Paving the way or blocking the road? : University-related support mechanisms for student-led entrepreneurship & innovation activities

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Award date:
2018

Technische Universiteit Eindhoven University of Technology

Department of Industrial Engineering and Innovation Sciences
Innovation, Technology, Entrepreneurship & Marketing Research Group

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A single case study of Eindhoven University of Technology commissioned by TU/e innovation Space

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In partial fulfillment of the requirements for the degree of:
Master of Science in Innovation Management

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Eindhoven, 2018

Keywords: academic knowledge valorization, student entrepreneurship, student innovation, entrepreneurial university, university support mechanisms

Management summary

Universities can either pave the way or block the road for students to become involved in student-led entrepreneurial or innovation activities (SE&I). The TU/e (Eindhoven University of Technology) is actively stimulating students to take part in SE&I through experimental educational programs. The mission of TU/e is to educate a new generation of engineers with a stronger orientation and drive to create innovative solutions for practical problems by integrating SE&I activities within education. In line with these experiments in education, this study aims to improve the academic knowledge valorization (AKV) performance of the TU/e by identifying mechanisms that a university could implement to initiate and stimulate SE&I activities. Besides experiments in education, many mechanisms are implicitly in place to either directly help or hinder students when undertaking entrepreneurial or innovation activities during their enrollment at the TU/e. However, an explicit and holistic overview of these university-related support mechanisms (URS) mechanisms is lacking in literature and practice which results in ambiguity on how to best support student entrepreneurial or innovation (SE&I) activities at TU/e.

The main research question is: *Which URS mechanisms on SE&I activities could the TU/e use to enhance AKV?*. The subject of this thesis are URS mechanisms (mechanisms under direct control of the university) which can affect SE&I activities in order to enhance AKV performance. This thesis describes a taxonomy of URS mechanisms derived from literature and an empirical analysis of the TU/e case and proposes a typology of SE&I activities suited to study and measure the effect of URS mechanisms on these activities. This provides the university with clear directions on how to best support and stimulate SE&I activities.

Methodology

This study is grounded in design-science as it combines insights from theory and practice and aims at designing artifacts (Berglund et al., 2018). Both empirical data and theoretical findings (on SE&I activity and URS mechanisms) have contributed to defining these artifacts (Morgan, 2007). This thesis follows the reflective design approach. This approach is illustrated in Figure 1. First, a theoretical analysis was conducted which included an extensive literature review. This theoretical analysis was complemented with an empirical analysis of 14 interviews with relevant stakeholders at the TU/e (Yin, 2008). By synthesizing design principles from both theory and practice, two artifacts (a SE&I typology and a URS mechanism taxonomy) were designed. Finally, based on a qualitative and quantitative assessment of the URS mechanisms, suggestions for improvement were derived. The reflective redesign approach was concluded with a reflection on the academic contribution, future research directives and managerial implications.

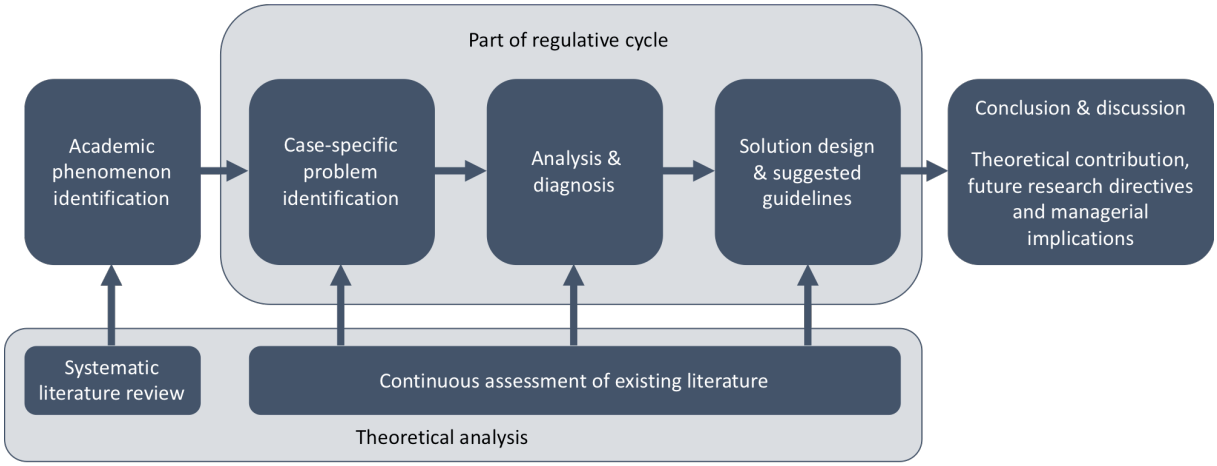

Figure 1: The reflective design approach (Van Aken et al., 2012)

Theoretical analysis

There is a growing emphasis on knowledge valorization in the form of entrepreneurial and innovation (E&I) activities at universities (Wissema, 2009b). Most studies tend to select researchers, companies or university management as a subject of study (Wright et al., 2017). Other studies concerning knowledge transfer or valorization do mention student-led entrepreneurship and innovation projects as an important source for knowledge transfer, but none has developed a holistic overview of university-related support (URS) mechanisms which impact student entrepreneurial and innovation (SE&I) activities (van Burg et al., 2008; Wright et al., 2017; Siegel & Leih, 2018).

The theoretical analysis in this thesis has led to the identification of a typology of SE&I and the derivation of a set of 27 theoretical URS mechanisms stated as design principles based on multiple studies (Graham, 2014; Bengtsson, 2015; Walshok & Shapiro, 2014; Shirokova et al., 2016). A theoretical framework has been designed based on existing studies on the theory of planned behavior and contextual behavioral models (Ajzen & Fishbein, 1977; Gollwitzer & Brandstatter, 1997; Trivedi, 2017; Elfving et al., 2017). As can be seen in Figure 2, the framework formed the basis of the analysis of how the different URS mechanisms affect SE&I activity through intention and action.

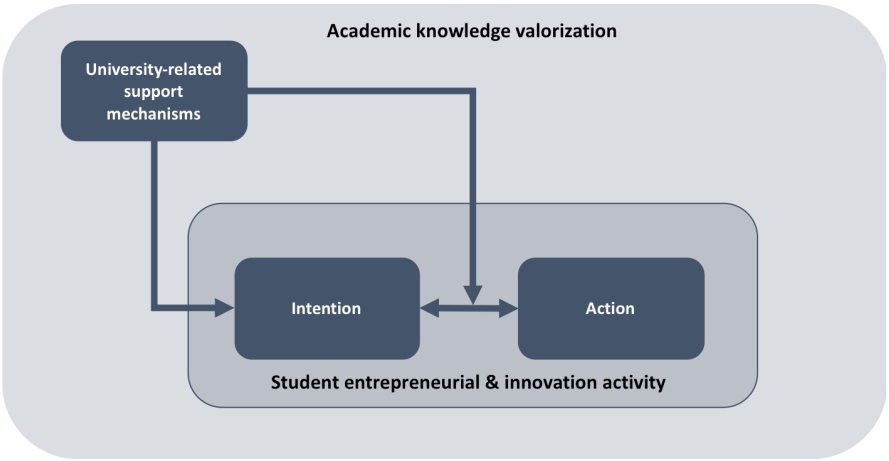

Figure 2: Theoretical framework of this research based on theoretical analysis.

Empirical analysis & diagnosis

First, the SE&I activity types and phases were analyzed empirically. Two types of student-led entrepreneurship were identified: a student-led startup and a student-led spin-off. Three types of student-led innovation activities were identified: in-company innovation activity, study-related innovation activity and extra-curricular innovation activity and two phases were derived: intention phase and action phase.

The empirical analysis has yielded a set of 36 practice-based URS mechanisms stated as design principles. Combining these practice-based URS mechanisms with the theory-based URS mechanisms, comparisons were drawn between theory and practice. A set of 40 unique URS mechanisms is the result: 13 URS mechanisms discovered in practice were not identified in theory and 4 URS mechanisms described in theory were not identified in practice.

The empirical analysis was completed by both a qualitative and quantitative assessment of URS mechanisms. The qualitative sentiment analysis of practice-based URS mechanisms has yielded in-depth insight into the current performance of four URS mechanisms: the negotiation process, high-level integration of valorization, IP regulations and legal support. The quantitative satisfactory analysis on theory-based URS mechanisms has provided an overview of the perceived performance of URS mechanisms at the TU/e. The result of this quantitative analysis is shown in Table 1. The outcomes of the assessments were used to select URS mechanisms for improvement in the solution design phase.

Table 1: Quantitative assessment of theory-based URS mechanisms

Mechanism	Average	St. Dev.
Legal support	2,0	1,15
IP policy	2,4	1,40
Special entrepeneurial status	2,6	0,94
Mentoring program on campus	3,0	0,75
Predefined entrepreneurial mindset	3,2	1,42
Promote as occupation	3,3	1,27
Accelerator	3,3	1,50
Recruitment campaign	3,4	1,02
Flexible curricula	3,6	1,22
Entrepreneurial competence education	3,8	1,57
Collaboration projects with industry	4,0	1,14
Incubator	4,0	1,10
Local capital seed funds	4,0	1,50
Business contest	4,1	1,37
Affordable office space	4,3	1,62
Networking facilitator	4,4	1,28
Success story telling	4,4	1,10
Access to grants	4,4	1,41
Entrepreneurship in University mission	4,4	1,70
Access to scale-up funding	4,5	1,07
Events	4,5	0,83
Matchmaking between students	4,6	1,32
Event space	4,7	1,23
Free co-working space	5,0	1,32
Expermental education center	5,7	0,82
Extracurricular teams	5,7	0,90
Accessbility to high-tech facilities	6,1	0,40

Solution design

First, a typology of SE&I was designed which takes into account the kind and level of URS given to SE&I activities. The design is shown in Figure 3. This design has implications for the definition of a student-led spin-off. Traditionally, spin-offs are identified by the involvement of university-owned intellectual property. This thesis broadens the view on student-led spin-offs by presenting a definition based on URS mechanisms to explicate university support which improves SE&I activity. Metrics on each of the activity types are suggested in order to be able to track their performance.

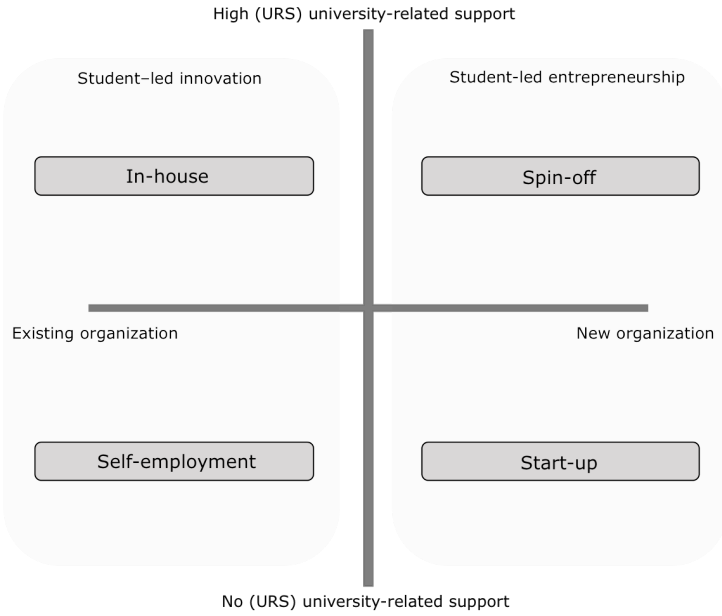

Figure 3: Design of the SE&I activity typology

Second, a taxonomy of URS mechanisms was designed by combining design principles extracted from the theoretical and empirical analysis. The classification of URS mechanisms is based on the cultural, social and material attributes of the mechanisms, the phase of the SE&I activity it supports (intention or action) and the type of SE&I activity it affects (entrepreneurial projects and/or innovation projects). The full taxonomy is presented in Table 2.

Third, four underperforming URS mechanisms at TU/e that were identified in the qualitative and quantitative assessments at TU/e: negotiation process, IP policy, legal support and board-level integration of valorization are analyzed and guidelines for improvement are suggested.

Conclusion & discussion

Currently, academics debate about how universities could explicitly support and nurture student-led entrepreneurship and innovation besides the well-known mechanism of entrepreneurial education (Wright et al., 2017; Siegel & Leih, 2018). This thesis has created a taxonomy of URS mechanisms and proposes a model which implies an increase in SE&I activity performance when these URS mechanisms are cultivated and combined. As a result, based on the URS mechanisms support an alternative definition for a (student-led) spin-off is proposed and a typology of SE&I activities has been designed based on the URS mechanisms.

The designed artefacts open up new research directives, where the effect of the identified URS mechanisms could be measured on different activities in the student-led entrepreneurial and innovation typology. Explicit insight in these mechanisms could enable a university to become more entrepreneurial and stimulates the integration of valorization activities with the still Humboldtian education and research activities (Wissema, 2009b).

Finally, managerial implications are presented based on the designed guidelines for improvement. First, the board of the TU/e should install a clear negotiation process when the university negotiates with student spin-offs. This process is strongly connected to the revenue model of the university (Barrow et al., 2014). Therefore, the board of the TU/e should evaluate revenue model they apply to student spin-offs.

Second, TU/e innovation Space should implement education about IP and legal issues in their curricula. When students undertake SE&I activities, legal and IP issues will raise. Legal support or education on legal topics is currently completely lacking at TU/e for SE&I activities.

Finally, as most of the guidelines affect actions by board-level, a dedicated portfolio holder for student-led valorization should be assigned. This portfolio holder could initiate and oversee the strategic actions needed to continuously improve on URS mechanisms.

Table 2: Taxonomy of URS mechanisms

	Mechanism					Outcome	
	Name	*Description*	*Phase*	*Attribute*	*Type*	*Quantitative metric*	*Qualitative metric*
M.1	Accelerator	Accelerator for SE&I activity	Moderator	Material	E	#SE&I activity in accelerator	Satisfaction rate%
M.2	Acceptance of entrepreneurial career	Acceptance on advancing on the entrepreneurial ladder intead of the academic	Intention ; Moderator	Cultural	E		Satisfaction rate%
M.3	Access to grants	Accessibility to grants for SE&I activity	Moderator	Social	E & I	#SE&I activity receiving grants	Satisfaction rate%
M.4	Access to seed funding	Accessbility of local capital pre-seed funds	Moderator	Social	E	#SE&I acitivity funded	Satisfaction rate%
M.5	Accessbility to high-tech facilities	Accessibility of high-tech facilities for SE&I activity	Moderator	Material	E & I		Satisfaction rate%
M.6	Affordable office space	Affordable office space for SE&I activity	Moderator	Material	E & I	#SE&I acitivty in office space	Satisfaction rate%
M.7	Alumni relationships	Involvement of alumni in valorisation activities	Intention ; Moderator	Social	E & I	#Alumni in SE&I activity	Alumni monitor%
M.8	Business contest	Availability of a bussines plan contest for SE&I activity	Intention ; Moderator	Cultural	E	#SE&I activity in contests	Satisfaction rate%
M.9	Challenge-based courses	Courses designed around challenges	Intention ; Moderator	Material	E & I	#Courses in curricula	Satisfaction rate%
M.10	Collaboration projects with industry	Collaboration projects with industry during study	Intention ; Moderator	Social	E & I	#Resource to U/I interaction	Satisfaction rate%
M.11	E&I in curricula	Adoption of SE&I activities in standard curricula	Intention ; Moderator	Material	E & I	#EI activity in curricula	Satisfaction rate%
M.12	Entrepreneurial competence education	Avaibility of appropriate entrepreneurial courses for SE&I activity	Intention ; Moderator	Material	E & I	#Courses in curricula	Company advisory board%
M.13	Entrepreneurship & innovation in mission	Adoption of SE&I in university mission statement	Intention	Cultural	E & I		Satisfaction rate%
M.14	Events	Availability of appropriate events for SE&I activity	Intention ; Moderator	Social	E & I	#SE&I-related events	Satisfaction rate%
M.15	Experimental education center	Availability of a experiential education center for SE&I activity	Intention ; Moderator	Material	E & I		Satisfaction rate%
M.16	Extra-curricular teams	Availability (to start) university-supported extracurricular innovation teams	Intention ; Moderator	Material	I	#Extracurricular teams	Satisfaction rate%
M.17	Financial incentives	Availability of financial incentives for staff to participate in SE&I	Moderator	Material	E & I		Satisfaction rate%
M.18	Financial investing	Availability of (small) financial investments of university	Moderator	Material	E		Satisfaction rate%
M.19	Graduate with spin-off	Graduation with a spin-off as student	Moderator	Material	E	#Graduates	Satisfaction rate%
M.20	Incubator	Availability of an incubator for SE&I activity	Moderator	Material	E	#Spin-offs in incubator	Satisfaction rate%
M.21	Integraton of valorisation	Integrate valorization within research and education on university-board level	Intention	Cultural	E & I		Satisfaction rate%
M.22	IP policy	IP policy on SE&I activities	Intention ; Moderator	Material	E & I		Satisfaction rate%
M.23	Legal support	Availability of appropriate legal support for SE&I activity	Moderator	Social	E	#Supported SE&I projects	Satisfaction rate%
M.24	Life-long learning	Opportunities at the university for life-long learning	Intention ; Moderator	Material	E & I	#Lifelong learners	Satisfaction rate%
M.25	Matchmaking between students	Accessibility of students with from other discipline to start SE&I activity	Intention	Social	E & I		Satisfaction rate%
M.26	Mentoring/coaching program	Availability of a mentoring program for SE&I activity on campus	Moderator	Social	E & I		Satisfaction rate%
M.27	Multidisciplinair research themes	Multidisciplinair research themes to spur new ideas	Intention	Material	I		Satisfaction rate%
M.28	Negotiation process	Clear negotiation process for a quid pro quo from students in SE&I activities	Moderator	Material	E		Level of trust%
M.29	Network facilitator	Accesibility of oustide network for SE&I activity	Moderator	Social	E & I	#External at events	Satisfaction rate%
M.30	Pre-defined E&I mindset	Adoption of a predefined E&I mindset on campus	Intention	Cultural	E & I		Satisfaction rate%
M.31	Recruitment campaign	University-wide campaigns on SE&I activity	Intention	Cultural	E & I		Satisfaction rate%
M.32	Revenue model	Clear revenue model in place of how universities could benefit from SE&I activit	Moderator	Material	E		Satisfaction rate%
M.33	Role models	Availability of role models in EI in university staff	Intention	Cultural	E & I		Satisfaction rate%
M.34	Selection of first-year students	EI-driven selection procedure on first-year student	Intention	Cultural	E & I		Satisfaction rate%
M.35	Special recognition entrepreneurs	Availability of a special recognition for students in SE&I activity	Moderator	Cultural	E	#Special recognitions granted	Satisfaction rate%
M.36	Student-led community	Availability of a community where students can network and learn from eachot	Intention ; Moderator	Social	E & I		Satisfaction rate%
M.37	Study-related pressure	Study-related pressure perceived by students	Intention ; Moderator	Cultural	E		Pressure perceived%
M.38	Success story telling	Story telling on successful SE&I activity on campus	Intention	Cultural	E & I		Satisfaction rate%
M.39	University staff competence	Availibity of staff whom are experienced in entrepreneurship	Intention ; Moderator	Material	E	#EI experts in staff	Satisfaction rate%
M.40	Visibility of E&I activities	SE&I activities in a visible setting at the campus	Intention	Cultural	E & I		Satisfaction rate%

Acknowledgements

I am grateful to be born in a time where humanity begins to realize that global challenges can only be overcome when we 'as a for now on-earth-relying species' collaborate and innovate. Fighting the grand global challenges requires pro-activeness, creativity, empathy and a problem-solving attitude. All these traits, in my opinion, are embedded in 'entrepreneurship & innovation'. Exactly this, is why I believe that this era needs us humans to act as bold entrepreneurs. And no, you do not need to 'own' a company, you need to understand the challenges, imagine the solutions and keep on executing on them. I believe that's what our grand-grand-children need.

Now, back to reality, first of all I am very grateful for the help of my mentor Isabelle, it would not have been possible to execute this master dissertation without our discussions, late-night mails and lively passion. Without Isabelle, there would not even be an innovation Space or an entrepreneurial community at the TU/e. On behalf of all current and future students I thank you for all the hard work you put in Isabelle! I also want to thank Alfons, who have showed me the importance of a critical stance on the matter and Myriam who has an eye for every little detail in my writing, both have been a tremendous support for developing the thesis and reaching an academic standard. Also, I owe thanks to the ladies from the secretary of ITEM, without them it would not have been possible to talk to either of my supervisors.

Thanks as well to all interviewees who took the time to explain their view on the matter. All these people whose quotes remain anonymous will live eternally in this piece of paper via their quotes and contributions. That takes me to my friends, especially Bas, Jeroen, Rein, Michiel and Robbert. Together we have laid the foundation for innovation Space from the bottom up in 2016 and 2017. It was and still is great to work with these great people and I wish them all the best in their future endeavors. Without them I would never have thought about initiating innovation Space from the student-side on the first place.

In addition, if I had not been convinced by the first Solar Team Eindhoven to join the second team in 2014, I probably would never ever have gotten involved in TU/e innovation Space. I could not be more grateful for all students taking the leap when joining the Solar Team Eindhoven teams. These students are definitively not only paving the way for clean mobility, they also demonstrate the need for changing the university education system. I believe TU/e innovation Space is just the start of a radical change in the way universities educate their students.

Finally I want to say thanks to my close family, my mom, sister and grandparents for their patience while listening to my talks, my dad for his sincere interest in my research and specially my girlfriend, you were, are and will be there for me, always.

Contents

Abbreviations

AKV	Academic knowledge valorization
CRT	Cross-disciplinary research themes
IP	Intellectual property
E&I	Entrepreneurship & innovation
SE&I	Student-led entrepreneurship & innovation
TIS	TU/e innovation Space
TPB	Theory of Planned Behavior
TU/e	Eindhoven University of Technology
URS	University-related support

List of Figures

List of Tables

1 Introduction

As a vital part of the newly founded TU/e innovation Space, research is conducted on several aspects of (student-led) entrepreneurship & innovation. A deeper understanding of how students gain an entrepreneurial mindset and how this state of mind is translated into high-quality activities is of great importance in order to form an entrepreneurial ecosystem around the TU/e campus. Nowadays, the research group in which this thesis was conducted has a strong focus on *design-science research*. This research adopts this design-science view as well to determine design principles.

This approach was also applied in the master dissertation of Velasco-Montañez (2017) on which this thesis builds. Considering the future research directions of the study of Velasco-Montañez, this study explores how the TU/e can improve their academic knowledge valorization (AKV) strategy by leveraging student entrepreneurial and innovation (SE&I) activities through university-related support (URS) mechanisms (Velasco Montañez, 2017).

Within the ambiguous field of knowledge valorization, universities can play a significant role in the transfer of academic knowledge into a meaningful societal context (Etzkowitz et al., 2000; Etzkowitz, 2003; Mulgan & Abdo, 2010). Many studies investigated the valorization role of universities focussing on researchers and university staff or explained how SE&I activities could contribute to knowledge valorization via entrepreneurial education. However, an analysis on how university-related support mechanisms could be used to improve academic knowledge valorization by leveraging SE&I is lacking. Therefore, this research aims to develop a taxonomy of URS mechanisms. The taxonomy is based on design principles obtained from both theory and practice. These design principles show how different mechanisms influence SE&I activities and how this influence can be measured. The measurement is crucial because the impact of knowledge transfer via students has a great potential and should therefore be recognized as one of the main sources for knowledge valorization (Graham, 2014). The study therefore develops a theoretical framework for identifying, influencing and measuring SE&I activities within the context of the chosen single-case, the Eindhoven University of Technology. The outcomes of this study should be used to update the TU/e entrepreneurial innovation ecosystem strategy (Reymen, 2015).

This introduction (Chapter 1) describes the background of the Eindhoven University of Technology (TU/e) and the recently established education innovation center TU/e innovation Space (TIS), followed by the introduction of the concept of valorization as the third mission for universities. This background provides the context of this research. The chapter concludes with the problem statement, the research questions and the set of deliverables of this study.

Chapter 2 decribes the methodology of this research. The methodology is based on the best practices for fieldwork projects and is embedded in the design-science research paradigm by using a reflective redesign process as a knowledge generating approach (van Aken et al., 2012).

Chapter 3 contains the theoretical framework and introduces the concepts AKV, SE&I activity and URS mechanisms. The theoretical framework highlights the important relationship between SE&I activity and URS mechanisms in the context of AKV. A specific conceptual relationship model is developed in order to explain the effect of university-related support mechanisms on SE&I activities. Current insights from literature are presented on how SE&I activities originate, how they might be influenced by university-related support mechanisms, what results they yield and how these results can be measured. All URS mechanisms identified are subsequently presented as theory-based design principles. Chapter 3 concludes with the identification of a literature gap and a distinct theoretical contribution of this study to the existing research body on the stimulation of student-led innovation & entrepreneurship.

Chapter 4 contains the results of the empirical analysis and a quantitative and qualitative diagnosis of the identified URS mechanisms. The empirical analysis is based on the coding schemes of the data collection and yields practical insights.

Chapter 5 presents a typology of SE&I activity and a taxonomy of URS mechanisms with metrics that is based on both theory and practice. The chapter concludes with four guidelines for improvement of TU/e-specific URS mechanisms.

Finally, in Chapter 6, the results of the study are discussed and theoretical implications are presented. The thesis concludes with the limitations and future research directions followed by the managerial implications.

1.1 Background of Eindhoven University of Technology

The TU/e was founded in 1956 in close collaboration with the industry. The foundation was part of the reconstruction of the Netherlands right after the second world war (Huiskamp, 2006). One of the driving forces of the foundation was technology company Philips. The Eindhoven-based multinational was in great need of engineers who were able to develop new technologies and were familiar with work in high-tech operations (Vossers, 1991).

More than 60 years after the foundation, the TU/e is a vibrant technology engineering University with a strong focus on industry-oriented research. The TU/e currently hosts more than 10.000 students and 3.000 staff members of which 1.500 are PhD students (TU Eindhoven, 2016). The TU/e is an international front-runner in the fields of photonics, (bio)chemistry, molecular systems and high-tech systems and a world leader in industry-oriented research measured in number of co-publications with innovative companies (Tijssen & Yegros, 2017). Many professors and university staff members work part-time at the university and part-time in industry which helps to bridge the gap between academic research and commercial needs.

Currently, the TU/e is reconfiguring its research, educational and valorization strategy with a program called TU/expedition2030. This program discusses various topics within the fields of future education and valorization, new focus areas and state-of-the-art industry collaboration initiatives (Mengelers & Blok, 2017). The aim is to bridge the valley of death between fundamental research and real world applications. A system called Technology Readiness Levels is used at the TU/e to provide insight into the different steps that a technology takes before it enters society. A broader call for reform comes from leading professors at the university, putting forward the need to innovate in an open and flexible ecosystem (Steinbuch, 2016).

This thesis aims to contribute to this strategy discussion by exploring how TU/e could leverage student-led entrepreneurship & intrapreneurial activities within its academic knowledge valorization strategy by mapping the mechanisms which influence these activities and testing the mechanisms on performance. The topic of this research has been approved by the scientific director (Isabelle Reymen) and the managing director (Alfons Bruekers) of the recently established TU/e innovation Space (TIS).

1.2 Background of TU/e innovation Space

TU/e innovation Space is designed as a hands-on learning environment where interdisciplinary teams of students work on real-world challenges brought in by companies or researchers (Reymen & Bruns, 2016). The idea originated at a field trip to the Aalto Design Factory in Helsinki. Shortly after the trip, Isabelle Reymen and Miguel Bruns formed a founding team to kick-start the development of TIS which was a unique combination of researchers and students.

The mission of TIS is to develop a community where students, researchers and industry work together on real-world challenges. To achieve this goal, new courses and graduation projects are designed where students get assigned to these challenges guided by researchers and industry professionals. To ensure autonomy and freedom to act, TIS is set up as a separate organization within the TU/e. As can be seen in the governance structure in Figure 1.1, the management team of TU/e innovation Space is directly governed by the Rector Magnificus, the Dean of the Bachelor College and the Chairman of valorization at TU/e. In this perspective, the combination of research, education and valorization is covered in the governance structure. However, ultimately the education board of the University is end responsible.

The TU/e already has some experience in organizing interdisciplinary teams to work on challenges in the form of extracurricular student teams. These student teams have set an example of intrinsically motivated students gathering together from multiple departments for a grand challenge. Solar Team Eindhoven is a successful example of a student team that won three successive world championships of solar car racing. Solar Team Eindhoven is a team of more than 20 students from various departments at the TU/e. Other teams, like STORM Eindhoven, successfully demonstrated the possibility of driving an electric motor bike around the world in 80 days. Another example is Team Blue Jay that has created domestic drones in health-care. Students within these teams did not receive ECTS (European credits transfer system) for their work in these teams, which has resulted in study delays. Also, these students did not get any monetary rewards other than a compensation for their tuition fees. Despite these obstacles, the students proved highly motivated and stimulated each other to cope with difficult complex challenges and to persevere in delivering feasible, viable and desirable solutions. Coping with complex challenges is essentially different from dealing with complicated challenges and the teams somehow managed to do this without direct coaching or guidance by accredited teachers (Cuban, 2011; Selten et al., 2015).

The ambition of TIS is to offer all students at Tu/e a learning experience that is similar to the learning experience of students in the student teams. This learning experience should be integrated within the education curricula in order to grant ECTS for working on these challenge-based courses. After all, students do not study to just get ECTS granted, right?

