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A Science-Based Design Perspective

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ABSTRACT

Academic entrepreneurship by means of university spinoffs commercializes technological breakthroughs, which may otherwise remain unexploited. However, many universities face difficulties in creating spinoffs. This article adopts a science-based design approach, to connect scholarly research with the pragmatics of effectively creating university spinoffs. This approach serves to link the practice of university spinoff creation, via design principles, to the scholarly knowledge in this area. As such, science-based design promotes the interplay between emergent and deliberate design processes. This framework is used to develop a set of design principles that are practice-based as well as grounded in the existing body of research on university spinoffs. A case-study of spinoff creation at a Dutch university illustrates the interplay between initial processes characterized by emergent design and the subsequent process that was more deliberate in nature. This case study also suggests there are two fundamentally different phases in building capacity for university spinoff creation: first, an infrastructure for spinoff creation (e.g. including a collaborative network of investors, managers and advisors) is developed, that then enables support activities to individual spinoff ventures. This study concludes that, to build and increase capacity for creating spinoffs, universities should:

1. create university-wide awareness of entrepreneurship opportunities, stimulate the development of entrepreneurial ideas, and subsequently screen entrepreneurs and ideas by programs targeted at students and academic staff;
2. support start-up teams in composing and learning the right mix of venturing skills and knowledge by providing access to advice, coaching and training;
3. help starters in obtaining access to resources and developing their social capital by creating a collaborative network organization of investors, managers and advisors;
4. set clear and supportive rules and procedures that regulate the university spinoff process, enhance fair treatment of involved parties, and separate spinoff processes from academic research and teaching;
5. shape a university culture that reinforces academic entrepreneurship, by creating norms and exemplars that motivate entrepreneurial behavior.

These and other results of this study illustrate how science-based design can connect scholarly research to the pragmatics of actually creating spinoffs in academic institutions.

1. Introduction

University spinoffs such as Lycos and Genentech serve to transform technological breakthroughs from university research, which would probably remain unexploited otherwise. However, some universities generate substantially higher numbers of spinoffs than others (e.g., Di Gregorio and Shane, 2003; Klofsten and Jones-Evans, 2000; Kondo, 2004). Moreover, university spinoff activity creates several difficulties, such as the potential conflict of interest between commercial and academic work and the risk to university reputation if founders of spinoffs act inappropriately (Bird, Hayward and Allen, 1993; Shane, 2004; Slaughter and Rhoades, 2004).

Academic entrepreneurship by way of university spinoffs is an emerging field of research focusing on the process of creating, discovering and exploiting technological opportunities created by university research. More broadly, the field of entrepreneurship is currently searching for a methodology that would fit its research object (e.g., Davidsson, 2004; Sarasvathy, 2004). Shane and Venkataraman (2000) propose a framework that focuses on explaining and predicting entrepreneurship as a unique set of empirical phenomena. This framework now is an important benchmark in entrepreneurship research (e.g., Davidsson, 2004); this suggests (academic) entrepreneurship research is increasingly being modeled after mainstream management research, drawing on causal frameworks, models and theories. This type of research has brought a growing understanding of university spinoffs including, among others, the role of different technological regimes (Shane, 2004), the selectivity of the incubator model adopted (Clarysse et al., 2005), the role of the technology transfer unit in providing access to resources and support services (Bekkers, Gilsing and Van der Steen, 2006; Debackere and Veugelers, 2005), and the differential ability of universities to generate start-ups (Di Gregorio and Shane, 2003).

This growing body of literature focuses on spinoffs that have been established already. However, *how* they got established in the first place tends to remain unaddressed. In this respect, causal explanation and reasoning helps to explain existing artifacts, but may be inadequate to understand the creation of such artifacts (Romme, 2003; Sarasvathy, 2001 and 2004; Van Aken, 2004). A more integral understanding of the process of *creating* university spinoffs is therefore still in its infancy (Shane, 2004).

To analyze this process, a *science-based design* perspective is adopted in this study. Simon (1996) and Sarasvathy (2004) argue that design involves human beings using knowledge to create what should and could be. Science, by contrast, develops knowledge about what already is. In this respect, a science-based design approach connects the (emerging) body of research to the pragmatic, action-oriented knowledge of practitioners (Romme, 2003; Romme and Endenburg, 2006). To deepen understanding of the process of spinoff creation, this article will take this more pragmatic body of knowledge as its starting point. We present a case study of how a university infrastructure for the creation of spinoffs was established. The spinoff practices in this case study were, initially, strongly driven by a more pragmatic approach and subsequently reshaped by insights derived from scholarly knowledge.

Why is this Study Important?

This study connects pragmatic knowledge about *how* to create university spinoffs to scholarly work explaining *why* certain practices in this field work and others do not. As such, it makes three contributions to the literature. First, the science-based design approach adopted in this article is fundamentally different from design approaches in other work. Previous studies tend to conceive design as either an emergent process (e.g., Garud, Kumaraswamy and Sambamurthy, 2006; Sarasvathy 2001) or a deliberate process driven by design principles (e.g.,

Romme and Endenburg, 2006; Van Aken, 2004). This article explores the initiating role of an emergent process toward a more deliberate one. In other words, we focus on the interplay between emergent and deliberate design, and explore how this interplay can serve to develop a cumulative body of knowledge that is relevant for both practitioners and scholars. A second contribution involves the area of application of the science-based design approach: technology commercialization and entrepreneurship in a university setting. This setting clearly differs from earlier applications (e.g. Denyer, Tranfield and Van Aken, 2008; Romme and Endenburg, 2006) and serves to advance theory development regarding university spinoffs (cf. Whetten, 1989). Third, this article provides an in-depth analysis of a specific case. Such an in-depth study may yield new insights that are relevant beyond the local context of this particular university. Moreover, it may deepen understanding of the creative tension between general theories and principles and the specific local contexts in which universities engage in spinoff creation.

This article is structured as follows. We start by defining the methodology of science-based design and then discuss the case study method adopted. The subsequent section describes the case study. Finally, key findings from this case study as well as the merits and limitations of the methodology adopted are discussed.

2. Science-Based Design

This article adopts the science-based design perspective currently emerging in organization research (e.g., Dunbar, Romme and Starbuck, 2007; Romme, 2003; Van Aken, 2004) and to a lesser extent also in entrepreneurship research (e.g., Sarasvathy, 2003 and 2004). The framework proposed here links the scientific knowledge base produced by entrepreneurship researchers to the pragmatic and creative work of practitioners (e.g., entrepreneurs and those advising these

entrepreneurs). More in general, it attempts to bridge the gap between managerial practice and academic research (cf. Karniouchina, Victorino and Verna, 2006).

Following Romme and Endenburg (2006), these epistemically rather different 'worlds' are linked by means of design principles. One way to apply this core idea involves using principles grounded in research to create (i.e., conceptual) solutions to be subsequently tried out and implemented in practice (Romme and Endenburg, 2006). Alternatively, experimentation with new practices and solutions can also serve to derive design principles (cf. Plsek, Bibby and Whitby, 2007).

