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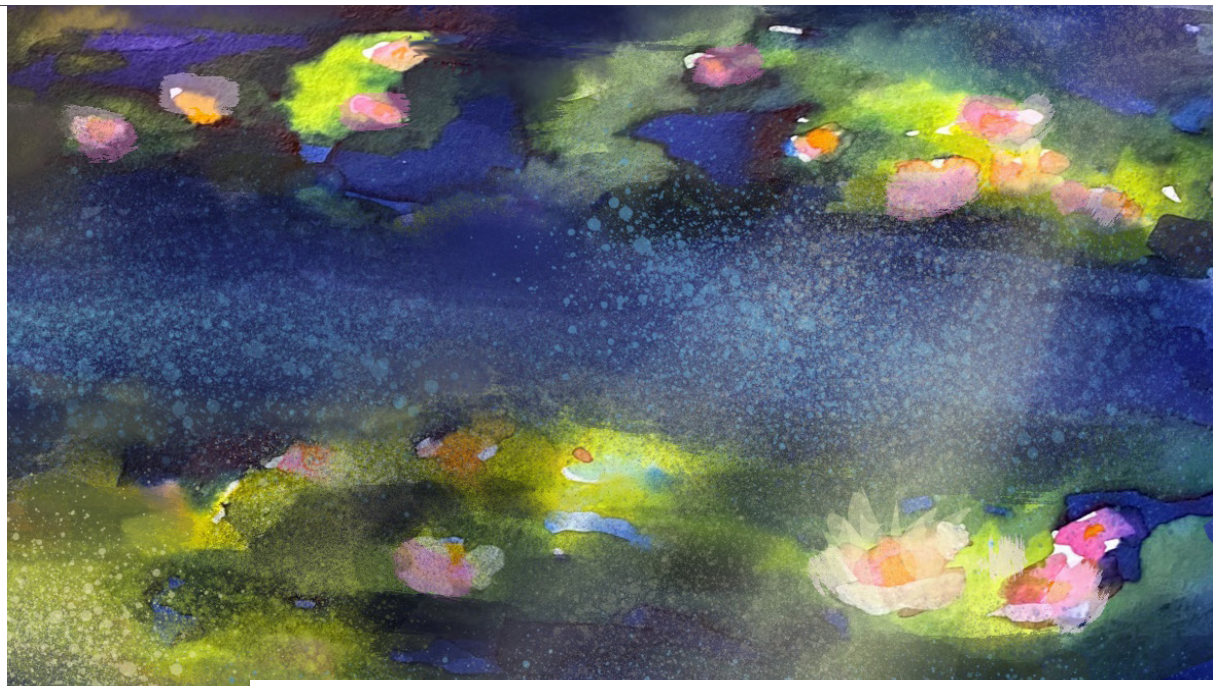

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Carl-Johan Asplund

LUND UNIVERSITY

DOCTORAL DISSERTATION

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Title and subtitle
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Most companies and organizations are primarily interested in universities' educational activities and to a lesser extent in universities' research activities. Yet, research on collaboration between universities and the surrounding society is primarily directed towards research collaboration between universities and companies/organizations rather than educational collaboration between universities and companies/organizations. The purpose of this thesis is to increase both the empirical and theoretical knowledge of educational collaboration between universities and the surrounding society, specifically companies and public organizations. The thesis particularly wants to contribute to increased knowledge about the advantages and success factors related to educational collaboration for universities, students and teachers as well as the collaborating companies and public organizations. This contribution is made by answering the overarching research question:

- What are the benefits of university-industry educational collaboration and how can university-industry educational collaboration succeed?

Five studies have been conducted. Two qualitative studies on student-written cases and student-written teaching notes within a master's course "Technology Strategies" co-delivered with collaborating companies and public organizations. A quantitative study of MSc theses at the Faculty of Engineering and the School of Economics and Management, both at Lund University, during 2016 as well as a survey study of collaborating companies and organizations related to the MSc theses. Finally, a conceptual study has been conducted to develop the theoretical understanding of university educational collaboration.

The thesis demonstrates that educational collaboration within individual courses must be planned and implemented carefully with collaborating companies or/and organizations, e.g., purpose of the collaboration must be clearly communicated to all stakeholders. The thesis presents a tested model for how student-written cases and teaching notes co-delivered with companies and organizations can be planned and implemented in teaching and in the practice of industry.

The survey of master thesis projects show that it is mainly larger companies in the region that have realized the value of educational collaboration, mainly through recruiting students and for knowledge support in their innovation processes, i.e., product innovations and early innovation phases, i.e., screening of new technologies and development of applications. The SMEs that get involved in master thesis projects have a greater interest in problem solutions in the later innovation process, i.e., prototyping and testing them. To engage more SMEs in master thesis projects, more information and stronger incentives, such as vouchers, are required to increase interest. The thesis concludes with elaborating a conceptual framework that describes the development stages of a university institution's collaborative capabilities.

Key words University-Industry collaboration, University-Industry Educational collaboration, Knowledge spillover, knowledge spillin, Knowledge transfer, Collaborative capabilities.

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To my parents Ingrid and Anders Asplund
– you made a difference and made me believe in always seeing the opportunities.

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Paper I

Bengtsson, L. & Asplund, C-J (2008). Case writing projects in co-operation with companies and organizations. *International Journal of Case Method Research and Application*, Vol. 16, pp 389-398.

Paper II

Asplund, C-J (2011) Orchestrating Case Learning: On the key importance of the teaching note *International Journal of Case Method Research & Application,* Vol 23, 2, pp. 129-138.

Paper III

Asplund, C. J., & Bengtsson, L. (2020). Knowledge spillover from master of science theses in engineering education in Sweden. *European Journal of Engineering Education*, *45*(3), pp. 443-456.

Paper IV

Bengtsson, L. & Asplund, C-J (2024). The Ivory Tower versus the Collaborative Innovation Platform – Comparing MSc Theses in Engineering and Business Education.

Status: Under review in Journal of Praxis in Higher Education. An earlier version of the paper was presented at the *European Academy of Management* (EURAM) 2020, Dublin.

Paper IV

Asplund, C. J., & Bengtsson, L. (2024). Three stages of university-industry educational collaboration.

Status: Submitted to Industry and Higher education for review. An earlier version of the paper was presented at the *Irish Academy of Management* 2015, Galway.

Related papers and publications

Bengtsson, L & Asplund, C-J. (2004). Case writing in teaching and assessment. The Academy for Creative Teaching, Vol 7, pp. 3-15.

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I also hope that this thesis will contribute to filling a gap in the empirical and theoretical knowledge about University-Industrial Educational Collaboration. May it be a springboard for forthcoming development projects in academia, industry and public organizations. May "the force" be with us as partners towards future challenges!

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Carl-Johan Asplund

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Abstract

Most companies and organizations are primarily interested in universities' educational activities and to a lesser extent in universities' research activities. Against this background, it is strange that the research on collaboration between universities and the surrounding society is primarily directed towards research collaboration between universities and companies/organizations and to a lesser extent towards educational collaboration between universities and companies/organizations. The purpose of this thesis is to increase both the empirical and theoretical knowledge of educational collaboration between universities and the surrounding society, specifically companies and organizations. The thesis particularly wants to contribute to increased knowledge about the advantages and success factors related to educational collaboration for universities, students, and teachers as well as the collaborating companies and public organizations. This contribution is made by answering the overarching research question:

- What are the benefits of university-industry educational collaboration and how can university-industry educational collaboration succeed?

Five studies have been conducted. Two qualitative studies on Student-Written Cases within a master's course "Technology Strategies" which are based on real cases within collaborating companies. A quantitative study of MSc theses was performed at the Faculty of Engineering and the School of Economics and Management, both at Lund University, during 2016, as well as a survey study of collaborating companies and organizations related to these MSc theses. Finally, a conceptual study has been conducted to develop the theoretical understanding of educational collaboration.

The thesis demonstrates that educational collaboration within individual courses must be planned and implemented carefully with collaborating companies or organizations. The purpose of the collaboration must be clearly communicated to all stakeholders. The thesis also presents a tested model for how Student-Written Cases and teaching notes based on real situations in companies and public organizations can be planned and implemented in teaching.

When it comes to MSc projects that are carried out in collaboration with companies and organizations, studies show that it is mainly larger companies that have realized the value of educational collaboration. They have seen the importance of this mainly in terms of recruiting students, but also for knowledge support in their innovation processes, especially for product innovations and in the early innovation phases, i.e., screening of new technologies and development of applications. The thesis also shows a slightly lower interest from Small and Medium-sized Enterprises (SMEs) in

educational collaboration. The SMEs that get involved in MSc thesis projects have a greater interest in problem solutions in the later innovation process, i.e., prototyping and testing them. To engage more SMEs in MSc thesis projects, more information, and stronger incentives, such as vouchers, are required to increase interest. The thesis concludes with elaborating a conceptual framework that describes the development stages of a university institution's collaborative capabilities.

Populärvetenskaplig sammanfattning

De flesta företag och organisationer i vårt samhälle är främst intresserade av universitetens utbildningsverksamhet och i mindre grad av universitetens forskningsverksamhet. Mot denna bakgrund är det märkligt att forskningen om samverkan mellan universitet och omgivande samhälle främst riktats mot forskningssamverkan mellan universitet och företag/organisationer och i mindre grad mot utbildningssamverkan universitet och företag/organisationer. Syftet i denna avhandling är att öka både den empiriska och teoretiska kunskapen om utbildningssamverkan mellan universitet och omgivande samhälle, det vill säga företag och organisationer. Avhandlingen vill särskilt bidra till ökad kunskap om fördelarna och framgångsfaktorerna relaterade till utbildningssamverkan för universitet, studenter och lärare samt de samverkande företagen och offentliga organisationerna. Detta bidrag sker genom att besvara den övergripande forskningsfrågan:

- Vilka är fördelarna med utbildningssamverkan och hur kan utbildningssamverkan lyckas?

Fem studier har genomförts. Två kvalitativa studier om studentskrivna case inom en masterkurs ”Teknologistrategier” som baseras på verkliga case inom samarbetande företag. En kvantitativ studie av examensarbeten som framlagts vid Lunds Tekniska Högskola och Ekonomihögskolan under året 2016 samt en enkätstudie till samverkande företag och organisationer relaterade till dessa examensarbeten. Slutligen har en konceptuell studie gjorts för att utveckla den teoretiska förståelsen av utbildningssamverkan.

Avhandlingen visar att utbildningssamverkan inom enskilda kurser måste planeras och genomföras noga med samverkande företag eller organisation. Syftet med samverkan måste vara klart och tydligt kommunicerat. En testad modell för hur studentskrivna case och handledningar baserade på verkliga situationer i företag och organisationer kan planeras och genomföras i undervisningen presenteras.

När det gäller examensarbeten som genomförs i samverkan med företag och organisationer visar studierna att det är främst de större företagen som insett vikten av utbildningssamverkan. De har sett betydelsen av detta främst när det gäller rekrytering av studenter men också kunskapsstöd i deras innovationsprocesser, främst för produktinnovationer och i de tidiga innovationsfaserna, dvs screening av nya teknologier och utveckling av applikationer. Avhandlingen visar också på ett något mindre intresse från mindre och medelstora företagen (SMFs) för utbildningssamverkan. De SMFs som engagerar sig i examensarbeten har ett större intresse av problemlösningar i den senare innovationsprocessen, dvs prototypframtagning och testning av dessa. För att engagera fler SMFs i examensarbeten krävs mer information och starkare incitament, t ex vouchers, för att öka intresset. Avhandlingen avslutas med utvecklingen av ett konceptuellt ramverk som beskriver utvecklingen av en universitetsinstitution som strävar mot utbildnings-samverkansexcellens.

Abbreviations

University-Industry Collaboration (UIC)

University-Industry Educational Collaboration (UIEC)

University-Industry Research Collaboration (UIRC)

Case Writing Projects (CWP)

Student-Written Cases (SWC)

Student-Written Teaching Note (SWTN)

Bad collaboration is worse than no collaboration.

Morten T. Hansen

There´s always one moment in childhood (and life – CJ)
when the door opens and lets the future in.

Graham Greene

Chapter 1.

University-Industry Collaboration

This chapter gives the background into the research of University-Industry Collaboration (UIC) and especially educational collaboration. The importance and relevance of this research are presented. Finally, I present and motivate the research purpose, the research questions, and the delimitations.

1.1. Introduction

The National Academy of Engineering (2003) listed six different ways that universities and colleges may deliver value to regional industry's development and expansion:

- through the provision of well-educated graduate students who become the key stakeholders in regional business;
- through the performance of basic research contributing to research knowledge and which is open to private companies;
- by celebrating and promoting an atmosphere of intellectual diversity that tolerates different approaches to how to solve technical problems;
- through direct cooperation and partnerships with industry both through specific projects and long-term relationships;
- by providing test environments for new technologies and research equipment eventually transferred to business;
- by setting up new enterprises that contribute to new types of industries and business.

The list indicates that universities' value deliveries to regional and industry development go through education, research, collaboration, providing specialized equipment as well as an atmosphere of intellectual diversity. Yet academic research on universities' contributions to society and industry has overwhelmingly focused on

research and University-Industry Research Collaboration (UIRC), and much less on University-Industry Educational Collaboration (UIEC) (Thune, 2011; Nsanzumuhire & Groot 2020; Zhuang & Shi, 2022).

The value of university R&D is for most firms and public organizations limited compared to the value of a pool of skilled labor and a constant flow of graduate students (Bramwell & Wolfe 2008; Kunttu 2017). Even for companies that have extensive R&D activities, higher education, and access to a pool of educated labor often play a more important role than relevant university R&D (Audretsch & Feldman, 1996).

There are several reasons why UIEC relative to UIRC is as important or more important to both universities and industry. The primary missions of universities are both education and research (Kunttu 2017, Olo, Correia, & Rego, 2021) thus University-Industry Collaboration should be related to both these missions. UIEC is more likely to generate benefits for students and teaching while UIRC is more likely to generate benefits for their researchers (Nsanzumuhire & Groot, 2020). Universities provide education for many professions, such as engineers, medical doctors, lawyers, managers, psychologists and more, thus it makes sense to provide an education with practical relevance and boost their job prospects (Borah et al., 2021). In most developed economies, the service sector dominates the economy and the knowledge-intensive service sectors in particular are growing (OECD, 2012). These sectors rely heavily on recruiting higher education employees, such as engineers. Moreover, increasing globalization and development of Information and Communication Technologies (ICT) throughout almost all industries and organizations has put a premium on young employees with generally better language, cultural and ICT skills than previous generations of employees (Korhonen-Yrjänheikki, Tukiainen & Takala, 2007). Thus, research and knowledge regarding UIEC is at least as important as UIRC to understanding the overall value of UIC created and delivered to industry and other stakeholders.

UIRC and UIEC may take several forms. Some collaborative activities are formalized through formal agreements and contracts, but many are also informal between individual companies and individual university units and/or individual university employees (Person & Rosenbaum, 2006; Thune, 2011). The most common activities for UIRC are joint R&D-projects, consulting to business, and mobility of staff (Davey et al., 2018). The most common UIEC activities are curriculum co-design (Tukiainen, Takala, & Ing, 2006; Fagrell, Fahlgren & Gunnarsson, 2022) curriculum co-delivery (guest lectures, live cases etc.), mobility of students (internships and placements), and student project work (MSc and BSc theses) (Bramwell & Wolfe, 2008; Kunttu, 2017; Davey et al., 2018).