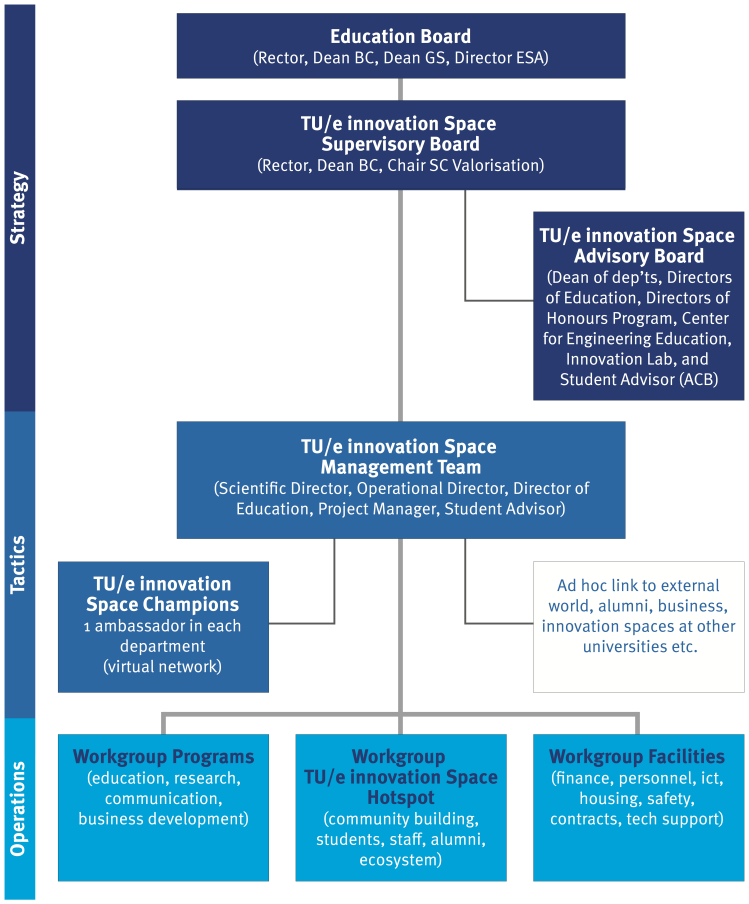

Figure 1.1: The governance structure of TU/e innovation Space within the TU/e

1.3 Valorization as the third mission

The first European university founded in 1088 was designed for education purposes only. Roughly 700 years later in 1810, Wilhelm von Humboldt was the first to create the modern-day university by the symbiosis of education and research into one institution (von Humboldt, 1809). As of today, this Humboldtian model remains the leading organizational design for most universities. Meanwhile, between 1810 and 2018, our world has seen a remarkable growth in welfare, for a large part driven by technology (Steinbuch, 2016). Four industrial revolutions have caused a massive wave of technological applications and the last revolution is still accelerating advancements in technology today.

Nowadays, universities are becoming increasingly involved in a demanding ecosystem with both private and public interests to bridge the gap between basic principle research and commercialization of technology (Graham, 2014). For decades, this technology development role has been adopted by research and development departments at corporates that translated university research into valuable products, or even did fundamental research themselves. However, this dynamic is shifting as corporates tend to focus more and more on making short-term profits. The ecosystem around a university more and more expects the university to take the role of technology developer. This valorization trend combined with the increased technology advancements in the field of big data and artificial intelligence creates a whole new dynamics, tensions

and opportunities affecting the way in which students could and should be educated (Libecap, 2005; Mulgan & Abdo, 2010; Unger et al., 2018).

A more societal argument can be raised for why universities should more actively valorize their knowledge through their students. As proposed by Mazzucato (2011), nations should strive to find ways to direct innovation to solve the pressing global challenges of our time. A focal role for government-funded universities could be proposed in a mission-oriented innovation ecosystem as a knowledge and talent supplier (Mazzucato, 2011, 2017, 2018).

Students within universities participating in valorisation could learn how to act like an ecopreneur with an interest in commercially viable and technological feasible solutions as well as a focus on human desirability and ecological sustainability (Klomp, 2017). Stanford University, one of the world's leading universities, is already anticipating on purpose and mission-oriented learning (Cheng, 2016). The education vision of Stanford is based on the shifting demands on the future workforce. As lifelong learning is becoming an important factor within the dynamic ecosystem, Stanford University designs teams based on the concept of challenge-based, hybrid learning teams where age, race, experience, background and discipline are mixed (World Economic Forum, 2017).

This study focusses on academic knowledge valorisation by studying the role students could play within this 'third' mission in entrepreneurial and innovation projects and builds upon the latest insights from world leading institutes.

1.4 Problem statement

Stakeholders from multiple departments and experts from outside the university were interviewed. An overview of the interviewees is given in Appendix D. These interviews were highly unstructured and not documented. The aim of the interviews was to get a first understanding of how universities could improve performance of SE&I activities.

One of the conclusions from the interviews was that there is still little alignment between TU/e innovation Lab, TU/e innovation Space, Startup/ Eindhoven, departments and the general management of the TU/e on SE&I activities. An overview of the problem tree is presented in Figure 1.2. Experts from other universities that were interviewed also mentioned that alignment on how to stimulate SE&I activities in their universities remains a challenge but is deemed crucial.

As can be seen in Figure 1.2, since the universities formally adopted the valorization mission, there is still a lack of alignment on how to support and formally integrate valorization activities within the university, especially for students. Nowadays, a university researcher can gain formal support to start-up a venture or innovate within an existing company. At the TU/e, this support for students is still very much ad-hoc, arbitrary and non-organized.

The problem statement is formulated as follows:

The TU/e lacks insight in and organization of currently implicit URS mechanisms to stimulate student entrepreneurial and innovation (SE&I) activities.

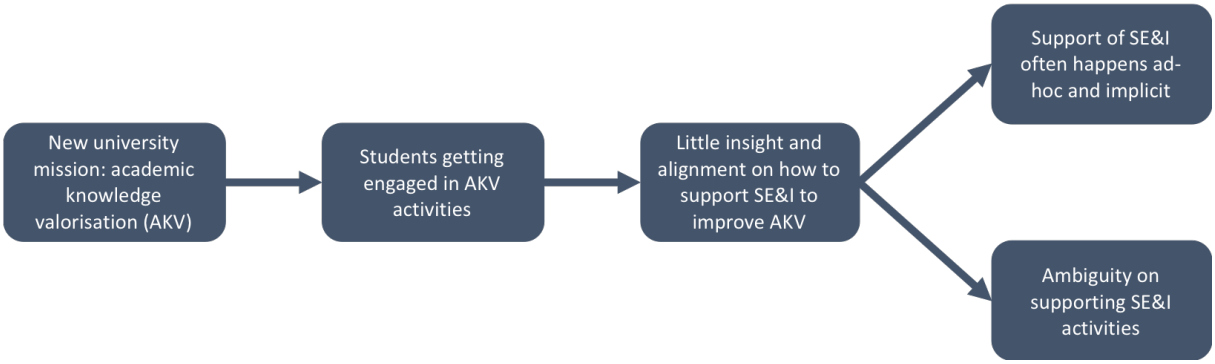

Figure 1.2: The simplified problem tree.

1.5 Research objective & questions

Commissioned by the Eindhoven University of Technology (TU/e), this thesis explores how the academic knowledge valorization (AKV) strategy of the TU/e can be improved by an identification of student entrepreneurial and innovation (SE&I) activities and a deeper insight in how these activities can be directly initiated and stimulated by the university. This research objective is translated into a main research question and several derived sub-research questions. When all sub-research questions are addressed, the main research question can be answered.

Main research question

Which university-related support (URS) mechanisms on student-led entrepreneurial & innovation (SE&I) activities could the Eindhoven University of Technology (TU/e) use to enhance academic knowledge valorization (AKV)?

Sub-research questions

1. How do URS mechanisms influence SE&I activity?
2. How could SE&I activities and URS mechanisms be defined and classified for TU/e?
3. How could the performance of SE&I activities and URS mechanisms be measured for TU/e?
4. How does the TU/e currently perform at their URS mechanisms?
5. What modifications could TU/e possibly make to a selection of their URS mechanisms in order to enhance SE&I activities?

1.6 Research deliverables

Based on the concept of URS mechanisms, a typology of SE&I activities is designed. These URS mechanisms are presented in a taxonomy. Finally, guidelines are given to improve some of the identified mechanisms at the TU/e. In total 5 research deliverables are presented in this thesis. The first three concern identifying and measuring SE&I activities and URS mechanisms, the latter two improving these activities and mechanisms specifically at the TU/e:

1. A theoretical framework for investigating how URS mechanisms initiate and stimulate SE&I activities
2. A typology of SE&I activities including metrics
3. A taxonomy of theoretical and practical design principles of university-related support mechanisms including metrics
4. A qualitative and quantitative assessment of the performance of URS mechanisms at TU/e
5. Guidelines of how TU/e could improve on a set of identified URS mechanisms.

An overview of how the research questions and deliverables are related is shown in Figure 1.3. The research deliverables are further discussed in chapter 2.3.

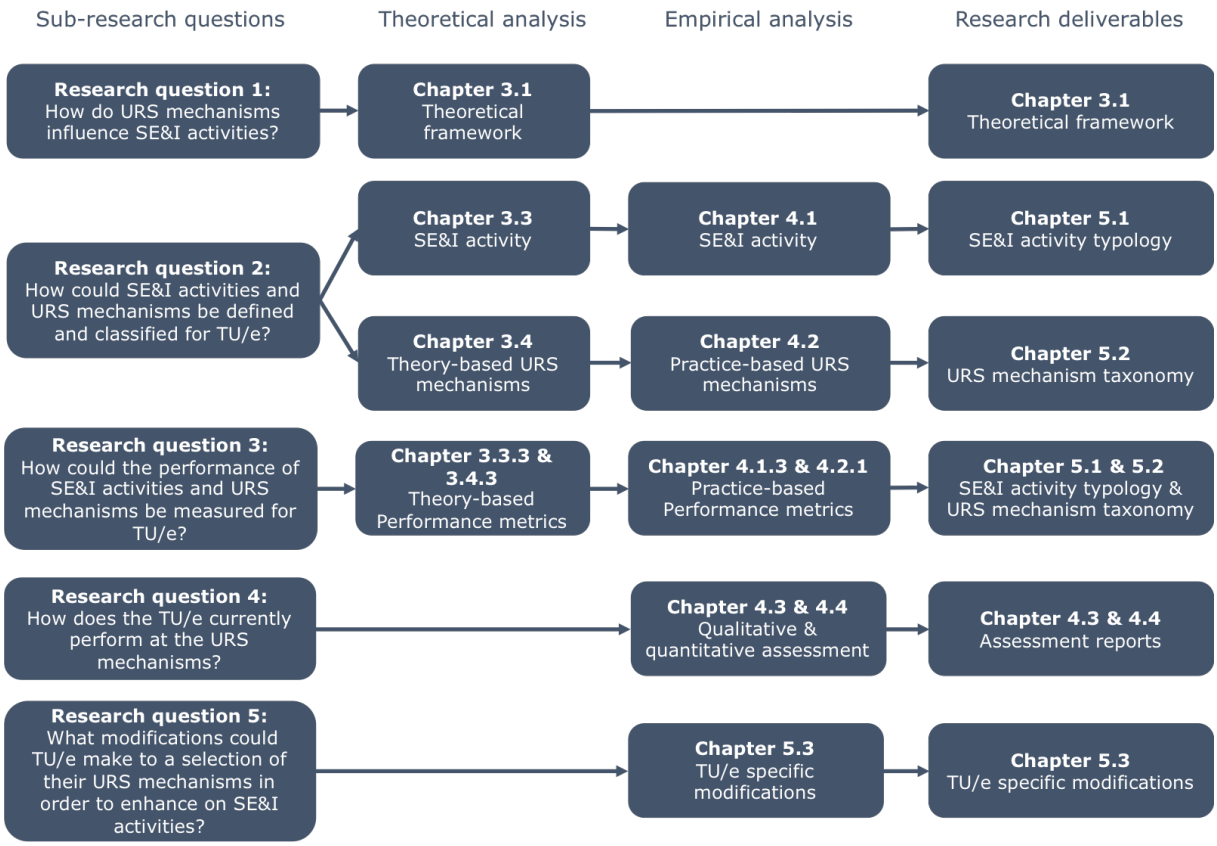

Figure 1.3: Interrelations between the research questions and the research deliverables.

2 | Research methodology

The research methodology is based on the best practices for fieldwork in business presented by van Aken et al. (2012), who have proposed two basic process structures for a master thesis in management science: the *empirical cycle* and the *problem solving (or regulative) cycle* (van Strien, 1997).

The empirical cycle, as shown in figure 2.1, aims to develop theories within a dominant research paradigm. The developed theory exists of a set of coherent rules which predict or explain relationships between variables. The cycle consists of five different steps. First, a certain business phenomena or problem is observed and studied by assessing academic literature. Then, aided by related literature, possible explanations are developed for the phenomena. This step is inductive in nature as it tries to determine generic explanations based on the business problem. The most promising ideas from the induction step are then translated in testable hypotheses, in this way the generic theory is deducted and formulated in context specific statements. The hypotheses are tested through statistical analysis and finally examined and interpreted, which could lead to new observations. The researcher in this process is assumed to be a spectator and not part of the problem being studied. From an epistemological perspective, the empirical cycle is grounded in objectivity.

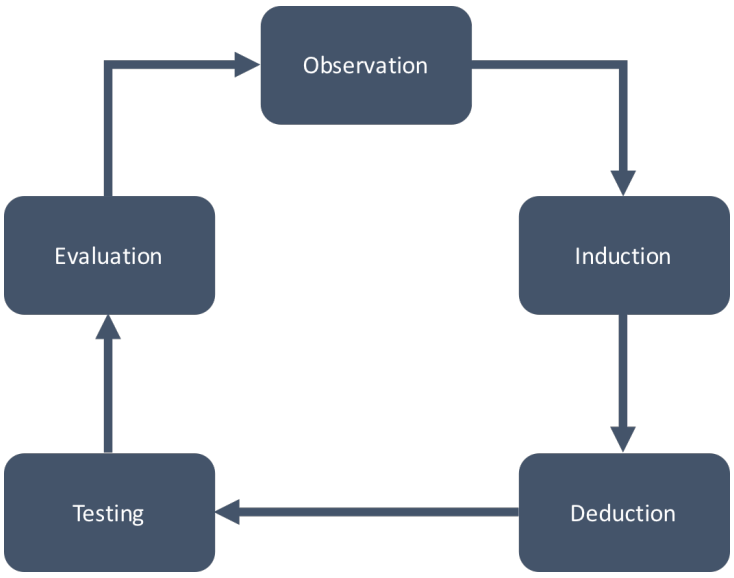

Figure 2.1: The empirical cycle (Van Strien, 1997)

However, as this research is embedded in a social structure of a specific university (TU/e), it is not feasible to test hypotheses on a pure objective basis. In contrast with developing and testing a theory within the empirical cycle, van Aken et al. (2012) have proposed a structure focused on solving a business problem resulting from a problem mess and embedded in the *design science research paradigm*. The epistemological focus in this paradigm is not on finding a generic truth but rather on developing pragmatic tools for specific contexts (Romme, 2016, 2003). These tools or design principles act as the bridge between theory and practice. The design principles are grounded in theory but testable in practice as shown in Figure 2.2 (Berglund et al., 2018).

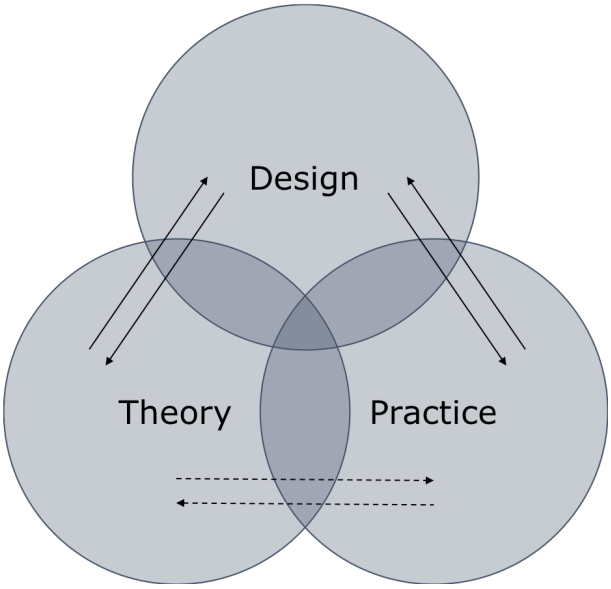

Figure 2.2: The interplay between theory, practice and design (Berglund et al. (2018)

Taking the design-science view, the regulative cycle is applicable. This cycle first starts with identifying and structuring the problem mess. Then, the causes of the problem and the context are analyzed and specific solutions are designed for each of the identified causes. In addition to the designed solution, an implementation plan should be constructed. Finally, the intervention step should take place followed by an evaluation. This evaluation could lead to the definition of a new problem and the cycle starts all over again. This problem solving or regulative cycle is presented in Figure 2.3.

The regulative cycle does not serve as a basis for the generation of a new generic theory. In principle, when following the regulative cycle strictly, the result is a solution-oriented (context-specific) theory instead of a generic explanatory theory. As pointed out by van Aken et al. (2012) systematic, controlled and triangulated observations together with methodical case analyses and peer-reviewed and tested conclusions are the basis of developing a solution-oriented theory. The researcher during this research aims at developing new concepts and tools rather than explaining existing phenomena and systems. This is in line with the prospective perspective as mentioned by Dimov (2016). Instead of testing formal hypotheses related to finite outcomes, this research seeks to elicit generative mechanisms (Dimov, 2016).

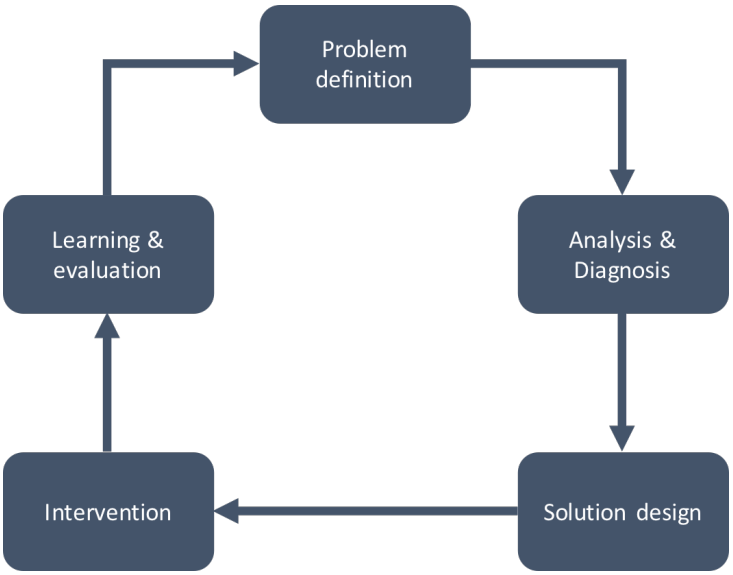

Figure 2.3: The regulative cycle (Van Aken et al., 2012)

2.1 Theory generating approach

Van Aken et al. (2012) demonstrated that three different theory-generating research processes can be derived from both the empirical cycle and the regulative cycle, namely:

1. Theory development process (inductive approach)
   Developing a specific theory based on induction, with the outcome as a set of propositions.

2. Theory testing process (deductive approach)
   Testing a specific theory based on deduction and statistical analysis.

3. Reflective redesign process (abductive approach)
   Determining a specific solution to a problem and a generic design proposition for solving the type of business problems based on abduction.

As mentioned by van Aken et al. (2012), researchers should be careful with combining these research processes as it can result in validity or reliability-related problems (van Aken et al., 2012). For example, theory development and testing on a single dataset is not valid. Also, theory testing should be based on a significantly sound dataset which is in the case of this research not attainable. As the objective of this research is to design a best working solution to a specific field problem, this research is embedded in the *design science paradigm* and thus justified by *pragmatic validity* based on the reflective redesign process.

The literature review on the identified problem statement has led to the conclusion that existing literature has not addressed or solved the problem in an adequate way. The literature on university-related support mechanisms for SE&I is still very exploratory and is missing a comprehensive overview of all possible mechanisms as is shown in the theoretical analysis chapter. Therefore, besides a specific solution to the problem in the context of TU/e, a first step towards more generic theory has been developed following the reflective redesign process.

2.2 Reflective redesign process

The reflective redesign process is followed to discover a potential novel theory. Discovering new theories depends on the ability to extend and modify existing theories in new ways (James, 1981). To find out what is missing in an area of study, thorough knowledge of multiple theorizations is necessary. Therefore, rather than engaging in literature only at the beginning or end at the research project (as respectively the inductive approach or the deductive approach advises), the abductive approach assumes extensive familiarity with existing theories throughout every research step (Eekels & Roozenburg, 1991; Timmermans & Tavory, 2012). The outcomes of the literature assessment in this study are compared with the empirical results of the case study in order to develop some generic theory as proposed by van Burg et al. (2008). The reflective redesign process is presented in figure 2.4 and will be examined in further detail

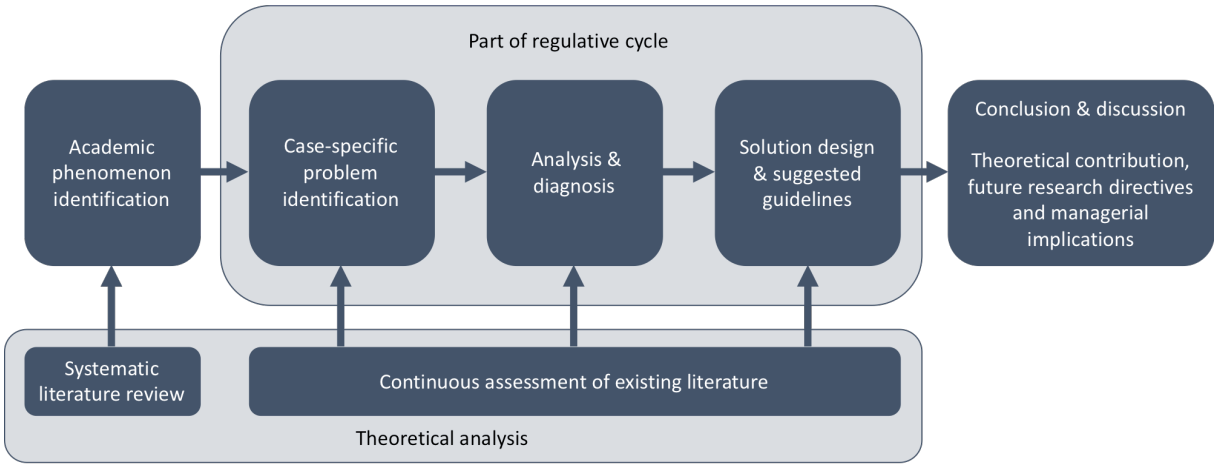

Figure 2.4: The reflective redesign process (Van Aken et al., 2012)

2.2.1 Academic phenomena identification

The reflective redesign process starts with the detection of a phenomenon within a specific context: in this case, the role of student-led entrepreneurship and innovation in universities. This phenomenon is derived from the research objective. To assess whether this phenomenon has been studied before, a systematic literature review was conducted and formed the start of this exploration. Following the reflective redesign process, theory assessment of existing literature was constantly applied during the whole study.

Systematic literature review

A systematic review process was followed to obtain a broad understanding of the research topic. The review followed the best practices from Tranfield, Denyer and Smart (2003). Initially, the search terms student entrepreneurship, knowledge transfer and knowledge valorization or Boolean combinations of these terms were used to scan a broad range of articles from the databases of Google Scholar and Web of Science (Tranfield, Denyer, & Smart, 2003). Articles, books or conference proceedings with the following criteria were included in the literature review:

1. Studies with a focus on student-led entrepreneurship or innovation in higher education
2. Studies preferable conducted after 2010 to ensure relevancy
3. Studies preferably published in Innovation Management related scientific journals to ensure quality (see Appendix A for the list of journals)

The systematic literature review has yielded a total number of 112 articles. These articles were all title and abstract scanned. When the scanning resulted in an article complying with the three criteria, the article was completely read and a snowballing procedure was used to find other relevant literature. This procedure has led to an overview of the core concepts of the research as suggested by Machi & McEnvoy (2016). The identified core concepts are academic knowledge valorization (AKV) , SE&I activities and URS mechanisms. The concepts were discussed and explained by citing the articles found in the literature review (Machi & McEnvoy, 2016).

The explanation of the core concepts has resulted in an iteratively designed theoretical framework presented in section 3.1, which explains the underlying relationship of how university-related support mechanisms stimulate or discourage students when undertaking an innovation or entrepreneurial activity. This relationship has been theoretically underpinned by searching and selecting specific and relevant studies which mention the key concepts of the relationship: university-related support mechanisms, student entrepreneurial intent and SE&I activities. In order to measure the performance of SE&I activities and the effectiveness and efficiency of university-related support mechanisms several key metrics have been derived from literature.

Finally, a literature gap has been identified and the specific contribution of this study to the innovation management research body is outlined in section 3.5.

2.2.2 Case-specific problem identification

The next phase of the reflective redesign process is the problem identification phase. A context-specific field problem is required in the design-science research approach in order to develop new theory (Berglund et al., 2018). In this case knowledge about university-related support mechanisms and their influence on SE&I activities is sought for in order to fill the identified gap in the literature. Interviews were conducted and analysis of these have led to the formulation of a context-specific problem and related research questions.

Because the problem identification phase was very exploratory in nature, the interviews conducted to identify the problem were very unstructured and open-ended (Brown & Wyatt, 2010). Several stakeholders at TU/e and experts in the field of academic knowledge valorization and mentoring students in entrepreneurship and innovation were interviewed. The overview of interviewees is presented in Appendix B. Most of the interviews were unplanned and undocumented but have significantly contributed to the in-depth understanding of the problem. Experts outside of TU/e were interviewed as well to ensure external validity of the identified problem (e.g. at other universities).

The problem derived from this exploratory problem identification phase and related research questions are stated in section 1.4 and section 1.5.

2.2.3 Analysis & diagnosis

After the identification of the phenomena and the case-specific problem, the analysis and diagnosis phase aimed at the design of a best-suited solution to the problem based on theoretical reasoning and empirical data-collection. As abductive reasoning is applied, the researcher acknowledges the fact that the data collection is incomplete and the solution is a best prediction.

The theory-informed analysis of this phase is presented in chapter 3. The empirical part consist of empirical data collection and analysis on a single-case and results are presented in chapter 4.

Theoretical analysis

The theoretical analysis compromises both the initial literature review and the continuous assessment of literature during the study. The theoretical analysis of SE&I activities has yielded 4 types of activities and two different phases of activities. Also, a set of metrics on SE&I activities has been identified. The theoretical analysis on URS mechanisms has resulted in 27 design principles following the CMO-logic (Context, Mechanism, Outcome) (Denyer et al., 2008; Van Burg & Van Oorschot, 2013; Romme & Reymen, 2018). The CMO-logic is based on the CIMO-logic but in-cooperates the intervention in the mechanism. For each URS mechanism, it is defined what the outcome should be, and how to measure this outcome in both quantitative and qualitative terms as proposed by Walshok & Shapiro (2014).

Case selection

This research focussed on an in-depth analysis of a single case (Baxter & Jack, 2008; Yin, 2008). The selected case is the University of Technology of Eindhoven with university-related support mechanisms for SE&I activities as a subject of research. The newly founded experimental education center TU/e innovation Space, the startup incubation Startup/Eindhoven, the technology transfer office TU/e innovation lab, student business clubs, student teams, student startups and the services and faculties at the university form the university ecosystem of TU/e. Figure 2.5 presents an overview of all these relevant stakeholders. Each stakeholder was represented in the interviews.

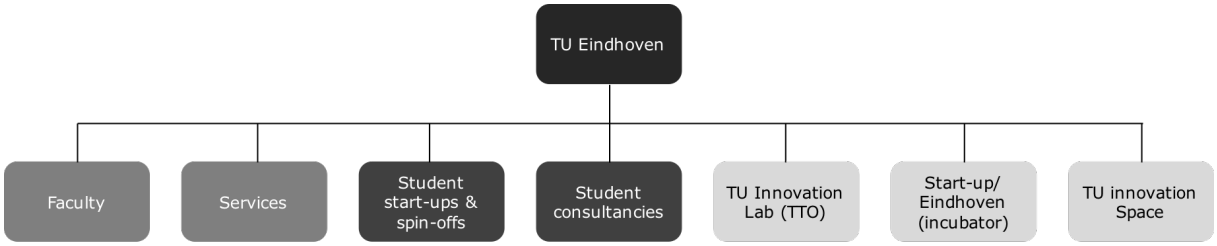

Figure 2.5: Overview of the stakeholders for the specific case.

Data collection

The data required to determine the practice-based principles for the design of the university-related support mechanisms has been derived from a set of data collection methods as depicted in Table 2.1. A triangulation of methods was used to yield a collectively exhaustive overview of design principles on university-related support mechanisms.