Science-based design therefore involves the following two key notions linking practices and research findings (cf. Romme and Endenburg, 2006): design principles and design solutions. *Design principles* involve a coherent set of normative ideas and propositions, grounded in (e.g., entrepreneurship) research, which serve to design and construct detailed solutions. These principles serve as a 'boundary' object between the descriptive and explanatory nature of entrepreneurship research and the prescriptive and pragmatic nature of the design process (Romme and Endenburg, 2006). An individual design principle is typically part of a bundle of principles that is loosely coupled to other bundles of principles (Ethiraj and Levinthal, 2004; McCarthy , Tsinopoulos, Allen and Rose-Anderssen, 2006). In this article, the process of formulating design principles is structured by separately developing principles based on practice (practice-based principles) and principles merely based on scholarly knowledge (research-based principles). The synthesis of these principles results in design principles, which thus draw on both practitioner knowledge and research knowledge (see Method section).

Design solutions are representations of the practices being (re)designed with help of the design principles, involving actions in the virtual world of drawings, models, narratives, simulations, and so forth. These virtual solutions are more contextualized than design

principles, that is, solutions tend to include elements specific to the local setting. These solutions can be directly tested in practice. Representations of a design may be visual (e.g., a diagram depicting the business model of the start-up), physical (e.g., a prototype of the intended product), narrative (e.g., anecdote illustrating customer value attributed to the product), or combinations of these different forms of representation (e.g., a 3D simulation).

In the context of entrepreneurship and innovation, design processes tend to be as much emergent as deliberate in nature (Hargadon and Douglas, 2001). The framework in Figure 1 suggests there are ample opportunities for experimentation (practice) to drive the creation of, for example, design solutions and principles. This more emergent design process arises from what Schön (1987) calls reflection-in-action: that is, the rethinking that leads to on the spot experiments as well as the further thinking "that affects what we do – in the situation at hand and perhaps also in others we shall see as similar to it" (Schön, 1987: 29). Weick (2004) characterizes the experience of engaging in emergent design as 'being thrown' into an continuously evolving and ambiguous context. This emergent quality of the research-design-development cycle in Figure 1 is likely to prevail when design principles are non-existent, underdeveloped, or unknown to practitioners. In a more mature discipline, this cycle is as much emergent as it is deliberate: the emergent dimension serves to respond to and account for the unique and dynamic nature of the local setting, whereas the deliberate dimension serves to build a body of knowledge that cuts across multiple settings. The field of entrepreneurship, and of university spinoffs in particular, still lacks a widely accepted methodology or theoretical framework. Therefore, the deliberate and emergent dimensions of (academic) entrepreneurship need to interact and converge in building a cumulative body of knowledge and practice.

Insert Figure 1 about here

The two faces of design also reflect the need to decontextualize and contextualize principles and solutions (see Figure 1). The process of abstracting solutions and their underlying principles from, for example, a first sample of new ventures processed through a university-based incubator involves *decontextualization*. Similarly, effectively applying a set of general principles to for example the creation of spinoffs in university X implies adaptation to the institutional and regional setting of this university. Moving from right to left in Figure 1, knowledge therefore becomes increasingly *contextualized*, also in view of the rapidly diversifying nature of organizational, industrial, technological, regional and cultural settings (cf. MacCormack and Verganti, 2003; Orlikowski, Yates, Okamura and Fujimoto, 1995; Rousseau and Fried, 2001).

Science-based design can also be understood in terms of the interplay between causal and effectual reasoning (cf. Sarasvathy, 2001). The scholarly body of research findings largely draws on causal propositions and empirical studies testing these propositions. By definition, these studies focus on existing artifacts: for example, spinoff firms generated by a sample of universities in the past ten years. By contrast, the experimentation and implementation stage in Figure 1 largely draws on effectual logic that is inherently creative. For example, the attempt to create a technology-based firm heavily draws on resources such as personal skills, patented technology, and social as well as professional networks (Sarasvathy, 2001; Shane, 2004). Using these resources, the entrepreneur imagines and tries out possible effects that can be created with them.

3. Method

The case study in this article serves to illustrate both emergent and deliberate design dimensions and, in particular, the pivotal role of design principles in the interplay between both dimensions. The case study involves the creation and implementation of an infrastructure for generating and facilitating spinoffs at a Dutch university of technology. The study draws on data collected in the period 2005-2007. The data were gathered in two different roles. One of the authors of this article was involved as one of the key agents in the redesign and implementation processes (cf. participant-observer data). The other authors performed semi-structured interviews and collected documentary data from the usual 'outsider' perspective. The interviews were transcribed, checked with the interviewees, and coded according to the procedure outlined by Strauss and Corbin (1990). Interviewees involved a large number of entrepreneurs (in spe) involved in spinoffs, several managers of the spinoff support unit, two start-up advisors, an IP advisor, and several entrepreneurship professors. In total, 25 interviews were conducted.

The case study approach in this article is a clinical rather than descriptive one. The clinical nature of the case study arises from its dual purpose to improve the spinoff performance of the incumbent university as well as to analyze and understand the underlying processes in this case. In tracking the deliberate and emergent design dimensions, we took three steps to identify, create and use design principles:

- first, so-called practice-based principles are developed by converting the largely tacit knowledge of key agents in university spinoff creation into explicit principles (cf. Plsek et al., 2007);
- second, principles are derived from a review of the literature; these research-based principles then serve to understand (and possibly improve) practices and solutions

already in place as well as create entirely new solutions (cf. Romme and Endenburg, 2006);

- third, the practice-based and research-based principles are synthesized in a set of design principles – defined as principles that are tested in practice as well as grounded in the existing body of research (Van Aken, 2004; Romme, 2003).

The *practice-based principles* are derived from the data by means of a careful coding and reduction process (Strauss and Corbin, 1990). The first involves coding all different practices and experiences that starters and support advisors reported and those that were described in key documents. Next, the coded practices were clustered and reduced to a small number of categories. For each category, crucial elements of the solutions and any common denominators are identified. Finally, for each of the practice-based principles the different experiences of support staff and entrepreneurs are listed.

Research-based principles were derived by means of a systematic literature review that draws on a qualitative meta-synthesis approach (Denyer and Tranfield, 2006; Tranfield, Denyer, Marcos and Burr, 2004; Tranfield, Denyer and Smart, 2003). The domain of this review was defined in terms of all research in the area of university spinoffs. The purpose of the review is to derive normative (general) principles rather than to provide a comprehensive overview. Therefore, the review protocol takes several existing literature reviews as a starting point, complemented by research not included in these reviews. Three recent literature reviews were identified: Shane (2004), Djokovic and Souitaris (2006), and O'Shea, Allen, O'Gorman and Roche (2004). The findings from these three reviews were synthesized in a number of key concepts and a preliminary set of principles. The latter result was compared and extended with about fifteen publications and working papers (not used in the three previously published literature reviews). Subsequently, this set of research-based principles was linked to any general theories

that explain the key mechanisms addressed by these principles (cf. Denyer, Tranfield and Van Aken, 2008; Pawson, 2001). Because some of the empirical findings regarding university spinoffs still lack theoretical explanation, we also explored other (related) literatures.

Finally, we composed a set of *design principles* by confronting and comparing the list of practice-based principles with the list of research-based principles.