Davey et al. (2018) report on a large European survey (n=17 410 responses from European academics and managers) of University-Industry Collaboration (UIC), i.e., research collaboration, educational collaboration, and valorization. Some of the more important findings are:

- 75 % of academics surveyed do not have any industry collaboration at all (though some of them might collaborate with public and social organizations),
- research collaboration is the most common type of collaboration,
- valorization activities and strategies (commercialization of R&D, academic and student entrepreneurship) are the most developed,
- the level of educational collaboration is low, mostly focused on mobility of students, i.e., internships,
- there is lack of measurement and indicators for educational collaboration activities and their outcomes,
- universities are formally committed to UIC but lack strategies for implementation,
- limited resources, lack of time, and bureaucracy are some of the highest barriers to UIC,
- regional firms are the main collaboration partners.

The report (Davey et al., 2018) concludes that there is large potential for positive effects for both university and industry if they increased their research and educational collaboration. For educational collaboration they recommend increased levels of curriculum co-design and co-delivery, more inclusion in courses, student projects and thesis work, as well as more problem-based and work-based learning. In addition, they recommend facilitating options for managers to take up work in universities with positions such as Professor of Practice and Practice Expert.

The European survey (Davey et al., 2018) of educational collaboration is one of few empirical investigations on how educational activities at universities can be a source of knowledge for industry. Other notable contributions include Bramwell and Wolfe (2008), Lucia et al. (2012), Kunttu (2017), and Zhuang et al. (2024).

There are several reasons why UIEC might not be beneficial for universities, students, teachers, and higher education at large. Industry may press for curriculums that are shorter, focus on specific application knowledge and skills for employability, and less on more general knowledge, scientific methods, and critical analysis (Thune, 2011). Large companies can also directly and indirectly influence the directions and content

of education to ensure a flow of students with competencies aligned with current and future needs and wants (Bramwell & Wolfe, 2008; Zhuang et al., 2024). This might be beneficial in the short term but have negative effects if the company decides to change their strategy or move out of the region. Another problem might be to involve SMEs in educational collaboration, due to their limited resources. This problem has been observed in UIRC (Laursen & Salter, 2004) where large companies dominate the research collaborations. At the same time, SMEs might be the group of firms that would benefit most from UIEC as asserted by Bramwell & Wolfe (2008). The issue of how SMEs could be more involved in UIEC is thus of importance.

Apart from the lack of empirical data and knowledge of UIEC, there is a lack of theoretical frameworks that enable understanding and analysis of the benefits and success factors of UIEC. In UIRC research it is common to study knowledge spillover from university R&D activities to regional firms and organizations. Knowledge spillover (e.g., Audretsch & Feldman 1996; Agarwal, Audretsch & Sarkar, 2010) means that companies and public organizations absorb knowledge without compensation in the nearby university's research and development (R&D) and use them primarily in their innovation activities. Knowledge spillover from university R&D can occur through active collaboration activities, e.g., collaborative research projects, or passive collaboration forms, e.g., seminars, conferences, publications (Giovannetti & Piga, 2017). Numerous empirical studies have demonstrated the knowledge spillover benefits from university R&D activities to local companies' innovation activities such as patenting and introduction of new products and processes (e.g., Audretsch & Feldman, 1996; Fernandes & Ferreira, 2013; Koch & Simmler, 2020). In contrast, empirical studies of knowledge spillover from UIEC to local and regional industry are rare, with Bramwell & Wolfe's (2008) study of knowledge spillover from University of Waterloo's system of internships and student project works to the firms in Ontario, Canada being the primary exception.

The reverse knowledge flow, knowledge spillins, i.e., learning that flows back to the knowledge-producing unit due to the collaboration activities with an external partner, such as new ventures by former employees that maintain contacts with their former employer (Kim & Steensma, 2017), are much less studied in UIRC. Knowledge spillins to universities, or their students and teachers, in relation to UIEC activities with companies and organizations, have not, to my knowledge, explicitly been addressed, with the exception of Bramwell & Wolfe's (2008) study, in prior research.

In this introductory essay (kappa), knowledge spillover and spillins will be used as a theoretical lens to further analyse and understand the knowledge flows in UIEC activities, related to the benefits and success factors of UIEC activities.

1.2 Research purpose

As introduced above, prior research on UIEC has identified the potential for realizing innovation-oriented services and providing educated talent for industry, while at the same time increasing the quality of education. However, earlier research on UIEC has been given *limited* attention, as well as the understanding of its role in relation to UIRC. Against this background, the research purpose of this dissertation is to increase the empirical and theoretical knowledge of UIEC. In particular, this dissertation intends to make a research contribution regarding the *benefits* of UIEC to the *main stakeholders* of UIEC, i.e., universities, students, teachers, collaborating companies and public organizations, and *success factors* leading to the realization of the benefits. This will be done by answering the overarching research question:

- What are the benefits of university-industry educational collaboration and how can university-industry educational collaboration succeed?

The overarching research questions are divided into a set of sub-questions that are presented in the appended papers.

1.3 Delimitations

In prior research, UIEC activities have been divided into three types based on the intended impact or benefits of these activities (e.g., Brandt et al., 2008; Thune, 2011); 1) Collaboration aimed at creating new or revising existing undergraduate and graduate *programs*, 2) Collaboration aimed at involvement in *teaching and learning processes*, 3) Collaboration aimed at facilitating the *transition* between studies and working life. This dissertation focuses on UIEC aimed at collaboration activities in teaching and learning processes and the transition between studies and working life. UIEC aimed at creating new or revised undergraduate or graduate programs does not form part of this study. For interested readers on UIEC activities on new or revised undergraduate and graduate (master's thesis level) curricula, see a recent dissertation by Fagrell (2020).

As mentioned above, there are several forms of UIEC. This dissertation limits its empirical studies to two forms of UIEC: 1) Course involvement in the form of Student-Written Cases (SWCs) and Student-Written Teaching Notes (SWTN) describing contemporary problem situations in companies, based on data from the managers in the collaborating company, 2) Master's (MSc) theses carried out in collaboration with companies and organizations with the aim of solving a particular problem or exploring a new (technological or other) phenomenon. The studies are mostly performed within

the engineering faculty and the engineering programs of Lund University. This thesis also incorporates findings from master's theses from the business faculty of Lund University.

1.4. Author contributions

The studies reported in the appended papers are the result of combined efforts with my colleague Lars Bengtsson. All appended papers, except paper 2, are co-authored with him. In the table below I have listed the research activities which I and Lars Bengtsson have had main responsibilities for related to the five appended papers.

Appended paper	Carl-Johan Asplund	Lars Bengtsson
Paper 1	Conceptualization, methodology, data collection, analysis, writing – review & editing.	Analysis, writing – original draft, writing – review & editing.
Paper 2	Sole author	
Paper 3	Conceptualization, methodology, data collection, analysis, writing –original draft, writing – review & editing.	Conceptualization, methodology, analysis, writing – original draft, writing – review & editing, funding.
Paper 4	Conceptualization, methodology, data collection, analysis, writing – review & editing.	Conceptualization, methodology, analysis, writing – original draft, writing – review & editing, funding.
Paper 5	Conceptualization, methodology, analysis, writing – original draft, writing – review & editing.	Conceptualization, methodology, analysis, writing – original draft, writing – review & editing.

1.5. Overview of thesis

Chapter 2 presents prior research on UIEC and a theoretical framework of the benefits of and success factors for UIEC in relation to UIRC.

Chapter 3 describes the chosen research design as well as the research process. In this chapter, the use of a mixed method approach will be described and motivated. The specific data collection methods, e.g., case studies, surveys, interviews that have been applied in the different studies are presented in each paper.

Chapter 4 presents the studies and the main findings in the five appended papers.

Chapter 5 starts with a summary of significant findings of the studies reported in the appended papers 1-5. This is followed by a discussion of the significant findings from

the perspectives of prior research and the theoretical framework. The chapter ends with discussing implications related to the significant findings for the main stakeholders in UIEC, i.e., universities, teachers/faculty, students, and managers in companies and organizations.

Chapter 6 contains two types of proposals of future studies. First a proposal to further develop the knowledge-based theory of University-Industry Educational Collaboration (UIEC). Second, proposals of further empirical studies of university-industry educational collaboration.

Chapter 2

Framework for University-Industry Educational Collaboration

This chapter presents the overall theoretical framework including prior research on University-Industry Research Collaboration (UIRC) and University-Industry Educational Collaboration (UIEC). This includes discussions of the types of benefits of and success factors for UIEC in relation to UIRC. This is followed by theories of knowledge spillover and spillin for innovation and theories of collaboration capabilities for educational collaboration and their development. The prior research and the theories and concepts form the overall theoretical foundation for the dissertation.

Several systematic literature reviews of published research on University-Industry Collaboration (UIC) have been published in the last five years (De Wit-de Vries et al., 2019; Rybnicek & Königsgruber, 2019; Sjöö & Hellström, 2019; Nsanzumuhire & Groot, 2020; Figueiredo & Ferreira, 2022). All of them, except Nsanzumuhire & Groot, 2020, focus explicitly or implicitly on research on University-Industry Research Collaboration (UIRC). That these recent literature reviews overlook University-Industry Educational Collaboration (UIEC) activities comes as no surprise, as discussed in the introduction. However, the reviewed research is still relevant regarding the benefits of UIEC to the main stakeholders of educational collaboration, i.e., students, teachers, and collaborating companies, as well as the success factors leading to the realization of the benefits. When conceptualizing and constructing the theoretical framework (Bruzelius, 2021, Gray, 2021), I have taken the point of departure in specific research (Thune 2011, Bengtsson, 2013; Nsanzumuhire & Groot, 2020; Borah et al., 2021; Zhuang & Shi, 2022) on UIEC that discuss the types of UIEC activities, the benefits of UIEC and the success factors involved. In particular, previous frameworks developed by Thune (2011), Bengtsson (2013), Thune & Støren (2015), Nsanzumuhire & Groot (2020) and Zhuang & Shi (2022) have been utilized.

Theoretical perspectives on UIEC have been lacking. To develop theoretical understanding I have used knowledge spillover, spillin and capability theoretical frameworks in order to build theory on UIEC. These frameworks on knowledge

spillover and spillins (Andersson, Quigley & Wilhelmson, 2004), and organizational capabilities for innovation purposes (De Wit-de Vries et al., 2019), have been used to develop theory on UIRC to throw light on the innovation knowledge flows between university and industry.

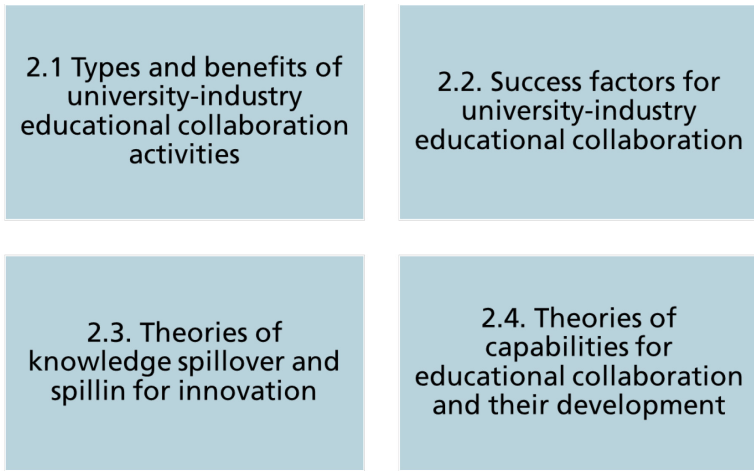

Figure 1: The overall theoretical framework for University-Industry Educational Collaboration

2.1. Types and benefits of University-Industry Educational Collaboration activities

The collaboration between universities and industry or organizations manifests itself in various forms. Some collaborative activities are formalized through formal agreements and contracts, while many are also informal, occurring between individual companies and specific university units and/or individual university employees (Thune, 2006; 2011). The pattern of collaboration activities is highly diverse and complex, varying depending on the country, region, type of university, and field of study (e.g., Goldstein 2010; Mora, Detmer, & Vieira, 2010; Nsanzumuhire & Groot, 2020; Zhuang & Shi, 2022; Zhuang et al., 2024).

A number of UIEC studies (Brandt et al., 2008; Næss et al., 2012; Thune, 2011; Thune & Støren, 2015) developed a typology of UIEC activities based on the intended impact or benefits of these activities:

1) Collaboration aimed at creating new or revising existing undergraduate and graduate *programs*. This primarily occurs through advisory committees, where

representatives from individual companies, industry organizations, trade unions, and other organizations can propose and provide input on the content, structure, timing and location of educational programs, teaching methods, examinations, and more.

2) Collaboration aimed at involvement in *teaching and learning processes*. This occurs primarily through guest lectures, investigative and developmental projects, theses, external supervision, internships, live case studies, and study visits.

3) Collaboration aimed at facilitating the *transition* between studies and working life primarily occurs through internships, theses, mentorship, recruitment fairs, career counselling, and education. Universities often have specialized organizations, such as career centers, for recruitment, career-related issues, and associated services.

An interesting recent research study focusing on UIEC for creating new or revised higher educational programs is Fagrell's study (2020) on industry's role in updating and renewing Swedish engineering programs. In relation to Fagrell's study, this dissertation focusses on the two latter types: UIEC for involvement in teaching and learning processes and the transition between studies and working life. According to Nsanzumuhire & Groot (2020), previous studies on educational collaboration for involvement in teaching and learning processes are virtually non-existent. They identify only one prior publication, i.e., Kunttu (2017) on this type of educational collaboration. The type of collaboration related to the transition from studies to working life has received much more research interest, generally concerning internships, projects, and master's theses (e.g., Bramwell and Wolfe, 2008).

Collaboration aimed at involvement in teaching and learning processes are primarily in the forms of guest lectures, living cases and seminars, investigative and developmental projects, bachelor's, master's and doctoral theses, external supervision, internships, live case studies, and study industry visits (Asplund & Bjerke, 2008; Thune, 2011; Bengtsson, 2013; Kunttu, 2017). Collaborations aimed at facilitating the transition between studies and working life are usually performed through internships, theses, mentorship, recruitment fairs, career counselling, and in training of employability competencies (Bramwell & Wolfe, 2008; Thune, 2011; Bengtsson, 2013; Davey et al., 2018; Borah et al. 2021). Thus, there are considerable overlaps between the two educational collaboration mechanisms, as they both occur through similar educational forms such as internships and master's theses. In this study, I have focused on Student-Written Case studies (SWCs), including Student-Written Teaching Notes (SWTN), and master's theses. SWCs and SWTNs can be considered as an educational activity

that primarily intend to involve companies and organizations in the teaching and learning processes (Asplund & Bengtsson, 2002) and less on the transition to working life. Master's theses, as they are generally the final part of engineering education, or other higher education can be considered an educational activity that potentially could involve companies and organizations in teaching and learning as well as facilitating the transition to working life.

The potential benefits of these collaboration types are of different natures and vary for the involved stakeholders (Bramwell & Wolfe, 2008; Thune, 2011; Bengtsson, 2013; Kunttu, 2017; Davey et al., 2018; Borah et al., 2021). Benefits or impacts can be categorized based on the main stakeholders:

1) Benefits for companies: Primarily related to short- and long-term recruitment needs. Through educational collaboration, companies can connect directly with potential candidates for various tasks and positions. In the long term, companies can also directly and indirectly influence the directions and content of education to ensure a flow of students with competencies aligned with companies' current and future needs and wants. Furthermore, companies may be interested in knowledge transfer in certain areas, such as improving their current and future technologies, product- and process improvements, increasing innovation capabilities i.e., resources and processes, either through direct contact and/or recruitment of students or/and through contacts with specific teachers/departments and researchers/research groups.

2) Benefits for universities: Primarily related to the identity, image, and profile of the university, quality of the university's programs, and the possibilities to attract external funding. Educational collaboration can create an increased student demand and interest in the university's educational programs and courses, which, in turn, can be an argument for e.g. expansion, revamping of the curriculum and increased funding, including funding for research supporting educational programs.