The methodology of semi-structured interviews was chosen to ensure comparability and face validity. The structured questions were used to compare answers and uncover patterns. The unstructured part of the interviews ensured validity as the predetermined questions might not trigger all the data needed. Therefore, the combination of both an structured and unstructured part has resulted in an relatively comprehensive and valid data collection. Also, every interview was audio-recorded and transcribed which has increased the controllability and has reduced reporting bias. The interview itself was designed in such a way to minimize moderator bias, leading question bias and answer bias. See Appendix C for the interview consent letter and the overview of interview questions. To reduce selection bias, every stakeholder was represented in the selection of interviewees as shown in Appendix D. From each group of stakeholders, one up to three representatives were identified who have a formal role to support student entrepreneurship or innovation. The selection of the stakeholders was carefully made in consultation with the company supervisor and the first assessor of this thesis who has almost 20 years of working experience at the TU. Since the total population of stakeholders is quite small, every stakeholder formally supporting student entrepreneurship or innovation is included in the study. This procedure has resulted in a list of 14 interviewees as shown in Appendix D.

According to Brown (2008), merely asking what stakeholders need does not yield a complete answer (Brown & Wyatt, 2010). Therefore, besides semi-structured interviews, observations from entrepreneurial teams at the TU/e from an entrepreneurial course at TU/e innovation Space were gathered and used to validate the effectiveness and efficiency of the university-related support mechanisms and the performance of SE&I activities. These observations provided good insights into student behavior when exposed to university-related support mechanisms, for example practical entrepreneurship education. To minimize the impact on the observants behavior (i.e. the Hawthorne effect), the researcher of this research did not mention that a formal observation was taking place. Two limitations of the observations are first the fact that it was not possible to determine the process of thinking of the observants during the course and second the limited number of observants. Also, both the confirmation bias and desired outcome bias have lowered the reliability of the observations. Written internal and external reports and documents were analyzed to get a broader understanding of the current activities and proposed plans at the TU/e on university-related support mechanisms. This ensured that the final design could be tested with the overall formal TU/e strategy. A limitation of this document analysis is that the reports and documents might be outdated and not exhaustive.

Concluding, the data triangulation was applied in order to increase the probability of identifying a real problem instead of a perceived problem by a group of individuals (van Aken et al., 2012). The data triangulation ensures face validity of methods to derive the practice-based design principles on university-related support mechanisms. In this way, the credibility of this research is enhanced because the different data collection approaches are complementary.

Table 2.1: The pro's and cons of the data collection methods used.

Data collection method	Pro	Con
Semi-structured interviews with internal stakeholders	1. Adapt questions to interviewees 2. Understand thought process 3. Yield up-to-date data	1. Analysis difficult on unstructured data 2. Selection bias 3. Moderator bias 4. Leading question bias 5. Answer bias 6. Reporting bias
Observation of students in entrepreneurial courses and entrepreneurial teams	1. Insight in difference of individual behavior 2. Observe for granted behavior	1. No insight in thought process 2. Selection bias 3. Hawthorne effect 4. Confirmation bias 5. Desired outcome bias
Report & document scanning	1. Understand context & background 2. Cross-validation of interviews	1. Outdated information 2. Reporting bias 3. Selection bias

To ensure saturation of the data collection, the cumulative number of identified mechanisms was tracked as a function of the number of analyzed interviews. As can be seen in Figure 2.6, after 14 interviews were analyzed, it was concluded that saturation has occurred.

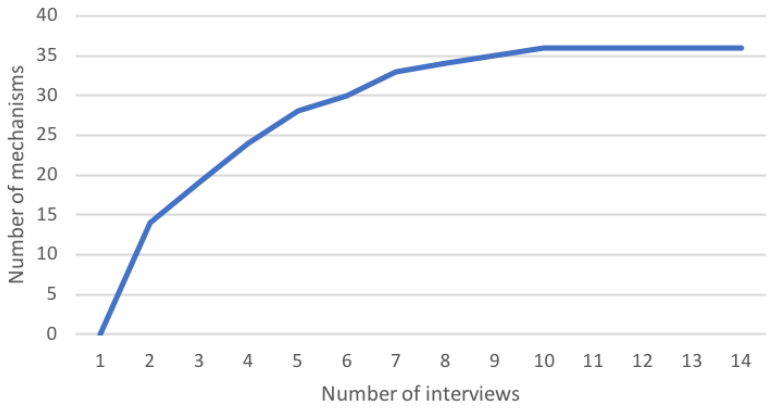

Figure 2.6: Saturation analysis on interviews.

Data analysis

The semi-structured interviews with the stakeholders were codified using computer-aided qualitative data analysis software (NVIVO). For coding the interviews, a template-approach was chosen to yield new insights on existing theory (van Aken et al., 2012; King & Brooks, 2016). The overview of the templates per concept (SE&I activity and URS mechanism) is shown in appendix H.

In the analysis of the concepts, both a qualitative and quantitative assessment was executed in order to determine the current performance of the URS mechanisms at the TU/e. These analyses were used to select relevant URS mechanisms and specific suggestions for improvement in order to boost the performance of SE&I activities at TU/e.

SE&I activity The template for SE&I activities consisted of activities and metrics identified in literature. The data analysis has confirmed these activities and metrics. Also, one new activity and several other metrics not mentioned in literature were identified during the data analysis.

URS mechanisms The template used for coding the URS mechanisms consists of the theory-based design principles on the URS mechanisms including related metrics. This overview of theory-based design principles is enriched with the insights from the interviews (van Aken et al., 2012). The codification of the interviews was cross-validated with the observations and insights from the report & document scanning which has resulted in several newly identified mechanisms. These mechanisms were translated into design principles using CMO-logic (Context, Mechanism, Outcome) (Denyer et al., 2008; Van Burg & Van Oorschot, 2013; Romme & Reymen, 2018).

Qualitative assessment The qualitative assessment is based on a sentiment analysis of data-rich mechanisms. The selected data-rich mechanisms are based on the number of entities mentioning the mechanisms and the frequency of mentioning these mechanisms. This procedure was followed to ensure reliable statements on the sentiment. The sentiment analysis was done manually and is essentially a contextual mining of text to understand the sentiment about the URS mechanisms at the TU/e.

Quantitative assessment The quantitative assessment is based on a satisfaction analysis using a 7-point Likert-scale. This assessment took only the theory-based URS mechanisms into account due to the fact that the practice-based URS mechanisms were not derived yet at the time of the quantitative assessment. Normalization of the assessment has reduced the central tendency bias (Lisef, 2014).

2.2.4 Solution design

This thesis has adopted a combination of design thinking and systems thinking which is in line with the abductive approach and design science based approach (Romme & Endenburg, 2006). The research used customer feedback in the form of stakeholder interviews, observations and document scanning to iteratively design the research deliverables as presented in section 1.6.

As shown in Figure 2.7, design principles obtained from both the theoretical & practical analysis can be used to design the solution (Reymen, 2018). In this case, the theory-based and practice-based design principles for URS mechanisms were used in the design of the taxonomy.

For both the design of the URS mechanism taxonomy and the design of the SE&I activity typology a set of design requirements has been defined. According to van Aken, et al., (2012), these requirements are divided into four categories:

1. Functional requirements, which constitute the core of the requirements, in the form of performance demands on the object to be designed.
2. User requirements, which are the specific requirements from the viewpoint of the user.
3. Boundary conditions, which are to be met unconditionally.
4. Design restrictions, which comprise the solution space preferred by the problem owner.

The designed URS mechanism taxonomy and SE&I activity typology is designed to be used by the TU/e and other universities to test, track and benchmark their SE&I activity and URS mechanism performance. Also, the taxonomy opens up new research directives where the effect of URS mechanisms could be measured on different activities in the SE&I typology.

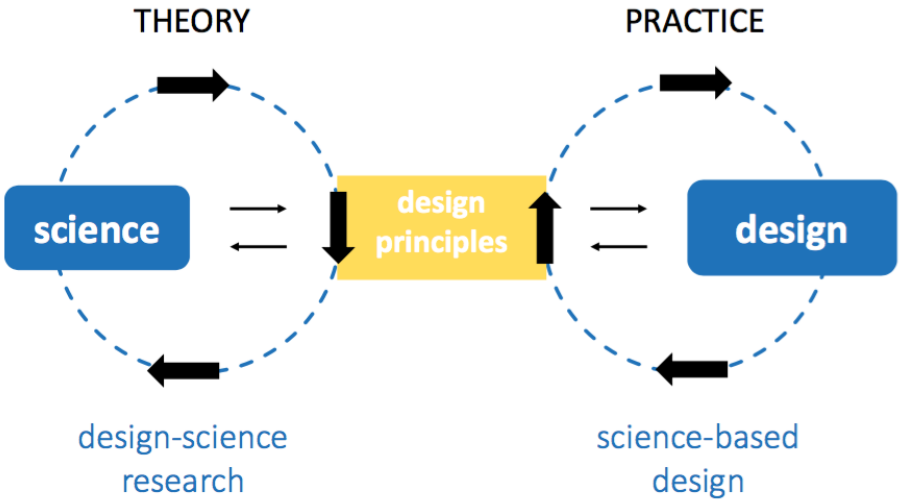

Figure 2.7: Combination of design-science research and science-based design (Reymen, 2018).

Solution implementation & Evaluation

Implementation and evaluation as suggested in the regulative cycle are not part of this study due to the restricted goals of the study and time constraints. This thesis focuses on an identification and classification of URS mechanisms within a taxonomy. As this topic is relatively new and such a framework does not exist yet in literature, the goal of this research is to give future scholars the possibility to test, implement and evaluate specific mechanisms.

However, several guidelines for improvements and implementation have been constructed focused on a few selected URS mechanisms at TU/e which could boost SE&I activities when implemented. These URS mechanisms were selected as both the quantitative and qualitative assessment indicate a strong potential for positive effects.

2.2.5 Conclusion & discussion

The reflective design approach ends with a conclusion and discussion. This step answers and discusses the main research question of the study. A theoretical reflection based on the theoretical implications of the research is presented. Second, limitations of the study are stated together with the research directive on which future scholars can conduct studies. Finally, managerial implications of the solution designs are presented together with the TU/e specific suggestions for improvements focussed on a few URS mechanisms with greatest potential benefits.

2.3 Design artifacts

The SE&I activity identification and URS taxonomy mentioned in section 1.6, are defined as artifacts. Within the design science paradigm, a research should produce knowledge in order to create effective artifacts (March & Smith, 1995). The research deliverables or artifacts are a result of the research questions. As can be seen in Figure 1.3, the research questions and the research deliverables are highly interrelated.

The first sub-research question is of theoretical nature and provides insight in the behavioral science behind how URS mechanisms could stimulate or discourage students to participate in SE&I activities. This conceptual model sets the stage for further empirical research.

The second sub-research question concerns both the typology of SE&I activities and the framework of URS mechanisms. From this classification based on theory (literature review) and practice (interviews), design principles have been constructed on various mechanisms. As mentioned by March & Smith (1995), it is important for artifacts to measure if they work effectively. Therefore, sub-research question three is about measuring the effectiveness and efficiency of the mechanisms on SE&I activities. The metrics are incorporated in the two artifacts.

Finally, sub-research question four and five provides an assessment of the current performance of URS mechanisms at the TU/e and improvements are suggested to increase performance.

2.4 Quality of research

As this research used an abductive approach within a single-case environment, the research is very limited in its external validity. Based on a set of methods (see Table 2.1), best possible artifacts have been designed to solve the problem statement for the TU/e in as explained in section 1.4. To increase the level of integrity and competence of the researcher, the code schemes were reviewed by another independent researcher. After an initial discussion, coding categories and coding constructs were reviewed and improved until consensus was reached between the two researchers. Subsequently, one interview was manually checked for agreement in the application of the codes. After this revision, the coding scheme was finalized with the retrieved feedback and used during the subsequent analysis of the empirical data. The qualitative approach to the review of the codes helped to identify reasons for disagreement or consensus. A quantitative method was not applicable due to compatibility issues with the coding software. The final coding schemes are presented in chapter 4. A cross-case analysis based on the taxonomy of URS mechanisms could add very valuable new information and insights. However, this analysis is suggested as a future research direction.

In order to ensure relevancy of the research, an extensive systematic literature review was conducted on the topic of SE&I activities and university-related support mechanisms. This has identified a clear literature gap which is addressed within section 3.5. The scientific rigorousness is ensured by a controllable research methodology called the reflective redesign approach. Following this approach, each step can be reproduced. Also, the data collection methods are explained and are designed to have a high internal validity and reliability. However, as this research is of qualitative nature and does not incorporate theory testing, there are some risks of having a low external validity and general predictability.

3 | Theoretical analysis

The theoretical analysis is based on a systematic literature review and iterative approach of searching for additional theories. The concepts and interrelations of SE&I activities (existing of entrepreneurial intent and action) and URS mechanisms are defined and explained. The iteratively developed theoretical framework aims to explain this relationship in order to provide the TU/e with an overview on how to identify and stimulate SE&I activity. The theoretical framework substantiates the importance of the URS mechanisms and highlights the effect of these URS mechanisms on SE&I activities.

The theoretical framework is presented in section 3.1. Next the concept of academic knowledge valorization is explored and insights on how students could play a role in AKV are presented in section 3.2. The different types of SE&I activity and the different phases of SE&I activity are discussed in detail in section 3.3. This section also includes an overview of the different URS mechanisms identified from theory. Using existing and proven theories, the influence of the URS mechanisms on the different phases of SE&I activity is theoretically underpinned. Finally, based on the findings a gap in current literature is identified which this research intends to fill.

3.1 Theoretical framework

Figure 3.1 presents the theoretical framework. The theoretical framework was iteratively constructed based on the concepts derived from the literature review. The development of the framework started by executing a systematic literature review and mapping the core concepts of this review (Tranfield et al., 2003; Machi & McEnvoy, 2016). The framework represents an overview of the concept of SE&I activity within the scope of academic knowledge valorization (AKV) and the influence of URS mechanisms on SE&I activity.

Following the research questions in chapter 1.5, an identification and classification of SE&I activity and URS mechanisms has been made based on findings in existing literature. Working definitions were stated for SE&I activity and URS mechanisms conform the scope of this research. Finally, metrics were determined to measure the performance of the URS mechanisms and SE&I activity. The interactions shown in figure 3.1 between the URS mechanisms and the SE&I activity are explained in greater detail below using existing and proven theories.

The view on the epistemology of the framework is subjective (*"what works for the greatest number is true"*) and the framework adheres to the pragmatic theoretical perspective (*"what works is true"*). The theoretical framework is aimed at actionable URS mechanisms which influence SE&I activities (Ries, 2011; MacIntosh, 2014).

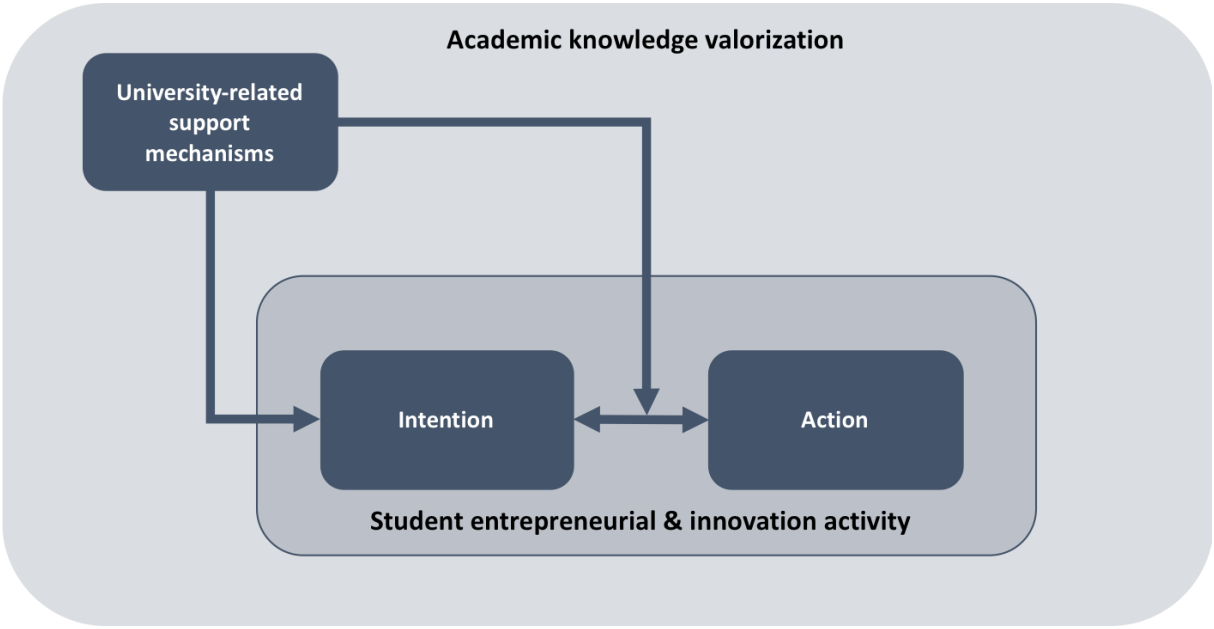

Figure 3.1: Theoretical framework of this research.

3.2 Academic knowledge valorization

There has been a growing emphasis on knowledge valorization at universities (Wissema, 2009b). Originally, a university was defined as a body of research and teaching. A university should therefor value the freedom of teaching and academic self-governance (von Humboldt, 1809) (Boulton & Lucas, 2011). During the second half of the 20st century, universities became recognized as 'innovation powerhouses' because of their ability to translate and transfer research into feasible, viable and desirable innovations (Froyd et al., 2012; Perkmann et al., 2013). This technology transfer role has been formalized over the years and often referred to as knowledge commercialization, knowledge valorization, knowledge transfer or technology transfer (Etzkowitz et al., 2000; Wissema, 2015).

This thesis uses the term academic knowledge valorization to refer to the knowledge transfer or knowledge commercialization role of a university. The term knowledge commercialization or transfer might be perceived as knowledge transfer based on intellectual property derived from research and owned by the university. This definition limits the scope of this research. Academic knowledge valorization is a more generic term for knowledge transfer introduced by the government of the Netherlands (VSNU, 2016). The leading definition states (VSNU, 2012):

The process of value creation from academic knowledge, where academic knowledge is made applicable and accessible to serve both an economic and/or societal benefit through translation in competitive products, services, processes and new ventures.

The concept of academic knowledge valorization extends the narrow definition of knowledge commercialization towards other and more informal and tacit sources of knowledge transfer (Pirnay et al., 2003; Wissema, 2009a).

Valorization activities

Intellectual property in the form of patents and licenses is often mentioned as one of the most valuable assets within knowledge valorization (Verspagen, 2006). However, knowledge transfer occurs in many forms. According to Agrawal & Henderson, direct consulting and hiring of graduates by external actors (companies, external organizations e.g.) are more impactful sources of knowledge transfer than for example, patenting and licensing (as mentioned even amongst those who do patenting). As shown in Table 3.1, faculty members at Massachusetts Institute of Technology value qualitative aspects of academic knowledge valorization over quantitative aspects like the number of journal publications or patents. As highlighted in the table, SE&I activities are mentioned as high-impact sources of knowledge valorization.

Table 3.1: Academic knowledge valorization prioritized by relative importance (Agrawal & Henderson, 2002)

Sources of knowledge valorization	**Impact**
Direct consulting by university employees to external actors	1
Publications in journal or conference papers	2
Hiring graduates by external actors	3
Creation of spin-offs and startups	4
Collaborative research with external actors	5
Patents & licenses	6
Coincidental conversations	7

In addition to Agrawal & Henderson, Bekkers & Freitas (2008) made an extensive overview of six clusters of valorization activities and drew the same conclusion as Agrawal & Henderson (2002). As can be seen in Table 3.2, quantitative metrics of knowledge valorization like number of patents and publications were of less perceived value than the qualitative sources like informal contacts and organized events.

Table 3.2: The valorization clusters defined by Bekkers & Freitas (2008)

Sources of knowledge valorization	**Importance**
Scientific output, informal contacts and hiring of students	1
Labor mobility	2
Collaborative and contract research	3
Contacts via alumni or professional organizations	4
Specific organized activities (startups)	5
Patents & licenses	6

These clusters have been ranked by conducting a hierarchical cluster analysis on data from industry and university researchers. The respondents concluded that patents and licenses were the least important cluster in terms of knowledge valorization. Bekkers & Freitas therefore advise Technology Transfer Offices not to limit their valorization scope towards patents and licenses only. Student-led entrepreneurship was mentioned as a very important source, but was not studied extensively as the study of Bekkers & Freitas focused mainly on industry and university researchers (Bekkers & Freitas, 2008).

A few studies have conducted research on SE&I activities as a part of university-industry collaborations (Bengtsson, 2015; Syed et al., 2018). Some studied the effect of hiring and training of students by industry partners, which is conceived as a fruitful and more 'soft' way of valorizing knowledge (Cyert & Goodman, 1997; Meyer-Krahmer & Schmoch, 1998; Santoro & Gopalakrishnan, 2001). Other studies mention a university-industry collaboration were students are involved in industrial environments. Learnings obtained from these environments are shown to be of real value to the curriculum development and quality of teaching (Santoro & Chakrabarti, 2001). The quality of teaching could also be improved by enabling a student to carry out practical R&D work guided by professionals (Polt et al., 2001).

In most of the studies on knowledge valorization, the student is mentioned as a potential channel within the university-industry collaborations but not studied as a central stakeholder within academic knowledge valorization activities (Siegel et al., 2003; Siegel & Leih, 2018). Moreover, student-led entrepreneurship is not even highlighted as an opportunity in literature review studies on U-I collaboration (Perkmann et al., 2013; Urbano & Guerrero, 2013; Fayolle & Liñán, 2014). Other studies about knowledge valorization do mention student-led entrepreneurship as an important source for knowledge transfer, but none developed an overview of mechanisms which a university could directly impact and improves SE&I activities (van Burg et al., 2008; Van Burg & Van Oorschot, 2013; Wright et al., 2017; Siegel & Leih, 2018).

3.3 SE&I activity

The opportunity of involving student-led entrepreneurship in the academic knowledge valorization strategy is mentioned by Bengtsson (2015) and widely seen as a huge opportunity (Etzkowitz et al., 2000; Bengtsson, 2015). Bengtsson has made a distinction between student-led innovation activities and student-led entrepreneurship activities. Four different archetypes are defined based on new firm creation or existing firm consulting:

1. Student entrepreneurship based on (new) research knowledge (surrogate entrepreneurship);
2. Student-led entrepreneurship based on students' own knowledge (student-led entrepreneurship);
3. Student innovation based on (new) firm's knowledge (student corporate venturing);
4. Student-led innovation based on student's own knowledge (student-led improvement).

Graham (2014) has also presented a differentiation based on the origin of the initiative for the activity. She made a distinction between top-down activities (e.g. IP-based spin-offs) and bottom-up activities (e.g. student start-ups). This distinction shows some similarities with the differentiation of (Pirnay et al., 2003). Pirnay differentiates on the status of the individual (researcher or student) and the nature of the transferred knowledge. An individual can either be pushed by the university or be pulled by a market opportunity.

Steffensen et al. (2000) also mentioned this differentiation when introducing a spontaneous occurring spin-off and a planned spin-off (Steffensen et al., 2000) . Planned spin-offs are mainly pushed by a university where as spontaneous occurring spin-offs are pulled by an identified

market opportunity by the founders (researchers or students).

A similar discriminative approach was mentioned by Bathelt et al. (2010) in the context of regional development by local universities (Bathelt et al., 2010). The study differentiated on student entrepreneurship by sponsorship from the university, character of university knowledge applied and co-localization of the start-up founders. Almost 50 percent of the investigated university startups by Bathelt et al. (2010) fell into the category of non-sponsored start-ups which applied generic knowledge to build their initial product. The university played a role by providing basic technical education and by propagating product development through their courses.

Current literature acknowledges that entrepreneurial and innovation activities arise from a mindset which imagines new ways to solve problems and to create applications instead of just founding new ventures or doing just research for the sake of generating new knowledge (Carsrud, 2009). The following paragraphs will analyze literature on the process of 'becoming' entrepreneurial, what results it yields and how these results could be measured for students at universities.

Working definition of SE&I activity

This thesis builds upon the division of Bengtsson as both the knowledge applied (or support given) in the SE&I activity and the context in which the activity happens are taken into account. The definition of student entrepreneurial and innovation activities of Bengtsson is therefore much richer than the ones of Graham (2014), Steffensen (2000) and Bathelt (2010) as discussed in the previous section. The working definition for (SE&I) activities is stated as:

A students' intention to act on new ways to solve challenges and an observable activity of persistently executing on this intention for the sake of creating real-life applications.

The definition excludes entrepreneurial behavior from university researchers or staff members and activities not involving real-life applications which solve nowadays challenges (Luthje & Franke, 2003; Reynolds, 2005; Bengtsson, 2015; Mazzucato, 2018). It also goes beyond a entrepreneurial mindset because this mindset cannot easily be measured and does not directly contribute to knowledge valorization in the short run. On the long run, a student who gained an entrepreneurial mindset at the university and utilizes on this mindset years after graduation is a form of valorization, however, this is an indirect effect and could not reliably measured.

3.3.1 Types of SE&I activity

The differentiation of Bengtsson (2015) is applied to get a broader understanding of student-led entrepreneurial and innovation activities. As can be seen in Figure 3.2, four archetypes of SE&I are defined based on two dimensions. First, a student-led entrepreneurial activity can be defined on the basis of the prime knowledge source for the invention. A student can implement a (patented) invention based on university-related research knowledge or an invention based on self-developed, tacit or ambiguously available knowledge which could hypothetically also be accessed outside the university environment (Polt et al., 2001; Wright et al., 2008)

Second, an entrepreneurial activity can be identified based on the environment in which it takes place: integrated in an existing firm or taking place in a new firm (Bengtsson, 2015). These 4 forms of student entrepreneurship and innovation are subject of analysis for this literature study. We want to understand how university-related support mechanisms could trigger entrepreneurial intention which results in one of the four types of SE&I activities and how these support mechanisms could improve the performance of SE&I activities.

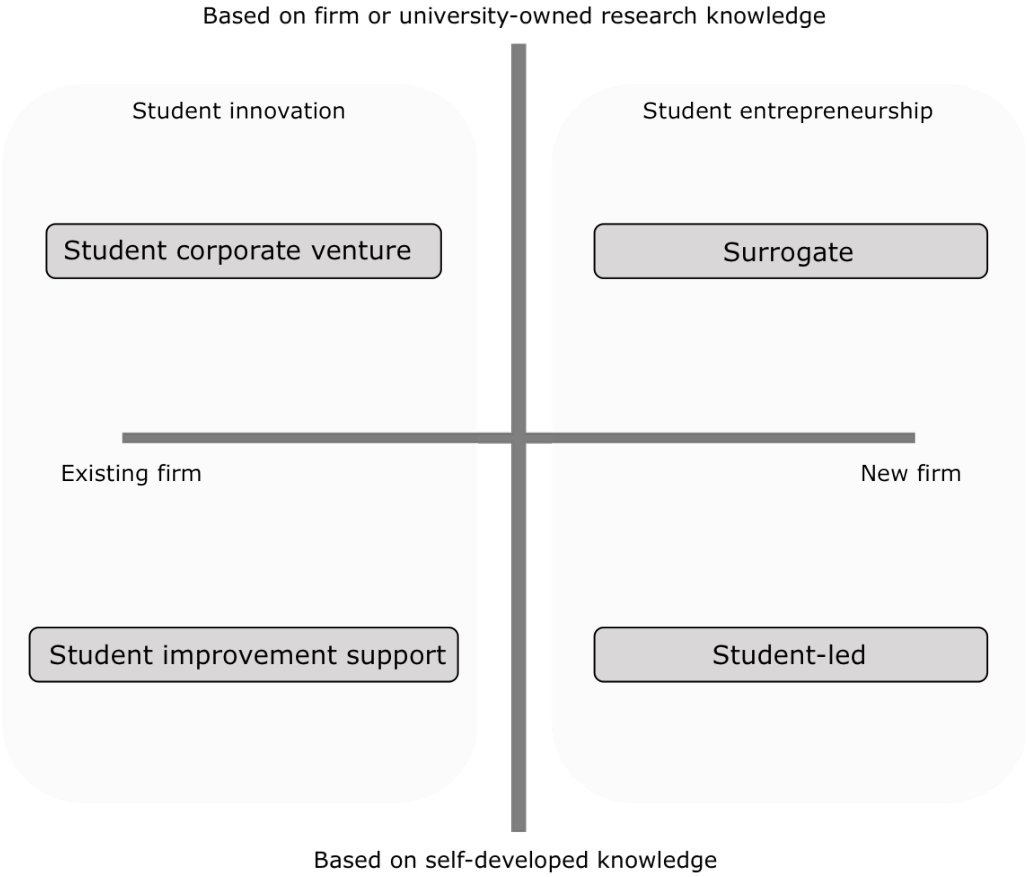

Figure 3.2: SE&I activity typology based on Bengtsson (2015)

3.3.2 Phases of SE&I activity

As we want to understand the mechanisms driving the start of an innovation or venture, we need to understand how the SE&I activity arises in the mind of a student (entrepreneurial mindset) . Previous research on entrepreneurship concludes that personal variables (static demographic characteristics and personality traits) and situational variables are generally weak direct predictors for entrepreneurial action (Ajzen & Fishbein, 1977; Robinson et al., 1991). Modeling these mechanisms generally yields small predictive validity and explanatory power. Instead, intention-based models that indirectly link these personal and situational variables to entrepreneurial intention has yielded satisfying results (Krueger et al., 2000; van Gelderen et al., 2008).