4. Case Study

This section starts with a description of several key events and issues in building capacity for spinoff creation at Eindhoven University of Technology. Subsequently, we focus on how two key practices emerged and explore the underlying practice-based principles. We then turn to how a more deliberate approach, drawing on research-based principles, served to redesign these solutions.[1] One potential redesign solution is discussed in more detail. Finally, the set of design principles, resulting from a synthesis of the two sets of principles, is presented.

A university spinoff is "a new company founded to exploit a piece of intellectual property created in an academic institution" (Shane, 2004: 4). University spinoffs therefore are a subset of all start-up companies created by students and employees of universities. As such, this definition focuses on the opportunities (based on intellectual property of a university) exploited by new business start-ups, rather than on the business founders themselves. The intellectual property exploited by university spinoffs typically involves patented inventions; other spinoffs draw on copyright protection.

Key Events

Until the late 1990s, Eindhoven University of Technology (TU/e) was strongly focused on applied technology research and education, with strong linkages to several multinational firms

in high-tech industries in the region. TU/e therefore excelled in commercializing some of its technological inventions by means of selling or licensing these inventions to established firms. As a result, many technologies and their potential applications remained unexploited – in particular, those that were not relevant or too immature for the multinational firms the university typically partnered with.

With the appointment of a new chairman of the board in 2002, TU/e's top management decided to change this situation by investing in the creation of an infrastructure that would serve to commercialize key inventions by spinning off new technology ventures. An external professional was hired to set up a spinoff support unit (called InnovationLab), involving start-up advisors and IP professionals. The staff of the spinoff support unit initiated the creation and implementation of a number of key solutions, including:

- An undergraduate minor program in entrepreneurship was created and made available from the management school of TU/e (as of 2005). This minor program is now one of the two most popular minors at TU/e.
- A protocol for transferring IP to spinoff firms and distributing revenues among the internal stakeholders (inventor, research group, university, and entrepreneur) was created in view of the first set of experiments in starting up technology firms (in 2003-2004), involving a high level of anxiety among university representatives, inventors, (student) entrepreneurs and investors about revenues distribution. This protocol was developed to create transparency about key standards in the process while maintaining sufficient flexibility in negotiating tailor-made deals about the transfer of IP to spinoffs.
- At the level of all M.Sc. programs, a so-called Technology Entrepreneurship certificate program was tested and implemented.

- A regional network, involving eight organizations, was created to pool resources and provide access to each others' contacts and resources.

The last two design solutions will be discussed in more detail in the remainder of this section.

Until 2005 the experiments with these design solutions were self-contained, in the sense that they were driven by a local search for ideas, benchmarks, and so forth. In other words, the initial stages of the design process were largely emergent in nature (cf. Figure 1). In the summer of 2005, a research team came on board and engaged in studying the design and practice of spinoff creation at TU/e; this included a sustained effort to develop design principles grounded in research findings to assess and improve the solutions already in place as well as construct new solutions. Since 2005 the process thus evolved as a more balanced interplay between emergent and deliberate design.

Technology Entrepreneurship Program

The first idea for a university-wide entrepreneurship program for Master students arose from an experiment set up by a professor in chemical technology, who formerly worked in the lab of a multinational firm: "Over there, I got infected by the high tech entrepreneurial attitude: the combination of research into technology and the attempt to commercialize this research. This is a research mentality of not just doing funny things in the lab, but also bringing them to the market." In 2003, this professor collaborated with a visiting professor from Brown University (USA), and they decided to experiment with Brown University's engineering entrepreneurship program. They formed three teams with students from both the management and chemistry schools; the two initiators and an entrepreneurship professor supervised these teams. The teams conducted applied research on a patented technological invention from the chemistry school's lab. For example, in one of the teams a chemistry student worked on a final graduation (M.Sc.)

project in which an application of the technology was prototyped in the chemistry lab, whereas the management student did his M.Sc. final project on the market, strategic and financial approach toward commercializing this application; together, these two students wrote a business plan for the new venture. Two team projects failed to generate a valid business proposition, but the third team was able to develop a successful spinoff. This venture attracted its first major clients and recently built its first plant.

This initial experiment motivated the spinoff support unit to develop a university-wide program along the same lines. The program was further developed, renamed, and embedded in the management school. Compared to the pilot developed in the chemistry school, the program was further developed in terms of an on-line self-assessment system; a contracting stage to align the perceptions of inventor, university, and (student) entrepreneurs; several courses offered by the management school; a master class in entrepreneurial skills; and a coaching and supervision system. An important aspect of the redesigned program is that students can obtain the certificate in Technology Entrepreneurship (TE) by completing their individual final projects and the educational components of the program, even when the effort to start up a new firm fails.

These adaptations and extensions of the initial pilot were motivated and constructed with help of principles derived from research on university spinoffs and entrepreneurship education. In this respect, the Technology Entrepreneurship program links entrepreneurial intentions to explorative activities to set up and realize a venture. Several scholars report a positive effect of entrepreneurship education on intentions to create ventures and spinoffs (e.g., Peterman and Kennedy, 2003; Vesper and Gartner, 1997). However, the challenge is to move from intentional to actual, nascent entrepreneurship because there is a gap, or at least a time lag, between intention and action (Souitaris, Zerbinati and Al Laham, 2007). Nascent entrepreneurs

are people who actually are performing activities to establish a company – for example, by developing prototypes, acquiring personal commitments, searching for financial support, contacting clients (cf. Lichtenstein, Carter, Dooley and Gartner, 2007). Souitaris et al. (2007) found evidence that entrepreneurship programs that include teaching, business-planning, interaction with practice, and university support, enhance students' entrepreneurial intentions and their propensity of being nascent. The Technology Entrepreneurship program at TU/e attempts, and in certain cases succeeds, to bring students from being intentional entrepreneurs to become nascent entrepreneurs or even actually found a new firm. Typically, the new firm is actually founded after graduation, so the program primarily deals with the nascent stage.

Since the formal start of the university-wide program in Technology Entrepreneurship (in 2004), 18 projects have been kicked off with 28 students involved. In the meantime, three projects have produced a spinoff firm. Eight projects were completed, but without starting a spinoff; that is, all students involved completed their M.Sc. degree and obtained the TE certificate, but the process of writing a business plan led the participants to conclude that the intended business is not (yet) feasible. The remainder of the 18 projects are still running.

In case of the aborted attempts to generate spinoffs, our interview data suggest that in most cases the technology was still too immature to be commercialized. Moreover, the students aborting these start-up projects did not want to invest in further work on start-ups with a highly uncertain payback (period). Overall, the program has produced several successful technology spinoffs in a relatively short period, and in the other cases, the program has created graduates with valuable entrepreneurial experience.

Incubator Network

In 2003, TU/e's spinoff support unit set up a regional incubator network. In this network, eight regional organizations work together to support start-ups. Involved are three regional development organizations, a local bank, the incubator of a multinational firm (Philips), an applied research organization (TNO), an undergraduate college, and TU/e. The incubator network was created to pool resources as well as to provide access to each others' contacts, expertise, and resources.