3) Benefits for students: Primarily linked to the quality, relevance and rigor of education, engagement, extrinsic and intrinsic motivation for studies, and facilitating the transition from studies to working life, including the inclination towards personal or/and collective entrepreneurship. Could strengthen both generic skills (e.g., analytic, communication, interpersonal, oral and written presentation) and domain-specific skills (e.g., skills related to the domain of their education such as technical skills).

4) Benefits for teachers: Primarily linked to development of teaching material such as authentic case material describing problem situations to be solved or examples of solutions and practices. Better knowledge of contemporary industry and public organizations ways of working and their challenges which may provide early-warnings for obsolete or outdated teaching material.

2.2. Success factors for University-Industry Educational Collaboration

What then will determine the success and realization of benefits for different stakeholders involved in UIEC? Five types of conditions or factors have been identified as potential success (or failure) factors for the realization of the above-mentioned benefits (Thune, 2011; Bengtsson, 2013; Davey et al., 2018; Rybnicek & Königsgruber, 2019; Zhuang & Shi, 2022). These factors are environmental, contextual, organizational, process and output factors. These identified factors (figure 2) function separately and together as a complex adaptive system (Edgren & Barnard, 2012, Johansson, 1988) e.g., a change in one factor can alter another.

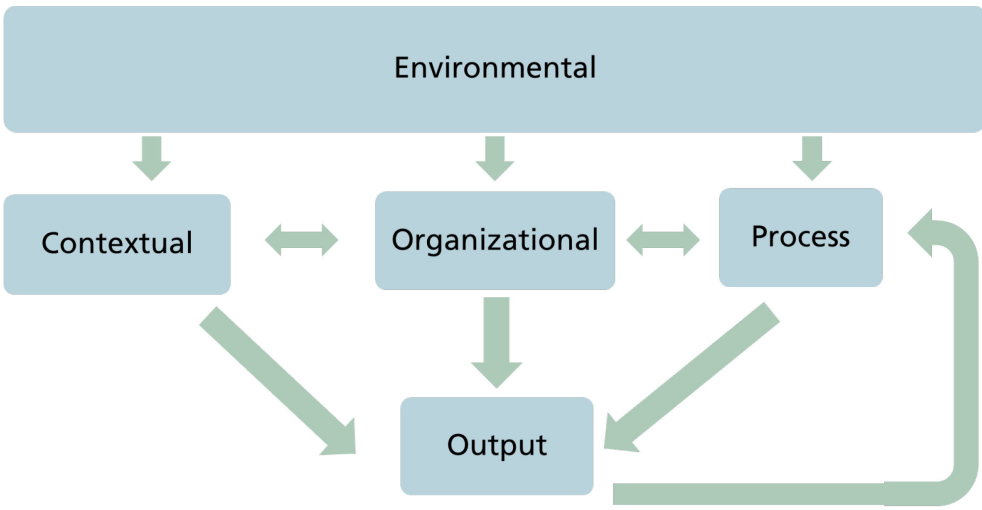

Figure 2 Five success factors for University-Industry Educational Collaboration.

Environmental factors related to educational collaboration are governmental support, legal regulations, and the market environment (Bengtsson, 2013; Rybnicek & Königsgruber, 2019). Government funding, tax incentives and policy intent may create beneficial conditions for the formation and expansion of collaborative activities (Bengtsson, 2013; Rybnicek & Königsgruber, 2019; Zhuang et al., 2024). Intellectual property rights, such as university ownership or university inventorship systems (Bengtsson, 2017), might create challenges for collaborations. The market demand for students with certain educations might create shifting interest in collaboration activities (Bengtsson, 2013).

Contextual factors consist of the choice of collaboration partners and geographical proximity. In UIRC (e.g., Rybnicek & Königsgruber, 2019; Sjöö & Hellström, 2019), it is common for success in collaboration to be associated with previous collaboration partners that have prior collaboration experience, complementary competencies, and shared objectives.

Geographical proximity is also a success factor in UIRC (Fernandes & Ferreira, 2013; Rybnicek & Königsgruber, 2019) but seems to be even more important in UIEC than in UIRC (Thune, 2011). Contextual factors such as size of university, type of discipline, private or public university, level of industrial embeddedness and level of research intensity might support or hinder collaborative formation and outcomes (Borah et al., 2021).

In addition, companies' and managers' absorptive capacity, i.e., their ability to deeper understand and utilize university-educated students, is crucial for the quality of collaboration (Thune, 2011). The company must possess a similar level of expertise and competence to the university to achieve effective outcomes in educational collaboration. Generally, SMEs have less absorptive capacity than larger companies (Bramwell and Wolfe, 2008). This limitation for SMEs also seems to apply in UIRC as it is dominated by large firms (Laursen & Salter 2004). Generally, SMEs suffer from liability of smallness (Aldrich & Auster, 1986), i.e., their limited size creates difficulties accessing and retaining resources.

Organizational factors: success factors also lie in the organization of collaboration. The formalization of a collaboration project is a success factor, meaning that there are formal agreements, an organization structure (boundary-spanning functions and intermediaries), allocated resources for collaboration, and a full commitment from the management of the company or public organization in both UIEC and UIRC (Gulbrandsen & Larsen, 2000; Mora-Valentin et al., 2004; Thune, 2011; De Wit-de Vries, et al., 2019; Rybnicek & Königsgruber, 2019; Sjöö & Hellström, 2019; Zhuang & Shi, 2022).

Furthermore, it is crucial to have commitment from several key individuals (i.e.stakeholders) and teams/departments involved in the collaboration, and not to have the success of collaboration dependent only on individual key persons (Rybnicek & Königsgruber, 2019). In addition, resource availability is key, meaning that collaboration projects are allocated sufficient human, technological and financial resources that allow for development opportunities (Mora-Valentin et al., 2004; Sjöö & Hellström, 2019; Zhuang et al., 2024). Regarding resource availability, in UIRC, different forms of Intellectual Property Rights (IPR), mainly patents, are an important resource (Rybnicek & Königsgruber, 2019; Granstrand, 2020). IPR, in the form of

patents, seems be a minor issue in UIEC. Instead, it is important to agree on a code of conduct and protection of each other's interests when collaborating (Zhuang & Shi, 2022).

Process factors – this is the fourth group of success factors. These include effective project management of collaborations, including establishing common goals, objectives and expectations, developing operational project planning including activities, and monitoring and assessing project development and fulfilment. Dedicated, competent and experienced project managers and teams are often a vital part of successful collaborative projects in UIRC (Barnes et al., 2002; Butcher & Jeffrey, 2007; Sjöö & Hellström, 2019) as in UIEC (Bramwell & Wolfe, 2008). Good communication skills are another key success factor (Mora-Valentin et al., 2004; Butcher & Jeffrey, 2007; Lewis, 2018; De Wit-de Vries et al., 2019; Zhuang & Shi, 2022), leading to better mutual understanding and reducing various forms of uncertainties during the project collaboration period. Another process factor is social and cultural competence (Bramwell & Wolfe, 2008; De Wit-de Vries et al., 2019; Rybnicek & Königsgruber, 2019; Sjöö & Hellström, 2019) between the stakeholders, as well as mutual respect and commitment between the collaborating parties. Social capabilities and cultural competence (Schein, E, 2017); Lewis, 2018) often take a long time to build up.

Output factors are the last category of success factors, i.e., the type and level of output associated with University-Industry Collaboration (Rybnicek & Königsgruber, 2019). Outputs meeting the objectives will be decisive for the continuation (or termination) of the collaboration, at least in the long run (Rybnicek & Königsgruber, 2019; Larsson et al., 1998). Effective knowledge and technology transfer is also important for University-Industry Collaboration in UIEC (Bramwell & Wolfe 2008; Zhuang et al., 2024).

Research on successful collaboration is often based on subjective assessments and measures from involved parties (Barnes, Pashby & Gibbons, 2002; Hansen & Nohria, 2004; Mora-Valentin et al., 2004) and to a lesser extent on various objective measures of success. The most common objective performance measure used in research is "continuity in collaboration," meaning that the stakeholders continue to collaborate (Bouty, 2000; Mora-Valentin et al., 2004). Thune & Støren (2015) have investigated outcomes of various UIEC activities such as study effects (e.g., completed studies on time) and employment after graduation. They note that studies on learning benefits for students from UIEC activities are rare in research. Overall, UIRC is expected to generate outcomes such as R&D results, patents, spin-offs, products, and process innovations as well as continued R&D projects (Fernandes & Ferreira, 2013; Sjöö & Hellström, 2019). UIEC, as presented above, is expected to have three general outcomes, or impacts for universities, students, and teachers: i.e., new, or revised study

programs, new teaching methods/materials and learning effects for students and facilitating effects for students' transitions to work life. Prior research on UIEC describes mainly two types of outcomes for industry: recruitment of graduate students and knowledge transfer of innovation knowledge (Bramwell and Wolfe, 2008). It is important to remember that the outcomes of collaboration can be perceived quite differently by different stakeholders, depending on various expectations, cultural backgrounds, and previous experiences.

2.3. Theories of knowledge spillover and spillin for innovation

Educational collaboration activities, such as doctoral and master's theses and project work, are according to Bramwell & Wolfe (2008), often an underestimated part of knowledge spillovers and interactive learning between university and industry. *Knowledge spillover* (e.g., Audretsch & Feldman, 1996; Andersson, Quigley & Wilhelmson, 2004; Agarwal, Audretsch & Sarkar, 2010) means that companies and public organizations absorb knowledge from activities in the nearby university's research and development (R&D) and education and use them in their work processes as well as in innovation activities. Thus, knowledge spillover enables one organization to create knowledge, based on another organization's creation of knowledge without or with low compensation (Agarwal et al., 2010). The proximity to university R&D and education facilitates knowledge transfer from the university to the nearby (or sometimes distant) located companies and public organizations, i.e., knowledge spilling over from the university to companies and public organizations. Knowledge spillover from UIRC activities can occur through active collaboration activities, e.g., collaborative research projects or research partnerships, or passive collaborations forms, e.g., seminars, conferences, publications, or licensing of patents (Giovannetti & Piga, 2017; De Wit-de Vries et al. 2019). The knowledge spillover from educational activities is in prior research mostly described in active collaboration forms, such as engaging students in project work, master's thesis projects, internships, recruiting educated students, co-delivery of courses as well as informal contacts and discussions with teachers/researchers (Bramwell & Wolfe, 2008; Kunttu, 2017).

A less studied knowledge flow is *knowledge spillins*, i.e., learning that flows back to the knowledge-producing unit due to the collaboration activities with an external partner, such as new ventures by former employees that maintain contacts with their former employer (Kim & Steensma, 2017) or university patenting interacting with similar corporate patents (Moreira & Soares, 2020). Knowledge spillins to universities, or their students and teachers, in relation to UIEC activities with companies and organizations,

have not, to my knowledge, explicitly been addressed in prior research. However, earlier research on knowledge spillins, without explicitly using the term, has been reported related to more specific UIEC forms such as internships, and master's thesis projects, in the form of new course material, co-delivery of courses, mentoring of students, and improved domain-specific and generic competencies for students (e.g., Bramwell & Wolfe, 2008; Kunttu, 2017; Borah et al., 2021; Zhuang et al., 2024).

In line with the literature review by Nsanzumuhire & Groot (2021), I have found a limited number of prior studies that investigate both knowledge spillovers and spillins from UIEC activities, i.e., three studies: Bramwell & Wolfe (2008), Lucia et al. (2012), and Kunttu (2017). Another two studies have focused only on spillins (Borah et al., 2021; Zhuang et al., 2024).

Table 2.1. Studies of knowledge spillovers and spillins in UIEC

Study	Knowledge spillovers	Knowledge spillins
Bramwell and Wolfe (2008) Co-op programs at University of Waterloo, internships and thesis work	- Opportunity to evaluate students performance in the workplace before hiring them - Students transfer new knowledge and skills, which means, among other things, that they educate employees in certain areas, such as qualified use of ICT	- Students returning to class after internships are highly focused on applied technical problems they have been working on, which influences the way faculty present new material in their classes. - Students as "early warning system" that keep teachers abreast of major pending technical advances
Lucia et al. (2012) Case study of large firm (Bosch and Siemens Home Appliance Group – BSH) collaborates with the University of Zaragoza on induction heating technology in both research and education	- Source of creative ideas and a well-trained, new workforce	- Lectures, additional real examples, hands-on sessions developed concerning induction heating - Extended theoretical knowledge on resonant power conversion and induction heating - Improved practical and communication skills - Improved groupwork skills - Closer industry knowledge
Kunttu (2017) Nine case studies of educational collaboration activities, master's thesis projects, other student projects and tailored degree courses	- Recruitment of graduates - New research-based ideas and insights - Insights into customer behavior	- Real world examples - Gaining industry knowledge in certain research areas
Borah et al. (2021) Large scale survey of Indian universities, impact on graduates' employability competencies		- Domain-specific technical competencies - Generic skills in language, language and quantitative techniques
Zhuang et al. (2024) Case studies of 22 teaching-focused UIC in China.		- Bringing in authentic industrial cases and collaborative teaching - Contextualizing and visualizing textbook knowledge - Co-designing courses - Providing student internships - Mentoring practice-oriented innovation and entrepreneurship contests

In the first three above-listed studies (Bramwell & Wolfe, 2008; Lucia et al., 2012; Kunttu, 2017), the opportunity to recruit engineering graduates, including having a good assessment of them during student projects/assignments or master's thesis projects, has been identified as a very important source of knowledge spillover in educational collaboration. Many companies and public organizations are trying to attract competent, talented students. Being involved in recruiting students during or at the end of their studies is the best way to access the knowledge they have accumulated during their education, or as Bramwell & Wolfe (2008:1180) put it: "The Best Tech Transfer is a Pair of Shoes".

State-of-the-art knowledge acquired at universities as well as creative ideas are also seen as important knowledge spillovers, regardless of future recruitment or not (Bramwell & Wolfe, 2008). Students may also act as "teachers/instructors" for management/employees in companies, teaching them state-of-the-art knowledge and practices such as in rapidly developing knowledge fields e.g., AI, programming, industrial design, technology strategy, block chains and so on.

Knowledge spillins to teachers mostly come in the form of development of courses and programs, course components and contents e.g., examinations formats and lecture materials such as technology and business cases (Lucia et al., 2012; Kunttu, 2017). For the students, knowledge spillins come in the form of a variety of practical generic skills and competences, including improved communication skills and groupwork skills (Lucia et al., 2012; Borah et al., 2021) as well as improved domain-specific competences and generic competencies (Borah et al., 2021; Zhuang et al., 2024). Overall, the insights into practical technology and/or related innovation work and getting real practical examples of development work are important knowledge spillins for both students and teachers (Kunttu, 2017; Borah et al., 2021; Zhuang et al., 2024).

Knowledge spillover studies mostly describe the knowledge spilled over to industry as to be used for innovation purposes (e.g., Audretsch & Feldman, 1996; Agarwal, et al., 2010), often on an aggregated level such as the region. Prior UIEC research has, to my knowledge, not made any attempts to find out in more detail what the knowledge spilled over is used for by industry. In line with prior UIRC research, I would hypothesize that, especially master's thesis projects, will be used in companies' incremental development and innovation processes. Innovation is here defined according to the OECD-definition (OECD, 2005), consisting of implemented product, process, marketing, and organizational innovations. The innovation process is, in the innovation management literature, generally described in a linear fashion, with stages such as creating options, selecting innovation projects, development of project, capturing value, building capabilities and learning (Dodgson, Gann, & Phillips, 2013). In line with this literature and to make a more fine-grained understanding of how the

spilled over innovation knowledge has been used, I have chosen the well-known stage-gate process (Cooper, 2008), i.e., the stages of screening new technologies, scoping new technologies, developing a business concept, developing prototypes, testing and validating of prototypes, and commercialization.

