars et al. 2008; Haase and Lautenschlager 2011)	-Opportunities are created, it is believed - hence, entrepreneurship can be taught -Entrepreneurship education generally accepted within all types of educational trajectories -Labor market demands students with entrepreneurial skills		x
	- educational function of internships	(Chang et al. 2018; Ratinho and Henriques 2010; Yi 2018)	-emphasis in program on experiential learning -learning to switch smoothly between theory and practice -development entrepreneurial skill set		x
3. Cultivating student entrepreneurship through entrepreneurship education	- role of university environment	(Mars et al. 2008; Dabbagh and Menasce 2006)	-university provides playground in multiple ways -university encourages participations of students in start ups developed by academic entrepreneurs in Faculty of Science	x	
	- role different culturally influenced ideas on entrepreneurship	(Shirokova et al. 2016; Botha and Ras 2016; Hahn et al. 2017)	-most culturally diverse student inflow of Netherlands -diverse cultural background of students bring in broad spectre of culturally determined ideas of entrepreneurship -study trips are organized to different innovation cultures to sensitize students on effect of culture on entrepreneurial activities		x
4. Creating university spin-offs through entrepreneurship education	-role of students in creating spin-offs	(Rasmussen and Wright 2015; Kroll and Liefner 2008)	-students already practice with skill set during their educational program by creating and participating in spin offs		x
	- role of SBEE in regional innovation systems	(Wennberg et al. 2011; Karnani 2013; Sarfraz 2011)	-special internship coordinator appointed to arrange access to laboratories and R&D facilities to students, thus contributing to knowledge circulation between university and industry -value of playgrounds in which SBI students practice their skills is explicitly acknowledges in national science agenda.	x	

Embedment of entrepreneurship education in a university context

The embedment of entrepreneurship education in a university context has been discussed via distinguishing four topics in the literature: academic entrepreneurship, the effect of academic entrepreneurship students on regional innovation systems, mono-, inter- and transdisciplinarity in entrepreneurship education, as well as the link between research and education in entrepreneurship education. The case study shows that entrepreneurship education has become an important component of the third mission of universities. It also showed that pressure from national government to develop an entrepreneurial attitude in Academia has been exerted. Furthermore, the Dutch universities have signed topsectors innovation contracts in order to stimulate university-industry technology transfer; which provides a push towards academic entrepreneurship and entrepreneurship education. Lastly, we recognized attempts to developing academic entrepreneurship not only through research but as well through education. This topic is well covered in the program.

The embedment of entrepreneurship in a science faculty brings a distinct advantage to this type of education. As Barr et al. (2009) state, a thorough understanding of both the natural sciences as well as of entrepreneurship is needed for students in the SBEE program to be able to fulfill a role in university-industry technology transfer. The entrepreneurial intentions of business administration students are less affected by subjective norms in their surroundings than those of science and engineering students, as Maresch et al. (2016) have researched. This study shows that science and engineering students however not only experience a hindrance from their surroundings, but profit from it as well. Through their firm embedment in, and close contact with the natural sciences, they gain a deep understanding of this world of work. This understanding helps them in crossing the 'valley of death' (Barr et al. 2009) – which means that it assists students in translating the technology into a commercially worthwhile application, whereas otherwise, it could have been filed as a promising technology for which no funding was available to bring it on the market.

Balancing entrepreneurship education between theory and practice

In this analytical category, three topics were distinguished: the debate on if entrepreneurial opportunities are discovered or created, the so-called teachability dilemma, and the discussion on the educational function of internships. We recognized that, implicitly, a strong belief in the creation of entrepreneurial opportunities, and thus the belief that entrepreneurship can indeed be taught and is not solely an inborn quality. However, this belief is not made explicit in the program, and thus the consequences and opportunities for the program are not fully exploited yet.

There is also little attention within the program for the so-called teachability dilemma in entrepreneurship education (Haase and Lautenschlager 2011; Mars et al. 2008). No continuous and explicit attention is currently paid to striking a good balance between theory of, and practice on entrepreneurship. Making this balance explicit may assist in justifying certain choices that are made within the program. This might assist young people in their choice to become a student in the program, and also assists in communicating the goals and aims of the SBEE program to external parties, such as external visitation committees.