Every two weeks, representatives of all eight organizations meet to discuss ideas, plans and presentations by (would be) entrepreneurs - including students or staff from TU/e. In these meetings, people get direct feedback on their ideas and plans and the representatives from the eight organizations are invited to explore how their networks and contacts can contribute to the proposed new ventures. The group of representatives also frequently provides starters with experienced coaches. For example, one of these representatives explains: 'It gives them possibilities at Philips Research and at TNO. The first time a starter needs something, they can use equipment from these research sites for free or with a discount. So, they can use such equipment to see if their concept 'works' or not.'

Around the eight formal partners in the incubator network, there are another 20 firms (e.g., lawyers, tax consultants, recruitment and selection firms) that are committed to help starters with advice or services against reduced fees. In addition, the incubator network has created a fund to directly support starters and it frequently provides starters access to banks, informal investors and venture capital firms. This fund helps to make the first investments to develop a prototype (as a proof of principle), thus bridging the first stages of the 'valley of death' from invention to innovation (Auerswald and Branscomb, 2003). Each year, about 75 students from TU/e ask for assistance from the incubator network, and if they are selected, they

get access to the resources and services of the network. Annually, about 50 applications are granted.

The interview data collected suggest the incubator network helps starters in developing their own networks as well as in acquiring financial and other resources. For most starters, the single most valuable aspect is that it helps them build relationships with investors, coaches, other starters, potential clients and other (support) organizations. In addition, the incubator network also creates reputation value for the starter (e.g., in approaching and dealing with potential clients, investors, and the tax office).

The incubator network was pioneered by TU/e's spinoff support unit. When a research team (the authors of this article) came on board in 2005, it started identifying key opportunities for further development of the network. A core issue here was the development of the personal and professional networks of the participating starter-entrepreneurs in the incubator network. The incubator network at that stage merely served to refer starters to helpful contacts, rather than motivate and facilitate starters to build interpersonal relationships.

Both network and entrepreneurship researchers, however, have emphasized the importance of these interpersonal ties – especially those with relevant people outside academia (Nicolaou and Birley, 2003a; Ring and Van de Ven, 1994; Shane, 2004). In this respect, people involved in university spinoffs start out with interpersonal networks that are primarily academic in nature; if they do not invest in ties with the industrial and financial world, industry representatives and investors are likely to consider the spinoff as an academic venture rather than a real company (e.g., Bekkers et al., 2006; Vohora et al., 2004). Drawing on social capital theory, Nicolaou and Birley (2003b) argue that networks around spinoffs have four potential benefits. First, networks augment the opportunity identification process, as it enhances the entrepreneurs' recognition capabilities because entrepreneurs can discover the opportunity

through the right personal contact. Second, networks provide access to loci of resources, for example to acquire access to capital, as is offered in the TU/e case by the cooperation with the bank in the incubator network. Third, networks engender timing advantages, because the entrepreneur is able to know and utilize opportunities quicker. Fourth, a network such as the incubator network constitutes a source of trust and credibility with regard to the start-up company, because these network partners are credible organizations that back the start-up (Nicolaou and Birley, 2003b). Because of these benefits, the establishment of a network is closely related to the success of the start-up (Hackett and Dilts, 2004).

Therefore, the incubator network decided to invest more resources and effort in recurrent events intended to motivate and facilitate the development of interpersonal ties. Within the incubator network program, starters can now attend a variety of network events, including so called Meet & Match sessions where starters pitch their propositions to investors and representatives from industry. These sessions are perceived to be very useful for skill development, feedback received, and opportunities to develop new interpersonal ties. For example, one of the starters evaluated the last Meet & Match event he attended: "Last time, there was a Meet & Match. Starters and business sit down together. We got three useful contacts out of it. That's the way we get our first clients."

Synthesis into Design Principles

To illustrate the process of developing design principles, the construction of one principle is discussed here. First, a practice-based principle is extracted from practitioners' experiences; and subsequently a related principle is derived from research findings, using a meta-synthesis approach. Table 1 provides an overview of the set of design principles arising from this study.

Many of the interviewees emphasized that awareness of opportunities to become an entrepreneur is an important precondition of eventually and successfully starting a spinoff company. For example, spinoff support professionals observed that many (would be) entrepreneurs contact these professionals relatively late, because they were not aware of the facilities and resources available within the university. To increase awareness among students and staff, the incubator support unit increased the exposure of entrepreneurship courses, appointed 'scouts' in each academic department, trained staff in commercializing research findings, and cultivated entrepreneurial role models. These measures have had major effects: 'In the past, one was not allowed to talk about entrepreneurship. But now, a number of people is triggered by the attention to it, and says: that's funny, I will do it' (start-up advisor). These findings led to the following practice-based principle: *Make potential entrepreneurs (students, Ph.D.-students, staff members) aware of opportunities to start a venture based on a research finding.*

Insert Table 1 about here

In the literature several programs and practices dealing with the incubation, selection and support of (proposed) ventures are studied and assessed. First, programs such as business plan competitions are important to provide inflow of potential academic entrepreneurs into subsequent stages of the incubation process (Djokovic and Souitaris, 2006; Fini, Grimaldi and Sobrero, 2006). The selection of these potential entrepreneurs and their ideas depends upon the goals of the spinoff support (Clarysse et al., 2005). In a well designed support infrastructure, these goals also determine the degree and kind of support. This support by skilled people (Mowery, Nelson, Sampat and Ziedonis, 2004) should at least help with the development of appropriately composed venturing teams, especially with regard to knowledge and skills (Djokovic and Souitaris, 2006; Vohora, Wright, and Lockett, 2004; Shane, 2004). Team

development support can involve creating other team compositions, development of skills or network development. These research findings are captured in the following research-based principle: *Screen technologies and ideas for new ventures, and subsequently provide start-ups with advice and coaching from skilled people.* In addition, we listed theories describing the generative processes underlying this principle: opportunity identification theory provides a theoretical framework that explains the role of programs targeting the emergence of entrepreneurial ideas (Ardichvili, Cardozo and Ray, 2003; Djokovic and Souitaris, 2006; Shane, 2000 and 2004); moreover, knowledge theory explains how (previous and current) training, coaching and advice processes affect the entrepreneurial dispositions and intentions of students and staff (Djokovic and Souitaris, 2006).

A comparison of the practice-based and research-based principles previously described results in the following observations. The practice-based principle involves information provision, visible support, and scouting potential entrepreneurs. The research-based principle deals with emergence of ideas, goals for spinoff creation, advice, coaching and training. Both principles focus on the idea generation phase of the spinoff process; in addition, the research-based principle deals with advice, coaching and training. Because other practice-based and research-based principles also consider the advice, coaching and training aspects, we included these in another design principle. This results in the first design principle listed in Table 1.

The process of comparing and synthesizing the two sets of principles leads to the following set of design principles: *To build and increase capacity for creating spinoffs, universities should design and implement practices that:*

1. *Create university-wide awareness of entrepreneurship opportunities, stimulate the development of entrepreneurial ideas, and subsequently screen entrepreneurs and ideas by programs targeted at students and academic staff.*

2. *Support start-up teams in composing and learning the right mix of venturing skills and knowledge by providing access to advice, coaching and training.*
3. *Help starters in obtaining access to resources and developing their social capital by creating a collaborative network organization of investors, managers and advisors.*
4. *Set clear and supportive rules and procedures that regulate the university spinoff process, enhance fair treatment of involved parties, and separate spinoff processes from academic research and teaching.*
5. *Shape a university culture that reinforces academic entrepreneurship by creating norms and exemplars that motivate entrepreneurial behavior.*

Table 1 links this set of design principles to aspects of practices created in Eindhoven University of Technology as well as to the theories that explain the processes in these principles.