2.4. Theories of capabilities for educational collaboration and their development

Knowledge spillover and spillin research seldom discuss the causal mechanisms of the knowledge spill process, i.e., how knowledge is transferred from one organizational unit to another and the conditions affecting this transfer process (Agarwal et al., 2010; De Wit-de Vries et al., 2019). However, the success factors for UIEC presented above, indicate that there are many factors that will affect if the knowledge spilled over, or in, will be absorbed and used by the collaborating partners. The context factor highlights the importance of selecting a collaboration partner with similar or complementary objectives and knowledge backgrounds, preferably in geographical proximity. The organizational factor highlights the importance of having formal structures and routines for the collaboration, as well as available resources and commitment from management and teachers. The process factors highlight the importance of dedicated project managers and good project management, as well as good communication skills in a respectful and trusting collaboration.

Thus, the collaborating partners (i.e. stakeholders) need to develop the corresponding capabilities to these factors to successfully create and perform UIEC. The corresponding capabilities include networking capabilities (Kazadi et al, 2016; Edgren & Skärvad, 2014), relational capabilities (van Lancker et al., 2016), and desorptive capabilities (Behnam et al., 2018). *Networking capabilities* involve the ability to attract and involve external stakeholders in the organization's projects. *Relational capabilities* relates to managing relationships with external stakeholders to form and sustain partnerships (Edgren & Skärvad, 2014) and to build innovation network. *Desorptive capabilities* involve selecting, engaging, and aligning internal stakeholders with external stakeholders in organizational projects.

Organizational capabilities are not developed overnight; i.e., they need to be identified, practiced, learned from, modified, practiced again, learned from, and changed again in an iterative process. Research on capability development conceptualizes this as capability life cycles (Helfat & Peteraf, 2003), a dynamic iteration of the resource-based and capability theories of the firm (Barney, 1991; Teece, 2007). The concept of

capability life cycles posits that firm's capabilities undergo development and erosion over time (Helfat & Peteraf, 2003). In this context, strengths or weaknesses in university or company capabilities may either facilitate or impede the adoption of educational collaboration, thereby influencing the potential for innovation knowledge spillover and spillin (cf. Helfat & Peteraf, 2003).

Based on Helfat and Peteraf's (2003) concept of capability life cycles, it is possible to conceptualize a trajectory of capability development for a university department or a company or public organization. The founding phase of a capability commences when individuals, such as teachers, organize to establish a capability aimed at achieving a specific objective. This could be e.g. developing a capacity for co-delivering courses with industry partners to contextualize textbook knowledge and enhance students' domain-specific skills in work-life context. During the initial development stage, the team of teachers gradually refines and scales up the capability, creating supporting elements such as information for managers and students, education of managers, schedules, routines, checklists, and follow-up procedures.

The further trajectory of capability development is influenced by various external- and internal factors. *External factors* may include shifts in student demand for study programs and courses, advancements in communication technologies, and governmental policies (cf. Helfat & Peteraf, 2003). *Internal factors*, e,g. managerial decisions, such as an increased emphasis on co-delivering the curriculum, can also impact capability development (cf. Helfat & Peteraf, 2003). When a factor gains sufficient strength, capability branching may occur, resulting in the transformation of the capability. These branches represent different paths of capability transformation, categorized into factors threatening obsolescence and those creating opportunities for change and development (Helfat & Peteraf, 2003). Factors threatening obsolescence may prompt managers to retire or retrench the capability, while factors creating opportunities for change and development may lead to the renewal, replication, redeployment, and/or recombination of capabilities (Helfat & Peteraf, 2003).

The amalgamation of capability life cycles with educational collaboration capabilities provides a theoretical basis for conceptualizing a stage-based model of UIEC. This framework facilitates an enhanced understanding of why and how knowledge is transferred from universities to industries and public organizations.

Chapter 3

Research Design and Practical Method

This chapter describes the research design as well as the research process, i.e., a mixed methods approach. The practical data collection methods (e.g., surveys, case studies) that have been applied in the different papers will briefly be presented. More details are found in the appended papers.

Research phase	1	2	3
Paper	1-2	3-4	5
Perspective	Insider: Being both teacher and researcher	Outsider: Researcher	Combined inside and outside: Researcher and teacher
Method	Qualitative & Quantitative	Qualitative & Quantitative	Conceptual & Qualitative
Data collection	Literature reviews, surveys, interviews, case workshops	Surveys, interviews and statistical analysis	Literature reviews and case studies

Figure 3 Overview of the Research Process.

3.1. Research approach – A mixed methods approach

While not planned from the start of the research process (see next section) this dissertation uses a mixed methods approach, i.e., it has used qualitative, quantitative, and conceptual methods to research the success factors and benefits of UIEC. Moreover, it combines nomothetic and idiographic methodologies (Luthans & Davies, 1982; Bengtsson, Elg & Lind, 1997; Skärvad & Lundahl, 2016), by employing both qualitative and quantitative methods as well as an insider and outsider view on the phenomenon of UIEC. The first phase of studies, reported in papers 1 and 2, started as qualitative studies with an insider view, inspired by action inquiry or action research methods (e.g., Tripp, 2005). This phase explored the workings and benefits of involving companies in Student-Written Cases (SWC) and teaching notes (i.e., instructor guides). As is typical for action research in education (Tripp, 2005), the aim

was to improve teaching practice by involving companies in SWCs, and in the process carefully document the different stages of the process.

The first phase of the studies was inspired by action inquiry methods (Tripp, 2005), i.e., a research process that aims to improve practice.

> Action Inquiry is a generic term for any process that follows a cycle in which one improves practice by systematically oscillating between taking action in the field of practice and inquiring into it. One plans, implements, describes, and evaluates an improving change to one's practice, learning more about both the practice and action inquiry in the process. (Tripp, 2005:2)

In education and teaching, action inquiry methods, often called action research methods (Heikkinen, Kakkori & Huttunen, 2001), are commonly used to improve educational and teaching practices. But any improvement, change or professional development process usually follows an action inquiry process, i.e., to plan the change or improvement, to implement the change or improvement, to describe the effects of the change or improvement, and then to evaluate the effects of the change and improvement, and iterate if necessary (Tripp, 2005). It is also key, in the research project, to problemize (Skärvad & Lundahl, 2016) in order to describe, understand and explain both the theoretical and the practical problem

> .. important to problemize e.g. twist and turn the problem, setting it in its theoretical context and identify the theoretical problem. It is also important to know the current state of the knowledge accumulation is, i.e. what is known about the research area, and to sketch out the theoretical framework (Skärvad & Lundahl, 2016:21)

In many of these research projects the teacher and the researcher are the same person: this creates opportunities and challenges which I will comment on in section 3.6. — My role as researcher.

As mentioned in the previous chapter, industry's involvement in teaching and learning is a particularly ill-researched area, with few previous empirical studies (Bramwell & Wolfe, 2008; Lucia et al. 2012; Kunttu, 2017) Thus, an initial explorative approach using an idiographic, qualitative, and action inquiry-inspired method was considered appropriate. However, the research related to the transition from studies to work life is much better researched (e.g., Thune & Støren, 2015), especially qualitative studies related to internships and project work (e.g., Bramwell & Wolfe, 2008). Here there was a lack of more systematic and larger empirical studies, especially the specific form of master theses. Thus, a quantitative study from an outside view was designed to survey master theses in engineering, and to survey the students and collaborating companies

to validate some of the claims in previous research on transition and knowledge spillover and spillin benefits (Bramwell & Wolfe, 2008; Thune & Støren, 2015). To develop a more holistic understanding of the success factors of the phenomena of UIEC, I did a final conceptual study, in paper 5, reflecting (Bruzelius, 2021); Gray, 2021) on how the success factors of UIEC can be developed and institutionalized into a university department that develops UIEC in their activities and organization.

3.2. Background and early inspiration

Since the beginning of my doctoral studies at Lund University, I have had a perspective on research "as a genuine learning process" (Normann, 1977). I saw the outcome in gaining new value, knowledge and knowledge production (Normann, 2001; Wikström, 1992) as a development of a unique "language" (Normann, 1977, 1986, 2001; Kolb, 1984; Morgan, 2006) to describe, understand and explain a phenomenon. I did not use the concept of the idiographic research approach (Luthans and Davis, 1982) for my understanding of research back then. In hindsight, the idiographic research approach summarizes my view on research at the time. In the beginning of the research process, I did not know that collaboration between academy and industry was to become the focus of my future research interest. I started in the research field of organization culture and symbolism (Alvesson & Berg, 2011). I formed together with Professor Per-Olof Berg (School of Economics and Management, Lund University) and other international scholars the organization and conference platform SCOS (Standing Conference on Organizational Symbolism and Culture). Then in 2001, I started to collaborate with Professor Björn Bjerke (who had vast experience both as an academic and as an international academic entrepreneur) who worked at the department of Technology and Economy at Malmö College (later Malmö University). Our mutual interest lay in developing the research and empirical insights about the phenomena of "Social Entrepreneurship and Public entrepreneurship". We together formed a research group consisting of both practitioners and researchers. Through theoretical conceptual studies, case studies, and cases, as well as developing frameworks, we pursued this emerging phenomenon (Bjerke, Hjorth, Larsson, & Asplund, 2007). Bjerke and I identified, presented and tested these newly developed frameworks, concepts, case studies and cases in an international research group called PEER (Pan European Entrepreneurial Research) at Paris-Dauphine University. The collaboration with Björn Bjerke and international colleagues in various research projects (e.g. Asplund, C. J., Léger-Jarniou, C., & Tegtmeier, S. (2011) from e.g. France, Germany, England,

Finland, Poland have had and continue to have a great impact on my development as a researcher.

Looking back into the various ideas, ventures, and projects I ventured into/initiated/collaborated, the phenomenon and focus of collaboration becomes very clear when viewed in retrospect. It's been a sort of common thread in my research.

Before the founding of Malmö University College (later to become Malmö University) in 1998, I acted as one of eight investigators tasked with suggesting and developing courses and research areas in the planned faculty for Technology and Economy (Teknik och Ekonomi). I worked in close collaboration with the management (Associate professors Lars-Göran Pärletun and Anders Petterson) and the other seven investigators of the university college as well as with local and international companies and public organizations.

In 1998, still at Malmö University College, I developed, with a fellow researcher and teacher (Alexanderson & Asplund, 2001) frameworks to investigate into the field of human capital (i.e. Human relations). We worked together with the students e.g. identifying and matching the learning content with the learning format. We called the format in class and online for "learning arenas". We were then (1999) researching into and teaching the subject of "Human Capital Theory". We were influenced by e.g. Kolb (1984) and his view on experimental learning and mainly the view that knowledge is an iterative transformation process that is continuously being created and recreated.

I also worked with clinical research at EFL (Executive Foundation, Lund, Sweden) which gave me in-depth insights into the knowledge and practice of companies, public organizations, its managers and human resources. For example, I facilitated the forming of multicompetent teams to address the actual needs and wants of the company clients more effectively. I also learned from this experience the value of starting "where the client is, not where you are" and to develop insights regarding the mindsets of managers.

3.3. First phase of studies

In 2001, on request from the Programme Dean Professor Jan Holst and the department of Industrial Management and Logistics , I developed a new master's level course "Technology Strategies" at the Faculty of Engineering, Lund University (Lunds

Tekniska Högskola – LTH)[1] for the master's degree specialisation and programme "Enterprise and market development" later renamed as "Business and Innovation", for the new LTH engineering program "Industrial Engineering and Management".

I also participated actively in the development of the whole new engineering program in Industrial Engineering and Management (Industriell Ekonomi) at LTH with Professor Jan Holst, Professor Sven Axsäter, Professor Sten Wandel and the student representative Paul Björnsson. We, in this ad-hoc development group, all represented different key research and teaching areas that were valuable to the new engineering programme. This field of Industrial Engineering and Management was later further developed and refined into a full master's specialization "Business and Innovation" together with a collaborative team consisting of Ola Alexanderson, Ingela Elofsson, Bertil Nilsson and myself at the department of Industrial Management and Logistics, LTH.

Together with the researcher (Lars Bengtsson) that I had previously worked with for many years at the Lund School of Economics and Management, we searched for and investigated innovative ways of how to achieve deep learning instead of surface learning (Marton et al., 2005) in the newly developed Technology Strategies course with the specialization of Business and Innovation. In the process of developing this course I met Associate Professor Bengt Kjellén (Kjellén et al.,1994), Stockholm University, Professor Hans Klein (Director of WACRA: The World Association for Case Method Research & Application), Professor James Erskine Ivy School of Business, University of Western Ontario, Canada, and Professor Louis B. "By" Barnes from Harvard Business School, Boston. They all, in different ways, articulated, voiced, promoted the use and application of the case method. Professor James (Jim) Erskine was especially important in this journey and learning about the case method and its applications. He is one of the world's leading authorities on case teaching and case construction at Ivy School of Business, Ontario, Canada. Jim Erskine regularly organized workshops for university teachers on case teaching and case construction based on his books (Erskine, Leenders & Mauffette-Leenders, 1981; Erskine & Leenders, 1989). Lars Bengtsson and I attended several of these case workshops. (I also co-hosted a case workshop together with Professor Erskine at the Faculty of Engineering). These workshops presented the case method as an interesting and proven learning vehicle and method to challenge and train students, managers, and other stakeholders, to achieve deep learnings by using real cases e.g. technological and business challenges, encountered by managers in companies and organizations.

[1] The acronym LTH (Lunds Tekniska Högskola) is used in the text for the Faculty of Engineering at Lund University, Sweden.

The collaboration with Lars Bengtsson, in conjunction with my earlier interest (Asplund & Johansson, 1995) in letting the students write their own cases, sparked our mutual interest in developing and applying the case method in a new format, i.e., the Student-Written Case method (SWC), followed by the Student-Written Teaching Note (SWTN). The teaching note or instructor's guide served as a pedagogical tool of how to both analyze and apply the case in practice. We realized that *both* were needed (i.e., case and teaching note) to achieve more in-depth knowledge and competence for all stakeholders: students, managers, university, and companies. We saw this combination (i.e. SWC and SWTN) as a complete learning- and assessment vehicle. This first phase of my research studies is reported in papers 1 and 2.

These first studies were inspired by action research (e.g., Tripp, 2005) i.e., we were both (I and my co-author Lars Bengtsson) involved as teachers and researchers at the same time. This involved being Head of Course, teacher on the course, and at the same researching into and studying how the SWC method and SWTN worked for us as teachers, as well for the students and managers at the relevant companies. Students' oral and written course evaluations, interviews with company managers and our own reflections after the course constituted the empirical material that we based our research on. Papers 1 and 2 were reviewed, presented, and discussed with academic colleagues at the World Association for Case Method Research & Application's (WACRA) annual conferences (in 2006 and 2010) and then subsequently submitted, peer-reviewed, revised and published in their journal (Bengtsson & Asplund, 2008; Asplund, 2011). I also tutored master's students (Herrlander and Lundberg, 2008), who wanted to pursue and learn more in depth about combining technology and business using the case method as a vehicle. The case method the master's students applied and tested was developed with a fellow researcher from National Louis University in Chicago, USA and me (Asplund & Jordan, 2006). We called this integrated case- and learning vehicle/method: The Multidiscipline case method. This master's thesis was conducted in close collaboration with the company Gambro, Lund, and its managers from several departments. The produced case, teaching notes including solutions and learnings for both academy and companies were codified in their master's thesis (Herrlander and Lundberg, 2008). This application and testing provided both the students, company and me a lot of new insights into the learnings from using cases in both academy and industry.