SBI has a strong inclination towards developing entrepreneurship in students by confronting them with case study based examples. The mentoring approach (Clarysse et al. 2009) to cultivate an entrepreneurial mindset may be a valuable addition to this type of learning. Next to a reflection on the use of internships of teaching entrepreneurial skills, which has been discussed by Henry et al. (2005).

It is therefore recommended that SBEE programs explicitly think through their perspective on the issues of opportunity creation or -discovery, teachability of entrepreneurship, and on the function of internships. Can entrepreneurship indeed be taught? Which elements of entrepreneurship can be taught through theory, and which ones must be experienced in practice? Are internships an adequate method to teach students this through experiential learning in internships? To what extent do they need to be guided or mentored during such trajectories (Clarysse et al. 2009)? All these questions could be integrated in evaluation and improvement projects in the SBI program.

Cultivating student entrepreneurship through entrepreneurship education

Two topics were distinguished under this heading, namely the role of university environment and the role of different culturally influenced ideas and conceptions of entrepreneurship.

The university provides experience places in multiple ways. VU University encourages participations of students in start ups developed by academic entrepreneurs in VU's Faculty of Science. There is however no systematic mentoring assistance available for students who want to develop their own ventures, whereas the literature shows that this is a crucial element in order for a program in SBEE to contribute to university-industry technology transfer (Rasmussen and Wright 2015).

VU University Amsterdam has the most culturally diverse student inflow of the Netherlands. The diversified cultural background of students brings in a broad spectre of culturally determined ideas and conceptions of entrepreneurship. Study trips are organized to different innovation countries and their cultures to sensitize students on the effects of culture on entrepreneurial activities. Brush et al. (2003) point out the importance of cultural perceptions of entrepreneurship in entrepreneurship education. The case study points out that there is an inflow of students with diverse cultural backgrounds and different understandings and valuation of entrepreneurship at VU University Amsterdam in general.

The role of culturally influenced ideas and conceptions of entrepreneurship in entrepreneurship education is a topic in need of discussion – especially since VU University Amsterdam has the highest inflow of students with a diverse cultural background. It certainly has an effect, and most likely enriches students' understanding of notions of entrepreneurship in the classroom – but how is yet unclear, let alone made instrumental in the educational trajectory. Studies on this topic in the context of this program have not been conducted yet. This provides an avenue for further practice and for research.

Creating university spin-offs through entrepreneurship education

Two topics were distinguished in this category: the role of students in creating spin-offs and the role of SBEE in regional innovation systems.

Students already practice with the acquired knowledge and skills set during their educational program by creating and participating in spin offs. They do so more or less on their own initiative. They are not guided or assisted by the academic staff to do so. However, an internship coordinator is appointed to arrange access to laboratories and R&D facilities to students, thus contributing to knowledge circulation between university and industry.

Providing more guidance or assistance is important in increasing university-industry technology transfer, as well as a way to enrich theoretical teaching of entrepreneurship with practical cases. The lessons learned on this topic now remain implicit, as tacit knowledge, as Karnani (2013) states. The students' contribution to the creation of spin-offs is under researched and in need to be made more explicit through further research on the topic. Thus, here, a practical recommendation to SBEE programs follows that they should pay attention to this in the form of practical guidance.

The case study showed that creating an attractive, experiential, even playful surrounding for students to practice with entrepreneurship, through the Demo Lab for example, helps them in developing entrepreneurial skills. The value of experience places in which SBI students practice their skills is explicitly acknowledged in the Dutch National Science Agenda. Thus, this element of entrepreneurship education is quite explicitly present in the program. The importance of such experience places has been researched by Kroll and Liefner (2008) and Wennberg et al. (2011).

The contribution of students in entrepreneurship education programs to spin-offs is currently under researched. Further research is needed in order to research the factors that increase the attractiveness of academic environments in order to stimulate students to develop their own initiatives and to eventually create successful spin-offs.

Limitations and avenues for further research

An in-depth case study has been performed in order to explore the potential of SBEE as a means for university-industry technology transfer. Due to the single-case study research design, the analytical generalizability of the case study is limited. Future research based on a multiple case study research design which, later on, can be enriched with quantitative data, may enhance the analytical generalizability of our findings.