Intention phase

A critical success factor in nurturing SE&I activity is to understand aspects of the entrepreneurial intention of a student. Entrepreneurial intention is empirically recognized as having a very high accuracy in predicting (entrepreneurial) behavior (Bird, 1988; Fayolle & Liñán, 2014) (Bird, 1988). This behavior can be explained through different intention-based models (Miranda et al., 2017). Three models that dominate the literature are the entrepreneurial event model (Shapero & Sokol, 1982), the theory of planned behavior (Ajzen, 1991) and the model for implementing entrepreneurial ideas (Bird, 1988). However, the model of Bird (1998) has yet to be validated and will therefore not be studied within this research proposal (Fayolle & Liñán, 2014). The common denominator of the almost identical models of Ajzen (1991) and Shapero (1982) is the suggestion that attitudes and subjective norms (perceived desirability) and self-efficacy (perceived feasibility) result in an entrepreneurial intention with the decision to start a new venture or pursue an innovation (Fayolle & Liñán, 2014). In addition to the theory of planned behavior from Ajzen, Shapero has added one extra factor to the model: propensity to act. The propensity to act can be seen as a situational momentum (Krueger et al., 2000) (Krueger et al., 2000). This variable has a strong temporal character and is studied by (Kwong & Thompson, 2016) as the temporal dimension when students start their own ventures or engaging in innovation activities. Kwong & Thompson based their model on the study of Carsrud & Brannback (2011) who have defined stages where entrepreneurial intentions turn into entrepreneurial actions.

As can be seen in Figure 3.3, three stages have been defined and a transition to each stage is characterized by a specific intention: a goal intention ("I want to achieve a goal ") or an implementation intention ("I am going to achieve a goal by acting on it") (Gollwitzer & Brandstatter, 1997; Brannback et al., 2007; Carsrud & Brännback, 2011).

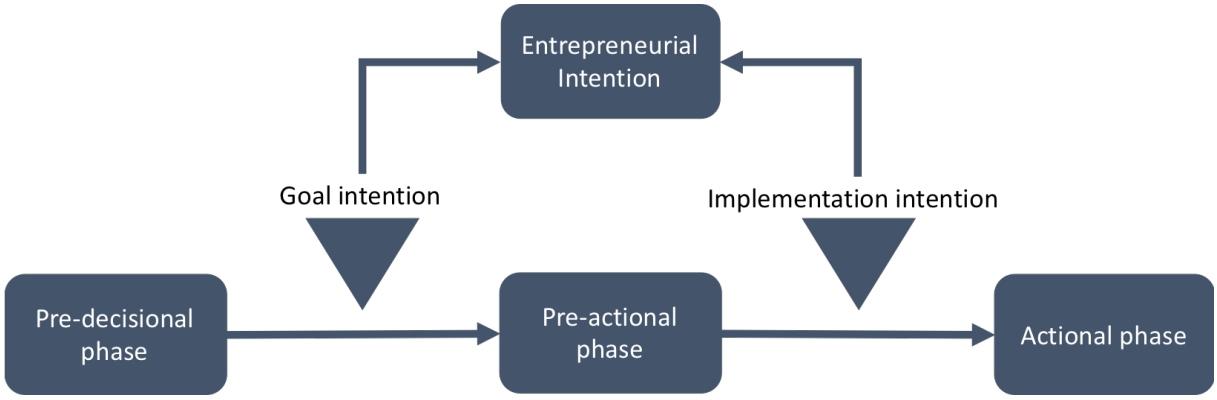

Figure 3.3: Model of entrepreneurial intent based on Gollwitzer & Brandstatter (1997)

The model is embedded in the goal setting theory of Locke and the social cognitive theory of Bandura (Bandura, 1989; Locke & Latham, 2006). These models suggest that the motivation to achieve a goal in combination with a high level of self-efficacy will result in a goal intention. The result of this goal intention together with a high propensity to act is mentioned to as goal-directed behavior. The strength of the goal-directed behavior depends highly on the strength of the motivation (Bird & Schjoedt, 2009). In other words, the strength and duration of the action phase depends on the strength of the motivation of the student entrepreneur (Shepherd et al., 2015).

Relation between intention and action phase

As both the theory of planned behavior and the entrepreneurial event model are linear models, reciprocity is not assumed. However, recent studies have shown a bi-directional relationship between attitudes and behavior (Brannback et al., 2006; Krueger et al., 2007). Attitudes do influence behavior, but behavior also constantly influences attitudes. And following Ajzen, when attitudes are influenced, intentions are influenced as well. This has called for a framework where intentions can change and are directly influenced by the behavior (Krueger, 2009). One of the first frameworks that added this feedback loop was the contextual model of entrepreneurial intentions (Elfving et al., 2009). This framework is presented in Figure 3.4. The framework assumes a hierarchy of goals based on the hierarchy of goals theory (Bagozzi & Dholakia, 1999). A trigger event triggers a motivation, which results in the stimulation of a superordinate goal which influences the entrepreneurial intention together with perceived desirability and feasibility based on Shapero (1982) and Ajzen (1991). However, this model does not take the propensity to act into account, leaving the temporal factors aside.

Krueger (2009) has proposed the theory of trying as an explanation for entrepreneurial behavior and clearly distinguished between a goal intent (*"is someone intending to start the process?"*) or an implementation intent (*"Is someone really pursuing a venture or innovation launch?"*). The theory of trying suggests that an intermediate goal (what you do) is serving an end-state goal (what you want and why) based on the goal hierarchy theory (Bandura, 1989; Bagozzi & Dholakia, 1999)

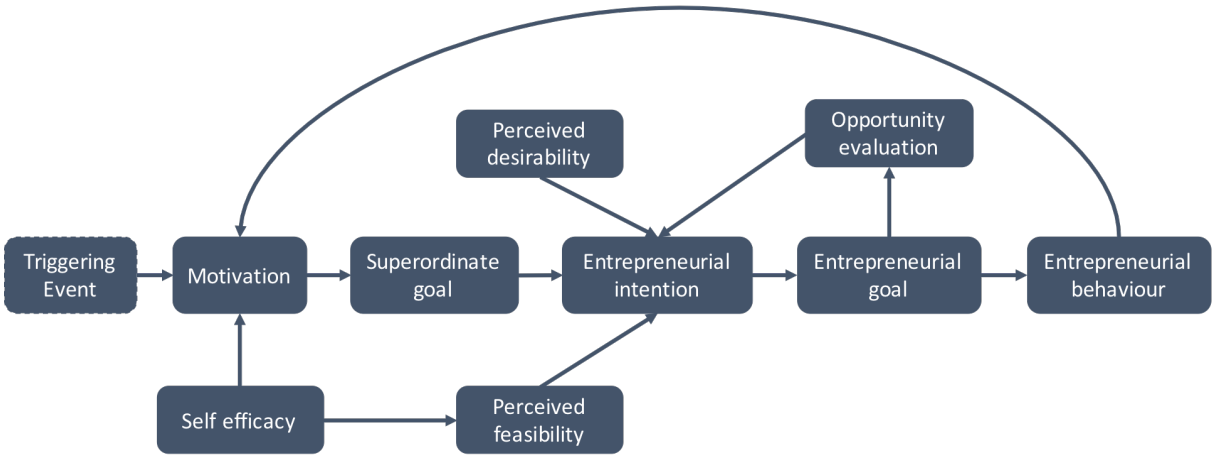

Figure 3.4: Context-specific entrepreneurial intention model (Elfving et al. 2009)

The model presented in Figure 3.4 could incorporate the theory of trying and the goal hierarchy theory by stating a superordinate or end-state goal (*why do you want it?*) and a following entrepreneurial or intermediate goal (*what are you going to do?*) which could correspond with the goal intent and implementation intent presented in Figure 3.3.

When the entrepreneurial goal is stated, the entrepreneurial behavior reciprocally affects the motivation based on the social cognitive theory. This reciprocal relationship could be explained as a continuous process of changing motivations and behaviors (or tries). The effectuation theory also supports this reciprocal relationship in the form of continuously changing means and goals based on entrepreneurial behavior (Sarasvathy, 2001).

Working definition of the intention phase

The definition for student entrepreneurial intent which is used in this research proposal exists of both a goal intent and an implementation intent. The definition is stated as follows:

Student entrepreneurial intent is the combined SE&I goal intent and implementation intent of a student to engage in a SE&I goal-directed activitiy.

This definition is in line with the model of Gollwizter & Brandstatter (1997) and combines the goal intent and implementation intent with the context-specific model of Elving (2017). The motivation to perform an SE&I activity is based on the propensity to act of Shapero (1982) and the findings of Kwong & Thompson (2016) which mention a triggering event as the start for innovative behavior. The model which is used for explaining student entrepreneurial intent is thus the one presented in Figure 3.4 and Figure 3.5. The theories used to construct the definition and explain in detail how entrepreneurial intention and action arise are explained in Appendix E.

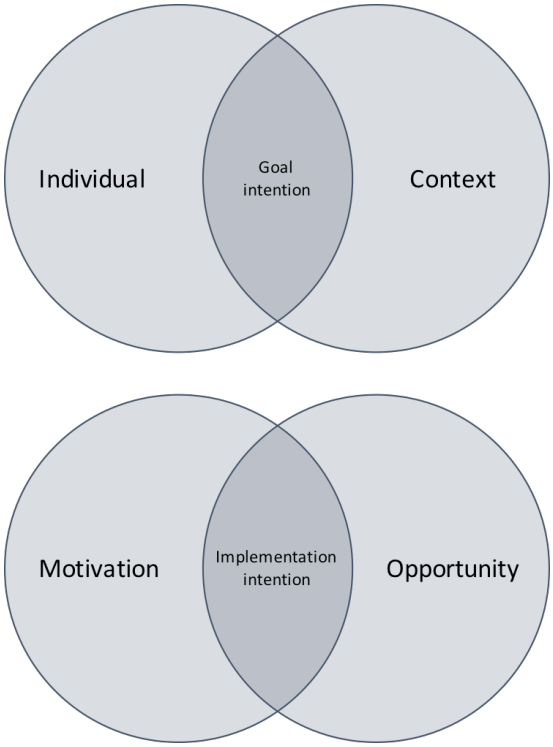

Figure 3.5: Two types of intention based on Elfving et al. (2017)

Working definition of the action phase

The definition of the action phase is based on the behavioral part of the definition on SE&I activity and is defined as follows (Carsrud & Brännback, 2011; Graham, 2014; Bengtsson, 2015):

Student entrepreneurial action is observable SE&I goal-directed behavior of students directed at solving real-world challenges by creating real-life applications in new or existing organizations.

3.3.3 SE&I activity metrics

The SE&I activity metrics and URS mechanism metrics employed in this study are both based the following definition:

A statistic that ties to specific and repeatable SE&I activities or URS mechanisms which can be improved by the organization.

Graham (2014) has proposed four different clusters of metrics which measure the output of activity of a university. Table 3.3 presents these clusters (Graham, 2014). The first cluster is mainly based on companies founded on the basis of university-owned IP. The third cluster explicitly measures impact of students. The latter cluster measures mainly impact on the broader ecosystem. Metrics which could be used or slightly redesigned to measure SE&I activity are marked. Some of the metrics are quantitative and other more qualitative. A complete overview of the metrics by Graham is given in Appendix G.

Table 3.3: Activity metrics of Graham (2014)

Cluster	**Activity metric**
Technology transfer office throughput	Number of disclosures and patents *Number of start-ups/spin-offs* License success rate Number of licenses bearing royalties Income generated from licenses
Creation of sustainable companies	*Company survival rate after 10-15 years* *Number of companies with more than 'x' employees* *Total money raised from external investors* *Total sales in the marketplace* *Total financial value of the companies created*
Impact of the university graduates	% alumni remaining in or returning to ecosystem % of graduates working in tech-related business *% alumni engaged in entrepreneurship or innovation* *Wealth created by graduate' companies*
Broader development of the ecosystem	People moving into the region for opportunities Growth rate of all startups and high tech companies *(PhD) Students employed by startups and spin-offs* Total employment generated by the ecosystem Attraction of entrepreneurial-minded students University contributed to changing national policies

Walshok & Shapero (2014) also developed several clusters of metrics for the entrepreneurial university. Two clusters, talent development contributions and tech-transfer activities and outputs are presented in Table 3.4 (Walshok & Shapiro, 2014). The metrics related to SE&I activity are marked. The metrics developed by Walshok & Shapero mostly complement the metrics developed by Graham. Where the focus of Graham still mainly rests on companies based on university-owned IP, Walshok & Shapero take a broader stance on student entrepreneurship by including student research and education projects as well.

Combining the metrics of Walshok & Shapero and of Graham leads to a set of 13 metrics which are used in the coding template. The complete clusters of metrics of Walshok & Shapero are presented in Appendix G.

Table 3.4: Activity metrics of Walshok & Shapero (2014)

Cluster	**Activity metric**
Talent development contributions	*Undergraduate internships in companies*
	Undergrad and graduate job placements
	Education certificates serving companies
	Business plans vetted
	Number of student research & education projects
	Number of post-docs employed in region
Tech-transfer activities and output	*Patent application & awards*
	Licensing applications & awards
	Spin-outs annually
	Equity positions taken in startups
	Amount of licensing revenue
	Number of invention disclosures
	Amount of royalties

3.4 URS mechanisms

University-related support mechanisms are analyzed in detail in this section. First, the working definition of URS mechanisms is given based on the phase of SE&I activity it affects. Then, a classification into attributes is presented building on existing literature on support mechanisms. Finally metrics are presented and an overview of theory-based URS mechanisms is given based on current insights from literature.

3.4.1 URS mechanism and SE&I phases

Auken (2013) has presented and studied a model where environmental experiences (one of them being the university entrepreneurial environment) influence the interest or intention to own a business (Auken, 2013). The study found that the program structure (lectures, company tours) positively affected the interest in starting a business (the entrepreneurial intention). As shown recently by Trivedi (2016), university support relates positively to entrepreneurial attitude and perceived behavioral control and thus indirectly influences the entrepreneurial intent of students (Trivedi, 2016, 2017).

Shirokova (2016) and Zollo (2017) found models where the relationship between entrepreneurial intent and SE&I action is moderated by university innovation ecosystem mechanisms (Shirokova et al., 2016; Zollo et al., 2017). Without the interaction with mechanisms intention does effect action however, the presence of mechanisms reinforces the relationship. This effect proofs the existence a moderation (or interaction) effect. Therefore, a reciprocal moderated mediation model of URS mechanisms and and SE&I activity is proposed.

Reciprocal moderated mediation model

Figure 3.6 shows the proposed reciprocal moderated mediation model of university-related support mechanisms, student entrepreneurial intention and SE&I activity including feedback mechanisms. The model follows the findings of Shirokova (2016) on the moderating effect of university innovation ecosystem mechanisms between intent and action, the findings of Auken (2013) and Trivedi (2017) on the direct effect of university innovation ecosystem mechanisms on student entrepreneurial intent via the theory of planned behavior, and the results of Brannback et al. (2006), Krueger et al. (2007) and Elfving (2017) on the feedback (or reciprocal) effect between student entrepreneurial intent and SE&I activities (Krueger et al., 2007; Brannback et al., 2006; Elfving et al., 2017) .

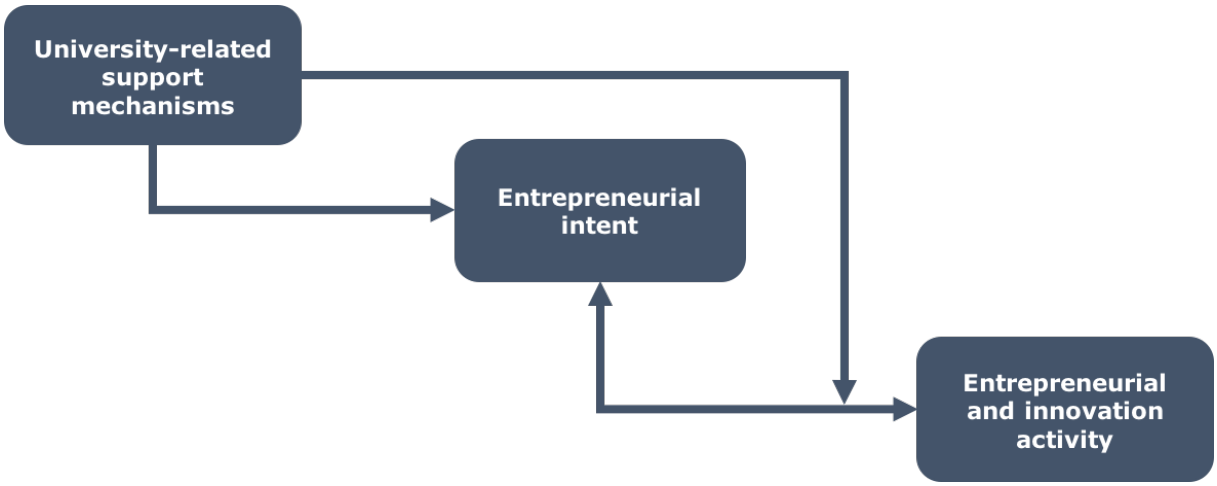

Figure 3.6: Moderated-mediation feedback model of university-related support mechanisms

Control variables

According to Piperopoulos & Dimov (2015), individual characteristics have to be ruled out as they are alternative explanations to the variation in entrepreneurial intentions (Piperopoulos & Dimov, 2015). Other control variables as introduced by Lucas & Cooper (2004) are measures as self-assessment of business skills and entrepreneurship enthusiasm (Lucas & Cooper, 2004). All control variables combining Piperopoulos & Dimov (2015) and Lucas & Cooper (2004) are:

- Age
- Gender
- Average grade
- Nationality
- Entrepreneurial background (are parents business owner or not)
- Previous entrepreneurial experience
- Enthusiasm for entrepreneurship
- Self-assessment of business skills
- Personality traits (e.g. perceived behavioral control)

Working definition of URS mechanisms

The definition of URS mechanisms is based on the university innovation ecosystem mechanisms and its role within this moderated-mediation model and is defined as follows:

"University-related support mechanisms are mechanisms which could indirectly influence the entrepreneurial intent of students and/or could interact in the reciprocal relationship between student entrepreneurial intent and action and which can be initiated and influenced by university staff members and/or students."

The direct initiation by university staff members of the mechanisms and their influence on the mechanisms is important in this definition. This research wants to offer tools for the university to solve problems and therefor mechanisms should be actionable (e.g. directly initiated and influenced by the university staff or students) (Ries, 2011). The university, however, could acquire new resources or capabilities when existing resources are not capable of executing on the mechanisms which calls on the dynamic capability of a university (Teece et al., 1997).

3.4.2 URS mechanism attributes

The mechanisms can be divided into several attributes as defined by Spigel (2015). The differentiation into cultural, social and material attributes was specified for regional ecosystems where universities act as a provider of potential entrepreneurs and knowledge spillovers (Spigel, 2015; Isenberg, 2010). However, the differentiation could also be viewed from a university perspective (Matt & Schaeffer, 2018). As this research proposal focuses on mechanisms which could be influenced by the university, the differentiation of Spigel is applied to the university-related support mechanisms. The attributes presented by Spigel (2015) combined with Isenberg (2010) and geared towards a university ecosystem are presented in Table 3.5.

Table 3.5: Attributes of mechanisms based on Spigel (2015) and Isenberg (2010)

Attribute	**Definition**	**Examples**
Cultural	Underlying beliefs and outlooks about entrepreneurship within a university	Supporting an entrepreneurial career Showing visible success stories Tolerating mistakes, failure, risk taking and contrarily thinking
Social	Resources tied to the university via social networks	Organizing (networking) events or workshops Offering access to a community Providing a mentoring platform Connecting to networks specialized in assisting early-stage firms (advisors, grants, investors and workers)
Material	Tangibly present attributes at a university in the from of physical spaces, support services or supporting policies	Access to (affordable) office and design spaces Investing financially in entrepreneurial projects Access to incubator or accelerator facilities Offering high-quality entrepreneurial education Supportive services & policies

3.4.3 Theory-based URS mechanisms

Having explained the effect of URS mechanisms on SE&I activity , we can now investigate which mechanisms could support or hinder SE&I activity and how this could be measured. Shirokova (2016) has researched the effects of some university ecosystem mechanisms. She has posed six different hypotheses based on how the intention-behavior link is moderated by exogenous variables. Table 3.6 presents an overview of the hypotheses and the effect on start-up activities by an analysis of the GUESSS survey database using a 7-point Likert scale questionnaire based on Franke & Lüthje (2004). The start-up activities undertaken by student entrepreneurs where controlled by the education, country, entrepreneurial skills, perceived behavior control and locus of control.

Table 3.6: Moderators and outcomes of the intention-behavior link (Shirokova, 2016)

Moderator	**Effect**	**Outcome**
Family entrepreneurial background	reinforcing	significant
Gender	link for males is stronger	significant
Age	reinforcing	significant
University entrepreneurial environment	reinforcing	significant
Uncertainty avoidance	weakening	significant

Several other studies have also mentioned university entrepreneurial environment as a driver for entrepreneurial activities of students and are included in table 3.7. To determine case-specific URS mechanisms, a resource-based view on a university could be used (Kraaijenbrink et al., 2009, 2010). This resource-based view helps to determine which university-specific mechanisms are available and can be used in moderating the relationship between entrepreneurial intent and SE&I results (Urbano & Guerrero, 2013).

Well-known mechanism: entrepreneurship education

Entrepreneurship education is broadly mentioned as an important factor in stimulating student-led entrepreneurship (Turker & Selcuk, 2009). Several studies have examined best practices for practitioners of entrepreneurship education to trigger entrepreneurial intention. Klofsten (2000) presented an extensive overview of 13 best practices of teaching entrepreneurial courses as can be seen in Appendix F (Klofsten, 2000). The best practices are based on experiences in conducting training programs for nascent entrepreneurs at a university. The program has two criteria used to recruit people, (1) the person or team must have an idea and (2) as a person, be strongly motivated. The program focuses on the individual or team rather than the greatness of the idea. As shown in Appendix F, many of the best practices relate to the process of teaching the course. As Autio & Klofsten (1998) have pointed out, a process orientation is preferred over configuration orientation (only describing the needed facilities, budgets, organizational charts) when studying the success mechanisms of an entrepreneurial course (Autio & Klofsten, 1998). However, based on Klofsten it is still not clear whether entrepreneurial education could motivate entrepreneurial intentions of students.

Chen et al. (2015) found no significant improvement in entrepreneurial intention of students after they have followed an entrepreneurial course (Chen et al., 2015). This finding is in line with Harkema & Schout (2008) who have shown that the teaching method and cultural environment influences the entrepreneurial intention but did not improve it (Harkema & Schout, 2008). As proposed by Auken (2013) an entrepreneurship course could stimulate the students' entrepreneurial intention or improve the business and entrepreneurial skills as the students observed in his research did reduce their entrepreneurial intent while gaining entrepreneurial skills. Zhang, Duysters & Cloodt (2014), found a positive significant relationship on entrepreneurial intent from entrepreneurship education with a greater effect for students of technical majors (Zhang et al., 2014). Concluding, entrepreneurial education alone is not a stimulating mechanism of SE&I activity. This justifies the search for more URS mechanisms besides education.

Other university-related support mechanisms

Besides entrepreneurial education as the most extensively studied factor several other URS mechanisms have been studied as well. The availability and effectiveness of incubator facilities on a university campus with mentoring programs towards students who already have started their innovation or entrepreneurial activity is seen as an important mechanism (Hughes, Ireland, & Morgan, 2007; Nielsen & Lassen, 2012). Also, third party network platforms are mentioned as effective mechanisms which could increase the likelihood of students collaborating with industry partners during their study (Villani et al., 2017). A mechanism which is a repeating subject of discussion is intellectual property ownership of ideas which students have generated (Rutgers, 2017). There is a lack of consensus on how to manage generated IP of bachelor and master students, not only in the US but also in the Netherlands. According to Duval-Couetil et al. (2014), communication is critical in how the policy is perceived (Duval-Couetil et al., 2014; Wright & Katz, 2016).

As can be seen in Table 3.7, Shirokova (2016) has defined 5 different mechanisms within the university-related support ecosystem (which she names environment). Almost every factor enhances the entrepreneurial spirit and facilitates entrepreneurial intention development. These mechanisms are key in developing the ability of students to recognize opportunities and act on them. By offering these mechanisms, universities help to increase the motivation and self-efficacy of students, which is, according to the context-specific model of entrepreneurial intentions, the foundation for entrepreneurial behavior. Zollo et al. (2017) has also found a significant effect of university-related support mechanisms mechanisms on the entrepreneurial intent.

Graham (2014) has mentioned the integration of SE&I into the university governance, mission, policy and incentive schemes as a main challenge for University boards. For many of the universities studied in her research, the incentives built into the university were root causes of the problem that SE&I activities are not aligned with the core university functions of research and education. Moreover, the incentive structures were stagnating the university entrepreneurial growth. Graham has provided a clear checklist which can be used by universities to form an effective entrepreneurial strategy including incentives and various university innovation ecosystem mechanisms. This checklist is shown in Appendix G and is used to identify metrics on URS mechanisms in the next section.

Table 3.7: University-related support mechanisms used by Shirokova (2016)

University-related support mechanism	Sources
Entrepreneurship education	(Piperopoulos & Dimov, 2015); (Kassean et al., 2015); (Oosterbeek et al., 2010); (von Graevenitz et al., 2010); (Klofsten, 2000)
Incubator facilities	(Graham, 2014); (Hughes et al., 2007)
Mentoring programs	(Nielsen & Lassen, 2012)
(Third-party) network platforms	(Nielsen & Lassen, 2012); (Walter et al., 2006)
Funding programs	(Parker & Belghitar, 2006)

3.4.4 URS mechanism metrics

The performance of the URS mechanisms can indirectly be measured, following the model in Figure 3.6, through the performance of the SE&I activity. However, the performance of the URS mechanisms can also be measured directly. Graham (2014) has defined several clusters on input and process indicators which can be identified as metrics for URS mechanisms. The measurements proposed by Walshok & Shapero (2014) as presented in Appendix G are in line with the metrics proposed by Graham. However, most of the indicators are high-level and hard to measure. Also, some of the indicators focus on university staff instead of students. The relevant metrics are highlighted in Table 3.8.

Most of the metrics are measuring quantity (16 of them), meaning they represent a number or percentage based on fact instead of a opinion or belief. Five of the SE&I metrics are highly qualitative; the attitude and level of trust in TTO, the coherence of E&I policy, student career intentions, prominence of role models and peer entrepreneurial talent recognition. Graham does not state how to measure these qualitative metrics. Following the URS mechanism definition and metric definition in this thesis, some of these metrics stated by Graham will instead be treated as mechanisms (e.g. availability of role models) and will be included in the theory-based mechanism overview.

3.4.5 Overview of theory-based URS mechanisms

A set of 27 university-related support mechanisms has been identified on the basis of the literature review. A complete overview of these mechanisms is shown in Figure 3.9. The mechanisms are classified according to cultural, social and material attributes as proposed in section 3.3.1. Also each mechanism is assigned to the phase it influences (intention or action) as proposed in section 3.3.2. In the end, 13 material, 8 social and 7 cultural mechanisms are revealed. 16 relate to the intention phase and 20 to the action phase. It should be noted that a mechanisms can influence one or both phases but is usually related to only one attribute (cultural, social or material).

The theory-based mechanisms are stated in CMO-logic way, see section 2.2.4. The metrics are therefor applied to a university-context and should have a measurable outcome. Further design is out of scope of this theoretical analysis and is presented in section 5.2.