3.4. Second phase of studies

The findings from the first phase of studies on the SWC and SWTN confirmed that involving companies in courses and teaching and learning processes could have beneficial effects for all parties involved, i.e., students, teachers, and company managers, if the involvement was organized and managed effectively. Hence, papers 1 and 2 present detailed instructions of how to organize SWCs and SWTNs with a company or an public organization. However, the beneficial effects had only been studied in one particular master course, Technology strategies, for engineering students at LTH. The pressing question was if these beneficial effects could also be seen in other courses and for other study programs. If so, how would you organize and manage such educational collaborations, to reap the positive rewards?

In 2016 an opportunity arose that could give me insight into these questions. I got the opportunity to join a Vinnova-project (Vinnova, project number 2016-05266) led by my colleague Lars Bengtsson titled "Master's theses in collaboration with industry and organizations". The project investigated all completed MSc theses in 2016 at LTH, School of Economics and Management (LUSEM), the School of Social Work, and the Department of Communication and Media, all at Lund University. 1020 MSc theses were surveyed to investigate the incidence and character of collaboration qualities and quantities with industry and other (public or voluntary) organizations. In addition, questionnaires were sent out to engineering and business students as well as to involved companies and organizations to research various aspects of the MSc theses, as well as possible benefits for students and companies. The second phase of studies resulted in papers 3 and 4.

Paper 3 focused on the character of the MSc theses in terms of innovation support to companies, with a particular emphasis on the differences between large companies and Small- and Medium-sized Enterprises (SMEs), as well as how it enhanced and supported students with the transition to working life.

Paper 4 focused on the differences between the two faculties, LTH and LUSEM, at Lund University. The incidence of collaborative master's thesis projects is much higher at LTH (64 %) than LUSEM (7 %). The differences in purpose of the MSc theses, the academic norms and traditions, as well as facilitation or not for collaborative thesis projects explain much of the difference in incidence.

3.5. Third phase of study

Based on the earlier research (papers 1-4) and the success factors of UIEC summarized by Thune (2011), Bengtsson (2013) and Zhuang & Shi (2022) we decided to develop a conceptual dynamic model of UIEC, describing typical forms of activities, capabilities, processes, resources, and key success factors for each development stage. The model describes different stages of development and institutionalization of UIEC in a university department.

Some stages exhibited very limited institutionalization of UIEC activities, processes, structures, as a consequence of individual level capabilities (the distant stage). Some displayed advanced modes of institutionalization activities, processes, and structures due to more developed organizational capabilities to network, manage relations and align external and internal actors (the relational and interactive stages). As previous studies of SWCs and MSc theses had been focused on particular UIEC activities, this paper 5 propose a more systemic and holistic view of what a university department (and its management) would look like if it had a more or less developed UIEC capabilities.

3.6. My role as a researcher

As described above in section 3.1., I have been a member of the academic system for an extensive time, especially in two separate roles: as a teacher and as a researcher. Combining these roles while also keeping them apart has been of key importance in this dissertation project.

As a university teacher I have acquired the skillsets and competence of teaching at both basic bachelor's levels and advanced master's levels. I have also actively participated in ongoing teaching of competence development courses that have been offered and delivered by Lund University, Malmö University and SLU (the Swedish Agricultural University, campus at Alnarp). I have also, mainly at LTH, acquired the competence to develop and design programs as well as courses including courses in Technology Strategies, Industrial Management, and Business Organization. In short, I have over some 35 years, acquired the competence both to articulate and integrate the ontological (what to teach) as well as the didactical approaches (how to teach) in my teaching. This has given me a deep knowledge of learning processes in the higher education system, to better understand and address the needs of multiple stakeholders within universities

and in the collaborative context. This experience and knowledge enabled me to deliver the course curriculum on Technology Strategies that is the study context of the research presented in papers 1 and 2. Since 2003, I have also supervised some 80 MSc thesis projects at the Faculty of Engineering, almost all of them in collaboration with a company or an organization.

Before starting my dissertation project reported here, I participated in several different research projects. By working together with several research groups e.g. SCOS (Standing Conference on Organizational Symbolism) and the Kraft-research projects (Odenrick & Asplund, 2003), I acquired various skills to formulate, design, execute and evaluate research projects that gave me insights into the role of being a researcher.

The first phase of studies has been conducted from an inside perspective, as an insider, being both teacher and researcher. Doing inside research may, on the one hand, have its problems, such as confirmatory biases. On the other hand, it may also have its advantages (Alvesson, 2003; Brannick & Coghlan, 2007) or even be necessary (Melander, 2006) to get access to people, data, and knowledge. The deep knowledge of being a teacher, e.g., how to design and execute an academic course, and know what a master's thesis of good quality looks like, has been an advantage when designing collaborative activities, i.e., the SWCs in the Technology Strategies course, and when designing the master's thesis surveys. When interviewing managers about their experiences in relation to the SWCs, it was an advantage that I could interview experienced managers as an experienced teacher. If the same interview had been conducted by an outside person, with limited knowledge of teaching and the course in question, the interview would probably produce less valuable knowledge to help construct a pedagogical framework for SWCs.
While the dual role of teacher and researcher has enabled me to understand the "social world" of university teaching and education better than an outsider and given me access to data that would be hard for an outsider to access, it also has created problems with trustworthiness (Lincoln and Guba, 1985) of the research findings. My principal ways to increase trustworthiness in the research findings have been:

- to discuss and reflect on my findings with my co-author Lars Bengtsson, a partial outsider at the time of the SWC studies, but also a fellow teacher and researcher,
- to allow company respondents (in the studies reported in papers 1 and 2) to review and validate their responses,
- to present and discuss the findings in paper presentations at Swedish and international research conferences (e.g., the WACRA conference, Strategic

Management Society's annual conference, European Academy of Management's annual conference, Irish Academy of Management's annual conference)

- to respond to comments and questions in peer reviews in conjunction with conference paper acceptance processes and publication processes in research journals.

The details of how I have tried to deal with the issues of trustworthiness and authenticity (or validity and reliability if you will) will be described in the next section.

3.7. Trustworthiness

Idiographic and action inquiry-inspired methodologies are often criticised for being subjective and biased (Luthans and Davies, 1982). This is of course a criticism which often comes from researchers that prefer a nomothetic approach (cf. Bengtsson et al., 1997). However, in an idiographic, qualitative and action inquiry-inspired approach it is important that the research is trustworthy and authentic (Lincoln & Guba, 1985).

Trustworthiness consists of four criteria: credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). The credibility of findings has been established by following an action inquiry process and carefully documenting the steps of planning, implementation, monitoring, and evaluation in the studies of SWCs and SWTNs (papers 1 and 2). Moreover, the findings have been reported in papers 1 and 2 at conferences specifically focused on case teaching and case writing (WACRA-conferences in 2006 and 2010) as well as being peer-reviewed by experienced case teachers and researchers before being accepted for publication. Respondents in the studies, the participating company managers, reported in papers 1 and 2, have been given the opportunity to review their answers. The credibility of the MSc thesis study could be translated into the quantitative criteria of internal validity. As described in papers 3 and 4, all examined master's theses at LTH and LUSEM in 2016 were included in the survey. The proportion of collaborative MSc theses may vary somewhat over the years and across Swedish universities. However, the proportion of collaborative MSc theses at an engineering and business faculty has been confirmed by teachers at both Swedish and other Nordic universities and at conferences where previous versions of the papers have been presented (Nordic Academy of Management in 2018 and European Academy of Management in 2020). The company questionnaire was designed using prior research, especially Bramwell and Wolfe (2008). The response rates was 49 %. For more details see papers 3 and 4.

The transferability of the findings (equivalent to external validity in quantitative studies) is in qualitative studies generally low when it comes to statistical generalizability, but generally better when it comes to analytical generalizability (Yin, 2009). The results of papers 1 and 2, such as the model for teaching with SWCs in collaboration with companies is a good example of a finding that might be compared to other models of teaching with cases. The finding that companies respond with one of three collaboration strategies: obligation, relationship or intervention could be analytically compared to other models of collaboration strategies in UIEC. The transferability of the MSc thesis studies, papers 3 and 4, can be considered good when it comes to engineering and business studies in Sweden, as almost all higher education is state funded and regulated with regular national quality assessments (e.g., UKÄ, 2015). Transferability is also good for higher education in other Nordic countries with similar traditions of a master's thesis at the end of their educational program. The traditions are different in other European countries. In France, for example, the final component of master's level education is often an internship accompanied with a report.

As mentioned, the studies in this dissertation have been going on for a long time period, about 20 years. The first phase of studies started in the spring of 2002 and 2003 and continued until 2009. The second phase of studies were performed in 2017 and 2018. The long time period of studies may affect both credibility and transferability. Both higher education and educational collaboration have changed during this time, especially since the pandemic of Covid-19, in 2020-2022. Education and collaboration have become more digitalized using more remote forms of teaching and communication. New forms of teaching and communication have emerged such as distant teaching and guest lectures via software such as Zoom and Teams, webinars, pre-recorded videos and pods (Engzell & Norrman, 2023). Most of the administration is done in digital forms via various educational software and platforms. Most universities have developed online educational programs given wholly or partly in a remote fashion as well as massive open online courses. However, the ordinary educational programs, such as the 5-year civil engineering programs are still taught mainly in an off-line fashion even though the new educational technologies are used to complement the teaching by online guest lectures, webinars, meetings and coaching. Lund University and most other higher education institutions in Sweden and Europe that offer educational programs to young people between 18-25 years have declared that they will perform most of their teaching on campus.

All the studies in this dissertation are done before the pandemic and before most of this new educational software for online teaching were readily available and in common use. While this may affect the credibility and transferability of the studies and their findings,

I cannot find any reason why the findings should be irrelevant or obsolete in any major way.

Lincoln and Guba (1985) also mention dependability and confirmability as criteria for evaluating qualitative research. Dependability means having a well-ordered and documented whole research process so it could be checked by an outsider, Lincoln and Guba (1985) call it an auditor. The auditor should also have the objective to establish confirmability of the research, i.e., that the researcher has acted in good faith, not letting personal values or theoretical inclinations affect the research. To have a specific auditor in qualitative research projects is very unusual. The tradition is peer review by colleagues at seminars, conferences and in reviews for publication. As mentioned, the papers have been presented, discussed, and reviewed at various occasions, conferences and in peer review for publication. However, while not being a complete outsider or have the role as auditor, my co-author and fellow teacher and researcher, Lars Bengtsson, has partly performed a role that has checked the dependability and confirmability of my research findings.

Lars Bengtsson has been a professor at LTH in Industrial Engineering and Management since 2012. When we started our collaboration regarding SWCs he was an Associate Professor at LUSEM in Business Administration. He was a guest teacher in the Technology Strategies course for several years in the beginning of the 2000s. His role was to do a couple of guest lectures on the course, but he also helped with supervising some of the student groups in their case projects. Thus, the planning and execution of the SWC projects (except some supervision) were entirely my responsibility. I also performed all interviews with managers in the collaborating companies and documented them. After the course we jointly discussed and evaluated the quality of the SWCs and the interviews. I carried out an initial analysis of the interviews (Kvale & Brinkmann, 2014), using a thematic analysis method (Ryan & Bernard, 2003), and then we jointly discussed the analysis, arriving at findings we could agree on, as well as implications for the improvement of the teaching in the course, in the form of a model for teaching with SWCs.

In the MSc thesis study, Lars Bengtsson was the principal investigator in the Vinnova-sponsored project. My role was first to identify the population, i.e., all the MSc theses at LTH and LUSEM that had been examined in 2016. Then we divided up the work to categorize the MSc theses in collaborative and non-collaborative master's theses as well as to record the collaborating company and the company contact person. In some 30 master's theses we were in doubt if they should be categorized as a collaborative MSc thesis or not. Then we both read the MSc thesis, without revealing our own opinion, to determine the category. In all cases we concluded how to categorize the thesis. The questionnaire to the companies we constructed jointly. The statistical analysis was

performed by Lars Bengtsson, and we jointly wrote the papers including working out the discussion and implications of the findings.

In summary, Lars Bengtsson has been both a co-teacher, co-researcher, and co-author in these projects, but has also partly had an outside role, especially in the studies of SWCs and the teaching note (SWTN), checking the credibility, dependability, and confirmability of the studies.

Chapter 4

Appended Papers

Paper 1: Case writing projects in co-operation with companies and organizations – Bengtsson & Asplund (2008).

Paper 1 conducted a study on the implementation and evaluation of Student-Written Case (SWC) projects in collaboration with companies and organizations in a Technology Strategy course for engineering students at the master's level. The study aimed to explore the benefits of SWC projects for both the students and companies, as well as the challenges and dilemmas involved in the process. Unlike conventional teaching cases that are either developed by instructors or obtained from case clearing houses, SWC projects involved students and companies co-creating cases on topics that were relevant for the companies' technology introduction and strategy. The study drew on previous literature on case writing in education and designed the SWC projects accordingly.

The findings revealed that the companies that engaged closely with the students expressed high satisfaction with the SWC process and outcomes. A previous paper by Bengtsson and Asplund (2002) focused on the main benefits for the students, while this paper examined the benefits for the participating companies and managers. The benefits included enhancing public reputation, supporting higher education, receiving a third-party analysis, having a free opportunity to observe potential future employees, and maintaining good relations with higher education institutions.

We conducted a qualitative analysis of the companies' degree of engagement in the case writing process and identified three levels: obligation, relationship, and intervention. At the obligation level, the main challenge was the lack of genuine motivation among the managers and/or the organizations to participate in the collaborative project. Our findings indicated that providing more and better information about the SWCs did not increase their involvement or interest. Therefore, we suggest that the teachers

should improve its selection and preparation (i.e., information and education) of potential partners for this type of educational collaboration.

At the relationship level, the companies were motivated to collaborate but mainly valued the case writing projects as a means to enhance their relationship with the university. These companies could benefit from receiving more and richer information about the case projects from both faculty and students. The third level was intervention, where the companies recognized and exploited the full value of the case projects as a learning opportunity and a strategic tool. These companies were able to manage and organize the case projects internally to maximize their outcomes.

The main contributions of this paper are a) an evaluated and tested framework for working with companies in developing and using SWCs and, b) a typology of companies' engagement levels and corresponding benefits (values) for managers and organizations.

Paper 2: Orchestrating case learning: On the key importance of the teaching note – Asplund (2011).

This paper had three objectives. The first one was to describe the design, development, and implementation of the Student-Written Case (SWC) process in a master's course at LTH, Lund University. The second one was to assess the role, design, and function of the Student-Written Teaching Note (SWTN) in relation to the SWC. The third objective was to report the main findings from applying the SWTN in both academic and industrial settings. Previous research on the use and outcomes of the SWTN or SWC projects in university education was scarce. The SWTN framework that was developed and distributed at the beginning of the Technology Strategies course enabled the master's students to acquire a comprehensive and detailed understanding as well as a framework for how to approach, manage and work throughout the construction process. The master's students also learned about case learning methodology, which gave them a clear framework for how to design and facilitate the learning situation and experience for the different stakeholders, i.e., university and industry.

The research contributions indicated that the combined SWC and SWTN learning framework supported the students in a beneficial way when 1) writing and developing their technological cases. The SWTN framework also 2) enhanced and improved the communication of the case construction challenge for the participating managers and their companies and the case team. The SWTN framework also 3) significantly improved the final learning outcomes regarding understanding technology strategies.

Students were strongly advised to begin the case writing process by thinking about the teaching note, before starting any case writing.

This paper provides an evaluated and tested learning framework for universities (students and faculty) working with companies in creating and using both SWCs and SWTNs.