A second limitation is that only the management and program building efforts have been highlighted in the results section. A stakeholder analysis of how students experience the program, or a study on the connection of the program to market needs, has not been conducted. This could be a worthwhile addition to the further study of SBEE as a means for university-industry technology transfer.

Further research is needed as well in order to gain insight in the factors that increase the attractiveness of academic environments in order to stimulate students to develop their own initiatives and to eventually create successful spin-offs. Studies on the effect of culturally diverse conceptions of entrepreneurship in the context of SBEE have not been conducted yet. This also provides an avenue for further research.

Conclusion

The case study shows that all elements mentioned in the literature on technology based entrepreneurship and entrepreneurship education are present in the case studied. Yet, in some situations some components the literature brings up are not explicitly covered in the program. When each component, such as the role of embedment in its university and regional environment, or taking into account the teachability dilemma, is systematically addressed in the building and by the management of the program, the potential of SBEE in this program for university-industry technology transfer could be better exploited. This implies that the case being studied in this research is an either an example of effective university-industry technology transfer as well as an example of a program that has some major flaws on which it needs to work.

These findings are relevant as a starting point for the development or improvement of comparable programs as well. The SBI program studied at VU Amsterdam is part of a bigger trend whereby entrepreneurship education, more specifically SBEE, slowly but surely becomes embedded in the portfolio of educational programs at universities (Maresch et al. 2016).[31] These insights point out the level of sophistication that is needed in order to make SBEE fulfill an optimal role in university-industry technology transfer.

Support for the ambition to further develop educational tracks in science-based entrepreneurship, in order to contribute to university-industry technology transfer might, in the near future, turn out to be a highly rewarding investment in the innovation system: not only in terms of technology commercialization, but also in terms of creating societal value from technological innovation. Via SBEE, the role of universities in university-industry technology transfer is not only optimized over the dimension of research, but via their educational task as well.

References

Abreu, M., & Grinevich, V. (2014). Academic entrepreneurship in the creative arts. *Environment and Planning. C, Government & Policy, 32*(3), 451–470. https://doi.org/10.1068/c11144r.

Abreu, M., Demirel, P., Grinevich, V., & Karatas-Ozkan, M. (2016). Entrepreneurial practices in research-intensive and teaching-led universities. *Small Business Economics, 47*(3), 695–717. https://doi.org/10.1007/s11187-016-9754-5.

Aldianto, L., Anggadwita, G., & Umbara, A. N. (2018). Entrepreneurship education program as value creation: Empirical findings of universities in Bandung, Indonesia. *Journal of Science and Technology Policy Management, 9*(3), 296–309. https://doi.org/10.1108/jstpm-03-2018-0024.

[31] 'Overzicht vergelijkbare opleidingen inclusief instroom'. 'university programs in the Netherlands'. Overview university programs outside the Netherlands.