These design principles serve to reflect on the comprehensiveness of (previous) research and theory development and explore to what extent the practice of university spinoff generation is described and explained in scholarly work. In this respect, Table 1 illustrates that some design principles are not yet incorporated in literature about university spinoffs. A major example is the principle that says: Set clear and supportive rules and procedures that regulate the university spinoff process, enhance fair treatment of involved parties, and separate spinoff processes from academic research and teaching. This principle and some of the practices observed in the TU/e case are not yet grounded in any theoretical frameworks. Theories adopted from the complexity science and organizational justice literatures may provide such a deeper understanding of the generative processes behind this design principle. The complexity science literature provides a framework for understanding and managing universities as complex adaptative systems (Cilliers, 1998), that wish to perform academically as well as entrepreneurially. For example, Eisenhardt and Sull (2001) suggest that a set of well-chosen

simple rules can shape a wide range of resilient and productive processes. That is, when organizing becomes increasingly complicated and dynamic, its design should become simpler, and easier to modify (cf. Eisenhardt and Sull, 2001). In addition, the organizational justice literature may serve to develop a theory of the effectiveness and fairness of rules and procedures for university spinoff processes (e.g., Hosmer and Kiewitz, 2005).

Spinoff Creation: Results and Future Challenges

The TU/e case illustrates how a more emergent design process, driven by practitioners, can be extended and enhanced by means of a more deliberate approach. The two practices previously described – the Technology Entrepreneurship program and the incubator network – were pioneered by practitioners and subsequently fine tuned with help of a research-driven perspective. Table 2 provides an overview of the annual number of spinoffs, exploiting intellectual property developed at TU/e, over a ten-year period. The spinoffs in 2005 and 2006 include three spinoffs developed from the Technology Entrepreneurship program. The trend in Table 1 suggests that TU/e is on track in terms of increasing its ability to commercialize intellectual property by means of spinoffs.

Insert Table 2 about here

However, the design principles in Table 1 also expose blind spots and therefore major areas of improvement, as illustrated in the remainder of this section. Many interviewees observed that TU/e still misses an entrepreneurial culture. Academic staff tend to focus on academic research and education; technology transfer and especially spinoff formation is rather foreign to most academics in this university. This is therefore a major barrier to spinoff creation. For example, the coordinator of the Technology Entrepreneurship program observed: 'Students

experience resistance. They say: I'm allocated to a faculty subdepartment and I would like to combine my graduation project with exploring the start of a spinoff in the Technology Entrepreneurship program. However, my supervisor from the subdepartment is not convinced, because he has his own agenda and says: I 'd like that you do this research, because that's what I'm involved in. That clashes sometimes and causes that some students abandon the program. These students were quite enthusiastic, but when they go back to the research group they're graduating in, they may talk them out of it.'

Table 1 indeed implies that TU/e has hardly developed solutions and practices implied by the fifth design principle regarding an entrepreneurial culture in this table. Evidently, this is enormous challenge. More than any other principle in Table 1, the creation of an entrepreneurial culture requires a university-wide effort and long-term commitment by all stakeholders involved. Once such a university culture starts to develop, it helps to increase the awareness among scholars and students of opportunities to commercialize inventions developed in the university (Djokovic and Souitaris, 2006; Bird and Allen, 1989). Shaping such a culture takes much time, because both scholars and administrators need to adopt altered values (Clark, 1998; Debackere and Veugelers, 2005).

Some initial measures to create conditions for an entrepreneurial culture to arise have recently been adopted at TU/e including, for example, the cultivation of successful entrepreneurs as role models (see Table 1). Important other changes, such as adjusting the career-reward structure toward explicit incentives and rewards for entrepreneurial effort and performance (Siegel, Waldman, Atwater and Link, 2004), have not been implemented at TU/e. At most universities the key incentives for academic scholars motivate them to focus on publications rather than entrepreneurial activity (Siegel et al., 2004). Thus, many scholars in

TU/e and elsewhere tend to believe that engaging in entrepreneurial activities (with highly uncertain outcomes) will undermine their academic career.

Therefore, it is important to develop clear standards and rewards that specify how and why academic staff can engage in entrepreneurial activities: for example by offering leaves of absence for inventors who wish to found companies (Shane, 2004); temporarily freezing the tenure clock (Fini et al., 2006); and individual performance evaluation systems that are likely to increase the respectability of entrepreneurship (Kirby, 2006; O'Shea et al., 2004; Vohora et al., 2004). Moreover, Slaughter and Rhoades (2004) argue that faculty's entrepreneurial engagement may undercut their commitment to teaching and services, particularly those irrelevant to the pursuit of patents and firm start-ups. Strong incentives for entrepreneurial behavior may also shift attention from research areas with few patenting opportunities toward those with more patenting potential (Mustar et al., 2006). In addition, the patenting of university technologies, as an important basis for spinoffs, may prevent a free flow of knowledge within the academic world (cf. the studies reviewed by Shane, 2004). Creating a balance between incentives for research and teaching and those for entrepreneurship is therefore a delicate matter.[2]

5. Discussion and Conclusion

This article proposes a science-based design approach to the creation of university spinoffs. This approach was applied in developing an spinoff support infrastructure at a Dutch university of technology. The latter case study illustrates some of the benefits as well as problems of science-based design.

Major Research Results

As argued earlier, science-based design connects the body of scientific knowledge to the pragmatic, action-oriented knowledge of practitioners. In order to develop deeper understanding of the spinoff creation process, this study started with codifying practitioners' knowledge. As such, we discussed how an emergent design approach developed at a particular university enhances the ability to create more university spinoffs. Once a number of components of the infrastructure were in place at this university, a more deliberate design process served to extend and improve the existing practices and solutions.

In this respect, two important issues arise. First, a largely emergent design process induced the process, not a deliberate design process per se. This counters the prevailing view in the literature on the dominant role of a deliberate design approach, which tends to ignore the role of emergent processes. By contrast, the role of deliberate design in the TU/e case was mainly to fine-tune and improve the solutions created by pioneering practitioners.

Second, the TU/e case suggests two fundamentally different phases in the design process, with one phase involving the creation of an infrastructure for spinoff creation that creates conditions for a subsequent phase focusing on spinoff support. This differentiation into phases has been largely ignored in the university spinoff literature, that focuses on spinoff formation in terms of 'hands-on support' but has overlooked the role of an important phase preceding this. Thus, the literature tends to implicitly assume a certain university-wide infrastructure being in place and in operation. In this respect, the case study in the previous section suggests that it is critical to embed spinoff incubation in educational activities as well as network ties with industry, investors and other external stakeholders. These pre-incubation activities are likely to increase the inflow of people, ideas and resources in the process of actually creating ventures that may result in successful spinoffs. With the design and

implementation of pre-incubation systems and processes, any investment in direct support to spinoffs is more likely to pay off.