Paper 3: Knowledge spillover from MSc Theses in engineering education in Sweden – Asplund & Bengtsson (2020).

This paper aimed to investigate the extent and nature of master's theses collaborations between students and external organizations (such as firms, public institutions, non-governmental organizations, or communities) in business and engineering faculties. The research questions addressed were:

- What kinds of organizations participate in master's theses collaborations?
- How do master's theses collaborations facilitate the recruitment of new graduates?
- What types of knowledge are transferred from students to organizations during the master's thesis projects?
- How do knowledge spillovers from master's theses differ across business and engineering faculties?

The motivation for this study was the scarcity of systematic research on University-Industry Educational Collaboration (UIEC), especially regarding the knowledge spillovers from business and engineering students' master's theses to industry. The study was based on an analysis of 529 MSc theses completed at Lund University's Faculty of Engineering (LTH) in 2016, which revealed that MSc theses were a common mechanism for UIEC in engineering education.

The main findings were that collaborating organizations benefited primarily from recruiting students and acquiring technological knowledge. Moreover, the study found that most of the collaborating organizations were large firms located in the region, and that the knowledge spillovers to industry were mainly related to product innovations and occurred in the early stages of the innovation process. The paper also discussed the

implications of these findings for university policies and practices, and suggested ways to enhance the involvement of SMEs in UIEC activities with engineering students.

Research contributions include confirmation of earlier research conducted by Bramwell and Wolfe (2008) regarding the benefits (e.g., recruitment of students and transfer of knowledge) of master's thesis projects, as well as the dominance of regional diffusion of knowledge. The dominance of large firms in educational collaboration is a new result. A further finding was SMEs' thesis projects being significantly more focused on product innovations, prototype development and testing, while large firms' thesis projects focus significantly more on the screening of new technologies.

Paper 4: Ivory tower or collaborative innovation platform? – Comparing MSc theses in engineering and business education – Bengtsson & Asplund (2024).

The purpose of paper 4 was to empirically investigate and compare the size and patterns of UIEC activities between the two major faculties in most universities: the engineering school and the business school. We did this by comparing MSc theses from an engineering school with MSc theses from a business school within the same university, Lund University, Sweden.

The findings include that MSc theses are a frequently used collaboration mechanism between university and industry in engineering education but are very limited in business education.

Collaborating firms in engineering benefit mainly by recruiting students and by the transfer of technological knowledge. While collaborating firms in business benefit mainly by maintaining contact with the school.

This research contributes to showing the limited activity in UIEC for business schools, observed earlier in the UIRC-related research, increasing our understanding of the limited impact and knowledge spillover effects on regional development from social sciences.

The paper also presents a number of university suggestions including activities that could support business schools to involve themselves more in MSc educational collaboration.

An earlier version of the paper was accepted to and presented at the European Academy of Management's annual conference (EURAM) in 2020. The revised version of the

paper has been submitted for peer-review and possible publication in the Journal of Praxis in Higher Education.

Paper 5: Three stages of University-Industry Educational Collaboration – Asplund & Bengtsson (2024).

This paper is a conceptual study, using theories of stage-based development and life cycle capabilities, to create a model of stage-based development of educational collaboration viewed from the university department perspective. The model identifies three development stages: distant, relational, and interactive stages of educational collaboration with corresponding typical capabilities, activities, structures, potential effects, and success factors. To progress from one stage to another, the department needs to develop new or more advanced capabilities, i.e., networking, relational and desorptive capabilities.

The key contribution in the paper is a model of UIEC stages viewed from the perspective of the university department. The model specifies the corresponding capabilities, typical educational activities, resources, potential effects, and key success factors for each stage.

The model implies that knowledge flows between the university and industry do not spillover or spillin for free. The transfer of knowledge requires the development of relevant collaboration capabilities, which takes time and effort from the university department.

Submitted to the Journal of Industry and Higher education for review. An earlier version of the paper was accepted and presented at the *Irish Academy of Management* 2015, Galway.

Chapter 5.

Discussion of Findings and Practical Implications

In the introduction chapter, I referred to the background of the potential to expand University-Industry Educational Collaboration (UIEC) activities and the limited attention to and prior research on UIEC. Therefore, the research purpose of this dissertation is to increase both the empirical and theoretical knowledge on UIEC. In particular, this dissertation intends to make research contributions regarding the benefits of UIEC activities to the main stakeholders in educational collaboration, i.e., students, teachers/faculty, universities and collaborating managers in companies and organizations, and success factors leading to the realization of the benefits of educational collaboration.

This is done by answering the overarching research question:

- What are the benefits of university-industry educational collaboration and how can university-industry educational collaboration succeed?

The chapter starts with a summary of significant findings of the studies reported in the appended papers 1-5. This is followed by a discussion of the significant findings from the perspectives of prior research and the theoretical framework. The chapter ends with discussing implications related to the significant findings for the main stakeholders in UIEC, i.e., universities, teachers/faculty, students, and managers in companies and organizations.

5.1 Summary of the significant findings

In chapter three I differentiated between three types of UIECs following Thune's (2011) categorization: 1) Collaboration aimed at creating new or revising existing undergraduate programs, 2) Collaboration aimed at involvement in teaching and learning processes, and 3) Collaboration aimed at facilitating the transition between

studies and working life. The studies in this dissertation relate to type 2 *involvement* in teaching and learning, and type 3) the *transition* between studies and working life.

There is some overlap between these two types of UIEC and the studies reported in papers 1-4, but mainly papers 1 and 2 focus on the involvement in teaching; papers 3 and 4 focus on the transition between studies and working life. Paper 5 is a conceptual reflective paper and is mainly concerned with the capability development of university-industry educational collaboration, as described in three stages. Thus, the significant findings could be summarized as indicated below in table 5.1.

Table 5.1. Summary of significant findings in appended papers.

RQ/Paper	Paper 1-2	Paper 3-4	Paper 5
1) What are the benefits related to university-industry educational collaboration activities for students, universities, and industry?	Benefits for industry: Obligation (good citizen), relationships (look at potential employees, maintain contact with faculty/university), intervention (analysis support for internal use). Benefits for teachers: A tested model for teaching with student written cases including teaching note. Continous source of contemporary teaching cases.	Benefits for industry: Recruitment of engineering students, transfer of technological knowledge, especially product innovations and early stage. Regional firms more benefits, SMEs fewer benefits, mainly in later innovation stages. In business education mainly about maintaining contact and relations Benefits for students: job offers, practical problem solving for engineering students. Benefits for teachers: increased student motivation, support with applied research.	Level of benefits for all stakeholders depends on educational collaboration stage: Distant, Relational or Interactive.
2) What are the success factors affecting the realization of the benefits from university-industry educational collaboration?	Contextual factor: Selection of collaboration partner with similar or complementary objectives, overlapping knowledge and previous experience. Partner in geographical proximity. Process factor: A model for managing the process of involving companies in student written cases, including the teaching note. Establishing shared objectives (obligation, relationships, intervention).	Contextual factor: Large firms, regional firms. Organizational factor: Engineering faculty committed and organized to MSc theses as a way to facilitate transition to working life and innovation support. Output factor: High rate of job offers, implementation of results.	Different key success factors in the three different stages: Distant – none Relational – Contextual, organizational and process factors. Interactive – Environmental, contextual, organizational, process, and output factors.

The purpose of appended papers 1 and 2 was to present a method for conducting SWC, including a method for SWTN (paper 2), in collaboration with companies and public organizations in a master's course, Technology Strategies, for engineering students. In

paper 1, the company benefits connected to the SWCs were evaluated by managers in the collaborating firms. The main benefits for the companies were: 1) getting a good public reputation and supporting higher education, i.e., being a good citizen, 2) maintaining good relations with higher education, 3) a free look at possible future employees, and 4) getting an analysis by a third party to use in internal decision processes regarding technology and market development issues.

For the teachers the benefit was the opportunity to develop and test a method for SWCs and SWTNs that could be regularly used in upcoming courses, as well as to continuously produce new teaching cases and teaching notes that could be used in future courses. Teaching cases in technology strategies tend to become obsolete very fast due to the general pace of technology development in society. Thus, they often have a short lifespan. Having a source of contemporary teaching cases in this field of technology, was a major benefit for the teachers.

In terms of success factors in appended papers 1 and 2, the method for SWCs and SWTNs was a way to manage, structure and organize the process of involving companies and their managers in this type of teaching and learning. While it worked quite well from the start, it took a number of iterations to fine-tune and improve the co-delivery of SWC as well as inclusion of the SWTN as a major improvement. The SWTNs made both the students and the managers think more about what the main insights and key contributions (i.e., lessons learned) could and should be from the technological strategies case point of view, and then actively construct the technology strategy case, rather than the other way around.

The teachers involving the companies in the course saw two main potential benefits for the participating companies. These were getting both a case prototype/material and a case theoretical and practical analysis that could be used for internal company purposes (e.g., training, management development) and also creating a good learning relationship with the students.

The method for producing a SWC was introduced to the participating managers. The managers had, at least in the first iterations, before the inclusion of the teaching note, difficulty understanding what the SWCs were to be used for. They often had a clear understanding of a problem-solving student project or an MSc thesis. The SWCs were, however, more difficult to understand. This was due to SWCs not being a problem-solving project, as an MSc thesis normally is, but rather describing a problem or challenge for the company.

Thus, the companies' levels of engagement varied as the case project started and developed. The company levels of engagement and participation could be divided into 1) the obligation level (i.e., to be a good citizen), 2) the relationship level (i.e., to create

and maintain enhanced relations with students, teachers, and the university) and 3) the intervention level (i.e., to use in internal processes).

Choosing the right partners for educational collaboration was found to be a success factor. They required 1) the right objectives and expectations (a contextual success factor), 2) a thorough planning process making sure that all involved stakeholders (e.g., students, managers, and teachers) fully understood the main objectives and goals of producing a SWC, and 3) aligning these goals with the company values and strategy. It is also important to maintain mutually clear and timely communication (and understanding) during the whole process throughout the production phase of the teaching case and teaching note. The SWC and SWTN frameworks supported the project management of the whole process (process factor).

Appended papers 3 and 4 concern both companies' involvement in teaching, in the MSc thesis course, and the transition between studies and working life. These two papers report major benefits for the companies and students, especially for the MSc theses performed in engineering. The major benefits for the companies involving themselves in MSc thesis projects are the recruitment of students and transfer of knowledge related to their innovation process. Mainly large firms in the region of Skåne benefit from MSc thesis collaboration. Companies collaborate mostly on knowledge related to product innovations and in the early stages of the product innovation process. Overall, SMEs tend to involve themselves less in MSc thesis projects than large firms, but when they do, they tend to involve themselves significantly more than large firms in MSc thesis projects related to product innovations and later process stages, specifically in prototype development and testing.

The students benefit by receiving employment offers and work with company-based problem-solving projects, which gives them valuable insights into companies' work processes and work environments. If they do not get or accept an employment offer, they can still add their MSc thesis project to their CVs as valuable work experience. Thus, the MSc thesis project in collaboration with a company facilitates the transition between studies and working life, as well as creates supporting innovation knowledge for the companies. These benefits are, however, limited to the engineering faculty. Even though the business school educates students for the economics, management, accounting, or financial professions, they do not, to a full extent encourage company involvement in the MSc thesis projects (though, exceptions exist within the business schools' different departments).

The teachers benefit by increased student motivation, and for departments with applied research, the MSc theses might be valuable as part of their own research efforts.

In terms of *success factors* for the UIEC, contextual factors seem to be in favour of large and regional firms and disfavour SMEs. This might be due to the engineering school's focus on basic and developmental research (low Technology Readiness Levels), which aligns better with large firms' needs. SMEs are relatively more interested in innovation support when it comes to later stage processes of product innovations (high Technology Readiness Levels), such as prototypes and designs, rather than basic and developmental research.

The organizational factor of the engineering faculty's commitment to the benefit of involving companies in MSc theses, as well as dedicating resources, compared to the business faculty, is a success factor for UIEC at the engineering faculty. In addition, the engineering faculty has set up some organizational structures to inform as well as facilitate students and companies matching up with each other, e.g., announcements on social media.

The output factor is also an important success factor for the MSc thesis activity at the engineering faculty. That some 50 % of the engineering students get a work offer and about 70 % of the results from the MSc theses get implemented or partly implemented provides evidence of a very good level of knowledge transfer. Moreover, that many large regional firms host several MSc theses in the same year also indicates satisfaction from industry with this type of educational collaboration.

Paper 5 is a conceptual study on different stages of collaboration capability development of UIEC activities. The benefits to the university, teachers, and students, and to the collaborating companies, will depend on the stage of capability development. The paper describes three stages of UIEC development, i.e., distant, relational, and interactive. In the *distant stage* the benefits are mostly received by individual teachers, their students and the company managers who are engaged in UIEC activities. In this stage the collaborative capabilities: networking, relational and desorptive capabilities, are tied to a few enthusiastic individuals rather than being organizational.

In the *relational stage* the benefits increase due to the collaborative capabilities becoming organizational, which leads to increased level of activities with more involved teachers, students, companies and public organizations.

In the *interactive stage* the networking, relational and especially the desorptive capabilities have developed and benefits are received by most teachers, students, and the participating companies and public organizations. In this stage the educational collaboration has a strategic focus, aligning internal stakeholders: teachers, and researchers, with external stakeholders: e.g. managers and management, to focus on certain research and teaching areas in order to support and orchestrate, the strategic development of the university department.

In the distant stage success factors are insignificant. In the relational stage contextual, organizational, and process factors are important. In this stage it is important for the university department to be able to attract and manage the relations with external partners well. In the interactive stage all success factors become important. At this stage the university department is e.g. skilled at attracting and selecting suitable partners, managing the collaborative process, and supporting with agreements, dedicated competent human resources, suitable organizational arrangements, and budgets, as well as delivering adequate value creating (Normann, 2001) output(s). Moreover, it is skilled in finding external funding and sensing both the academic and market (and business) demand for suitable collaborative projects.

5.2. Discussion of findings

Overall, the findings in the studies reported in papers 1-5 give evidence of the *success factors* identified by Thune (2011) and others, i.e., contextual, organizational, process and output factors. Concerning *contextual factors,* the studies have shown the importance of geographical proximity, shared or complementary objectives and complementary knowledge and competences. Geographical proximity seems to facilitate communication and provide more opportunities for more efficient and effective collaboration. In relation to UIRC (University-Industry Research Collaboration), the higher importance of geographical proximity for UIEC is a significant difference. In light of COVID-19 and the intensified use of digital platforms and tools for distance learning, meetings and distance work, the importance of geographical proximity might have diminished. Our studies were completed before the pandemic; thus we have no data to support such a claim. However, for an additional discussion on geographical proximity related to knowledge spillover and spillins, see below.

Regarding the *organizational factors* the studies support the importance of a full commitment from both collaborating partners (i.e. stakeholders), including engagement from the department's or faculty's management, i.e., not only relying on a few enthusiastic teachers and managers. Moreover, there have to be allocated human, technological and financial resources for the collaboration, supporting organizational structures and availability of relevant resources such as work laboratories, workshops and specialized equipment if needed. In relation to UIRC, there are few differences compared to UIEC. The difference between SMEs and large firms shown in paper 3 might indicate that there is a difference in relevant resources. Large firms might have more use of university research-based specialised labs and equipment, while SMEs

might have more use for less advanced labs and equipment and more use for more industrial but expensive equipment, such as 3D-printers and VR-labs as well as the competence to handle and operate such equipment.

The importance of *process factors* such as effective and efficient project management, good communication skills, as well as developed social and intercultural insights and understandings has also received significant support in our research studies, particularly in the studies reported in papers 1 and 2. As with organizational factors, the difference in process factors between UIRC and UIEC does not seem significant.