Anderson, T. R., Daim, T. U., & Lavoie, F. F. (2007). Measuring the efficiency of university technology transfer. *Technovation, 27*(5), 306–318. https://doi.org/10.1016/j.technovation.2006.10.003.
Arias, E., Barba-Sanchez, V., Carrion, C., & Casado, R. (2018). Enhancing entrepreneurship education in a Master's degree in computer engineering: A project-based learning approach. *Administrative Sciences, 8*(4). https://doi.org/10.3390/admsci8040058.
Arpiainen, R. L., & Kurczewska, A. (2017). Learning risk-taking and coping with uncertainty through experiential, team-based entrepreneurship education. *Industry and Higher Education, 31*(3), 143–155. https://doi.org/10.1177/0950422217700994.
Audretsch, D. B. (2014). From the entrepreneurial university to the university for the entrepreneurial society. *The Journal of Technology Transfer, 39*(3), 313–321. https://doi.org/10.1007/s10961-012-9288-1.
Audretsch, D., & Caiazza, R. (2016). Technology transfer and entrepreneurship: Cross-national analysis. *Journal of Technology Transfer, 41*(6), 1247–1259. https://doi.org/10.1007/s10961-015-9441-8.
Audretsch, D. B., Lehmann, E. E., & Warning, S. (2005). University spillovers and new firm location. *Research Policy, 34*(7), 1113–1122. https://doi.org/10.1016/j.respol.2005.05.009.
Audretsch, D., Lehmann, E. E., & Paleari, S. (2015). Academic policy and entrepreneurship: A European perspective. *Journal of Technology Transfer, 40*(3), 363–368. https://doi.org/10.1007/s10961-014-9359-6.
Barr, S. H., Baker, T., Markham, S. K., & Kingon, A. I. (2009). Bridging the valley of death: Lessons learned from 14 years of commercialization of technology education. *Academy of Management Learning & Education, 8*(3), 370–388. https://doi.org/10.5465/amle.2009.44287937.
Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report, 13*(4), 544–559.
Berbegal-Mirabent, J., Sabate, F., & Canabate, A. (2012). Brokering knowledge from universities to the marketplace the role of knowledge transfer offices. *Management Decision, 50*(7–8), 1285–1307. https://doi.org/10.1108/00251741211247012.
Berbegal-Mirabent, J., Lafuente, E., & Sole, F. (2013). The pursuit of knowledge transfer activities: An efficiency analysis of Spanish universities. *Journal of Business Research, 66*(10), 2051–2059. https://doi.org/10.1016/j.jbusres.2013.02.031.
Berkhout, A., Hartmann, D., van der Duin, P., & Ortt, R. (2006). Innovating the innovation process. *International Journal of Technology Management, 34*(3/4), 390–404.
Blake Hylton, J., Mikesell, D., Yoder, J.-D., & LeBlanc, H. (2019). Working to Instill the Entrepreneurial Mind-Set Across the Curriculum. *Entrepreneurship Education and Pedagogy*, 2515127419870266. https://doi.org/10.1177/2515127419870266.
Blankesteijn, M. L., Sijde, P. V. D., & Sam, C. (2019). Understanding the governance of the engaged and entrepreneurial university in the twenty-first century: Towards a new research and policy agenda. In N. Caseiro & D. Santos (Eds.), *Specialization strategies and the role of entrepreneurial universities* (pp. 81–98). Hershey: IGI Global.
Blessing, J., Mekemson, K., & Pistrui, D. (2008). *Building an entrepreneurial engineering ecosystem for future genersations: The Kern Entrepreneurship Education Network.* Paper presented at the 2008 ASEE Annual Conference & Exposition, Pittsburgh, Pennsylvania.
Boh, W. F., De-Haan, U., & Strom, R. (2016). University technology transfer through entrepreneurship: Faculty and students in spinoffs. *The Journal of Technology Transfer, 41*(4), 661–669. https://doi.org/10.1007/s10961-015-9399-6.
Boocock, G., Frank, R., & Warren, L. (2009). Technology-based entrepreneurship education: Meeting educational and business objectives. *The International Journal of Entrepreneurship and Innovation, 10*(1), 43–53. https://doi.org/10.5367/000000009787414226.
Botha, M., & Ras, R. (2016). Entrepreneurship education: Enhancing or discouraging graduate start-up at the University of Pretoria. *Africa Education Review, 13*(2), 96–114. https://doi.org/10.1080/18146627.2016.1224106.
Brush, C. G., Duhaime, I. M., Gartner, W. B., Stewart, A., Katz, J. A., Hitt, M. A., et al. (2003). Doctoral education in the field of entrepreneurship. *Journal of Management, 29*(3), 309–331. https://doi.org/10.1016/s0149-2063(03)00014-x.
Chang, J. C., Hsiao, Y. D., Chen, S. C., & Yu, T. T. (2018). Core entrepreneurial competencies of students in departments of electrical engineering and computer sciences (EECS) in universities. *Education and Training, 60*(7–8), 857–872. https://doi.org/10.1108/et-10-2016-0160.
Clarysse, B., Mosey, S., & Lambrecht, I. (2009). New trends in technology management education: A view from Europe. *Academy of Management Learning & Education, 8*(3), 427–443. https://doi.org/10.5465/amle.2009.44287941.
Creswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry. *Theory Into Practice, 39*(3), 124–130.

Dabbagh, N., & Menasce, D. A. (2006). Student perceptions of engineering entrepreneurship: An exploratory study. *Journal of Engineering Education, 95*(2), 153–164. https://doi.org/10.1002/j.2168-9830.2006.tb00886.x.