Theoretical and Managerial Implications

This study has several implications. The case study suggests that emergent design processes can be essential in getting started as well as in experimenting with potential solutions. It also shows that a deliberate design approach can assure that the process stays on track by safeguarding and improving it, particularly by codifying design solutions and principles. The emergent and deliberate approaches therefore complement one another. The emergent design process underlines the complexity of the processual side of university spinoff creation, whereas deliberate design pushes an emergent process to go beyond its informal and at times chaotic ways of operating. Therefore, the confrontation and interaction of the two approaches helps to build a cumulative body of knowledge *and* practice, as an essential step to a common theoretical framework in the field of entrepreneurship and spinoff creation by universities.

More specifically, the set of design principles resulting from this study provides a benchmark for any future work that deliberately links efforts to increase spinoff creation capacity to scholarly research in this area. The principles described in Table 1 are preliminary in nature, in the sense that other case studies will adapt and extend these results. Moreover, these five design principles refer to basic conditions and practices (cf. minimum requirements) that need to be created to build some capacity for spinoff creation. That is, they apply to universities that experience major difficulties in creating spinoffs, rather than those already performing effectively in this area.

Limitations and Future Research Directions

A limitation of the approach taken in this article is its restriction to a single case. The single case study approach provides opportunities to develop an in-depth understanding of the process of spinoff formation at a particular university, but it limits the generalizability of our findings. In particular, it is difficult to generalize findings to other disciplines and university types. Previous studies imply spinoffs mainly originate from the sciences instead of the arts and the social sciences; within the sciences most start-ups tend to arise from the life sciences – for example biotechnology, pharmacy, and medical devices (e.g., Meyer, 2003; Shane, 2004). Thus, as TU/e is a university specializing in the sciences and technology, the principles developed in this article may not equally apply to other university types and research areas.

Moreover, future developments in the institutional context of universities may undermine the findings and principles arising from this study. For example, the findings that produce the design principle regarding supportive rules and procedures (principle 4 in Table 1) assume the IP regime that is currently prevailing the USA and most other countries in the western part of the world (e.g. Bayh-Dole Act in the USA and similar regulations elsewhere). If this regime changes significantly, the related design principle will also need to be revised. A completely different IP regime may indeed imply that universities can develop lean procedures and systems that avoid additional decision-making layers, in order to speed up the technology commercialization process and shorten cycle time (Litan, Mitchell and Reedy, 2007).

Overall, this study produces a number of new insights that carry relevance beyond the context of the case studied. Any university that wishes to stimulate spinoff activity needs to start by creating an infrastructure for pre-incubation as well as support of spinoffs. The TU/e case illustrates how this can be done. The experiences and resulting design principles can serve

as a basis for other universities wishing to engage in university spinoff creation as well as for future research in this area.

The case study also produced two design principles that need further development. The design principle regarding supportive rules and procedures is not yet grounded in the university spinoff literature. The previous section outlines several theoretical frameworks that can help to develop a deeper understanding of the role of rules and procedures regarding spinoff formation by universities. The design principle regarding entrepreneurial culture implies a major deficiency in the current practices of spinoff formation at TU/e. These findings suggest that building a entrepreneurial culture constitutes a challenging agenda for future studies, particularly those that draw on theories not yet used in the university spinoff literature.

A specific challenge is to decontextualize some of the issues arising from the TU/e case and to adapt them in such a way that they fit with another institutional context. In this respect, most previous studies suggest a 'general logic' regarding the process of spinoff formation. The approach chosen in this study implies that research findings following this general logic have to be adapted and contextualized in view of the local institutional contingencies (cf. Figure 1). When done effectively, two potential risks in the complex process of university spinoff creation can be diminished: 'getting lost' in the potentially overwhelming local complexity of spinoff creation on the one hand and developing too generic theories overlooking local idiosyncrasies on the other hand.

Examining more cases from a science-based design perspective will serve to increase our understanding of the contextual contingency of the design principles explored in this article. The examination of more cases will provide more insight in the relative importance of these

principles in different contexts. Future research can also test and adapt the proposed principles by creating and developing solutions for other universities.

Evidently, any set of design principles grounded in practice and research evidence is no guarantee for success. The issues raised by university spinoffs are extremely complex, even when participants have access to a body of knowledge and experience codified in design principles. Moreover, any body of knowledge will continue to evolve as a result of new empirical findings as well as experiences obtained in new settings.

In sum, science-based design provides a relatively new perspective on researching and practicing the creation of university spinoffs. This perspective suggests that studying and practicing academic entrepreneurship are two sides of the same (future) coin, involving a coherent body of explanatory and normative knowledge in this area.

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References

Ardichvili, A., Cardozo, R., and Ray, S. (2003). A Theory of Entrepreneurial Opportunity Identification and Development. *Journal of Business Venturing*, 18(1), 105-123.

Auerswald, P.E. and Branscomb, L. M. (2003). Valleys of Death and Darwinian Seas: Financing the Invention to Innovation Transition in the United States. *Journal of Technology Transfer*, 28(3-4), 227.

Bekkers, R., Gilsing, V. and Van der Steen, M. (2006). Determining Factors of the Effectiveness of IP-based Spinoffs: Comparing the Netherlands and the US. *Journal of Technology Transfer* 31(5): 545-566.

Bird, B.J. and Allen, D. N. (1989). Faculty Entrepreneurship in Research University Environments. *Journal of Higher Education*, 60, 583-596.

Bird, B., Hayward, D.J. and Allen, D.N. (1993). Conflicts in the Commercialization of Knowledge: Perspectives from Science and Entrepreneurship. *Entrepreneurship Theory and Practice* 17(4): 57-79.

Cilliers, P. (1998). *Complexity and Postmodernism: Understanding Complex Systems*. London: Routledge.

Clark, B.R. (1998). *Creating Entrepreneurial Universities: Organizational Pathways of Transformation*. Oxford: IAU Press.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. (2005). Spinning Out New Ventures: A Typology of Incubation Strategies from European Research Institutions. *Journal of Business Venturing* 20(2): 183-216.

Davidsson, P. (2004). *Researching Entrepreneurship.* New York: Springer.

Debackere, K. and Veugelers, R. (2005). The Role of Academic Technology Transfer Organizations in Improving Industry Science Links. *Research Policy* 34(3): 321-342.

Denyer, D. and Tranfield, D. (2006). Using Qualitative Research Synthesis to Build an Actionable Knowledge Base. *Management Decision* 42(2): 213-227.

Denyer, D., Tranfield, D. and J.E. van Aken (2008). Developing Design Propositions through Research Synthesis, *Organization Studies*, forthcoming.

Di Gregorio, D. and Shane, S. (2003). Why Do Some Universities Generate More Start-ups than Others? *Research Policy* 32(2): 209-227.

Djokovic, D. and Souitaris, V. (2006). Spinouts from Academic Institutions: A Literature Review with Suggestions for Further Research. *Journal of Technology Transfer*, forthcoming.

Dunbar, R.L.M., Romme, A.G.L., and Starbuck, W.H. (2007). Drawing Value from Organization Design. In: *Sage Handbook of the New and Emerging in Management and Organization*, D. Barry and H. Hansen (eds.). Newbury Park: Sage Publications, forthcoming.

Eisenhardt, K.E. and Sull, D.N. (2001). Strategy as Simple Rules. *Harvard Business Review* 79(1): 106-116.