Table 3.8: URS mechanism metrics of Graham (2014) and Walshok & Shapero (2015)

Cluster	**URS mechanism metric**
University policies and activities	*Number of E&I activities in curricula* Coherence in the E&I activities/policies *Employment of international experts in E&I programs* *Incubator/accelerator and student competitions in place* *Proof of concept center in place* *Level of university resource to U/I interactions* Extent to which E&I activities are considered in tenure Opportunities for regional companies partnerships
Education opportunities offered	*Curricular time devoted to E&I across all faculties* *E&I training offered to students and employees*
Student attitudes and aspirations	Student career intentions and options Prominence of faculty entrepreneurs as role models Peer entrepreneurial talent is recognized and admired *Student attitudes towards and level of trust in TTO*
University/industry engagement	Number of joint faculty & industry publications Number of joint university/industry initiatives *Involvement of practitioners in teaching and mentorship* Number of free movers in and out the university *Number of external attendees in networking events* Number of cost-free patent transfers to industry Number of pre-transactional interactions with industry
Relevance and quality of research	Volume of industry-sponsored research Average impact factor of faculty publications Volume of faculty consultancy with industry International league table ranking for university

Table 3.9: Overview of theory-based university-related support mechanisms

Mechanism	Definition	Attribute	Phase	Outcome	Source
Accelerator	Accessibility of an accelerator for SEI activity	Material	Action	# companies	Matt & Schaeffer (2018)
Access to grants	Accessibility to grants for SEI activity	Material	Action	# grants applied	Graham (2014)
Access to scale-up funding	Accessibility to scale-up funding for SEI activity	Social	Action	-	Parker & Belghitair (2006)
Accessibility of high-tech facilities	Accessibility of high-tech facilities for SEI activity	Social	Action	-	Isenberg (2010)
Affordable office space	Availability of (affordable) office space for SEI activity	Material	Action	# of students working in office space	Graham (2014)
Business contest	Availability of a bussines plan contest for SEI activity	Material	Intention; Action	# of students participated in contest	Wright (2017)
Collaboration projects with industry	Collaboration projects with industry during study	Material	Intention; Action	# university resources to U\I projects	Walshok & Shapiro (2014)
E&I in curricula	Adoption of SEI activities in standard curricula	Material	Action	# appreance of E&I in curricula	Graham (2014)
Entrepreneurial competence education	Avaibility of appropriate entrepreneurial courses for SEI activity	Material	Intention	# students in courses	Zhang et al. (2012
Entrepreneurship & innovation mission	Adoption of SEI in university mission statement	Cultural	Intention	-	Shah & Pahnke (2014)
Event space	Availability of event space for SEI activity	Material	Intention	# students visiting	Graham (2014)
Events	Availability of appropriate events for SEI activity	Social	Intention; Action	# events held	Walshok & Shapiro (2014)
Experiental education center	Availability of a experiential education center for SEI activity	Material	Intention; Action	# students E&I projects	Graham (2014)
Extracurricular teams	Availability University-supported extracurricular teams for SEI activity	Material	Intention; Action	# teams	Graham (2014)
Flexible IP policy	Flexilibility of IP policy on SEI activities	Material	Intention; Action	# trust of students	Hayter et al. (2006)
Free co-working space	Availability of free co-working spces for SEI activity	Material	Action	# student in co-working space	Graham (2014)
Fund raising	Availability of local capital pre-seed funds for SEI activity	Material	Action	# funded startups	Parker & Belghitair (2006)
Incubator	Availability of an incubator for SEI activity	Material	Action	# companies spin-off	Matt & Schaeffer (2018)
Legal support	Availability of appropriate legal support for SEI activity	Social	Action	# teams supported	Zollo et al. (2017)
Matchmaking between students	Accessibility of students with from other discipline to start SEI activity	Social	Intention; Action	-	Graham (2014)
Mentoring program on campus	Availability of a mentoring program for SEI activity on campus	Social	Action	# involved of practitioners	Hughes et al. (2007)
Networking facilitator	Accesibility of oustide network for SEI activity	Social	Action	# externals at networking events	Villani et al (2017)
Predefined entrepreneurial mindset	Adoption of a predefined entrepreneurial mindset on campus	Cultural	Intention	-	Isenberg (2010)
Promote as occupation	Promotion of purusing a professional career in SEI activity	Cultural	Intention	-	Matt & Schaeffer (2018)
Recruitment campaign	University-wide campaigns on SEI activity	Cultural	Intention	# campaigns held	Matt & Schaeffer (2018)
Role models	Availability of role models in EI in university	Cultural	Intention	# role models in EI activity	Graham (2014)
Selection of first-year students	Adoption of EI-driven selection procedure on first-year student	Cultural	Intention	# selected students	Graham (2014)
Special recognition of student entrepreneurs	Availability of a special recognition for students in SEI activity	Cultural	Intention; Action	# students receiving recognition	Graham (2014)
Success story telling	Adoption of story telling on succesfull SEI activity on campus	Cultural	Intention	-	Isenberg (2010)

3.5 Literature gap

As stated by Elving (2017), entrepreneurial research has put too much emphasis on trying to find general rules based on a positivist research tradition (Elfving et al., 2017). As pointed out by Shane & Venkataraman (2000), research is all about the agency (the entrepreneur) and not about the structure (the specific ecosystem or context) (Shane & Venkataraman, 2000). Therefore, this research uses the model of entrepreneurial intention of Gollwitzer & Brandstatter (1997) enriched with the context-specific (pragmatic) model of Elving (2017), as a basis for understanding SE&I activities at universities, specifically in the context of the University of Technology in Eindhoven. Within this defined framework, this research explores and defines URS mechanisms by building upon the research of Graham (2014), Walshok & Shapero (2014) and Spigel (2015).

Up until now, literature on SE&I activities has mainly focused on how education about entrepreneurship could influence the entrepreneurial intention (mindset) and the behavior of an individual student or student startup (Wright et al., 2017). Only some recent studies consider how universities could combine a set of mechanisms to stimulate or discourage students to become more entrepreneurial (Graham, 2014; Walshok & Shapiro, 2014; Shirokova et al., 2016; Wright et al., 2017). Even in these studies, university-related support (URS) mechanisms are limitedly studied and interchangeably used as mechanisms, indicators or metrics.

This study adds to the theoretical debate on how to support SE&I activity by creating a taxonomy of URS mechanisms and proposing a model which implies an increase in SE&I activity performance when these URS mechanisms are cultivated and combined. Also a typology of SE&I activities has been designed based on the URS mechanisms. Besides identification, this research also designs a way of both assessing the performance of SEI&I activity and the performance of URS mechanisms by defining outcome metrics.

4 | Empirical analysis & diagnosis

This chapter describes the empirical analysis which complements the theoretical analysis of the previous chapter and completes the analysis and diagnosis phase of the reflective redesign approach presented in section 2.2.

First, the coding scheme following the template approach is presented. These templates based on findings from literature were used to code the interviews and documents. These templates can be extended when codes are found which not fit the template derived from literature.

Second, the final coding scheme and empirical analysis on the SE&I activity is presented. The type and phases of SE&I derived from practice were contrasted with the findings from the theoretical analysis. Metrics on the SE&I activity were included in this analysis as well. The findings from this analysis were used for the design presented in the next chapter.

Third, the coded practice-based URS mechanisms were analyzed. The set of practice-based URS mechanisms were complemented with the theory-based URS mechanisms including the related metrics. Differences between mechanisms found in theory and in practice are analyzed in further detail.

Finally, this chapter concludes with the results of the qualitative and quantitative assessment of the URS mechanisms at TU/e. These assessments form the basis of suggestions for improvements that could be implemented at TU/e.

Template approach

The coding of the interviews followed a template approach based on three concepts: SE&I activity type, URS mechanisms and metrics of both. A definition and related sub-codes in the template are summarized in Table 4.1. As can be seen in Table 4.1, SE&I activity types are divided into three template codes based on the theoretical analysis: entrepreneurial activities, innovation activities and the phases of SE&I activity. The URS mechanisms concept is divided into 28 different sub-codes resulting from the theory-based mechanisms. The metric concept is divided into 13 SE&I metrics and 17 URS mechanism metrics. Complete coding scheme templates per concept are given in Appendix H.

The coding schemes presented in the remainder of this chapter were extended with codes derived from practice and from literature.

Table 4.1: Summary of the coding scheme template

Concept	Definition	Template code
SE&I activity types and phases	Different types and phases of student entrepreneurial & innovation activity	Entrepreneurship (2 codes) Innovation (2 codes) Phases (2 codes)
SE&I activity metrics	Metrics on SE&I activity performance	SE&I activity metrics (13 codes)
URS mechanisms	University-related support mechanisms	URS mechanisms (28 sub-codes)
URS metrics	Metrics on University-related support mechanism performance	URS mechanism (17 codes)

4.1 SE&I activity

First, the coding scheme of SE&I activity types and phases is presented in Table 4.2 and Table 4.3, followed by an in-depth analysis on types and phases and a presentation and analysis of the coding scheme of the SE&I activity metrics.

Table 4.2: Coding scheme of SE&I activity types

Concept	*Description*	*Empirical indicators*	*Illustrative quote(s)*
Student-led entrepreneurship	Student entepreneurial behavior within new firms (Bengtsson, 2015)	Classical form, spin-offs and start-ups	"Ik denk dat spinoffs 10% is en startups 90%." "Dus dat is natuurlijk een vorm van ondernemen, een beetje het klassieke." "De university-owned research knowledge nog beter gedefinieerd worden. Het is niet helder. De interpretatie is heel breed op dat aspect."
Spin-off	A new firm based on unique knowledge which is produced by the university (Steffensen et al., 2000)	Unique knowledge of university, patent-based	"Weinig studenten realiseren zich dat ze met kennis van de universiteit aan de slag kunnen. Als je kijkt wat er wordt gegenereerd aan publicaties, aan technologie." "Er zit een beperking aan de mogelijkheden om student spin-offs te starten omdat er niet tot de lange termijn een patent aanhouden vanwege de kosten"
Start-up	A new firm founded by a students, not neccesarily based on university-owned knowledge (Bengtsson, 2015)	Student started, own ideas	"Dat je als student, wat je natuurlijk ook heel vaak ziet, informatica dat je eigen bedrijfje begint met programmeren of wat dan ook. " "Als mensen zelf met ideeen komen zijn ze zo
Student-led innovation	Entrepreneurial behavior within existing organisations (Bengtsson, 2015)	Behaviour component, intrapreneurship	"Die gedragscomponent mis ik wel in de matrix." "Je hebt entrepeneurship en intrapeneurship dus dat is ook iets dat je steeds ziet gebeuren."
Within company	Entpreneurial behavior within external companies (Bengtsson, 2015)	New insights for company, new product or process development, intrapreneur	"Intrapreneurship (SURE Innovation in het klein), mensen die niet een eigen toko hebben maar in het geval van een dergelijk bedrijf om kansen te spotten en nieuwe producten en diensten te ontwikkelen." "Jazeker, ook als intrapreneur kun je bijdragen aan het bedrijf zonder dat het geld oplevert. "
Within study	Entrepreneurial behavior within curriculum	Course selection, entrepreneurial course	"Eigenlijk moet je er nog een ontwikkelen waarbij je binnen je studie ook ondernemend kan zijn."
Within extracurricular teams	Entrepreneurial behavior within a team outside curriculum	Student teams, board years, competences, innovation teams	"Ik denk dat de studenten teams daar onderdeel van zijn. Ik vind dat de meeste zuivere vorm van entrepreneurship die ik ken."

Table 4.3: Coding scheme of SE&I activity phases

Concept	*Description*	*Empirical indicators*	*Illustrative quote(s)*
SE&I phases	The phases through which a student goes when getting involved in SEI activityn (Gollwitzer & Brandstatter, 1997)	Development, continuation, retention	"De actie fase bestaat ook uit verschillende stadia, een retentie van de actie." "De actie fase kan uitmonden in het opzetten van een BV"
Intention	The combined SE&I goal intent and implementation intent of a student to show a SE&I goal- directed behavior when a motivation and opportunity to achieve a specific SE&I goal arises. (Gollwitzer & Brandstatter, 1997)	Willingness, thinking about, recognize opportunities, achieve, starting	"Kansen herkennen en zien." "Doorlopend worden uitgedaagd en dan willen starten." "Het aanwakkeren van een ondernemende houding" "1 of twee personen die iets verzinnen en dat willen." "Een opportunity zien in een markt."
Action	Observable entrepreneurial or innovative behavior of students to solve challenges by creating real-life applications in new or existing organizations. (Bengtsson, 2015)	Starting, beginning, team forming, behavior, developing, founding	"Het starten van een bedrijf of project." "Team formeren als je begonnen bent." "Een product ontwikkelen tot het in de maatschappij komt."

4.1.1 Types of SE&I activity

Empirical findings on the types of SE&I activity are presented. First, the student-led entrepreneurial activities are discussed in detail, followed by an analysis of the student-led innovation activities.

Student-led entrepreneurial activities

Entrepreneurial activities within new-founded companies are referred to as the 'classic form' of entrepreneurial activity. *"Founding new companies is of course a form of entrepreneurial activity of a student, it is the classical form"* (Employee TU/e services). When founding new companies, two distinctions where made. The first one are companies based on university-owned knowledge (in the form of intellectual property): *"The University founds 10 to 15 companies per year based on university-owned knowledge, a few of them run by students"* (Employee TTO TU/e). This type of entrepreneurship is referred to as a spin-off and is said to be mostly executed by university employees (post-docs, professors or Phd). On the other side, it is mentioned that students build their own companies based on more generic knowledge: *"We see a lot of students starting up their own company, for example in ICT. We expect this to grow"* (Employee TU/e incubator). This type of entrepreneurship is often referred to as a student start-up. However, besides founding a new company, entrepreneurial behavior within existing companies is mentioned as well: *"There also is intrapreneurship, people who do not own a company but show entrepreneurial behavior in existing organizations"* (Employee TU/e innovation Space). This research classifies this behavior as innovative behavior or student-led innovation.

The findings are similar to the the student-led entrepreneurial activities derived from the identification of Bengtsson (2015) however, in interviews the difference was mentioned between a start-up and a spin-off: *"The definition spin-off could be better defined, currently for us the interpretation is very broad when we negotiate with students"* (Employee TU/e TTO) and *"It is not clear whether the TU approaches you as a spin-off or start-up"* (Student start-up) and *"The TTO sees many student projects as spin-offs and want to treat them like spin-offs from academics"* (Employee TU/e TTO).

Student-led innovation activities

The term innovation was often used in the context of entrepreneurial or innovative behavior in many other situations, but not in the context of for instance starting a new venture. For example, showing entrepreneurial behavior in a study or a voluntary student team, project or association is illustrated by the next two quotes: *"You can also be entrepreneurial by selecting courses outside of the standard curricula when someone needs to know more to create a certain application"* (TU/e start-up) *"Doing a board year at an association or a more 'high-tech' student team, like a Solar Team or Bluejay, are also entrepreneurial activities"* (TU/e services). These quotes indicate that innovative behavior exists in many forms and should not be limited to starting new organizations only. The activities mentioned could also be classified as entrepreneurial but only when they fit the entrepreneurial definition as stated in section 3.3. This thesis explicitly excludes entrepreneurial or innovation activities where no real-life applications (products or processes) are being developed.

4.1.2 Phases of SE&I activity

Empirical findings on the SE&I activity phases are presented in this section, first for the intention phase, followed by the action phase.

Intention phase

The intention phase was characterized by recognizing opportunities and imagining new solutions for existing problems: *"Intention for me is seeing opportunities in a market and a willingness to seize them"* (Employee of TU/e incubator). *"Entrepreneurial intention for me is taking initiative to solve problems"* (Employee of TU/e services). Interviewed TU/e start-ups mention that it is not clear what a student could expect from the TU/e when having the intention to start: *"In the beginning of my entrepreneurial journey, it was not clear what the TU offered or wanted to have in return"* (TU/e start-up). *"The TTO mainly supports students with intention when patentable ideas are involved"* (TU/e startup). These quotes are in line with theoretical findings on TTO support, which is mainly focused on supporting university researchers who want to patent their findings. TU/e innovation Space states that they want to help and stimulate the entrepreneurial intent of students to undertake SE&I activities: *"We want to create a space where entrepreneurial intention is stimulated"* (Employee at TU/e innovation Space). The TTO of the TU/e recognizes the need to stimulate SE&I activities: *"I want to realize a real incubator program for students who want to be entrepreneurs."* (Employee to TTO TU/e) and *"We already support students in innovation projects via SURE innovation"* (Employee of TTO TU/e).

Action phase

The action phase was associated with a start of a venture or a project: *"A group of students who starts a new venture are entrepreneurs"* (Boardmember of TU/e) or with a visible innovative behavior of students: *"When you see a student of student team executing innovative projects"* (Employee of TU/e TTO). As already mentioned, continuation of the action phase results in

projects, companies or teams who persistently execute behavior resulting in real-world applications for existing challenges. This is in line with the definition of SE&I activity as stated in section 3.3.

A general remark on the SE&I activity phases was made during the interviews on the duration of the action phase: *Many mechanisms influence the action phase because the action phase could just be one student starting or it could eventually result in the formation of a formal company, team or project.* (Employee of TU/e TTO). The action phase therefore applies both to a student just starting an innovative project and a student who started a spin-off for several years.

4.1.3 SE&I activity metrics

The coding scheme of the empirical analysis of SE&I activity metrics is presented in Table 4.4. A total number of 13 SE&I activity metrics are identified. From this set of 13 metrics, 11 of the empirical SE&I activity metrics overlap with the identified theory-based SE&I activity metrics as presented in section 3.3.3.

As can be seen in Table 4.4, some of the metrics quantitatively measure the performance of SE&I activity (e.g. number of student-led startups or number of patents granted) where others measure the performance in terms of quality (satisfaction of companies with graduates hirings and entrepreneurial competence).

Table 4.4: Coding scheme of SE&I activity metrics

Concept	*Description*	*Empirical indicators*	*Illustrative quote(s)*
SE&I activity metrics		Measuring valorization, measuring entrepreneurship	"Er ook moet worden nagedacht over wat je moet gaan meten in termen van valorisatie en ondernemerschap op student niveau"
Connection with education	Measuring if SE&I activity has a connection with education via ECTS	Coupling with courses	" Bij de studententeams hier in dit huis is de koppeling met onderwijs een belangrijke metric."
Number of students in SE&I activity	Measuring number of students participating in SE&I activities	Participating in extracurricular activity, board years, student teams	"Zouden we eigenlijk ook moeten kijken hoeveel studenten doen er een bijvoorbeeld bestuursfunctie of studententeam naast hun studie"
Number of start-ups	Number of start-ups resulting from SEI activity	Student start-ups	"De belangrijkste vind ik spin-offs en startups "
Number of spin-offs	Number of spin-offs resulting from SEI activity	Student spin-offs	"Ja wat ik net zei, spinoffs en startups." "De belangrijkste vind ik spin-offs en startups."
Number of PdEng	Measuring the number of PdEngs started	PdEng projects	"De TU verzet zich echter impliciet tegen de PdEng, de AIO is belangrijker, die levert een boekje op en dat is belangrijker voor de ranking."
Business challenge participants	Measuring number of participants in business challenges	Business challenge participants	"Het aantal partijen die deel gaat nemen aan die challenge en vervolgens bedrijven begint en gaat groeien."
Revenue of start-ups & spin-offs	Total revenue created resulting from SEI activity	Revenue, turnover, sales	"Ik denk de simpelste manier is dat we naar omzet kijken vanaf de dag van oprichting."
Job creation of start-ups & spin-offs	Number of jobs created by companies resulting from SEI activity	Jobs created, FTE	"En naar FTE van een bedrijf."
Patents granted for students	Number of patent applications and awarded patents of SEI	Patent granted, patent application, patent awarded	" Ik hoor mensen veel zeggen, patenten moeten we niet willen, daar ben ik het deels mee eens maar ik vind het jammer dat er
Students graduate at company	Number of students who graduate at EI in companies	Graduation projects	"Aantal studenten die bij een bedrijf afstuderen bijvoorbeeld of in nauwe samenwerking "
Students internships at companies	Number of students in internships at EI in companies	Internships	"Projecten met studenten op innovatieve plekken op bedrijven als ze stage oplopen"
Company advisory board	Measuring satisfaction of companies with students	Company advisory board, hiring of students	"Zoals bijvoorbeeld een company advisory board die toetsen we dan van wat vinden jullie van onze studenten." "Hoe de afstudeerder naar buiten komt, dat is onze valorisatie als universiteit."
Entrepreneurial competences	Measuring entpreneurial competences of students	Entrepreneurial competences, skills, know-how	"Ja vaardigheden kun je meten, je moet een test hebben om die te meten."

4.2 Practice-based URS mechanisms

The data collection has yielded a set of 36 practice-based university-related support mechanisms (mechanisms assumed by the interviewees to influence SE&I activity). The complete coding scheme of the practice-based UR mechanisms is presented in Table 4.5. The table contains the definition of the URS mechanisms from literature and interviews and the empirical indicators and illustrative quotes which relate to the mechanisms. The list of practice-based URS mechanisms is compared to the list of URS mechanisms from the theoretical analysis in the next section 3.4.5. This assessment yields interesting insights in the differences between theory and practice. Several of the practice-based URS mechanisms are analyzed in further detail in section 4.3.

Table 4.5: Coding scheme of URS mechanisms

Subcode	*Definition*	*Emprical indicators*	*Illustrative quote(s)*
Accelerator	Accelerator for SEI activity	Acceleration, accelerator	"Via de incubator probeer ik de projecten een beetje verder op te werken en dan hoop ik dat die straks in een accelerator kunnen gaan landen."
Acceptance of entrepreneurial career for academics	Acceptance on advancing on the entrepreneurial ladder intead of the academic one	Two careers, earning money with business	"Wij zijn erg fundamenteel, dan kijk ik vooral naar werktuigbouwkunde."
Access to grants	Accessibility to grants for SEI activity	Grants, subsidy	"Als je ziet wat je daarvoor moet doen om dat voor elkaar te krijgen dan ben je een jaar verder."
Affordable office space	Affordable office space for SEI activity	Office space, design space	"Op de rest van de campus is een tegenwind, ruimtegebrek is een driver, een beetje interesse gebrek." "Facaliteren van een ruimte en een werkplek"
Alumni relationships	Involvement alumni in valorisation activities	Relation management with alumni, next generation, bonding	"Soort van relatie beheer met alumni startups, als er nu inderdaad een alumni startup officer zou zijn dan zou dat best chill zijn"
Business contest	Business contest or challenge for SEI activity	Business challenge, idea challenge, TU contest, awards, top10, prizes	"De TU contest is een idea challenge en er mist nog een echte business challenge"
Challenge-based courses	Courses designed around challenges	Competition, challenges, applicability	"Je moet challenges in het onderwijs neerleggen op TRL 2 tot 6."
Collaboration with industry during study	Collaboration projects with industry during study	Companies in education, push-pull, graduation projects, internships	"Het zit in de stages en afstudeeropdrachten." "Je moet de industrie helpen met de goede vraagstelling."
E&I in curricula	SEI activities in standard curricula	Study points, part of study	"Dat gaat stapje voor stapje. Dat kan ik nog niet roepen, dan roep je weerstand op." "Studiepunten zijn inderdaad een goeie, dat hadden mijn woorden ook kunnen zijn."
Entrepreneurial competence education	Appropriate entrepreneurial ccourses for SEI activity to develop competences	Entrepreneurial attitude, competences, technology transfer in courses, quality of education, product development in courses	"Ik geloof in het leren, trainen en oefenen van vaardigheden essentieel is." "Wat ik miste in mijn studie zijn de fases van productontwikkeling, de TRL's in combinatie met verkoop, financiering en opbouw team en rest bedrijf."
Entrepreneurship & innovation in mission	Entrepreneurship & innovation in the mission of the university	Mission, ambition, top-down	"Als je nu een interview op de campus gaat doen en willekeurig aan gaat spreken dan zul je bedroefd zijn over het antwoord wat je krijgt. Dan komt er nee uit. Als je het vraagt aan de huidig zittende bestuurders dan krijg je volmondig ja"
Events	Appropriate events for SEI activity	Events, workshops	"Aansprekende events waarbij je kan leren en in aanraking komt met andere ondernemers."
Experimental education center	Place at the campus where education experiments take place for SEI activity	innovation Space, proof-of-concept center	"innovation Space is een niet-traditionele onderwijsfabriek." "innovation Space is er om the exoerimenteren met onderwijs."

Subcode	*Definition*	*Emprical indicators*	*Illustrative quote(s)*
Financial incentives	Monetary incentives to stimulate staff to participate in valorisation	Monetary reward, resource allocation	"De faculteit wordt nu nog afgerekend door studententeams via de verdeelsleutel. Je zou kunnen voorstellen dat een succesvol studententeam zou moeten bijdragen aan de toegevoegde waarde van de faculteit."
Financial investing	Availability of (small) financial investments of university	Early phase finance, smart investments, risk investment, trust-based finance	"Bright Move doen wij niet puur vanwege de voorwaarden, zo werkt het niet." "Dat geld zou je vertrouwen gebaseerd willen inzetten"
Graduate with spin-off	Graduation with a spin-off as student or phd	Graduate on tech application	"Maak nou in plaats van dit onderzoek een onderzoek doen naar hoe photonica technologie kan worden toegepast in verschillende markten. Pak 6 maanden tijd en werk dat bedrijf uit."
Incubator	Incubator for SEI activity	Incubation, Innovation Lab, Startup Eindhoven, Bright Move, incubator program, incubation process	"Dat kunnen wij helemaal niet omdat we daar gewoon volstrekt geen capaciteit voor hebben"
Integraton of valorisation	Integrate valorization within research and education on university-board level	Reward of valorisation activity, integration, organisation of valoisation	"Ik zou zeggen, je moet op onze universiteit een dedicated portefeullie houder voor valorisatie hebben." "Een universiteit heeft natuurlijk alles ingericht op snelle studie en zo min mogelijk kosten, efficiënt zijn, hoge uitstroom van studenten."
IP policy	IP policy on SEI activities	IP-declaration, perception on IP policy, IP marketing, IP regulation	"Je ziet veel mensen om de TTO heen gaan. We krijgen hier ook mensen die op de TU zitten of gezeten hebben. " "De universiteit is wil dat de afspraken met bedrijven niet gebroken worden door studenten." "Het IP afstaan is een perceptie probleem. De marketing is niet goed."
Legal support	Appropriate legal support for SEI activity	Collaboration on legal support, legal support capacity	"Voor een deel outsourcen en je omgeving bij betrekken. Die kunnen er een rol in spelen. Informeel hebben we al wel samenwerkingen maar dat doen we daarin wel goed." "De legal support is mager, daar hebben we de capaciteit niet voor."
Life-long learning	Opportunities at the university for life-long learning	Professionals in courses	" Masterstudenten zijn veel meer geïnteresseerd om in vakken samen te werken met professionals op het grensvlak te werken tussen fundamenteel en toegepast."
Mentoring/coaching program	Mentoring program for SEI activity on campus	Coaching, alumni coaching program, mentoring	"Dat is er beperkt en moet er met een programma met alumni enzo wel komen." "Dat gebeurt denk ik te weinig. Je ziet Frank van de Ven. Die heeft ook geen tijd voor coaching."
Multidisciplinair themes	Multidisciplinair research themes to spur new ideas	CRT, research themes, strategic themes	"Ik denk dat we heel goed bezig zijn met de 6 cross-disciplinaire research themas die in het strategisch plan staan." "Die 6 CRT zijn voor mij zijn over 10 tot 15 jaar de 6 dingen wat we vroeger faculteiten noemden."
Negotiation process	Clear negotiation process for a quid pro quo from students in entrepreneurial activities	Negotiation, added value of TU/e, stake, shares, impact of TU/e	"Als je als studenten enkel je idee ontwikkelt, dan zie je de TU als een beschermend instituut. Je hebt niet het idee dat je moet gaan onderhandelen." "Wat ik jammer vind is dat er veel focust wordt op stakes nemen in ondernemingen, terwijl je eigenlijk moet zeggen als opleiding is ondernemendheid, die vaardigheden zijn veel belangrijker. "
Network facilitator	Accesibility of oustide network for SEI activity	Connections, knowledge sharing, orchestrating	"Mensen koppelen aan de startup en een netwerk inzetten om een startup te laten groeien doen we." "Je kan wel een slash uitbrengen met gave verhalen maar er moet een call-to-action achter liggen."

Subcode	*Definition*	*Emprical indicators*	*Illustrative quote(s)*
Recruitment campaign	University-wide campaigns on SEI activity	Campaign	"Een campagne die zorgt dat nieuwe student hier komen en zich er bewust van zijn dat ze proactief dingen kunnen doen die dus niet allen in het onderwijs zitten."
Revenue model	Clear revenue model in place of how universities could benefit from entrepreneurial activities	Revenue model, business model	"Wat we missen is een groter team om student ondernemerschap te begeleiden, het is logisch dat het ontbreekt omdat er geen helder verdienmodel voor is."
Role models	Role models in EI in university staff	Champions, role models, exemplary staff	"Ondernemende hoogleraren hebben grote invloed op studenten, we merkten een tijdje dat we een aantal innovaties hadden en toen zag je gewoon dat de studenten elkaar aansteken."
Selection of first-year students	EI-driven selection procedure on first-year student	Intrinsic motivation test, numerus fixus, selection	"Ik denk ook weleens met het aanname beleid; we hebben dus nu zo'n numerus fixus en het is natuurlijk ook moeilijk om te definiëren wat voor type
Special recognition entrepreneurs	Availability of a special recognition for students in SEI activity	Certificate, special status, recognition	"De keuze dat je wil gaan ondernemen betekend niet dat je je diploma gratis moet krijgen maar een certificaat zou kunnen."
Student-led community	Availability of a community where students can network and learn from eachother	ESBC, community	"In ESBC zit er geen ondernemerschap in, daar komen de ondernemers niet binnen lopen" "We moeten naar een community toe hier."
Study-related pressure	Study-related pressure perceived by students	Burn-out, time constraint	"Als ik nu praat met actieve studenten die zitten in besturen die lopen ook allemaal tegen burn-out aan zitten. " "Nu ben ik die slimme student en die gaat zeiken over tijd, je kan het altijd ernaast doen."
Success story telling	Story telling on succesfull SEI activity on campus	Roadshows, story telling,	"Roadshows, vertellen en optreden. Verhalen vertellen over startups. Bij de colleges ondernemerschap aanwakkeren."
University staff competence	Availibity of staff whom are experienced in entrepreneurship	Entrepreneurial staff, entrepreneurial behavior of staff, industry experience of staff	"Elk jaar hebben we 4 spin-offs en 50 startups, die kunnen keihard hulp gebruiken. Maar dat moet je dus organiseren. Op dit moment zijn er heel weinig mensen op de universiteit die kan kunnen." "Je moet dus ook onderwijzers hebben die een ondernemend gedrag kunnen laten zien."
Visibility of entrepreneurial activities	SEI activities in a visible setting at the campus	Visibility, smart housing	"En een zichtbaardere slimmere huisvesting en niet in Helmond, MMP of Momentum"

4.2.1 Comparison between theory-based and practice-based URS mechanisms

The comparison between theory-based mechanisms and practice-based mechanisms is presented in Table 4.6. This confrontation has led to 40 identified URS mechanisms.

First, we focus on the university staff and alumni related URS mechanisms. It has been demonstrated that the availability of academic role models (M.33) has a positive influence on the student entrepreneurial intent and action (Graham, 2014; Walshok & Shapiro, 2014). The effect of the other four on student entrepreneurial and innovation activity has not yet been studied in literature. These are: the acceptance of an entrepreneurial career for academics (M.2) and, related, financial incentives for academics to be involved with E&I (M.16), the involvement of successful alumni entrepreneurs in education (M.7) and life-long learning opportunities on E&I for alumni (M.24).