Davey, T., Hannon, P., & Penaluna, A. (2016a). Entrepreneurship education and the role of universities in entrepreneurship: Introduction to the special issue. *Industry and Higher Education, 30*(3), 171–182. https://doi.org/10.1177/0950422216656699.

Davey, T., Rossano, S., & van der Sijde, P. (2016b). Does context matter in academic entrepreneurship? The role of barriers and drivers in the regional and national context. *Journal of Technology Transfer, 41*(6), 1457–1482. https://doi.org/10.1007/s10961-015-9450-7.

De Jong, S. P. L., Smit, J., & van Drooge, L. (2015). Scientists' response to societal impact policies: A policy paradox. *Science and Public Policy, 43*(1), 102–114. https://doi.org/10.1093/scipol/scv023.

Duval-Couetil, N., Reeds-Rhoads, T., & Haghighi, S. (2012). Engineering student and entrepreneurship education: Involvement, attitudes and outcomes. *International Journal of Engineering Education, 28*(2), 425–435.

Duval-Couetil, N., Shartrand, A., & Reed, T. (2016). The role of entrepreneurship program models and experiential activities on engineering student outcomes. *Advances in Engineering Education, 5*(1), 1–27.

Fiet, J. O. (2001). The theoretical side of teaching entrepreneurship. *Journal of Business Venturing, 16*(1), 1–24. https://doi.org/10.1016/S0883-9026(99)00041-5.

Forti, E., Franzoni, C., & Sobrero, M. (2013). Bridges or isolates? Investigating the social networks of academic inventors. *Research Policy, 42*(8), 1378–1388. https://doi.org/10.1016/j.respol.2013.05.003.

Gilmartin, S. K., Chen, H. L., & Estrada, C. (2016). Investigating entrepreneurship models in undergraduate engineering education. *International Journal of Engineering Education, 32*(5), 2048–2065.

Haase, H., & Lautenschlager, A. (2011). The 'Teachability Dilemma' of entrepreneurship. *International Entrepreneurship and Management Journal, 7*(2), 145–162. https://doi.org/10.1007/s11365-010-0150-3.

Hahn, D., Minola, T., Van Gils, A., & Huybrechts, J. (2017). Entrepreneurial education and learning at universities: Exploring multilevel contingencies. *Entrepreneurship and Regional Development, 29*(9–10), 945–974. https://doi.org/10.1080/08985626.2017.1376542.

Henry, C., Hill, F., & Leitch, C. (2005). Entrepreneurship education and training: Can entrepreneurship be taught? Part I. *Education + Training, 47*(2), 98–111. https://doi.org/10.1108/00400910510586524.

Hixon, C., & Paretti, M. C. (2018). Unpacking why engineering faculty members believe entrepreneurship education is valuable for engineering education. *Advances in Engineering Education, 7*(1), 1–11.

Hsieh, H.F. & Shannon, S.E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277–1288.

Huang-Saad, A. Y., Morton, C. S., & Libarkin, J. C. (2018). Entrepreneurship assessment in higher education: A research review for engineering education researchers. *Journal of Engineering Education, 107*(2), 263–290. https://doi.org/10.1002/jee.20197.

Huffman, D., & Quigley, J. M. (2002). The role of the university in attracting high tech entrepreneurship: A Silicon Valley tale. *Annals of Regional Science, 36*(3), 403–419. https://doi.org/10.1007/s001680200104.

Jie, S. J., & Harms, R. (2017). Cross-cultural competences and international entrepreneurial Intention: A Study on Entrepreneurship Education. *Education Research International*. https://doi.org/10.1155/2017/9042132.

Karnani, F. (2013). The university's unknown knowledge: Tacit knowledge, technology transfer and university spin-offs findings from an empirical study based on the theory of knowledge. *Journal of Technology Transfer, 38*(3), 235–250. https://doi.org/10.1007/s10961-012-9251-1.

Kriewall, T. J., & Mekemson, K. (2010). Instilling the entrepreneurial mindset into engineering undergraduates. *Journal of Engineering Entrepreneurship, 1*(1), 5–19.

Kroll, H., & Liefner, I. (2008). Spin-off enterprises as a means of technology commercialisation in a transforming economy - evidence from three universities in China. *Technovation, 28*(5), 298–313. https://doi.org/10.1016/j.technovation.2007.05.002.