Ethiraj, S.K. and Levinthal, D. (2004). Modularity and Innovation in Complex Systems. *Management Science* 50(2): 159-173.

Fini, R., Grimaldi, F.R. and Sobrero, M. (2006). Factors Fostering Academics to Start up New Ventures: An Assessment of Italian Founders' Incentives. *Paper presented at the 2006 Academy of Management Annual Meeting.*

Garud, R., Kumaraswamy, A., Sambamurthy, V. (2006) Emergent by Design: Performance and Transformation at Infosys Technologies. *Organization Science* 17(2): 277–286.

Hackett, S.M. and Dilts, D.M. (2004). A Systematic Review of Business Incubation Research. *Journal of Technology Transfer* 29(1): 55-82.

Hargadon, A.B. and Douglas, Y. (2001). When Innovations Meet Institutions: Edison and the Design of the Electric Light. *Administrative Science Quarterly* 46(3): 476-501.

Hosmer, L.T. and Kiewitz, C. (2005), Organizational Justice: A Behavioral Science Concept with Critical Implications for Business Ethics and Stakeholder Theory. *Business Ethics Quarterly* 15(1): 67-91.

Karniouchina, E.V., Victorino, L., and Verma, R. (2006). Product and Service Innovation: Ideas for Future Cross-Disciplinary Research. *Journal of Product Innovation Management*, 23(3), 274-280.

Kauffman, S.A. (1995). *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*. New York: Oxford University Press.

Kirby, D.A. (2006). Creating Entrepreneurial Universities in the UK: Applying Entrepreneurship Theory to Practice. *Journal of Technology Transfer* 31(5): 599-603.

Klofsten, M. and Jones-Evans, D. (2000). Comparing Academic Entrepreneurship in Europe – The Case of Sweden and Ireland. *Small Business Economics* 14: 299-309.

Kondo, M. (2004). University Spinoffs in Japan: From University-Industry Collaboration to University-Industry Crossover. *Report by National Institute of Science and Technology Policy (NISTEP).* Tokyo: Yokohama National University.

Lichtenstein, B.B., Carter, N.M., Dooley, K.J., and Gartner, W.B. (2007). Complexity Dynamics of Nascent Entrepreneurship. *Journal of Business Venturing*, 22(2), 236-261.

Litan, R.E., Mitchell, L., and Reedy, E.J. (2007). *Commercializing University Innovations*. Working paper, National Bureau of Economic Research.

MacCormack, A. and Verganti, R. (2003). Managing the Sources of Uncertainty: Matching Process and Context in Software Development. *Journal of Product Innovation Management*, 20(3), 217-232.

McCarthy, I.P., Tsinopoulos, C., Allen, P., and Rose-Anderssen, C. (2006). New Product Development as a Complex Adaptive System of Decisions. *Journal of Product Innovation Management*, 23(5), 437-456.

Meyer, M. (2003). Academic Entrepreneurs or Entrepreneurial Academics? Research-based Ventures and Public Support Mechanisms. *R&D Management* 33(3): 107-115.

Mowery, D.C., Nelson, R.R., Sampat, B.N. and Ziedonis, A.A. (2004). *Ivory Tower and Industrial Innovation: University-Industry Technology Before and After the Bayh-Dole Act.* Stanford: Stanford Business Books.

Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B., and Moray, N. (2006). Conceptualising the Heterogeneity of Research-Based Spin-Offs: A Multi-Dimensional Taxonomy. *Research Policy*, 35(2), 289-308.

Nicolaou, N. and Birley, S. (2003a). Social Networks in Organizational Emergence: The University Spinout Phenomenon. *Management Science*, 49(12), 1702-1725.

Nicolaou, N. and Birley, S. (2003b). Academic Networks in a Trichotomous Categorisation of University Spinouts. *Journal of Business Venturing*, 18(3), 333-359.

Orlikowski, W.J., Yates, J., Okamura, K. and Fujimoto, M. (1995). Shaping Electronic Communication: The Metastructuring of Technology in the Context of Use. *Organization Science* 6(4): 423-444.

O'Shea, R., Allen, T.J., Chevalier, A. and Roche, F. (2005). Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities. *Research Policy* 34(7): 994-1009.

O'Shea, R., Allen, T.J., O'Gorman, C. and Roche, F. (2004). Universities and Technology Transfer: A Review of Academic Entrepreneurship Literature. *Irish Journal of Management* 25(2): 11-29.

Pawson, R. (2001). *Evidence Based Policy: II. The Promise of "Realist Synthesis".* ESRC UK Centre for Evidence Based Policy and Practice, Queen Mary, University of London, London.

Peterman, N.E. and Kennedy, J. (2003). Enterprise Education: Influencing Students' Perceptions of Entrepreneurship. *Entrepreneurship Theory and Practice*, 28(2), 129-144.

Plsek, P., Bibby, J. and Whitby, E. (2007). Practical Methods for Extracting Explicit Design Rules Grounded in the Experience of Organizational Managers. *Journal of Applied Behavioral Science*, 43(1), 153-170.

Ring, P.S. and Van de Ven, A.H. (1994). Developmental Processes of Cooperative Interorganizational Relationships. *Academy of Management Review*, 19(1), 90-118.

Romme, A.G.L. (2003). Making a Difference: Organization as Design. *Organization Science* 14(5): 558-573.

Romme, A.G.L. and Endenburg, G. (2006). Construction Principles and Design Rules in the Case of Circular Design. *Organization Science* 17(2): 287-297.

Rousseau, D.M. and Fried, Y. (2001). Location, Location, Location: Contextualizing Organizational Research. *Journal of Organizational Behavior* 22(1): 1-13.

Sarasvathy, S.D. (2001). Causation and Effectuation: Toward a Theoretical Shift from Economic Inevitability to Entrepreneurial Contingency. *Academy of Management Review* 26(2): 243-263.

Sarasvathy, S.D. (2003). Entrepreneurship as a Science of the Artificial. *Journal of Economic Psychology* 24(2): 203-220.

Sarasvathy, S.D. (2004). Making It Happen: Beyond Theories of the Firm to Theories of Firm Design. *Entrepreneurship Theory & Practice* 28(6): 519-531.

Schein, E.H. (1992). *Organizational Change and Leadership*. San Francisco: Jossey-Bass.

Schön, D.A. (1987). *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass.

Shane, S. (2000). Prior Knowledge and the Discovery of Entrepreneurial Opportunities. *Organization Science*, 11(4), 448-469.

Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Cheltenham: Edward Elgar.

Shane, S. and Venkataraman, S. (2000). The Promise of Entrepreneurship as a Field of Research. *Academy of Management Review* 25(1): 217-226.

Siegel, D.S., Waldman, D.A., Atwater, L.E. and Link, A.N. (2004). Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies. *Journal of Engineering and Technology Management* 21(1/2): 115-142.

Simon, H. A. (1996). *The Sciences of the Artificial.* Cambridge: MIT Press.

Slaughter, S. and Rhoades, G. (2004). *Academic Capitalism and the New Economy*. Baltimore and London: The John Hopkins University Press.

Souitaris, V., Zerbinati, S., and 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.

Strauss, A. and Corbin, J. (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* Newbury Park: Sage Publications.