Second, experimental education related URS mechanisms like the effect of challenge-based courses (M.9), multidisciplinary research themes (M.27) and the possibilities of graduating with a spin-off or a start-up (M.18) are not assessed in academic literature yet. These are relatively new mechanisms at universities and only a few universities experiment with them (Stanford, 2016).

Third, student-related URS mechanisms like study-related pressure (M.37) and the availability of a lively SE&I community (M.36) have received limited attention in literature. There are some studies mentioning these mechanisms but strong conclusions have not been published yet (Robertson et al., 2003; Graham, 2018).

Finally, strategic and organizational mechanisms as the board-level integration of valorization (M.21), the visibility of entrepreneurial activities across the campus (M.40) and a clear and transparent revenue model for universities on SE&I activity (M.32) are only very recently mentioned in studies but not yet studied in detail (Unger et al., 2018). These URS mechanisms are left for future research.

Table 4.6: Comparison between theory-based mechanisms and practice-based mechanisms

	Mechanism	Theory	Practise
M.1	Accelerator	x	x
M.2	Acceptance of entrepreneurial career for academics		x
M.3	Access to grants	x	x
M.4	Access to scale-up funding	x	
M.5	Accessbility to high-tech facilities	x	
M.6	Affordable office space	x	x
M.7	Alumni relationships		x
M.8	Business contest	x	x
M.9	Challenge-based courses		x
M.10	E&I in curricula	x	x
M.11	Entrepreneurial competence education	x	x
M.12	Entrepreneurship & innovation in mission	x	x
M.13	Events	x	x
M.14	Experimental education center	x	x
M.15	Extra-curricular teams	x	x
M.16	Financial incentives		x
M.17	Fund raising	x	x
M.18	Graduate with spin-off		x
M.19	Incubator	x	x
M.20	Collaboration projects with industry	x	x
M.21	Integraton of valorisation		x
M.22	IP policy	x	x
M.23	Legal support	x	x
M.24	Life-long learning		x
M.25	Matchmaking between students	x	
M.26	Mentoring/coaching program	x	x
M.27	Multidisciplinair themes		x
M.28	Negotiation process		x
M.29	Network facilitator	x	x
M.30	Pre-defined entrepreneurial mindset	x	
M.31	Recruitment campaign	x	x
M.32	Revenue model		x
M.33	Role models	x	x
M.34	Selection of first-year students	x	x
M.35	Special recognition entrepreneurs	x	x
M.36	Student-led community		x
M.37	Study-related pressure		x
M.38	Success story telling	x	x
M.39	University staff competence	x	x
M.40	Visibility of entrepreneurial activities		x

Access to scale-up funding (M.4) was not coded during the empirical analysis as a URS mechanism. This is probably due to the fact that many SE&I activities apply only in a later stage for scale-up funding and have probably left the university at that point. At TU/e there is no accelerator where scale-ups are located. Also, the TU/e has no tight relationships with scale-up investment funds yet.

Surprisingly, accessibility to high-tech facilities (M.5) is not mentioned during the empirical data collection. The interviewees might have assumed SE&I activity to not make use of high-tech facilities. Or the interviewees are so accustomed to the high-tech facilities at the TU/e that accessibility to high-tech facilities was not mentioned as a URS mechanism.

Finally, a predefined E&I mindset (M.30) and matchmaking between students (M.25) were not mentioned. These mechanisms might be too abstract. However, matchmaking and a consistency in a predefined E&I mindset which the university wants to teach her students are deemed as important mechanisms (Matt & Schaeffer, 2018).

4.2.2 URS mechanism metrics

The URS mechanisms metrics coding scheme is presented in Table 4.7. The empirical analysis has yielded 3 practice-based URS metrics. This low number of metrics might be due to the focus of the interviewees on output metrics instead of process metrics to measure the performance of SE&I activity. The first two metrics are already in place at the TU/e.

Table 4.7: Coding scheme of URS mechanism metrics

Concept	*Description*	*Empirical indicators*	*Illustrative quote(s)*
National Student Enquete	Measuring satisfaction of students with education	National student questionnaire	"De Nationale studenten enquête. Dan worden ze onder andere gevraagd hoe tevreden ben je op de beroepsoriëntatie in je onderwijs? In hoeverre bereid de universiteit je voor op de loopbaan. Nou ja daar scoren wij niet goed op. Veel universiteiten in Nederland hebben daar moeite mee maar wij zeker."
Alumni Monitor	Measuring satisfaction of alumni with competences	Alumni monitor	"We hebben ook nog NSE en Alumnimonitor daar zeggen studenten nu heel ontevreden over te zijn."
Student satisfation	Measuring student satisfaction with URS mechanisms	Satisfaction	"Ik denk daarbij aan tevredenheid van studenten met de mechanismes."

4.3 Qualitative assessment of URS mechanisms at TU/e

The qualitative sentiment analysis has given insight in three data-richest practice-based URS mechanisms: the negotiation process, the integration of valorization and IP regulations. These mechanisms were mentioned by most interviewees during the empirical analysis and have a large number of references (see Table 4.8). The frequency of mentions of all mechanisms is shown in Appendix I. Each of the selected UR mechanism has a minimum number of 20 references. However, a data-rich code does not necessarily result in an information rich code. So the data-richest URS mechanisms where manually text mined for sentimental indicators. These are words representing a certain sentiment (positive, negative or neutral).

The selected URS mechanisms were coded based on these sentimental indicators. These indicators indicate the sentiment in each coded reference. Each URS mechanism in Table 4.8 is assessed in further detail in the following sections.

Table 4.8: Sentiment analysis on practice-based URS mechanisms.

Mechanism	Definition	Sentiment	References	Persons
Negotiation process	Clear negotiation process for a quid pro quo from students in entrepreneurial activities	Fairness, transparency, greed, clarity, arbitrary	31	9
Integration of valorization	Integrate valorization within research and education on university-board level	Rewarding only on research and education, weak integration, lacking organization, too traditional	22	8
IP regulations	IP policy on SE&I activities	Flexibility lacking, corporate-focused, illegal, perception problem, weak communication	21	8

Negotiation process

The negotiation process is cited in 9 of the 14 interviews held. Most of these quotes are about the arbitrariness and ambiguity of the negotiation strategy with student start-ups and spin-offs about taking a stake in the company and a quid pro quo. The contrarily role of the university in this process is shown in the following quote: *"When developing your idea into a company as a student, you perceive the university as a safe haven. You don't have any idea they are going to negotiate with you afterwards"* (Student Start-up TU/e).

The problem probably lies in the fact that there is a broad interpretation on what is university-owned and what is not. This misconception is clearly outlined in the following quote: *"The term university-owned is interpreted differently across various actors at the campus. Some people only mention intellectual property in the form of patents, others also see coaching or attending a lecture as a base to say the activity is partially university-owned"* (Employee at TTO TU/e).

It is still not clear what quid pro quo the university can expect in return for the support they offer via the URS mechanisms. This expected return is strongly connected to the revenue model the university adopts for SE&I activity. However, leaving the revenue model aside, it could be argued that the current negotiation process, as a URS mechanism, should be redesigned in order to reduce the ambiguity and arbitrariness about whether a student-led start-up or spin-off is university-owned or not. A positively perceived negotiation process could have a positive moderation effect of students in SE&I activity to grant the university a return for the effort.

Integration of valorization

The high-level integration of valorization with education and research is often mentioned in documents and interviews. The university is currently financially rewarding faculties based on in-flux and out-flux of students and not on the SE&I activities they undertake. Also on top-level management, valorization is not explicitly embedded. Where research and education are both the responsibility of the Rector Magnificus, the responsibility for valorization is split between the president and vice-president of the TU/e. These findings are supported by the following quote: *"On management level there are too few discussions about how to integrate education, research and valorization"* (Employee at TU/e innovation Space).

Policies in other countries or at other Dutch universities were mentioned in relation to the integration of valorization. The United States was repeatedly named as a country where some universities explicitly value knowledge transfer as key tasks of university staff: *"In US, research groups are formed in such a way that there is a lot of room for valorization activities instead of just publishing papers or pursuing research grants"* (Professor at TU/e). The TU/e is perceived as a traditional university where the focus lies on fundamental research instead of applied research. A balance between applied and fundamental research is mentioned as a solid basis for valorization. *"I think our university is very fundamental in contrast to other engineering universities in the Netherlands. We could be more balanced"* (Professor at TU/e).

IP regulations

The IP regulation mechanism at TU/e is closely linked to the negotiation process mechanisms and the high-level integration of valorization. Right now, IP policies seem to be in place to protect research agreements between the university and companies. However, this has led to a stringent and rigorous IP policy towards students: *"The university is afraid that students could harm the relationships with cooperates"* (Employee of TU/e TTO). The current IP policy is not well enough communicated as students perceive that their IP belong to the university: *The IP regulation does not work well because it is perceived badly and because it is communicated weakly to students* (Student start-up).

Guidelines for improvement of these URS mechanisms and the URS mechanisms from the quantitative assessment of the next section, are presented in section 5.3. Other URS mechanisms like a revenue model for SE&I activities or fund raising opportunities are interesting topics for further research and should be carefully looked at by the university management.

4.4 Quantitative assessment of URS mechanisms at TU/e

To complement the qualitative assessment of practice-based mechanisms, a quantitative assessment of the theory-based URS mechanisms is conducted. All interviewees (see Appendix D) were asked to rate the satisfaction with the theory-based URS mechanisms at TU/e based on a likert scale. The averaged ratings of this satisfactory analysis are presented in Table 4.9.

To determine if the assessment has enough discriminative power, the internal rate of reliability (IRR) of the assessment was calculated. As this assessment is based on an ordinal scale,

the Krippendorff's alpha fits the IRR test best because it can handle missing values and an ordinal scale (the Likert-scale) very well (Gerdes et al., 2008). The Krippendorff's alpha was determined at **0.679**. The cut-off point for determining if the quantitative assessment is assumed inter-rater reliable is set on 0.667 as this research is highly exploratory (Krippendorff, 2004). The Krippendorff's alpha test can be examined in Appendix J. To reduce the central tendency bias and correct for differences in the degree of outspokenness between the interviewees, the individual ratings were normalized before averaging by calculating z-scores (Lisef, 2014). The z-score ranking is shown in Table 4.10.

Table 4.9: Satisfactory analysis of theory-based URS mechanisms

Mechanism	Average	St. Dev.
Legal support	2,0	1,15
IP policy	2,4	1,40
Special entrepeneurial status	2,6	0,94
Mentoring program on campus	3,0	0,75
Predefined entrepreneurial mindset	3,2	1,42
Promote as occupation	3,3	1,27
Accelerator	3,3	1,50
Recruitment campaign	3,4	1,02
Flexible curricula	3,6	1,22
Entrepreneurial competence education	3,8	1,57
Collaboration projects with industry	4,0	1,14
Incubator	4,0	1,10
Local capital seed funds	4,0	1,50
Business contest	4,1	1,37
Affordable office space	4,3	1,62
Networking facilitator	4,4	1,28
Success story telling	4,4	1,10
Access to grants	4,4	1,41
Entrepreneurship in University mission	4,4	1,70
Access to scale-up funding	4,5	1,07
Events	4,5	0,83
Matchmaking between students	4,6	1,32
Event space	4,7	1,23
Free co-working space	5,0	1,32
Expermental education center	5,7	0,82
Extracurricular teams	5,7	0,90
Accessbility to high-tech facilities	6,1	0,40

As shown in Table 4.9, several mechanisms are performing poorly where others perform really well. Especially the lack of legal support, the nontransparent IP policy, mentoring program and a special entrepreneurial status where mentioned as under-performing mechanisms. As can be seen in Table 4.10 the legal support and IP policy have a fairly low standard deviation and a very low score, especially when the response data was normalized (0.9 and 0.66 respectively).

Interesting are also the relatively high standard deviations for some of the URS mechanisms (affordable office space or entrepreneurship in mission). This might reduce the construct validity as the interviewees might have interpreted these URS mechanisms differently. Or they might have a biased view on the mechanism. As discussed in section 2.2.3, the answer bias and desired outcome bias might have led to biased answers.

Table 4.10: Normalization of satisfactory analysis of theory-based URS mechanisms

Mechanism	Average	St. Dev.
Legal support	-1,3	0,90
Special entrepeneurial status	-1,0	1,00
IP policy	-1,0	0,66
Mentoring program on campus	-0,8	0,56
Predefined entrepreneurial mindset	-0,6	0,92
Accelerator	-0,5	0,78
Promote as occupation	-0,5	0,75
Recruitment campaign	-0,5	0,61
Flexible curricula	-0,3	0,65
Entrepreneurial competence education	-0,2	0,92
Collaboration projects with industry	-0,1	0,81
Incubator	-0,1	0,89
Local capital seed funds	-0,1	0,75
Business plan contest	0,0	0,60
Events	0,0	1,12
Event space	0,1	1,18
Affordable office space	0,1	0,82
Access to grants	0,2	0,75
Success story telling	0,2	1,00
Networking facilitator	0,3	1,05
Entrepreneurship in University mission	0,3	1,36
Matchmaking between students	0,3	0,76
Access to scale-up funding	0,4	0,33
Free co-working space	0,5	0,81
Experimental education center	1,2	0,50
Extracurricular teams	1,2	0,49
Accessbility to high-tech facilities	1,5	0,30

Based on this satisfaction analysis of the theory-based mechanisms, the sentiment analysis on the practice-based mechanisms derived from the interviews and a consultation with the company supervisor of this thesis, guidelines to improve selected URS mechanisms are formulated and presented in the next chapter. Other URS mechanisms identified in this study for which limited empirical data was gathered, could be further assessed and studied in future research.

5 | Solution design

The insights from both the empirical analysis and the theoretical analysis were used to design the solutions. The solution designs are closely linked to the research deliverables as presented in section 1.6 and section 2.3. The solution designs are a tangible result from the reflective redesign process. The metrics on SE&I activity and on URS mechanisms are incorporated in the designs of the SE&I activity typology and the URS mechanisms taxonomy.

5.1 SE&I activity typology

First, the design requirements on the redesign of the SE&I activity typology are stated. These requirements followed naturally from the theoretical and empirical analysis. In line with these requirements, a redesign of the SE&I typology is presented. An important consequence from the designed typology is a new definition of a student-led spin-off or start-up, these definitions are further examined in this section. Finally, a set of metrics is proposed to measure the performance of the SE&I activity types.

5.1.1 Design requirements

Table 5.1 shows the design requirements for the SE&I activity typology. The typology builds upon the theoretical activity matrix of Bengtsson (2015) as presented in section 3.3. The typology should help to map the SE&I activities in a time efficient way. The typology should also push the university to keep track of the support they deliver for SE&I activity.

Table 5.1: Overview of design requirements on SE&I activity identification

Functional requirements	- The design should help the TU/e to identify SE&I activities - The design should help to identify highly supported and unsupported activities at TU/e - The design should help to measure performance of SE&I both in terms of quantity and quality
User requirements	- The design should be used intuitively - The design should fit the context of TU/e - The design should take a limited to time to use, especially gathering the metrics on SE&I activity - The design should provide a visualization of activities
Boundary conditions	The design should be delivered end of 2018
Design restrictions	The design should be limited to observable behavior

5.1.2 Design

The designed SE&I activity typology is shown in Figure 5.1. As can be seen in Figure 5.1, the y-axis is defined based on the level of university support instead of the origin of knowledge as defined by Bengtsson (2015). This requires the university to keep track of the support they offer towards SE&I activities. The x-axis is defined based on whether the activity is executed in an existing organization or a new organization.

The typology is not binary, a student could be involved in a self-employment activity and a spin-off activity at the same time. The type of activity differs in the degree in which the activity is supported and whether it takes place in an existing organization or a new one.

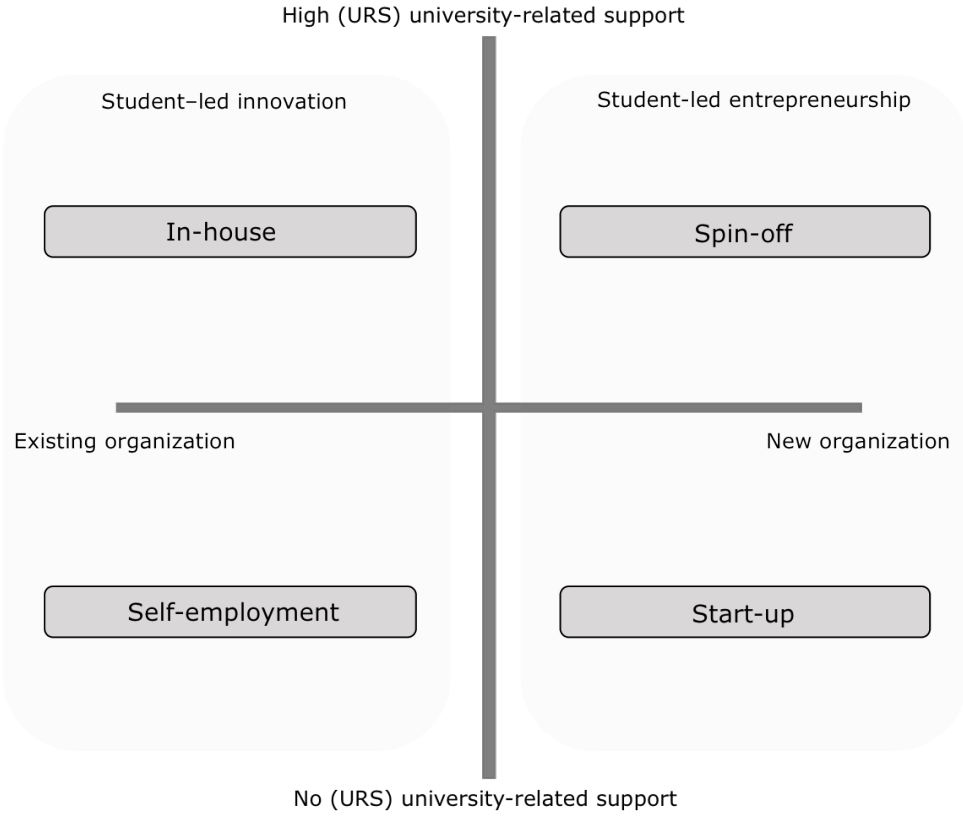

Figure 5.1: Design of the SE&I activity typology

Within this SE&I activity typology, four different types of SE&I activities are defined:

In-house student: A student who shows entrepreneurial behavior within an existing firm supported by the university (e.g. an internship or a graduation project on I&E within a corporate venture / a side-job in an innovative project supported by the university / a year in an innovative university-supported student team / a student following an E&I course at a university)

Self-employment: A student who shows entrepreneurial behavior within an existing firm not supported by the university (e.g. a student in an entrepreneurial side-job at an existing entrepreneurial company / a student in an innovative team not supported by the university.)

Student spin-off: A student who starts a new firm supported by the TU (e.g. a new firm residing at TU campus for free) / a new firm based on university-owned IP / a new firm granted free office space and coaching / a new firm offered network via TU employees / a new firm started based on a university-supported team)

Student start-up: A student who starts a new firm without much support of the university (e.g. a new firm residing outside of TU / a new firm not based on university IP/ a student developing a firm without coaching or following related courses)

The SE&I activity typology includes only those activities on which the university has a direct impact via identified mechanisms. Job placements in E&I positions within existing firms not under direct influence of the university or alumni who start a new entrepreneurial venture an 'x' number of years after their graduation because they enjoyed entrepreneurial education at the university during their study are out of scope of this research but might be interesting subjects of research in future studies.

Definition of student-led spin-off and start-up

An important consequence of this SE&I activity typology is the definition of the student-led spin-off. The definition of an academic spin-off is generally accepted as a spin-off based on university-owned intellectual property resulting from research as student entrepreneurship and innovation was not a focus of universities (Shane, 2004; Barrow et al., 2014). However, when differentiating not only on IP but on a broader set of URS mechanisms, the definition of a spin-off changes. To make a distinction between a student-led spin-off and a student-led start-up new definition are proposed:

Student-led spin-off: A new firm started by a (group of) student(s) which receives (a certain level of) university-related support.

Student-led start-up: A new firm started by a (group of) student(s) which does not receive (a certain level of) university-related support.

The level of university-related support can be measured by taking the URS mechanisms into account. Further research is needed in order to define the threshold in the amount of university-related support of an activity that makes the distinction between a start-up or spin-off. An important consequence is to prevent SE&I activities from receiving unlawfully state support. The difference between a start-up and spin-off is important from a legal perspective as well.

Also, the new definition could trigger universities to decide which support mechanisms they offer and which student-led ventures should receive support. Thus, this definition calls for more transparency as universities should track the support granted to student-led spin-offs. When this definition is adopted, the TU/e could design policies based on the support granted to SE&I activities. Student-led spin-offs are those activities benefiting from the URS mechanisms and student-led start-ups those not benefiting support.

Metrics

The metrics shown in Table 5.2 are both a combination of metrics based on practice as presented in section 4.2.2 and metrics based on theory as presented in section 3.4.4. The selection of metrics is based on the user requirements (gathering should not be too time consuming) and are divided into quantitative metrics (factual data) and qualitative metrics (perceptional data) and are linked to the SE&I activity types. Further development and implementation of the metrics have managerial implications for TU/e.

Table 5.2: Final set of metrics for tracking SE&I activity at TU/e

SE&I activity	**Quantitative metric**	**Description**
All	SE&I activity	Number of students involved in SE&I activity
All	Education connection	Number of SE&I activities connected to education via ECTS
All	Business challenge participants	Number of students in business challenges
Entrepreneurship	Spin-offs & Start-ups	Number of founded student-led spin-offs and start-ups
Innovation	Courses	Number of students in E&I courses per year
Innovation	Graduates & Internships	Number of students graduated on and in internships at E&I activity per year
Innovation	Job placements	Number of students placed at E&I jobs per year
	Qualitative metric	**Description**
Entrepreneurship	Revenue	Revenue created per student-led spin-offs and start-ups
Entrepreneurship	Job creation	Number of jobs created per student-led spin-offs and start-ups
Entrepreneurship	Company survival rate	Number of student-led spin-offs & start-ups existing after 10 years of foundation
Innovation	E&I company advisory board	Satisfaction rate of E&I companies with hired students
All	Entrepreneurial competence	Measuring entrepreneurial competences of students in SE&I activity

5.2 URS mechanism taxonomy

The URS mechanism taxonomy is a combination of both theory-based URS mechanisms and practice-based URS mechanisms derived from section 4.2.1. This comparison has resulted in a set of 40 URS mechanisms. First, the design requirements on the URS mechanism framework are stated. These requirements are based on consults with the company advisor of TU/e innovation Space. Then, based on the requirements, a design is made. The design includes both the theory-based metrics and the practice-based metrics to measure the outcome of each mechanism according to the CMO-logic (Romme & Reymen, 2018).

The term taxonomy was chosen because the design is a classification of mechanisms and shows underlying principles based on attribute (cultural, social and material), phase (intention, moderation on intention and action) and type (student-led entrepreneurship or innovation).

5.2.1 Design requirements

First, the design requirements on the URS mechanism taxonomy are stated. These requirements are based on comments made during the interviews and consults with the company advisor of TU/e innovation Space. Table 5.3 shows the overview of design requirements for the URS mechanism taxonomy. As can be seen, the taxonomy should help tracking the performance of the URS mechanisms. The qualitative assessment of the practice-base URS mechanisma and the quantitative assessment of the theory-based mechanisms in section 4.4 could be used as an example of how the mechanisms could be assessed.

Table 5.3: Overview of design requirements of the mechanism framework

Functional requirements	- The design should help the TU/e to identify URS mechanisms - The design should help the TU/e in measuring the performance of the URS mechanisms both in terms of quantity and quality
User requirements	- The design should be used intuitively - The design should fit the context of TU/e - The metrics in the design should not take a lot of time to track - The design should provide a visualization
Boundary conditions	The design should be delivered end of 2018
Design restrictions	- The design should be limited to URS mechanisms which are under direct control of the TU/e - The design should affect student-led innovation and entrepreneurship

5.2.2 Design

The comparison in Table 4.6 has yielded 40 URS mechanisms which will be integrated in the design. This set of URS mechanisms are translated to CMO (context, mechanism, outcome) design principles in the final set of URS mechanisms. This set is shown in Table 5.4 and contains extended descriptions for every URS mechanism. The outcomes are based on the metrics which are identified from theory and practice.

The URS mechanisms metrics are split into qualitative and quantitative metrics. Important for measuring the URS mechanisms from a subjective perspective is the satisfaction rate of the students and university staff about the URS mechanisms. The measurements of the URS mechanisms are the outcome of CMO-logic and tightly bounded to the URS mechanisms itself and can be viewed in Table 5.4. These measurements can also be collected on a (bi)-yearly basis and are important metrics of performance of the university. In further research, this data could be used to test the moderation effects as proposed in the theoretical framework. This could lead to new theoretical insights into the effectiveness of URS mechanisms.

An overview of the URS mechanism taxonomy is also presented in a web-based environment. The taxonomy is on-line accessible via `www.tueinnovation.space`.

Table 5.4: Taxonomy of URS mechanisms

	Mechanism					Outcome	
	Name	*Description*	*Phase*	*Attribute*	*Type*	*Quantitative metric*	*Qualitative metric*
M.1	Accelerator	Accelerator for SE&I activity	Moderator	Material	E	#SE&I activity in accelerator	Satisfaction rate%
M.2	Acceptance of entrepreneurial career	Acceptance on advancing on the entrepreneurial ladder intead of the academic	Intention ; Moderator	Cultural	E		Satisfaction rate%
M.3	Access to grants	Accessibility to grants for SE&I activity	Moderator	Social	E & I	#SE&I activity receiving grants	Satisfaction rate%
M.4	Access to seed funding	Accessbility of local capital pre-seed funds	Moderator	Social	E	#SE&I acitivity funded	Satisfaction rate%
M.5	Accessbility to high-tech facilities	Accessibility of high-tech facilities for SE&I activity	Moderator	Material	E & I		Satisfaction rate%
M.6	Affordable office space	Affordable office space for SE&I activity	Moderator	Material	E & I	#SE&I acitivty in office space	Satisfaction rate%
M.7	Alumni relationships	Involvement of alumni in valorisation activities	Intention ; Moderator	Social	E & I	#Alumni in SE&I activity	Alumni monitor%
M.8	Business contest	Availability of a bussines plan contest for SE&I activity	Intention ; Moderator	Cultural	E	#SE&I activity in contests	Satisfaction rate%
M.9	Challenge-based courses	Courses designed around challenges	Intention ; Moderator	Material	E & I	#Courses in curricula	Satisfaction rate%
M.10	Collaboration projects with industry	Collaboration projects with industry during study	Intention ; Moderator	Social	E & I	#Resource to U/I interaction	Satisfaction rate%
M.11	E&I in curricula	Adoption of SE&I activities in standard curricula	Intention ; Moderator	Material	E & I	#EI activity in curricula	Satisfaction rate%
M.12	Entrepreneurial competence education	Avaibility of appropriate entrepreneurial courses for SE&I activity	Intention ; Moderator	Material	E & I	#Courses in curricula	Company advisory board%
M.13	Entrepreneurship & innovation in mission	Adoption of SE&I in university mission statement	Intention	Cultural	E & I		Satisfaction rate%
M.14	Events	Availability of appropriate events for SE&I activity	Intention ; Moderator	Social	E & I	#SE&I-related events	Satisfaction rate%
M.15	Experimental education center	Availability of a experiential education center for SE&I activity	Intention ; Moderator	Material	E & I		Satisfaction rate%
M.16	Extra-curricular teams	Availability (to start) university-supported extracurricular innovation teams	Intention ; Moderator	Material	I	#Extracurricular teams	Satisfaction rate%
M.17	Financial incentives	Availability of financial incentives for staff to participate in SE&I	Moderator	Material	E & I		Satisfaction rate%
M.18	Financial investing	Availability of (small) financial investments of university	Moderator	Material	E		Satisfaction rate%
M.19	Graduate with spin-off	Graduation with a spin-off as student	Moderator	Material	E	#Graduates	Satisfaction rate%
M.20	Incubator	Availability of an incubator for SE&I activity	Moderator	Material	E	#Spin-offs in incubator	Satisfaction rate%
M.21	Integraton of valorisation	Integrate valorization within research and education on university-board level	Intention	Cultural	E & I		Satisfaction rate%
M.22	IP policy	IP policy on SE&I activities	Intention ; Moderator	Material	E & I		Satisfaction rate%
M.23	Legal support	Availability of appropriate legal support for SE&I activity	Moderator	Social	E	#Supported SE&I projects	Satisfaction rate%
M.24	Life-long learning	Opportunities at the university for life-long learning	Intention ; Moderator	Material	E & I	#Lifelong learners	Satisfaction rate%
M.25	Matchmaking between students	Accessibility of students with from other discipline to start SE&I activity	Intention	Social	E & I		Satisfaction rate%
M.26	Mentoring/coaching program	Availability of a mentoring program for SE&I activity on campus	Moderator	Social	E & I		Satisfaction rate%
M.27	Multidisciplinair research themes	Multidisciplinair research themes to spur new ideas	Intention	Material	I		Satisfaction rate%
M.28	Negotiation process	Clear negotiation process for a quid pro quo from students in SE&I activities	Moderator	Material	E		Level of trust%
M.29	Network facilitator	Accesibility of oustide network for SE&I activity	Moderator	Social	E & I	#External at events	Satisfaction rate%
M.30	Pre-defined E&I mindset	Adoption of a predefined E&I mindset on campus	Intention	Cultural	E & I		Satisfaction rate%
M.31	Recruitment campaign	University-wide campaigns on SE&I activity	Intention	Cultural	E & I		Satisfaction rate%
M.32	Revenue model	Clear revenue model in place of how universities could benefit from SE&I activit	Moderator	Material	E		Satisfaction rate%
M.33	Role models	Availability of role models in EI in university staff	Intention	Cultural	E & I		Satisfaction rate%
M.34	Selection of first-year students	EI-driven selection procedure on first-year student	Intention	Cultural	E & I		Satisfaction rate%
M.35	Special recognition entrepreneurs	Availability of a special recognition for students in SE&I activity	Moderator	Cultural	E	#Special recognitions granted	Satisfaction rate%
M.36	Student-led community	Availability of a community where students can network and learn from eachot	Intention ; Moderator	Social	E & I		Satisfaction rate%
M.37	Study-related pressure	Study-related pressure perceived by students	Intention ; Moderator	Cultural	E		Pressure perceived%
M.38	Success story telling	Story telling on successful SE&I activity on campus	Intention	Cultural	E & I		Satisfaction rate%
M.39	University staff competence	Availibity of staff whom are experienced in entrepreneurship	Intention ; Moderator	Material	E	#EI experts in staff	Satisfaction rate%
M.40	Visibility of E&I activities	SE&I activities in a visible setting at the campus	Intention	Cultural	E & I		Satisfaction rate%

Examples of URS mechanisms in CMO-logic

URS mechanisms which apply to certain activities can now be mapped and measured on their impact on SE&I activity using CMO-logic. As can be seen in two imaginary examples, the outcome of the CMO-logic is derived from the quantitative assessment (Romme, 2016):
TU/e innovation Space (context) stimulates intention and activation of students to start an in-house project by offering a challenge-based practical entrepreneurship course named XYZ (mechanism). In 2018, the course was followed by 200 students from which 2 spin-offs started and 18 in-house projects rose, the satisfactory rate was 8/10 (outcome).