Lackeus, M., & Middleton, K. W. (2015). Venture creation programs: Bridging entrepreneurship education and technology transfer. *Education and Training, 57*(1), 48–73. https://doi.org/10.1108/et-02-2013-0013.

Leloux, M., Wakkee, I., Stam, E., & van der Sijde, P. (2013). The University as an entrepreneur: The ingredients for valorization and valorization strategies. *New Technology-Based Firms in the New Millennium* (pp. 213-224).

London, J., Bekki, J., Brunhaver, S., Carberry, A., & McKenna, A. (2018). A framework for entrepreneurial mindsets and behaviors in undergraduate engineering students: Operationalizing the Kern family foundations "3 CS". *Advances in Engineering Education, 7*(1), 1–12.

Maresch, D., Harms, R., Kailer, N., & Wimmer-Wurm, B. (2016). The impact of entrepreneurship education on the entrepreneurial intention of students in science and engineering versus business studies university programs. *Technological Forecasting and Social Change, 104*, 172–179. https://doi.org/10.1016/j.techfore.2015.11.006.

Mars, M. M., Slaughter, S., & Rhoades, G. (2008). The state-sponsored student entrepreneur. *Journal of Higher Education, 79*(6), 638. https://doi.org/10.1353/jhe.0.0024.

Mazdeh, M. M., Razavi, S. M., Hesamamiri, R., Zahedi, M. R., & Elahi, B. (2013). An empirical investigation of entrepreneurship intensity in Iranian state universities. *Higher Education, 65*(2), 207–226. https://doi.org/10.1007/s10734-012-9539-y.

Morales-Gualdrón, S. T., Gutiérrez-Gracia, A., & Roig Dobón, S. (2009). The entrepreneurial motivation in academia: a multidimensional construct. *International Entrepreneurship and Management Journal, 5*(3), 301–317. https://doi.org/10.1007/s11365-009-0113-8.

Mustar, P. (2009). Technology management education: Innovation and entrepreneurship at MINES ParisTech, a leading French engineering school. *Academy of Management Learning & Education, 8*(3), 418–425. https://doi.org/10.5465/amle.2009.44287940.

Nichols, S. P., & Armstrong, N. E. (2003). Engineering entrepreneurship: Does entrepreneurship have a role in engineering education? *IEEE Antennas and Propagation Magazine, 45*(1), 134–138.

Philpott, K., Dooley, L., O'Reilly, C., & Lupton, G. (2011). The entrepreneurial university: Examining the underlying academic tensions. *Technovation, 31*(4), 161–170. https://doi.org/10.1016/j.technovation.2010.12.003.

Rae, D., & Melton, D. E. (2017). Developing an entrepreneurial mindset in US engineering education: An international view of the KEEN project. *Journal of Engineering Entrepreneurship, 7*(3), 1–16.

Rasmussen, E., & Wright, M. (2015). How can universities facilitate academic spin-offs? An entrepreneurial competency perspective. *The Journal of Technology Transfer, 40*(5), 782–799. https://doi.org/10.1007/s10961-014-9386-3.

Ratinho, T., & Henriques, E. (2010). The role of science parks and business incubators in converging countries: Evidence from Portugal. *Technovation, 30*(4), 278–290. https://doi.org/10.1016/j.technovation.2009.09.002.

Rosenberg, N. (2009). Some critical episodes in the progress of medical innovation: An Anglo-American perspective. *Research Policy, 38*(2), 234–242. https://doi.org/10.1016/j.respol.2008.12.007.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change, 16*(4), 691–791. https://doi.org/10.1093/icc/dtm023.

Sam, C., & van der Sijde, P. (2014). Understanding the concept of the entrepreneurial university from the perspective of higher education models. *Higher Education, 68*(6), 891–908. https://doi.org/10.1007/s10734-014-9750-0.

Sarfraz, A. M. (2011). *Science and technology based regional EntrepreneurshipGlobal experience in policy and program development*. Cheltenham: UK.