Compared to Thune's (2011) study, the dominance of large firms in UIEC is a new result, even though the pattern has been observed in a European survey (Davey et al., 2018) and for UIRC (Laursen and Salter, 2004). The study in paper 4 showed the limited activity in UIEC for the business faculty compared to the engineering faculty. That the frequency of UIEC varies greatly depending on field of study has been shown earlier in UIRC research (Goldstein, 2010; Mora, Detmer & Vieira, 2010; Nsanzumuhire & Groot, 2020; Zhuang & Shi, 2022).

From a knowledge spillover and spillin perspective, the higher importance of geographical proximity points to the importance of active collaboration activities compared to passive collaborations forms (Giovannetti & Piga, 2017). In UIRC the passive forms of knowledge spillover, such as guest lectures, seminars, conferences, and publications may be as important or more important as more active forms such as collaborative research projects (Giovannetti & Piga, 2017). The studies in paper 1,3,4 and paper 5, show that active participation and expectations from the company partner yields more knowledge spillover. The higher collaborative activity by large firms than SMEs in MSc thesis projects yields more knowledge spillover to large firms than SMEs. The higher collaborative activity in MSc thesis projects by engineering faculties, compared to business faculties, yields more knowledge spillins to engineering faculties.

The studies in paper 3 and 4 support the findings in prior research (Bramwell and Wolfe, 2008: Lucia et al., 2012; Thune & Stören, 2015; Davey et al., 2018; Kunttu, 2017) that the most important forms of knowledge spillovers to collaborating companies are the opportunity to meet, evaluate, and recruit students as well as transfer of knowledge related to the innovation process (*output factor*). Innovation, as an outcome, was in paper 3 defined as either a product innovation, process innovation, organizational innovation, or a marketing innovation in line with the OECD's definition (OECD, 2005). The innovation process was, in papers 3 and 4, defined as consisting of the stages in the so-called stage-gate process (Cooper, 2008), i.e., screening of new technologies, scoping of new technologies, development of business case, prototype development, test and validation, and commercialization. The unique and

significant finding of the study in paper 3, compared to prior research, is the distribution of knowledge spillover according to phases in the stage-gate process (Cooper, 2008) as well as the distribution between regional-national firms and large firms and SMEs. The results regarding knowledge spillover related to product innovations and early product innovation stages have not been reported before in extant research. A further new finding is the significant difference between SMEs' thesis projects being relatively more focused on product innovations, prototype development and testing, while large firms' thesis projects focus significantly more on the screening of new technologies.

From a knowledge spillin perspective, the studies in papers 1 and 2 show that the development of the method of SWC and SWTN benefitted from the interaction with managers in the collaborating companies and organizations. This was especially evident for the addition of the SWTNs as a response from managers lacking the in-depth understanding of the various values of the student-written technology strategies cases. In line with Lucia et al.'s (2012) and Kunttu's (2017) research, it also generated closer industry knowledge for both students and teachers/faculty, as well as acquiring teaching material in the form of contemporary, relevant teaching cases (including often a technology audit) with teaching notes/guides.

Comparing knowledge spillover and spillins between UIEC and UIRC, the knowledge spillover of recruited students and company-adapted need for innovation knowledge are unique to UIEC. The knowledge generated in UIRC is usually of a more general and basic character, with limited adaption to the specific needs of the company (Thune, 2011). In terms of spillins, UIRC generates additional research knowledge for the researchers, perhaps also knowledge applied to specific problem situations. Some knowledge might be used in teaching (Borah et al., 2023), but generally this is not the primary outcome of UIRC. The key differences between UIEC and UIRC discussed above are summarized in table 5.2 below.

Table 5.2. Comparison of UIEC and UIRC

	UIEC	UIRC
Success factors	Contextual factor of geographical proximity more important. Organizational factor: Relevant resources for educational collaboration purposes more important. Process factor: same	Contextual factor of knowledge proximity more important. Organizational factor. Relevant resources for research purposes.
Benefits to companies/knowledge spillover	Companies: Evaluation and recruitment of students. Improvement of relations Knowledge transfer of adapted innovation knowledge.	Companies: Research knowledge. Relations with research groups.
Benefits to universities, students and teachers/knowledge spillins	Teachers/faculty:Teaching material and contemporary technology cases, pedagogical innovation and development. Relations to industry. Students:Up-to-date industry knowledge and competence, authentic real world examples as well as development of domain-specific and generic competences.	Researchers: Additional research knowledge, applied in specific industry branches and situations. Some teaching support.

5.3. Main research contributions

The purpose of this dissertation as stated in chapter 1 one was: "to increase the empirical and theoretical knowledge of UIEC. In particular, this dissertation intends to make a research contribution regarding the benefits of UIEC to the main stakeholders of UIEC, i.e., universities, students, teachers, and collaborating companies and public organizations, and success factors leading to the realization of the benefits."

The main empirical contributions are:

1) The most important benefits for industry from involving themselves in educational collaboration in teaching and learning activities are the possibility to take a good look at the engineering students to recruit them and receive support with problem solving to be used in their innovation processes. These benefits have been shown both in involvement in courses and co-delivery of courses, student written cases, as well as in master's thesis projects. The benefits in the master's thesis study have been shown according to innovation type and innovation process stage. These empirical findings both verify previous findings by Bramwell & Wolfe (2008), Lucia et al. (2012), Thune & Stören (2015), and Kunttu (2017) as well as provide added empirical evidence in another country context. Moreover, the master thesis study (paper 3 and 4) provides evidence of these benefits in a large scale survey, while the above mentioned studies are case studies, except for Thune & Stören (2015). These findings also expand previous empirical findings as the master thesis study specifies what type of innovation knowledge and stage of the innovation process the knowledge is spilled over to.

2) The benefits for teachers are mainly in the form of support with bringing in authentic technology strategies cases, contextualizing and visualizing supporting article and text book knowledge, supplying teaching material with contemporary case illustrations, a tested method of co-delivery of a course with Student-Written Cases and teaching notes as well as raising student motivations through better learning, creating conditions for student relations with managers and work offers. These empirical findings verify previous findings by Bramwell & Wolfe (2008), Lucia et al. (2012), Kunttu (2017, Borah et al. (2021) and Zhuang et al. (2024) and provide added empirical evidence in another country context. It does so for a specific form of co-delivery of teaching: student-written cases (SWC) and teaching notes (SWTN).

3) The received benefits depend on a number of success factors affecting the university-industry educational collaboration. The most important shown in this research project are a) geographical proximity, b) company goals and objectives c) communication between the collaborating partners, d) project management of the collaborative activities, e) the faculty or discipline involved. Thus, the research project has empirically shown that contextual, organizational and process factors are success factors in UIEC. These findings are in line with Thune's (2011) and Zhuang & Shi's (2022) success factors for UIEC. However, in this study the relatively significant differences in UIEC activities between faculties, i.e., engineering and business studies faculty, stands out as a more important contextual factor than described by Thune (2011) and Zhuang & Shi's (2022).

The main theoretical contributions are:

4) A knowledge spillover theoretical perspective on educational collaboration, mainly for master's theses in the engineering faculty. The concept of knowledge spillover emphasizes that the knowledge flows to industry are uncompensated or at low cost and may raise productivity and innovativeness in the surrounding environment. As stated above, the main knowledge spillovers to industry are mainly recruitment of students and problem identification, and problem solving by students to be used as knowledge in the innovation process. While many studies have used the knowledge spillover perspective related to UIRC (e.g., Audretsch & Feldman, 1996), few have related it to UIEC (Andersson et al., 2004) and none to my knowledge specifically for co-delivery of courses and master's theses.

5) The character of the knowledge spilled over has in this research project been categorized as innovation knowledge in the form of different types of innovation (product, process, marketing or organizational) and according to the stage in the innovation process (screening new technologies, scoping new technologies, developing a business concept, developing prototypes, testing and validating of prototypes, and commercialization.). This is a unique addition to the knowledge spillover theoretical framework, operationalized and tested in a questionnaire, providing interesting empirical findings (see contribution one above).

6) In addition, a knowledge spillin theoretical perspective has been provided on the reversed and uncompensated knowledge flows from industry to the university, i.e., the teachers and students. As described in research contribution two above, in empirical research on UIEC these types of knowledge flows have been highlighted in the studies by Bramwell & Wolfe (2008), Lucia et al. (2012), Kunttu (2017, Borah et al. (2021) and Zhuang et al. (2024) without using the concept of knowledge spillin. The knowledge spillin concept provides added understanding that these reverse knowledge flows are generally free or at low cost for the university, the teachers and students and if absorbed could be a source of pedagogical and didactical innovation, enhancing student learning and motivation.

7) A conceptualization of a university department's stages of educational collaboration capabilities development, where individually held capabilities develops into organizational capabilities. Networking, relational and desorptive capabilities develop in stages enabling the university department to more skillfully take advantage of educational collaboration. The development stages were called distant, relational and interactive. The categorization of company objectives or approach towards the Student-Written Cases in paper 1 led to a discussion of a similar categorization for the university collaboration partner. The conceptualization is not entirely new, it draws on research on development stages, specifically on capability life cycles (Helfat & Peteraf, 2003) and open innovation capabilities (Pihlajamaa, 2023). The conceptualization in paper 5 is an adaptation to UIEC, and as such a unique contribution.

Figur 4 Three development stages in University-Industry Educational Collaboration

The main research method and pedagogical contributions are:

8) Papers 1 and 2 provide a (many times) tested teaching method for involving companies in Student-Written Cases and teaching notes, how to manage (i.e. orchestrate) the process with the collaborating partner.

9) The master's thesis study reported in papers 3 and 4 provide an operationalization of knowledge spillover into innovation types and innovation process stages. This has been tested in a questionnaire to the contact persons in the collaborating companies and organisations, providing interesting and unique empirical findings (see contribution one above).

5.4. Implications for policy, universities, and companies

The findings imply several university, company and public organizations insights. They also indicate actions to enhance and increase benefits (i.e. value) for all participating stakeholders, knowledge spillover to organizations and knowledge spillins to universities, i.e., their teachers, and students. Some of these implications are proposed in the papers. The overall implication is that both universities and companies need to identify, manage i.e., work proactively with the success factors of UIEC, to understand, design and execute on the systemic interconnected environmental, contextual, organizational, process and output factors so they maintain, and actively support and further encourage effective and efficient UIEC.

First, the environmental factor, e.g., governmental support, laws, demand for higher education, has not been in focus for the studies in this dissertation. Other researchers in the field have however proposed policies and policy actions to support UIEC. Bengtsson (2013) has proposed government programs for educational collaboration, equivalent to government programs in research collaboration, and tax incentives or vouchers for educational collaboration, especially for SMEs. China has, in so-called "teaching-focused university-industry collaboration initiatives" (Zhuang et al., 2024) since 2015 provided government financial support to industry for collaboration efforts. However, these programs aim to improve the standard of education rather than providing innovation support to industry (Zhuang et al., 2024). The size of university education relative to university research in Sweden is roughly 60 % education and 40 % research in Sweden's state budget for 2024.

The number of people involved (number of students and teachers compared to researchers involved) is very significant. The research on educational collaboration shows largely positive benefits and knowledge spillover and spillins (in this dissertation, Bramwell & Wolfe, 2008; Kunttu, 2017). Given all this, policy programs and actions should be put in place. This dissertation does not, however, give any evidence of the efficiency of such policy programs or actions.

Second, when involving companies in teaching activities in programmes as well as academic courses, make sure that objectives and goals, organizational factors, for both the teaching and the company align. Moreover, make sure the company and the managers fully understand the course environment, the curriculum including their time schedules, they enter into. They also need to grasp the full learning process of their intended and planned activity and contribution in the course or other teaching activity/situation. Good project management is key. This is especially important when involving companies, organizations, and managers as well as teachers for the first time in the co-delivery, but it is always a hygiene factor in all UIEC.

Third, the overwhelming dominance of large firms in MSc thesis projects means that a lot of SMEs might be at a disadvantage in getting involved in UIEC with engineering or other types of students. Universities should communicate as well as market their MSc thesis project capacity, focusing on SMEs, and especially regional SMEs. This could be done through direct personal contacts with e.g. the chamber of commerce, community hubs/network, or other organized network of SMEs, as well as through newsletters and using various other social media channels. One way of increasing the incentives for SMEs would be to hand out vouchers for an MSc thesis project to SMEs (see also the first implication above).

The management of engineering faculties should instruct various internal units to proactively act and work as "intermediaries" (i.e., with cross boundary spanning, Gratton, 2007) between the university and industry, such as university-industry advisory boards, offices, career centres, maker spaces and working labs (e.g. X-lab, Lund). For examples of such intermediaries in the agri-food sectors see Germundsson, Frankelius & Norrman (2021). This would elaborate, increase, and promote a proactive stand in their efforts and services for SMEs in educational collaboration. This could include the establishment and promotion of easy-to-use platforms and technologies i.e., online interactive platforms and services for SMEs to learn and then register their interest in, for example, a shorter student project or a thesis project. Examples of previous projects and MSc theses could be communicated via the platform. The universities and departments could also invite SME managers and employees to seminars and workshops so companies and organizations can meet up with students and faculties.

SMEs tend to need support with new product development, especially at later stages in the innovation process, such as prototypes and testing as shown in paper 3. Thus, makers spaces, work labs, working shops, and related equipment that may be used for such activities should be highlighted (and visually displayed) for SMEs and made available at low cost and effort for students collaborating with SMEs in their master's projects.

To keep track of progress in terms of registrations and completed MSc theses, projects should be categorized and identified by company/organization name, technological area, size, specific industry/branch, regional/national/international presence to monitor the development. This is important for university management at different levels to manage relations with large firms, but also to detect problems and opportunities in SME involvement. Perhaps also key KPIs could be used to track the progress.

Fourth, the large difference in UIEC activities between the engineering and business faculties implies that non-engineering faculties need to work on their success factors for UIEC, especially faculties leading to a profession. Obviously, this is a strategic question for national policy, universities, faculties, and their management and sometimes concerns national norms for different higher educations that are certified by higher education authorities.

Given that universities and their faculties wish to prioritize and encourage the involvement of companies and organizations in the educational curriculum, the following actions might be appropriate.

- Change the curriculum and syllabus of programmes, courses, and MSc thesis projects to encourage the students to work with real working life issues/problematic dilemmas, technical and professional development as well as management issues.
- Universities and faculty management should identify, build, and sustain core networks for companies and organizations, including alumni networks, to better communicate and connect with potential collaborating companies and organizations.
- The same actions to attract SMEs to engineering faculties and their MSc thesis project could be implemented for this cause.

Fifth, based on the conceptual study of the development stages of the collaborative capabilities of a university department aiming to elaborate and enhance UIEC. The leadership of a department (or even the whole faculty or university) needs to reflect upon this as a long-term mutual learning commitment, going from perhaps a few dedicated teachers' UIEC activities, to more institutionalized and integrated practices and supporting organization structures involving large parts of the department, the faculty.

Going from a distant to a more interactive model of collaboration requires making explicit strategic choices in selecting key collaboration partners, such as certain individual companies or group of companies that have objectives which align well with the university and department educational goals and objectives. Building and

supporting organizational structures and processes (Mintzberg, 2024, McAfee & Brynjolfsson, 2017, Edgren & Skärvad, 2014) as well as management knowledge and competences (Bruzelius & Skärvad, 2014, Hamel, 2007), should be identified, developed and maintained in order to orchestrate, highlight, encourage and foster lasting and sustainable UIEC support for teachers, faculty, students, companies, and organizations.