Other mechanisms apply to the continuation of the action phase by the moderation of intention and action relationship. This can be done by other mechanisms which are in place for stimulating retention of SE&I activity for example:
The TU/e incubator (context) stimulates the activation of student startups by offering them access to a mentoring platform (mechanism). In 2018, this mentoring platform has guided 24 student spin-offs and 12 in-house projects, the satisfactory rate was 9/10 (outcome).

5.3 Modifications on selected URS mechanisms at TU/e

Based on the quantitative assessment of theory-based URS mechanisms in section 4.4 and the qualitative assessment of practice-based URS mechanisms in section 4.3, a selection is made of URS mechanisms which could be improved. Other mechanisms could also be assessed in future research. The selection is made based on the information available about the URS mechanisms, the improvement possible based on the quantitative assessment and a consultation with the company advisor of this thesis. The guidelines (or alternatives) for improving these URS mechanisms are presented in the following way. First, the key issues of the current-state of the mechanisms are given. Then, based on the key issues, guidelines are suggested which could improve the performance of the URS mechanism. Some guidelines are alternatives but most of them are mutually exclusive.

5.3.1 Negotiation process

The negotiation process mechanism is defined as the process which the university has in place when negotiating with student entrepreneurial activities about what the university should receive in return for the value they deliver.

Key issues

The current negotiation process with start-ups and spin-offs is generally perceived as **nontransparent** and prone to **arbitrariness**. As mentioned during the interviews, the TU/e has no clear set of parameters that they use to determine the value delivered to the start-up or spin-off, mainly because the current negotiator of the TU/e represents only one stakeholder and does not oversee the complete net value. Also, there is a **lack of expectation management** up front of potential start-ups and spin-offs. It varies what and how much the TU/e asks in return for their delivered value towards start-ups and spin-offs.

Suggested guidelines

The following guidelines are suggested regarding the negotiation process based on the above stated issues:

1. The negotiation team which negotiates with student start-ups and spin-offs should be represented by multiple stakeholders at the TU/e to oversee all interests.
2. The TU/e should make clear to potential student start-ups and spin-offs what they will ask in return to reduce ambiguity about university-related support.
3. The TU/e should be able to quantify what value they deliver to the student start-ups and spin-offs to reduce ambiguity about university-related support.
4. The TU/e could, based on the perceived effect of the URS mechanisms on the value of the SE&I activity, assign a value to each form of support that the SE&I activity has received.

5.3.2 High-level integration of valorisation

The high-level integration of (student-led) valorization is defined as the integration of (student-led) valorization within the education and research mission at the university on macro (national) and micro (university top-management) level.

Key issues

Currently valorization is **not explicitly integrated** in the board of the TU/e. This has resulted in a **lack of organizational capacity** at the university to improve valorization performance. The responsibility is diffused over many stakeholders and **no performance metrics** on valorization are currently in place. Also, a nation-wide and even international **ranking is missing on valorization** which results in a lack of incentives for students and university employees to engage actively in valorization activities. The TU/e is said to have a **broad but scattered organization** when it comes to valorization. The TTO and the incubator are well connected but there are too few connections with innovation Space, the research groups on entrepreneurship and the faculties.

Suggested guidelines

The following guidelines are suggested regarding the integration of valorization based on the above stated issues:

1. The TU/e should create a dedicated portfolio holder at university board level for SE&I activity in academic knowledge valorization.
2. The TU/e should track the performance metrics on SE&I activity and URS mechanisms as proposed in this research.
3. The TTO at TU/e should lobby for a (nation-wide) university ranking on academic knowledge valorization with attention to SE&I activity.

4. The TU/e should aim to connect and establish communication between the different initiatives on SE&I activity (Honors School, TU/e innovation Space and TU/e innovation Lab) at strategic and operational level.

5.3.3 IP policy

The IP regulations are defined as the legal regulations communicated by the TU/e to their students about intellectual property.

Key issues

Many interviewees said the TU/e should facilitate students to obtain intellectual property. However, the TU/e is said to be afraid that students could **harm research contracts** with corporates when having no IP policy in place. Therefore, the TU/e has proposed a **lump-sum IP policy** to cover this risk. However, this IP policy caused student entrepreneurs to be **insecure** about their rights. Most of them are not aware of the legal rights they enjoy. This is mainly due to the **indistinct communication** about the IP policy. It is not clear when IP generated by the student belongs to him or her. During some negotiation processes with students, the TU/e **used IP policy as a non-legal argument** to gain a share of company. Only the faculty of Industrial Design was mentioned for having a transparent IP policy. Using the IP policy to gain shares in student start-ups also was named by students and employees of the TTO at the TU/e as inappropriate and hardly profitable.

Suggested guidelines

The following guidelines are suggested regarding the IP policy based on the above stated issues:

1. The TU/e should design a guideline to educate students about their IP rights up front (see a first design in Figure 5.2) and communicate this IP guideline effectively to students following Barrow et al. (2014).

2. The TU/e should reconsider in what situations IP rights could be 'used' as leverage in negotiation processes, see section 5.3.1.

3. The TU/e should re-evaluate their IP policy and consider a more targeted policy in situations where students interfere with corporate research contracts.

4. The TU/e could ask the ministry of Education, Culture and Science about the stance on the legal position of SE&I projects in Dutch law.

5. TU/e innovation Space should have clear policy on any IP developed within innovation Space.

The guideline presented in Figure 5.2 is a design for an educational guideline for students on their legal position. The guideline is designed in close consultation with specialists in intellectual property law (mr. Frank Rutgers) and administrative law (mr. Ali Mohammad). The aim is to design a web-based guideline which educates students and helps universities to understand the legal positions of student-led innovation and entrepreneurial projects (Barrow et al., 2014).

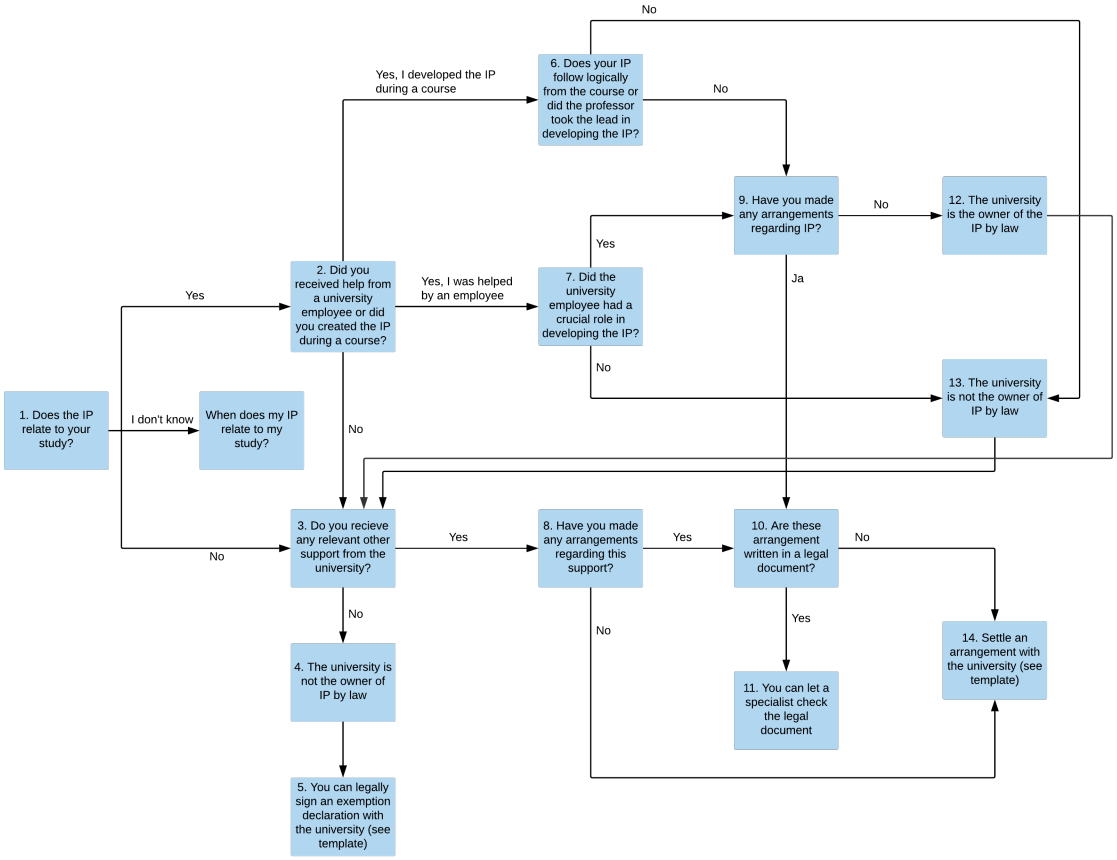

Figure 5.2: Concept of IP guideline for students

5.3.4 Legal support

The legal support mechanism is defined as support offered to SE&I activities based on financial, legal or fiscal issues.

Key issues

The legal support offered to students who want to apply for a patent is working properly. However, support on legal issues is limited mainly due to a **lack of resources**. The question remains if the TU/e should offer this support directly or indirectly via specialized partners. However, both the direct as indirect support are lacking. For researchers there is more legal support, a number of specialists is united in the **research support network** at the TU/e. However, this support also **focuses mainly on research-based projects** instead of business-based projects.

Suggested guidelines

The following guidelines are suggested regarding legal support based on the above stated issues:

1. The TU/e should set-up an (in)direct network on legal support, for example, with students from the faculty of law in neighboring university Tilburg.

2. The TU/e should offer workshops on a regular basis on finance, legal and fiscal themes for SE&I projects.

6 | Conclusion & discussion

The main research question of this study is answered by the design of a taxonomy of URS mechanisms. These URS mechanisms can either pave the way or block the road for SE&I activities to be successful at the TU/e. The taxonomy identifies university-related support mechanisms which enhances either student-led entrepreneurial or innovation activity.

The conclusion and discussion of this thesis is separated into three different parts. First, the theoretical contributions are stated which answer the first three research questions. Second, the limitations and future research directions are stated. Finally, managerial implications are drawn based on the answers to the final two research questions.

6.1 Theoretical contributions

This research contributes to the explicit understanding of ways in which universities can directly support students in gaining an entrepreneurial mindset and how this state of mind translates into high-quality activities (Wright et al., 2017; Elfving et al., 2017; Siegel & Leih, 2018). This understanding gives universities a holistic approach to structurally and explicitly support student-led entrepreneurial & innovation activities and enhances the academic knowledge valorization mission (Etzkowitz et al., 2000; Wissema, 2009b).

Theoretical contribution of this research consists of three distinct topics. First, this research establishes a theoretical framework on how SE&I activities arise and are supported by URS mechanisms. Second, to identify SE&I activities, a new SE&I activity typology is developed based on the level of university-related support received. Finally, a combination of design-science research and science-based design, has resulted in a new theoretical taxonomy of URS mechanisms aimed at improving SE&I activities (Berglund et al., 2018). These contributions answer the first three sub-research questions.

6.1.1 Theoretical framework

To define a theoretical foundation of how a contextual mechanisms (URS mechanisms) effect (student)entrepreneurship (SE&I activity), a reciprocal moderated-mediation model has been created by combining the theory of planned behavior (TPB), the model of entrepreneurial intent and the context-specific intention model (Ajzen & Fishbein, 1977; Elfving et al., 2017; Gollwitzer & Brandstatter, 1997; Trivedi, 2017). This model, stated in section 3.1, gives insight in the direct effect (via the TPB) and the interaction effect of the combination of URS mechanisms on SE&I activity which consists of a constant interaction between intention and action.

On face validity, the identified URS mechanisms can have an effect on the student entrepreneurial intention and/or the relationship between intention and action. A model which explains this relationship between URS mechanisms and SE&I activity is lacking in current literature and adds value for futures scholars that want to study the effect of URS mechanisms on SE&I activity.

6.1.2 SE&I activity typology

A new theoretical typology of SE&I activity has been developed (see section 5.1). Based on the previous work of Bengtsson (2015), a classification was made based on the level of URS mechanism support and the type of organization in which the activity occurs (new or existing). This typology has resulted in a definition of a student-led spin-off in addition to the standard definition of an academic or university spin-off which is based on the involvement of university-owned research knowledge (Shane, 2004). Different types of university support to student start-ups or new ventures has been researched before, however, the support has not explicitly been classified (Wright et al., 2017). Based on the findings of this thesis, a new venture of a student should classify as a spin-off or as a start-up based on the level of university-related support given. This answers part of the second sub-research question. Also, a set of metrics has been defined for both the entrepreneurial and innovation activities identified in the typology which answers part of the third sub-research question.

6.1.3 URS mechanism taxonomy

The URS mechanism taxonomy combines and measures mechanisms which could be initiated or influenced by university staff members and/or students and which interact with SE&I activity. The taxonomy as shown in section 5.2 classifies the URS mechanisms using three classes: the hypothesized effect following the theoretical framework, the type of SE&I activity and cultural, social or material attributes following the recent work on ecosystem mechanisms of Spigel (2015).

The taxonomy includes metrics derived from both literature and practice on the performance of the mechanisms following the CMO-logic (Romme & Reymen, 2018). The URS mechanisms taxonomy answers part of sub-research question two and three.

6.2 Limitations & future research directives

The limitations of this study are the characteristics of the methodology of the research which have influenced the interpretations of the findings of this research. This section will discuss how these limitations have affected the outcomes of the research and which future research studies could be conducted based on the limitations.

This research clearly opens up a new research directive, where the effect of the identified URS mechanisms could be measured on different activities in the student-led entrepreneurial and innovation typology. Explicit insight in these mechanisms could enable a university to become more entrepreneurial and stimulates the integration of valorization activities with the still Humboldtian education and research activities (Wissema, 2009b). Suggestions for future research are given below.

6.2.1 Benchmark studies

Because a single-case analysis was chosen, the research lacks external validity (Yin, 2008). The context, a Dutch engineering university, the TU/e, was analyzed and given this context a case-specific solution was designed with the potential to be generalized. The rationale for the single-case analysis was the trade-off between breadth and depth of the research given the time of the research. As existing literature on university mechanisms to stimulate SE&I is limited, depth of the analysis was preferred above externally validating the findings.

An extrapolation of the findings of this thesis towards universities or non-engineering universities should therefor be made with great caution. Future comparable studies in other universities might find URS mechanisms which could be added to the taxonomy developed in this thesis. In other words, the taxonomy is flexible and could be extended by future research. The taxonomy of URS mechanisms presented in section 5.2 now exists of 40 identified URS mechanisms based on an extensive literature review and empirical analysis of interviews, documents and observations reports.

A **multiple case analysis** at other universities might extend this set of identified URS mechanisms by exploring new ones. This analysis will increase the external validity of the taxonomy. Also, a **benchmark assessment of the performance of URS mechanisms** could be conducted by assessing the URS mechanisms at other universities using the methods presented in this thesis; both a sentiment and satisfactory analysis. In this way, universities can be compared and knowledge could be exchanged on URS mechanisms.

6.2.2 Individual URS mechanisms

Besides validating and extending the taxonomy and benchmarking the performance of URS mechanisms at other universities, individual URS mechanisms could be studied as well. This research focused on creating a holistic taxonomy of URS mechanisms instead of focusing on the effect of individual mechanisms. Future studies are therefore proposed which **in-depth study individual URS mechanisms** that are currently understudied.

One can assume that certain mechanisms have stronger effect on SE&I activities than others. In the current URS mechanism taxonomy every mechanisms has the same weight. Insights in the impact of individual URS mechanisms on SE&I activity by **conducting a conjoint analysis on individual URS mechanisms** could result in putting weights to individual URS mechanisms to distinct between stronger and weaker URS mechanisms.

More insight in individual URS mechanisms could also be achieved by **analyzing dependencies between individual URS mechanisms**. For example, do certain revenue models affect the satisfaction rate of the negotiation process? Or does a low satisfaction rate on coaching relate to the budget spend on entrepreneurial education?

This also calls for **input metrics for individual URS mechanisms**. This study has only researched the outcome (performance) of URS metrics (e.g. number of student internships at companies, revenue per spin-off) and performance of SEI&I activity. When input measures are taken into account, efficiency of the URS mechanisms could be determined as well.

6.2.3 Ecosystem context

The subject of research of this study were mechanisms which are under direct control of universities. This context fits the research objective. However, a more ecosystem-wide view could have added more insights into a broader range of mechanisms. Benchmarking other fields of literature (business, governmental e.g.) could add significant value when **determining ecosystem-related mechanisms** which are not under direct control of the university. These are mechanisms affected by by government, small and medium enterprises, other incubators or accelerators or even corporates in the region. These 'ecosystem-related' mechanisms could give insight in the dynamic capabilities needed to support SE&I activities. It could be researched how the university could actively reconfigure these external competences (Teece et al., 1997).

By focusing on the ecosystem, one could study how URS mechanisms have impacted alumni years after their graduation. This view could contribute to more insight in **life-long learning opportunities for universities**. It might be interesting to determine the impact of URS mechanisms on inexperienced students and experienced ones. Which URS mechanisms are especially important when lacking any entrepreneurial experience?

6.2.4 Stages of advancement of SE&I activity

The phases of SE&I activity studied in this research concern the individual level instead of activity-level. This research studied how URS mechanisms affect the (starting) intention and action of individuals in entrepreneurial or innovation activity. Future research could study **the effect of URS (and ecosystem-related) mechanisms when taking stages of advancement of SE&I activity into account**. For example, is a mentoring platform more valuable for a recently started SE&I activity than for more mature SE&I activities? Or does the availability of seed-investments only affect more mature entrepreneurial activities or also just started entrepreneurial activities? The difference in matureness of SE&I activity should also be considered when testing the theoretical framework.

6.2.5 Testing the theoretical framework

This thesis has adopted a theory development methodology. Therefore, theory testing has not been conducted in this thesis (van Aken et al., 2012). As existing theories are lacking on URS mechanisms, the study adopted a exploratory view on the matter. To explore different URS mechanisms, semi-structured interviews were held which has contributed to the development of a new theoretical framework.

Now, the theoretical framework (the reciprocal moderated-mediation model) could be tested as a conceptual relationship model. One should be careful that the proposed model has direct reciprocal or feedback loops between entrepreneurial intent and entrepreneurial activity (behavior). This feedback loop limits the possibility to analyze this model by traditional statistical methods like a regression analysis. However, **system dynamic modelling** could be applied to determine effects of URS mechanism on SE&I activity. System dynamic modeling is not new in the field of valorization and entrepreneurship, multiple studies have successfully used this method to proof relationships between variables (Bloodgood et al., 2015; Tofighi et al., 2017).

6.3 Managerial implications

The managerial implications of this research are closely linked to the research objective and the main research question of this thesis. The generic answer to the main research question lies in the identification of SE&I activities and a continuous assessment and improvements of university-related support mechanisms.

First, the managerial implication implementing the SE&I typology is discussed. Then, managerial implications when assessing the SE&I activity and URS mechanisms are presented. The implications conclude with the specific URS mechanism improvements for the TU/e.

6.3.1 Implement SE&I typology

To increase alignment on supporting SE&I activity at TU/e, the board of the TU/e could create a policy where faculties, TU/e innovation Space and the TTO are obliged to classify the SE&I activities they support. This support should be based on the URS mechanisms the SE&I activities receive. The university could select a limited set of support mechanisms that serve as a basis for deciding whether an entrepreneurial or innovation project classifies as a spin-off or an in-house project respectively.

The following mechanisms derived from the taxonomy are proposed to differentiate between a spin-off/in-house project or start-up/self-employment project at TU/e:

- Support in receiving government grants
- Support in receiving seed funds
- Access granted to high-tech facilities at the campus
- Affordable or free office space granted
- Support in graduating with E&I project
- Investments or sponsorships by the university
- Support in disclosing or licensing university-owned IP
- Legal support given
- Support in coaching program
- Special recognition granted to students in E&I projects

Other mechanisms could be added to the list. Clearly, IP is only one differentiator in classifying a SE&I activity as a spin-off. This typology creates awareness and transparency for both students and university employees about which URS mechanisms the TU/e offers.

6.3.2 Tracking SE&I activity performance

When the SE&I activities are classified, they can be tracked based on the outcome measures which are stated in section 5.1.2. The TU/e board could oblige TU/e innovation Space and the TTO to keep track of the metrics and report them on an annual basis. These metrics could then be communicated to the Dutch government or used for communication purposes. The metrics are translating the valorization mission of the university in actual numbers.

6.3.3 Tracking URS mechanism performance

A first quantitative and qualitative assessment of URS mechanisms at the TU/e has been performed in this research. The board of TU/e should appoint someone at the TU/e to annually assess the mechanisms. These assessments by both a quantitative and qualitative method as presented in this thesis provide insight in the performance of the university support in initiating and stimulating SE&I activity. Trends in performance can be analyzed and reported. Based on these insights, the university could act continuously to improve the URS mechanisms.

6.3.4 Improving URS mechanisms

When URS mechanisms receive a low score in either quantitative metrics or qualitative metrics, the board of the TU/e should analyze this mechanism deeper. This study has selected four URS mechanisms for improvement based on qualitative and quantitative assessment in this thesis and has proposed guidelines for improvement, see chapter 5.3. The guidelines are summarized below.

Negotiation process & revenue model

The board of the TU/e should install a clear negotiation process when the university negotiates with student spin-offs. This process is strongly connected to the revenue model of the university (Barrow et al., 2014). Therefore, the board of the TU/e should determine what revenue model they want to apply to student spin-offs. For example, does the TU/e want to have a stake in student spin-offs? Or do they want to design a policy where the student spin-offs pay the university in terms of a deferred loan? Besides the revenue model, the university board should create a policy on the value they assign to each mechanism. Currently, students in SE&I activity are not aware of the value the university delivers via the URS mechanisms.

IP policy & legal support

TU/e innovation Space should provide education about IP and legal issues to SE&I activity. When students undertake SE&I activities, legal and IP issues will arise. Legal support or education on legal topics is currently lacking at TU/e for SE&I activities. The TU/e innovation Space (together with the TTO) should design a guideline as proposed in section 5.3.3. The board of TU/e should re-evaluate their current IP policy and consider a more targeted one following the best practices studied by Barrow et al. (2014). Also, a collaboration with the university of Tilburg could be considered as law students could support SE&I activities at TU/e on legal issues. Finally, as this topic might occur at other universities as well, the ministry of Education, Culture and Science could be consulted to ask their stance on the matter.

Integration of valorization

The implications of this thesis mainly address the university board. Therefore, a dedicated portfolio holder for student-led valorization should be assigned to address these implications. This portfolio holder could lobby for financial incentives and a nation wide university ranking on academic knowledge valorization where SE&I activities are taken into account. And ultimately initiate and oversee the strategic actions needed to improve on URS mechanisms.

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Appendices

A Journal list of ITEM research group

Table A.1: Overview of Scientific journals of the ITEM research group

ITEM Journal List
Academy of Management Journal
Academy of Management Review
Administrative Science Quarterly
British Journal of Management
Creativity and Innovation Management
Decision Sciences
Decision Support Systems
Design Studies
Entrepreneurship Theory and Practice
Harvard Business Review
Human Relations
IEEE Transactions on Engineering Management
Industrial Marketing Management
Information & Management
Interfaces
International Business Review
International Journal of Operations & Production Management
International Journal of Research in Marketing
International Journal of Technology Management
International Marketing Review
Journal of Advertising
Journal of Advertising Research
Journal of Applied Psychology
Journal of Behavioral Decision making
Journal of Business Research
Journal of Business Venturing
Journal of Engineering and Technology Management
Journal of Interactive Marketing
Journal of International Marketing
Journal of Management
Journal of Management Information Systems
Journal of Management Inquiry

Journal of Management Studies
Journal of Marketing
Journal of Marketing Research
Journal of Operations Management
Journal of Organizational Behavior
Journal of Product Innovation Management
Journal of Retailing
Journal of Service Research
Journal of Small Business Management
Journal of Purchasing & Supply Management
Journal of Supply Chain Management
Journal of the Academy of Marketing Science
Management Learning
Management Science
Marketing Letters
Marketing Science
MIS Quarterly
MIT Sloan Management Review
Omega-International Journal of Management Science
Organization
Organization Science
Organization Studies
Organizational Behavior and Human Decision Processes
Organizational Dynamics
Production and Operations Management
Psychology & Marketing
QME-Quantitative Marketing and Economics
R & D Management
Research Policy
Research in Organizational Behavior
Research-Technology Management
Small Business Economics
Strategic Entrepreneurship Journal
Strategic Management Journal
Supply Chain Management - An International Journal
System Dynamics Review
Technological Forecasting and Social Change
Technology Analysis & Strategic Management
Organizational Dynamics
Technovation

B | List of interviewees for problem identification

Table B.1: Overview of interviewees used for the problem identification

Interviewee	**Function**
Amitrava 'Babi' Mitra	Executive Director New Engineering Education Transformation program at MIT
Richard K. Miller	President of Olin College of Engineering
Jonathan Marks	Editor-at-large Photon Delta & Innovation ecosystem expert
Akos Wetters	Founder Innovation Booster & Entrepreneurship lecturer
Michel Weeda	Program Manager at Brabantse Ontwikkelings Maatschappij
Isabelle Reymen	Professor in Design of Ecosystems & Scientific Director TU/e innovation Space
Alfons Bruekers	Managing Director TU/e innovation Space
Miguel Bruns	Assistant Professor Industrial Design & Director of education of TU/e innovation Space
Bert-jan Woertman	Commercial Director TU/e
Herman van Hoeven	Innovation Strategy & Partnership TU/e
Steven van Huiden	Founder Startup/Eindhoven (incubator TU/e)
Victor Donkers	Founder Usono (Startup at TU/e)
Rein Westerdijk	Founder Taylor (Startup at TU/e)

C | Interview consent form & questions

I have read the information presented in the information letter about a study being conducted by TGJ Selten for a master thesis project at the University of Technology Eindhoven. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be tape recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the course project paper to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time by advising the student researcher.

I was informed that if I have any comments or concerns resulting from my participation in his study, I may contact Tom Selten at t.g.j.selten@student.tue.nl

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

YES NO

I agree to have my interview tape recorded.

YES NO

I agree to the use of anonymous quotations in the course project paper

YES NO

Participant's Name :

Participant's Signature:

Date:

Dit interview heeft als doel om mechanismes te identificeren welke student ondernemerschap kunnen ondersteunen. Daarvoor is het van belang om allereerst de verschillende vormen van student ondernemerschap te bespreken waarna we de focus zullen verleggen op het ondersteunen hiervan. Dit onderzoek wordt uitgevoerd in het kader van academische kennis valorisatie en de implementatie hiervan op de Technische Universiteit Eindhoven.

Student ondernemerschap

Wat is (student) ondernemerschap volgens u?
Probe: definitie, start-up, consultancy, teams, bottom-up/top-down

Welke concrete student ondernemerschaps activiteiten herkent u op de TU/e?
Probe: feedback op activity matrix

Waarom is ondernemerschap wel/niet belangrijk voor de TU/e?
Probe: valorisatie, innovatie, TRL, future skills, verdienmodel

Waarom zouden de resultaten van student ondernemerschap moeten worden gemeten?
Probe: vsnu, kennisvalorisatie, verbeteren

Op welke wijze(n) kan de prestatie van student ondernemerschaps-activiteiten worden gemeten?
Probe: kwaliteit, kwantiteit, indicatoren

Welke fases van een student-ondernemerschaps activiteit kunt u onderscheiden? *Probe: feedback op intention model*

Mechanismen

Op welke wijze(n) kan de Universiteit bijdragen aan de intentie van studenten om ondernemende activiteiten aan te gaan?
Probe: cultuur, netwerken, onderwijs, honors

Op welke wijze(n) kan de Universiteit bijdragen aan het daadwerkelijk starten van ondernemerschaps activiteiten?