Schmitz, A., Urbano, D., Dandolini, G. A., de Souza, J. A., & Guerrero, M. (2017). Innovation and entrepreneurship in the academic setting: A systematic literature review. *International Entrepreneurship and Management Journal, 13*(2), 369–395. https://doi.org/10.1007/s11365-016-0401-z.

Secundo, G., Ndou, V., & Del Vecchio, P. (2016). Challenges for instilling entrepreneurial mindset in scientists and engineers: What works in European universities? *International Journal of Innovation and Technology Management, 13*(5). https://doi.org/10.1142/s0219877016400125.

Shirokova, G., Osiyevskyy, O., & Bogatyreva, K. (2016). Exploring the intention-behavior link in student entrepreneurship: Moderating effects of individual and environmental characteristics. *European Management Journal, 34*(4), 386–399. https://doi.org/10.1016/j.emj.2015.12.007.

Siegel, D. S., & Wright, M. (2015). Academic entrepreneurship: Time for a rethink? *British Journal of Management, 26*(4), 582–595. https://doi.org/10.1111/1467-8551.12116.

Siegel, D. S., Veugelers, R., & Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: Performance and policy implications. *Oxford Review of Economic Policy, 23*(4), 640–660. https://doi.org/10.1093/oxrep/grm036.

Souitaris, V., Zerbinati, S., & Al-Laham, A. (2007). Do entrepreneurship programmes raise entrepreneurial intention of science and engineering students? The effect of learning, inspiration and resources. *Journal of Business Venturing, 22*(4), 566–591. https://doi.org/10.1016/j.jbusvent.2006.05.002.

Standish-Kuon, T., & Rice, M. P. (2002). Introducing engineering and science students to entrepreneurship: Models and influential factors at six American universities. *Journal of Engineering Education, 91*(1), 33–39. https://doi.org/10.1002/j.2168-9830.2002.tb00670.x.

St-Jean, E., Tremblay, M., Janssen, F., Baronet, J., Loue, C., & Nafa, A. (2017). May business mentors act as opportunity brokers and enablers among university students? *International Entrepreneurship and Management Journal, 13*(1), 97–111. https://doi.org/10.1007/s11365-016-0397-4.

Taks, M., Tynjala, P., & Kukemelk, H. (2016). Engineering students' conceptions of entrepreneurial learning as part of their education. *European Journal of Engineering Education, 41*(1), 53–69. https://doi.org/10.1080/03043797.2015.1012708.

Un, C. A., Cuervo-Cazurra, A., & Asakawa, K. (2010). R&D collaborations and product innovation. *Journal of Product Innovation Management, 27*(5), 673–689. https://doi.org/10.1111/j.1540-5885.2010.00744.x.

van de Burgwal, L. H. M., Dias, A., & Claassen, E. (2019). Incentives for knowledge valorisation: A European benchmark. *The Journal of Technology Transfer, 44*(1), 1–20. https://doi.org/10.1007/s10961-017-9594-8.

Wach, K., & Wojciechowski, L. (2016). Entrepreneurial intentions of students in Poland in the view of Ajzen's theory of planned behaviour. *Entrepreneurial Business and Economics Review, 4*(1), 83–94. https://doi.org/10.15678/eber.2016.040106.

Warren, A., Hanke, R., & Trotzer, D. (2008). Models for university technology transfer: Resolving conflicts between mission and methods and the dependency on geographic location. *Cambridge Journal of Regions, Economy and Society, 1*(2), 219–232. https://doi.org/10.1093/camres/rsm009.

Wennberg, K., Wiklund, J., & Wright, M. (2011). The effectiveness of university knowledge spillovers: Performance differences between university spinoffs and corporate spinoffs. *Research Policy, 40*(8), 1128–1143. https://doi.org/10.1016/j.respol.2011.05.014.

Wright, M. (2014). Academic entrepreneurship, technology transfer and society: Where next? *Journal of Technology Transfer, 39*(3), 322–334. https://doi.org/10.1007/s10961-012-9286-3.

Yi, G. F. (2018). Impact of internship quality on entrepreneurial intentions among graduating engineering students of research universities in China. *International Entrepreneurship and Management Journal, 14*(4), 1071–1087. https://doi.org/10.1007/s11365-017-0491-2.

Yin, R. K. (2014). *Case study research : design and methods* (5th ed.). Los Angeles: SAGE.

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