Tranfield, D., Denyer, D., Marcos, J., and Burr, M. (2004). Co-Producing Management Knowledge. *Management Decision*, 42(3/4), 375-386.

Tranfield, D., Denyer, D., and Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management* 14(3): 207-222.

Van Aken, J.E. (2004). Management Research Based on the Paradigm of the Design Sciences: The Quest for Tested and Grounded Technological Rules. *Journal of Management Studies* 41(2): 219-246.

Vesper, K.H. and Gartner, W.B. (1997). Measuring Progress in Entrepreneurship Education. *Journal of Business Venturing*, 12(5), 403-421.

Vohora, A., Wright, M. and Lockett, A. (2004). Critical Junctures in the Development of University High-Tech Spinout Companies. *Research Policy* 33(1): 147-175.

Weick, K.E. (2004). Designing for Thrownness. In: *Managing as Designing*, R. J. Boland and F. Collopy (eds.). Stanford: Stanford University Press, 74-78.

Whetten, D.A. (1989). What Constitutes a Theoretical Contribution? *Academy of Management Review*, 14(4), 490-495.

Figure 1:

The Research-Design-Development Cycle from a Science-Based Design Perspective.

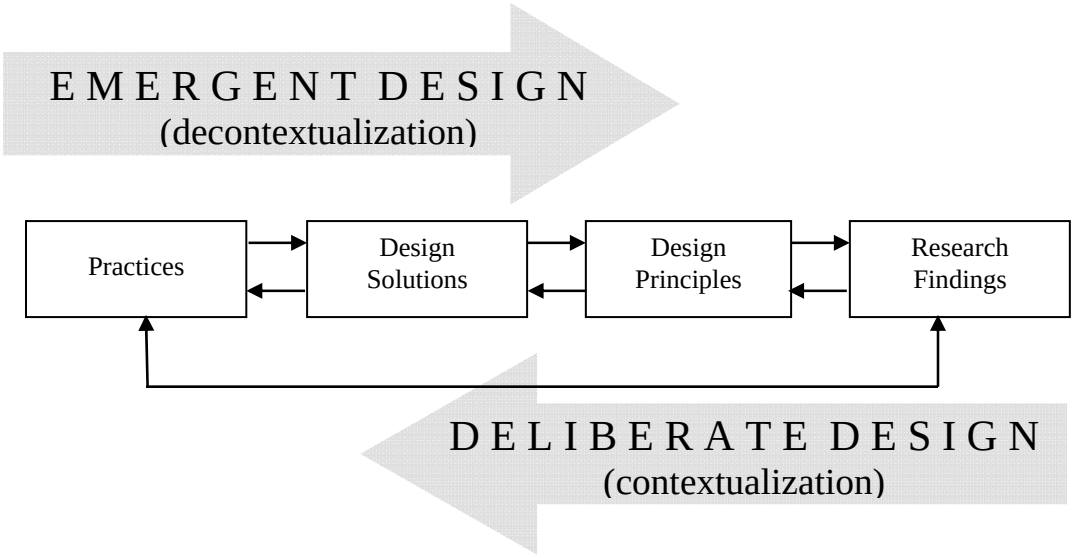

Table 1: Synthesis of practice and research in terms of design principles

Aspects of practices/solutions in case study	To build and increase capacity for creating spinoffs, universities should design and implement practices that:	**Underlying theories**
Involve start-up advisors in entrepreneurship education. Enable students to combine their thesis work with the preparations for starting a venture. Give students early in their study information about entrepreneurial opportunities. Appoint a contact person within each school Offer newly hired employees a training regarding technology commercialization. Screen and select potential entrepreneurs based on their potential.	1. Create university-wide awareness of entrepreneurship opportunities, stimulate the development of entrepreneurial ideas, and subsequently screen entrepreneurs and ideas by programs targeted at students and academic staff.	Opportunity identification (Djokovic and Souitaris, 2006; Shane, 2000 and 2004) Knowledge theories (Djokovic and Souitaris, 2006)
Create student (start-up) teams from multiple disciplines. Advice starters with regard to their business plan, facilities, finance, subsidy requests, start-up team, patenting, et cetera. start-up advisors need to be creative in finding solutions and approach starters in a personalized way. Create start-up teams with the right mix of skills, by training or by adding people to the team. Build a pool of entrepreneur coaches that are willing to advice starters from practice. Create a board of commissioners around each start-up. Provide advice regarding the acquisition of grants.	2. Support start-up teams in composing and learning the right mix of venturing skills and knowledge by providing access to advice, coaching and training.	Resource based theory (O'Shea et al., 2005) Organizational development theories (Clarysse et al., 2005)
Create arrangements for starters to use university labs and other resources. Provide office space with the possibility to use different services. Create flexible contracts and good conditions, but market prices. Enable starters to use the academic network of the university. Establish a network around the support organization of investors, industry contacts and financers. Set up regular meetings with the core network partners to discuss start-ups proposals, etc. Cultivate the prestige of the university to gain credibility. Organize networking events with starters. Create funds to support students and starters in de orientation stage. Create ways to obtain significant amounts of funding. Permit equity investments of the university in spinoffs, in exchange for payments. Create a structure that enables the university to have participations in spinoffs.	3 Help starters in obtaining access to resources and developing their social capital by creating a collaborative network organization of investors, managers and advisors.	Social capital theory (Nicolaou and Birley, 2003a) Organizational development theories (Clarysse et al., 2005)

Establish fair rules regarding the internal distribution of revenues from the exploitation of inventions. Create procedures to manage and assess the balance between academia and business. Allow staff to take equity in spinoffs.	4 Set clear and supportive rules and procedures that regulate the university spinoff process, enhance fair treatment of involved parties, and separate spinoff processes from academic research and teaching.	Organizational justice theory (not yet applied) (e.g., Hosmer and Kiewitz, 2005) Complexity theory (not yet applied) (e.g., Cilliers, 1998; Kauffman, 1995)
Create commitment at faculty boards. Cultivate successful entrepreneurs as role models. Establish a clear and accountable structure, with high commitment of the university board. Establish an organization that is operating 'businesslike'.	5 Shape a university culture that reinforces academic entrepreneurship by creating norms and exemplars that motivate entrepreneurial behavior.	Organizational culture theories (not yet applied) (e.g., Schein, 1992)

Table 2: Number of IP-based spinoffs from Eindhoven University of Technology 1997-2006

Year	IP based spinoffs
1997	1
1998	0
1999	0
2000	5
2001	3
2002	2
2003	0
2004	8
2005	7
2006	5

Endnotes

[1] The constraints of a single article imply we cannot discuss the practice-based and research-based principles in detail. A complete overview of both sets of principles is available upon request from the authors. The resulting design principles, synthesized from the practice-based and research-based principles, are discussed later in this section.

[2] Regarding the latter balance, we acknowledge universities should not engage in university spinoffs because of the expected financial benefits; there are hardly any, as the evidence collected by Shane (2004) suggests. If a university commits to entrepreneurship and incubation of new firms, they should do so to commercialize ideas and technologies developed in this university into applications with huge potential benefits to society. The side-effect, intended or not, is that the reputation and prestige of the incumbent university will very likely benefit.