Probe: financiering, netwerken, IP-afspraken, afstudeermogelijkheden

Op welke wijze(n) kan de Universiteit bijdragen aan de groei van een ondernemende activiteit?

Probe: financiering, werkplekken, netwerken

Huidige situatie TU/e

Probe: Theory-based design principles score

Hoe zou u het huidige ecosysteem op de Universiteit rondom student ondernemerschap omschrijven?

Probe: industry-link, research-driven

Welke mechanismen zijn er op dit moment op de TU/e om student ondernemerschap te stimuleren?

Probe: incubator, proof-of-concept center, kwaliteit

Welke mechanismen zijn er op dit moment op de TU/e die tegenwerkend zijn?

Probe: IP-policy, focus op ECTS

Hoe zouden de mechanismen gemeten moeten worden?

Probe: kwalitatief, kwantitatief

Gewenste situatie TU/e

Hoe ziet de ideale TU/e er voor u uit?

Probe: toekomstvisie, trends, cultuur, netwerken

Welke ondersteunende mechanismen missen we op de TU/e?

Probe: multi-disciplinair, trends, ondersteuning, incentives voor valorisatie

Hoe zou de TU/e deze mechanismen kunnen verkrijgen?
Probe: meer mankracht, ondernemers in organisatie, incentives in de organisatie

Afsluiting

Zijn er verder nog opmerkingen of ideeen welke u kwijt wilt?

Mogen we u in een later stadium contacteren als er nog informatie nodig is?

D List of interviewees for data collection

Table D.1: Overview of interviewees used for data collection

Interviewee	**Function**
Steef Blok	Director TU/e Technology Transfer Office (TTO)
Piet van der Wielen	Manager Knowledge Valorization TU/e (TTO)
Alfons Bruekers	Director TU/e innovation Space
Steven van Huiden	Manager TU/e student incubator (TTO)
Bert-Jan Woertman	TU/e commercial director (Services)
Victor Donkers	Founder Usono (Startup TU/e)
Cynthia Schreuder	Head of Career academy (Services)
Philip de Goey	Steering Group Knowledge Valorization TU/e (Faculty)
Ton Backx	Director Institute of Photonics TU/e (Faculty)
Robert Al	Head of Business Support (TTO)
Mark Cox	Student Business Support (TTO)
Henk Arnsz	Founder Snocom (Startup TU/e)
Jo van Ham	University board member (responsible for valorisation)
Lex Lemmens	Director Education Experimentation (Services)

E | Overview of intention models

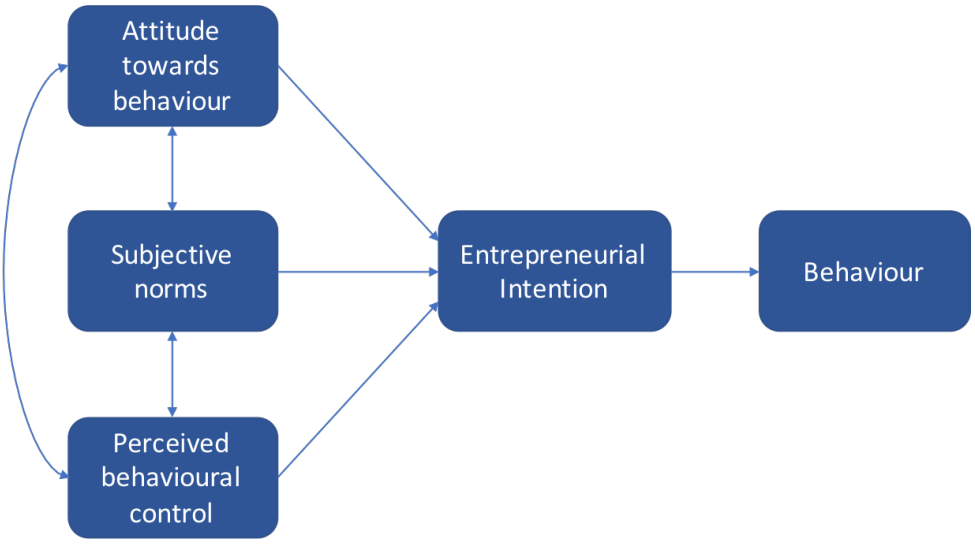

Figure E.1: Theory of planned behavior (Ajzen,1987)

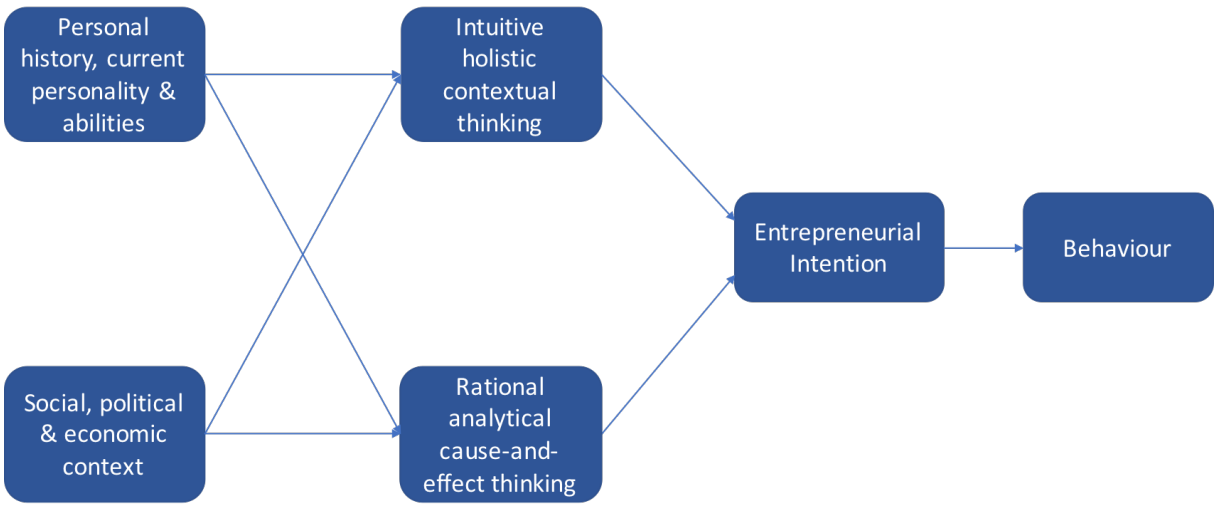

Figure E.2: Model for implementing entrepreneurial ideas (Bird,1989)

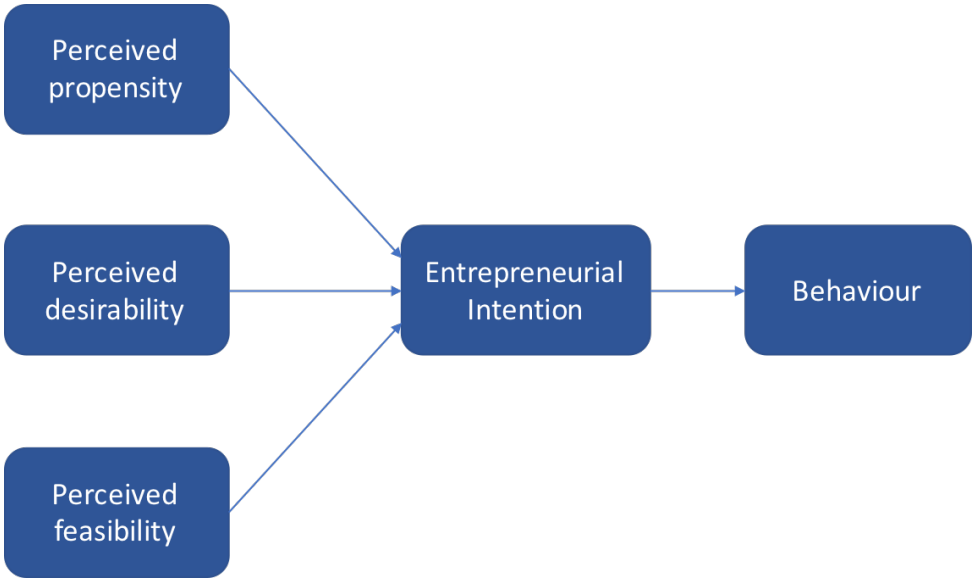

Figure E.3: Model of entrepreneurial events (Shapero & Sokol, 1982)

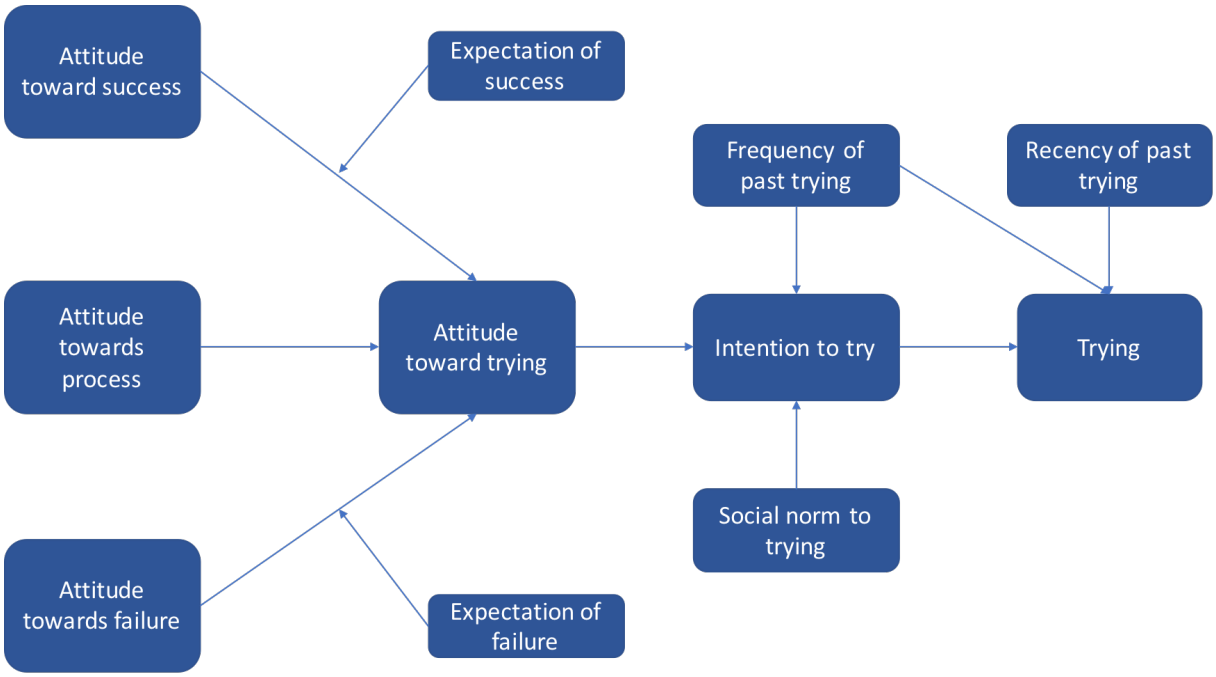

Figure E.4: Theory of trying (Bagozzi & Warshaw, 1990)

F | Overview of best practices for entrepreneurship education

Best practice	Description
Holistic overview	All conceivable aspects of starting a business should be covered
Dynamic competence	Continuously adjust the program to participant's situation and needs
Define real needs	Participants are not able to define their real needs, the program should
Network of firms	Provide a network of firms as participants often lack a network
Increase self-efficacy	Work on their self-confidence as an entrepreneur
Demand measures	Demand measurable returns on the work from the participants
Functioning toolboxes	Engage participants in 'well-tried' toolboxes used by senior entrepreneurs
Plan mentorship	Select mentors based on openness, personal chemistry, competence profile, entrepreneurial experience and age
Practice vs. Theory	Program should be practically oriented with some theoretical elements
Don't stress too much	Let ideas develop on their own, this can take time
Create credibility	Let the practitioners be open and frank with each other
Formal vs. informal	Orderliness must exist between action, flexibility and openness
Focus on target groups	Mix entrepreneurs from different fields (e.g. engineering, medical and sociology) would probably not work

Figure F.1: Overview of best practises of entrepreneurship education (Klofsten, 2000)

G | SE&I and URS mechanisms metrics from theory

Sample Measures of The Entrepreneurial University

Entrepreneurship Focused Culture	Commercial-ization Supports	Talent Development Contributions	Diversity of Industry Connections	Tech-Transfer Activities and Outputs
* Percent of leadership with industry knowledge and experience *Committees and initiatives focused on cross-disciplinary entrepreneurship * Campus identity tied to innovation and entrepreneurship * Number of offices and staff dedicated to industry relations * Leadership valuing & supportive of technology commercialization *Knowledge sharing and creating culture of risk tolerance * Content analysis of speeches, news releases, PR campaigns by university officials embracing economic development mandate	* Proof of concept centers (number, size, advisors, outputs) * Business planning and financing forums * Technology assessment groups/centers (activities on general campus, within TTO, and number of ideas evaluated annually) *Incubators and science parks (numbers and industry partners)	* Undergraduate internships in entrepreneurial companies * Continuing education certificates and seminars serving entrepreneurial companies *Entrepreneurship centers (curriculum, activities, number of participants, ideas/business plans vetted, outcomes) * Undergrad and grad job placements *Business service infrastructure *Number and types of student research and doctoral projects annually * Number of post-docs employed in the region 24	*Corporate affiliate programs (number of sectors served, company members, financial support) *Number of industry brokers in what department/ divisions * Size and industry of sponsored research *Advisory boards * Philanthropy (endowed chairs, faculty forums, private support, & fellowships) * Multi-disciplinary research centers * Number of research/outreach events annually & participation rates * Entrepreneur In Residence (EIR's), practitioners teaching	*Patent applications & awards *Licensing applications and awards *Spin-outs Annually *Equity positions taken in startups * Amount of Licensing Revenue * Number of Invention Disclosures * Amount of royalties * Number and revenues from Material Transfer Agreements (MTA's)

Figure G.1: Overview of mechanisms measurements

1. Input indicators: institutional approach

1.1 University policies and activities:

- Extent to which knowledge transfer and E&I activities are apparent within each school/centre in the university
- Connections between the E&I activities/policies across the university
- Whether the university has sought to employ international experts in E&I to deliver programs
- Breadth of activity/resources in place at the university (e.g. incubator/accelerator, student competitions, proof of concept centre)
- Level of university resource allocated to university/industry interactions
- Extent to which innovation and entrepreneurship are considered in faculty recruitment/promotions procedures
- Whether opportunities are offered by the university for partnership with regional companies

1.2 Education and development opportunities offered:

- Amount of curricular time devoted to entrepreneurship and innovation across all engineering and physical science disciplines
- Whether entrepreneurship and innovation training are offered to all university employees (including post-docs)

2. Process indicators: entrepreneurial culture and innovation capacity within the university

2.1 Individual student/staff attitudes and aspirations:

- Student and staff career intentions and options (self reported)
- The prominence of faculty entrepreneurs as role models
- The extent to which peer entrepreneurial talent is recognised and admired amongst the student body
- Percentage of engineering/technology students and staff involved in voluntary entrepreneurship and innovation activities
- Whether student and staff participation in voluntary entrepreneurship activities is increasing
- Faculty attitudes towards and level of trust in the university technology transfer office (or equivalent)
- Percentage of faculty engaged in disclosures/patenting activity

2.2 Connectivity and university/industry engagement:

- Levels of web connectivity between the university and industry
- Number of students who combine study with jobs with high-tech firms
- Proportion of engineering/technology students undertaking industry-based projects
- Numbers of joint publications between faculty and industry
- The number of joint university/industry initiatives launched (for any purpose)
- Involvement of practitioners in teaching and mentorship (numbers of professors of practice, entrepreneurs in residence etc.)
- The free movement of faculty in and out of the university
- Growth in external attendee numbers (professional service providers, industry and investors) at networking events
- Number of university patents that are transferred to industry partners at no cost
- Amount of pre-transactional interaction with industry (i.e. engagement that it not directed at securing a contract or licence)

2.3 Relevance and quality of university research:

- Volume of industry-sponsored research (for some, this should be measured as a percentage of the total R&D budget)
- Average impact factor of faculty publications
- Volume of faculty consultancy with industry (measured by both the percentage of faculty engaged and by the total income)
- International league table ranking for university

3. Output indicators: Ecosystem impact

3.1 Technology transfer office throughput (from university generated IP):

- Number of disclosures and patents
- Number of start-ups/spin-offs
- Number of licences or licensing success rates (number of licences per year/number of invention disclosures)
- Number of licences bearing royalties
- Income generated from licences

3.2 The creation of sustainable companies (from university generated IP):

- Company survival rate after 10-15 years
- Numbers of companies with more than 20 employees (for some, total number of jobs created by companies)
- Total money raised from external investors (for some, this should be measured as a percentage of research income)
- Total sales in the marketplace resulting from commercialisations
- Total financial value of the companies created

3.3 The impact of the university graduates:

- Percentage of alumni remaining in or returning to ecosystem
- Percentage of graduates working in technology-related businesses
- Percentage of alumni (aged 30-40) engaged in starting new companies or engaged in innovation (self-reported)
- Wealth created by companies founded by university graduates

3.4 Broader development of the ecosystem and beyond:

- Whether people (companies, entrepreneurs, investors, professional service providers) are moving into the region for opportunities
- Growth rate of all startups and high tech companies in the region (job growth, new investment etc.)
- The extent to which university PhD students are employed by startup and new companies in the ecosystem
- Total employment generated by the ecosystem
- Whether the university attracts entrepreneurially-minded, successful and ambitious students and faculty
- Whether the university has contributed to changing policies in the country/region (such as creating national IP legislation)

Figure G.2: Metrics on entrepreneurial activity

1. Leadership and institutional governance
Clear, well-articulated and unified university E&I strategy, which brings together priorities, activities and outputs related to both university-owned IP and non university-owned IP
Visibility of E&I in the university mission statement, with the vision vocally and publicly endorsed by senior university management and governing body of the institution
Clear performance metrics for university E&I that incorporate institutional E&I culture, connectivity and engagement as well as commercialisation and industry-funded research output
An approach that is responsive to changing institutional conditions and opportunities for E&I, based on a knowledge of the external E&I environment, on-going university E&I impact assessments and an awareness of international research and progress in the field
Provision of flexible, responsive and on-going funding streams to support E&I activities, resourced from internal budgets and/or brokered from agencies external to the university
2. Academic cultures and careers
Visibility of E&I in departmental and faculty activities, workload models, role allocations and performance targets
Recognition of E&I impact, experience and connectivity in the recruitment and promotion of faculty, researchers and teachers; a fact publicly promoted and endorsed by senior academic staff
Visibility of faculty role models and champions in E&I, celebrating both their successes and failures
Mechanisms to promote research collaboration, enquiry driven by end-user need and multi-disciplinary E&I across and beyond the university
3. University-led E&I activity
Distributed responsibility for delivery of the university E&I agenda, across several autonomous agencies, led by individuals with networks and experience within the E&I community
Range of university-led E&I activities, which can be accessed by staff and students via multiple routes, supporting each stage of an individual's entrepreneurial development, from early awareness-raising to accessing financing for commercialisation
Inclusion of E&I in the curriculum, exposing students to entrepreneurial ideas, projects, role models and opportunities from within their field of study
Formal E&I training for university faculty and researchers as part of their continuing professional development
Dedicated mentorship for student and staff startups, with particular focus on skill-building and the creation of well-balanced startup teams with insight into market need and access
4. Student-led and grassroots E&I activity
Empowered, cohesive and bold student-led entrepreneurship activity that is: • well-connected to and working in partnership with the regional E&I community, acting as a conduit between this community and the university, where necessary • informed and well-connected to the national/international student entrepreneurship community • autonomous in its direction and focus • supported by a highly-supportive point of contact within university senior management • led by students with personal experience of and networks in entrepreneurship • fresh and innovative in its thinking, supporting renewal and responsive to changing regional conditions, institutional environment and student needs
5. Connectivity with and support for the regional, national and international E&I community
Partnerships based on trust and mutual benefit with government, industry, alumni entrepreneurs and the regional/national E&I community, with a common understanding of the university's regional E&I role
Connectivity with the international academic E&I community, with strategic alliances, where appropriate, with established internationally-leading E&I universities
Range of mechanisms for members of the regional/national E&I community to support university-based E&I talent and ideas, allowing these individuals to play a visible and influential role in university life
Range of mechanisms – both within and beyond disciplinary departments – by which students, staff and alumni can access, network and collaborate with the regional, national and international E&I community

Figure G.3: Checklist of university support mechanisms according to Graham (2014)

H | Overview of coding scheme templates

Table H.1: Coding scheme template used for URS mechanisms

Theory-based Mechanisms	
Mechanism	**Definition**
Accelerator	Accessibility of an accelerator for SEI activity
Access to grants	Accessibility to grants for SEI activity
Access to scale-up funding	Accessibility to scale-up funding for SEI activity
Accessibility of high-tech facilities	Accessibility of high-tech facilities for SEI activity
Affordable office space	Availability of (affordable) office space for SEI activity
Business contest	Availability of a bussines plan contest for SEI activity
Collaboration projects with industry	Collaboration projects with industry during study
E&I in curricula	Adoption of SEI activities in standard curricula
Entrepreneurial competence education	Avaibility of appropriate entrepreneurial courses for SEI activity
Entrepreneurship & innovation in mission	Adoption of SEI in university mission statement
Event space	Availability of event space for SEI activity
Events	Availability of appropriate events for SEI activity
Experiental education center	Availability of a experiential education center for SEI activity
Extracurricular teams	Availability University-supported extracurricular teams for SEI activity
Flexible IP policy	Flexilibility of IP policy on SEI activities
Free co-working space	Availability of free co-working spces for SEI activity
Fund raising	Availability of local capital pre-seed funds for SEI activity
Incubator	Availability of an incubator for SEI activity
Legal support	Availability of appropriate legal support for SEI activity
Matchmaking between students	Accessibility of students with from other discipline to start SEI activity
Mentoring program on campus	Availability of a mentoring program for SEI activity on campus
Networking facilitator	Accesibility of oustide network for SEI activity
Predefined entrepreneurial mindset	Adoption of a predefined entrepreneurial mindset on campus
Promote as occupation	Promotion of purusing a professional career in SEI activity
Recruitment campaign	University-wide campaigns on SEI activity
Role models	Availability of role models in EI in university
Selection of first-year students	Adoption of EI-driven selection procedure on first-year student
Special recognition of student entrepreneurs	Availability of a special recognition for students in SEI activity
Success story telling	Adoption of story telling on succesfull SEI activity on campus

Table H.2: Coding scheme template used for SE&I activities

SE&I activity type	
Activity type	**Definition**
Student-led entrepreneurship	
Spin-off	Student entrepreneurship based on (new) research knowledge
Start-up	Student-led entrepreneurship based on students' own knowledge
Student-led innovation	
Corporate venture	Student innovation based on (new) firm's knowledge
Student support	Student-led innovation based on student's own knowledge
Phases	
Intention	The combined SE&I goal intent and implementation intent of a student to show a SE&I goal- directed behavior when a motivation and opportunity to achieve a specific SE&I goal arises.
Action	Observable entrepreneurial or innovative behavior of students to solve challenges by creating real-life applications in new or existing organizations.

Table H.3: Coding scheme template used for metrics

Metrics	
Activity type	**Definition**
SE&I activity metrics	
Number of start-ups/spin-offs	Number of start-ups and spin-offs resulting from SEI activity
Company survival rate after 10-15 years	Survival rate of start-ups and spin-offs resulting from SEI activity
Number of companies with more than 'x' employees	Number of companies from SEI activity more than 'x' employees
Total money raised from external investors	Total amount of money resulting from SEI activity
Total sales in the marketplace	Total sales in the marketplace resulting from SEI activity
Total financial value of the companies created	Total financial value created resulting from SEI activity
% alumni engaged in E&I	Percentage of alumni engaged in EI activity after study
Jobs created by graduate' companies	Number of jobs created by companies resulting from SEI activity
Students employed by startups and spin-offs	Number of studets working at start-ups and spin-offs
Undergraduate internships in EI	Number of students in internships at EI
Undergrad and graduate at EI job placements	Number of alumni in EI jobs
Business plans vetted	Number of business plans of EI activity vetted
Number of student SE&I projects	Number of students in Eiprojects
Patent applications and patent awarded	Number of patent applications and awarded patents of SEI activity
Number of invention disclosures	Number of invention disclosure resulting from SEI activity
URS mechanism metrics	
Number of E&I activities in curricula	Number of SEI activities offered in regular curricula
Employment of international experts in E&I programs	Number of international experts in EI in education programs
Incubator/accelerator & student competitions in place	Number of incubators, accelerators and competitions in place for SEI
Proof of concept center in place	Number of proof of concept centers at campus for SEI
Level of university resources to U/I interactions	Number of FTE spend on university-industry relations by university
Curricular time devoted to E&I across all faculties	Average number of ECTS granted per student to SEI activity
E&I training offered to students	Number of students in SEI mentoring programs
Involvement of practitioners in teaching and mentorship	Number of mentors or coaches for SEI activity
External attendees in networking events	Number of external attendees in SEI networking events

I Frequency analysis of practice-based URS mechanisms

Table I.1: Frequency analysis on practice-based URS mechanisms for sentiment analysis

Subcode	*Reference*	*Persons*
Negotiation process	30	9
Integraton of valorisation	22	8
IP regulations	19	8
Network facilitator	19	6
(Seed)fund raising	18	8
Acceptance of entrepreneurial career for	17	5
Mentoring/coaching program	16	7
(Success) story telling	15	4
Entrepreneurial competence education	13	6
Financial incentives	13	7
Business incubation	12	3
(Business) contest	10	4
Experiental education center	10	6
Extra-curricular teams	10	3
Revenue model	10	5
University staff competence	10	5
(Student-led) community	6	6
Challenge-based learning	6	4
Collaboration with industry during study	5	3
Corporate jobs	5	2
Life-long learning	5	2
Recruitment campaign	5	2
Selection of first-year students	5	1
Office space affordable	4	4
Study-related pressure	4	3
Accelerator	3	1
Events	3	2
Graduate with spin-off	3	1
Legal support	3	3
Multidisciplinair themes	3	1
Special status entrepreneurs	3	2
Visibility of entrepreneurial activities	3	1
Access to grants	2	2
Alumni relationships	2	2
ECTS granted	2	2
Faculty role models	2	2
Entrepreneurship in mission	1	1

J | Krippendorff's alpha test of IRR

The Krippendorff's alpha for this satisfaction analysis based on a ordinal scale is **0.679** which is fairly low but acceptable due to the exploratory nature of the study. In further research, higher inter-rater reliability can be achieved when the understanding of URS mechanisms are improved and benchmarked at other universities.

The determination of Krippendorff's alpha for this ordinal data scale is based on the following formulas (Krippendorff, 2011). The Krippendorff's alpha (α) is determined by formula J.1.

$$\alpha = 1 - \frac{D_{obs}}{D_{exp}} \tag{J.1}$$

where,
D_{obs} = The observed disagreements between values
D_{exp} = The expected disagreements based on chance between values

The observed disagreements between values (D_{obs}) is calculated by the averaged sum of products between the observed ordinal metric coincidences within the mechanisms (O) and the ordinal metric difference function (δ) as shown in equation J.2.

$$D_{obs} = \frac{1}{n} \sum_{i} \sum_{j} O_{i,j} \cdot \delta_{i,j} \tag{J.2}$$

The expected disagreements (D_{exp}) is calculated by the averaged sum product of the total coincidences per respondent (n) and the ordinal difference function (δ) and shown in formula J.3.

$$D_{exp} = \frac{1}{n(n-1)} \sum_{i} \sum_{j} n_i \cdot n_j \cdot \delta_{i,j} \tag{J.3}$$

The observed ordinal metric coincidences within the mechanisms (O) is determined by the formula J.4. The heat map of coincidences based on the formula is presented in Figure J.1.

$$O_{i,j} = \sum_{m} \frac{\text{Number of i-j pairs in mechanism m}}{T_m - 1} \tag{J.4}$$

where,
m = Mechanism m
T_m = Total number of values in mechanism m

The ordinal metric non-standardized difference function (δ) is determined by equation J.5. As can be seen, differences between pairs of values in mechanisms are always 0.

$$\delta^2_{i,j} = (\sum_{g=i}^{g=j} n_g - \frac{n_i + n_j}{2})^2 \tag{J.5}$$

where,
n_i = Total number of value entries per respondent i
n = Total number of value entries (see equation J.2 and J.3)

	1	2	3	4	5	6	7
1	2,39	4,158	1,9687	2,193	2,9153	0,1429	0,234
2	4,158	10,77	8,4823	7,2899	7,8495	2,7909	0,663
3	1,969	8,482	10,37	10,578	13,02	5,1692	1,408
4	2,193	7,29	10,578	11,76	14,042	4,7124	3,426
5	2,915	7,849	13,02	14,042	12,39	9,9996	3,78
6	0,143	2,791	5,1692	4,7124	9,9996	13,86	5,322
7	0,234	0,663	1,4076	3,4263	3,7797	5,3219	1,17

Figure J.1: Heat map of Krippendorff coincidence matrix