5.4 Limitations

This dissertation is based on empirical studies at one major Swedish university (Lund University) and predominantly at the engineering faculty (LTH) and involves companies and organizations collaborating with engineering students and teachers at the master's level. Thus, the empirical results apply foremost to engineering education at the master's level. The studies of the SWCs and SWTNs were done some 15-20 years ago and the master thesis study are based on master theses that were presented in 2016. The relevance of the results for higher education in other countries, other faculties, or study levels and at present time has to be determined in further research.

As discussed in the introduction, increased levels of UIEC might have its disadvantages and negative effects such as too much dependence on collaboration with individual large firms (Thune, 2011; Zhuang et al., 2024). The dependence might be on funding and a narrow focus on certain technology or knowledge areas. Apart from the dominance of large regional firms and relative lack of SMEs in master's thesis projects, I have not noted any other negative effects in my studies. I have not designed the studies to look for such negative effects, e.g., questions in the company survey; rather, I have focused on the benefits and what makes a UIEC succeed. This may result in an overly positive view of the phenomenon of UIEC.

Chapter 6.

Future Studies

Future studies of UIEC efforts and activities at other universities in Sweden and other countries as well in different faculties, would be very valuable to further validate the presented results in this thesis as well as the use and development of the theoretical frameworks of these studies.

This last chapter of the introductory essay contains two types of proposals of future studies. First a proposal to further develop the knowledge-based theory of university-industry educational collaboration. Second, proposals of further empirical studies of university-industry educational collaboration.

6.1 Towards a knowledge-based view of educational collaboration

In this dissertation I have used the theoretical concepts of knowledge spillover and spillin as well as organizational capabilities and capability life cycles to describe, explain, and understand the benefits and success factors of educational collaboration. Both knowledge spillover, spillin and organizational capabilities could be described as part of the knowledge-based view of the firm and organizations (Grant, 1996), i.e., a view of the organization as consisting of knowledge and knowledge flows, internal and external, including the view that some types of knowledge may be unique and valuable and may give the individual and/or the organization advantages.

The concepts of knowledge spillover and spillin emphasize the importance of knowledge flows between different organizations and networks, where one of the organizations gives away knowledge to another organization for free (or a fraction of its costs), to be used for the other organization's benefit and advantage. University knowledge is a prime example of such knowledge spillover, as the research knowledge developed by the university is given away for free in publications, conferences, webinars, podcasts and research partnerships. This is also the case for university

education, i.e., the educated students and their project work, are free to the industry to recruit or involve in their operations. As discussed in prior chapters, the knowledge spillover and spillin concepts are less used in UIEC than UIRC. These concepts could be further used in future empirical studies on educational collaboration, see below.

However, there is a problem with the concepts of knowledge spillover and spillin which constraints the type of studies you can do. Agarwal et al. (2010:273) describe the problem like this: *while knowledge spillovers clearly suggest a flow of knowledge resources and capabilities from one decision-making entity to another, what exactly is flowing, through which transmission mechanisms and how and who benefits the most from such transmissions is less clear.*

To study questions related to the content of knowledge flows, how it flows and to whom as well as how it benefits the recipient, Agarwal et al. (2010) recommend turning to the concept of knowledge transfer, a recommendation that is echoed by De Wit-de Vries et al. (2019) for UIRC.

In a way this dissertation has already begun the movement towards a knowledge transfer view of educational collaboration by studying the content of knowledge spillover (and to some extent spillins) as consisting of different types of innovation knowledge in papers 3 and 4. The studies by Giovannetti & Piga (2017) differentiating between active or passive collaboration forms is a similar example of moving into research questions closer to the concept and frameworks of knowledge transfer rather than knowledge spillover. Overall, there is a fine line between knowledge spillover and spillin versus knowledge transfer with no clear line of division (Agarwal et al., 2010).

While the knowledge spillover and spillin concepts assume that knowledge is freely available to the recipient, the knowledge transfer concept and related concepts problematize this (De-Wit-de Vries et al., 2019). Some knowledge may be available at low cost for the recipient, while other types of knowledge may be quite costly to transfer, even impossible to transfer. Three conditions determine the ease of knowledge transfer (De-Wit-de Vries et al., 2019): 1) the characteristics of knowledge (explicitness/tacitness), 2) similarities in prior knowledge and 3) capabilities to transfer knowledge. Explicit knowledge, i.e., knowledge possible to codify in text, drawings, pictures, computer programs or other forms, is easier to transfer than tacit knowledge, i.e., knowledge that cannot or can only partly be codified. Similar and related prior technical and other knowledge between the collaboration partners facilitates knowledge transfer. The third condition is the knowledge management capabilities of the recipient organization. Thus, the knowledge transfer view is that knowledge is not free or come at low cost for all kinds of organizations. For some organizations with prior relevant

knowledge, knowledge in codified forms and with good knowledge management capabilities, the knowledge may be more or less free.

Conceptually this development to a knowledge transfer view has already commenced in this dissertation with the conceptual paper on development stages of educational collaborative capabilities of a university department in paper 5. The stages imply that the amount and content of knowledge transferred (out and in) will depend on the development level of the networking, relational and desorptive capabilities.

The use and integration of a knowledge transfer framework of UIEC opens up a whole array of possible new studies of educational collaboration. Here I will only briefly propose a couple.

Giovannetti & Piga (2017) differentiate between active or passive collaboration forms in University-Industry Collaboration and note that passive forms may be as valuable, or even more valuable, than active forms for the recipient. Active and passive collaboration forms are close to the concepts of explicit and tacit knowledge, where active forms contain transfer of tacit knowledge and passive collaboration forms denote knowledge transfer of explicit knowledge. Educational collaboration seems to have more active collaboration forms (co-delivery of teaching, internships, student project work such as cases) than research collaborations that have many passive collaboration forms (published papers, open conferences, seminars etc). Perhaps the cost of knowledge transfer in educational collaboration generally is much higher and requires much more resources and effort for the industry to benefit from than research collaborations? Are the higher proportion of active forms for UIEC than in UIRC the cause of the higher importance of geographical proximity for UIEC than UIRC? Studies on educational collaboration from a knowledge transfer perspective might shed light on such issues.

The most valuable and effective knowledge transfer in educational collaboration is via the student (Bramwell & Wolfe, 2008). This knowledge transfer could be done by recruiting students at the end of their education, but also through internships, master's thesis projects and other student projects. From a knowledge transfer perspective, the student comprises both explicit knowledge, which could be listed in a CV, and tacit knowledge, such as oral communication skills, problem solving skills in practice, interpersonal skills and so on. While universities often monitor the students' progression in formal or domain-specific knowledge, they often lack systems for monitoring the more tacit generic or so called employability skills (Ramberg, Edgren & Wahlgren, 2021). To what extent do, companies and public organizations, try to find out this tacit knowledge, the employability skills, related to the student in internships, master's theses, and other student projects before possible recruitment? In other words, are

internships and student projects effective match-making mechanisms and do they lead to better recruitment of employees for both the companies and the individual? Are their differences between internships, master thesis projects and shorter student project works in terms of transfer of tacit student knowledge?

6.2 Suggestions for future empirical studies

An interesting new project could be including a selection of SMEs, larger companies, and public organizations, to empirically study the impact of the various benefits of UIEC. These studies could include further studies of the benefits of recruited engineering students with or without a prior MSc thesis. The studies could also go deeper into the companies' understanding and implementation of results and recommendations from the MSc thesis, i.e., the knowledge transfer processes.

It could also be very fruitful and interesting to conduct further action-inspired research with other engineering schools in Sweden, other Nordic countries and of course a selection of universities in the rest of Europe. In this way, we could detect interesting new patterns of collaboration efforts, benefits, and barriers.

The knowledge spillins to universities, teachers and students related to UIEC activities could also be studied more in detail e.g., the type of spillins for different UIEC activities and the impact on teaching and teaching material and equipment. Moreover, the impact on student motivation, learning, relations, networks, and future career prospects could be further studied related to various UIEC activities.

The orchestrated network is about making the different stakeholders in the network, seen as one entity, as strong as possible .

(Skärvad & Lundahl, 2016:75)

Structures are smarter than people

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Paper I

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CASE WRITING PROJECTS IN CO-OPERATION WITH COMPANIES AND ORGANIZATIONS

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Abstract

The purpose of this paper is to present the process and evaluation of case writing projects in co-operation with companies and organizations in a course for engineering students. The case writing projects could provide an illustration and example framework for working with companies in constructing cases. Normally cases are constructed for teaching purposes in higher education. However, in order to get closer co-operation and more interest from the companies the authors encouraged the students and the companies to construct cases on issues that the companies felt were especially relevant for them. Drawing on previous research on case writing in teaching case writing projects were set up. The companies who worked closely with the students were very satisfied with both the case writing process and the final cases. These companies expressed several benefits like getting a good public reputation, getting an analysis by a third party, a free look on possible future employees, maintaining good relations with higher education and also getting material for internal development purposes. The companies that had a more distant relationship to the projects or were the process had been problematic had a more critical view of the process and outcome. They saw few benefits with the case writing projects besides maintaining a good image.

KEYWORDS: Case writing, companies, co-operation, relationships between universities and industry, intervention

INTRODUCTION

Many universities all over the world use case studies in their teaching in order to approximate the reality of the decision-making process in firms and other organizations. The many strengths and benefits of the case method in teaching and learning are well documented [Erskine et al, 1998; Mauffette-Leenders et al, 2001]. Case studies are also used for assessing the students' performances in academic courses and programs for instance by grading participation in class discussions or case analysis in written reports. Even though case studies are a way of bringing reality into the classroom, the reality in the case is shaped by an author for pedagogical purposes and taken from a specific context. This could be a problem if the context of the case is foreign or unfamiliar to the students or written in foreign languages [cf Hornaday, 1995]. Many cases, at least in business and management education, are based on large and well-known firms while the students probably mostly will find their jobs in local small and medium-sized firms [Whitt et al, 1991]. Other problems with ready-made case studies are the vicarious reality it represents for the students and the missed learning opportunities that exist in having to construct

your own case. Students writing their own cases make the reality more vivid and profound as well as could provide stronger learning opportunities. While some research have been reported using case writing in academic education, e.g., Hornaday, [1995]; Barksdale-Ladd et al [2001], the topic is far from systematically explored [Sureshwaran and Hanks, 1998].

The educational program for engineers at Lund Institute of Technology at Lund University has for a long time included the use of case studies. Cases used are often set in foreign context, i.e., mostly American and British, and to some extent that poses some problems for the predominantly Swedish students. However, the greatest problem with case studies in the technology area is that cases fast become outdated and obsolete. With this in mind the authors decided to experiment with case writing in a course on Technology Strategy at the Lund Institute of Technology for last-year engineering students (year four). The objective was both to generate more Swedish based and contemporary technology strategy cases and to influence the students learning strategies towards using a broader set of skills and to understand technology strategy in a broader firm and societal context. The authors have earlier [Bengtsson and Asplund, 2002] reported the experiences and the outcomes of using case writing projects in this context. Overall the students seemed quite content with case writing as a teaching and assessment form. It also seemed reasonable to conclude that the case construction and its use as an assessment form significantly affected the students learning strategies. Especially important in this regard was the inclusion of the writing of a teaching note. However, it was also concluded that the quality of the case studies varied significantly due to the varied relations between student groups and companies. When first using the case writing projects the impression was that the best cases constructed were the ones where the co-operation between the companies and the student group worked well [Bengtsson and Asplund, 2002].

Previous research seems to lack concerning the experiences and outcomes for participating companies and organizations in case writing projects. A few exceptions do exist. Hornaday [1995] asserts that it demands certain responsibilities from students, faculty and organizations for case writing to work in undergraduate teaching. Also Whitt et al [1991] stress the win-win situation in case writing in co-operation between business and university education. For the companies and organizations studied possible benefits include analysis of their own strengths and weaknesses by a third party, a source of help for specialised problems, a free look at possible future employees, and public recognition. In a broader sense this issue concerns the division of business and management education into two encapsulated learning arenas: the university and the company [Leitch and Harrison, 1999]. Leitch and Harrison advocates a more interactive strategy and integration of these two learning areas especially when it comes to management and entrepreneurship education. Even though Leitch and Harrison do not explicitly discuss undergraduate education there is a need for teaching practices, e.g., case writing projects, which try to integrate and stimulate interactivity between these two learning arenas. Thus our study could both shed some light on company experiences and outcomes of case writing projects but also serve as an example of how these learning arenas could become more integrated and benefit from each other.

AIM AND STRUCTURE OF PAPER

The purpose of this paper is to present the process and evaluation of case writing projects in co-operation with companies and organizations in a course for engineering students. The case writing projects could provide an illustration and example framework for working with companies in constructing cases.

The paper is divided into four sections. The first section makes an overview on existing research on case writing in university teaching. Second, the case writing projects are described. Third, the companies' evaluation on the case writing projects is reported. The final section discusses the main learning points from the companies' evaluation and the project's contribution for case writing research.

CASE WRITING IN TEACHING AND ASSESSMENT

Case writing in teaching and/or as way of assessing students' performance in academic education has received very limited attention in research. Only a few articles seem to have been published in the area. For example, in WACRA proceedings only three papers regarding case writing in teaching and/or

assessment have been published during the last seven years [1995-2001]. Case writing is reported to be used in some teacher education programs were case writing as a way to reflect on and learn from their own teaching situations and teaching dilemmas [Barksdale-Ladd, 2001; Hunter and Hatton, 1998] or their own organization in management education [Coté, 1999]. Case writing has also been used in areas were there is lack of indigenous case studies, e.g., developing countries [Hornaday, 1995], small businesses [Whitt et al, 1991] and business development and entrepreneurship [Nelson, 1996]. For our purposes, using case writing in undergraduate teaching, the studies by Lamont [1995; 1998], Whitt et al [1991], Sureshwaran and Hanks [1998] give some valuable insights.

Whitt et al [1991] advocate the use of student-generated cases in small business education programs because of the lack of relevant case studies in the small business area. Furthermore, they assert that case writing by students have several advantages for students, faculty, the studied organizations and the school. For the students they list the following advantages:

- direct exposure to the dynamics of the organization,
- training in defining business problems,
- training in selecting and analysing data,
- working with experienced business leaders,
- selection of problem and issues appropriate to the students' knowledge and experience,
- working in teams,
- training in writing and presenting case material.

Whitt et al [1991] also maintain that case writing in teaching, properly executed, is a win-win situation for all parties involved. For faculty and school they discuss advantages like better links between local business/organizations and school, increasing faculty contact with business leaders, and possibilities for empirical research in local organizations. For the organizations studied possible benefits include analysis of their own strengths and weaknesses by a third party, a source of help for specialised problems, a free look at possible future employees, and public recognition.

Lamont [1995] describes a process for case development by undergraduate students in marketing management. The process consists of six steps: 1] identifying and selecting a case study topic, 2] organizing the case study research, 3] researching the case study, 4] preparing and testing the case study, 5] preparing the instructor's teaching note and 6] publication. Lamont reports that the students learn several research skills like sources of information, questionnaire design, and interviewing techniques. Moreover, writing skills, presentation skills and critical thinking are also trained. Lamont encourages the students to also construct a teaching note, however maintains that this is primarily a job for the teacher. Lamont [1998] reports on an evaluation of seven different teaching methods in marketing. One teaching method was team course project, a partially written case study that had to be complemented with additional information, e.g., marketing research data, by the students. The team course project scored high on educational outcomes like learning the practice of marketing, teamwork, interpersonal skills and decision making/problem solving.

Sureshwaran and Hanks [1998] develops a framework for applying case writing assignments in graduate agribusiness courses. For them, case writing by students means that the students are forced to confront the real situation and apply theories they previously have learned. They introduce an elaborate nine-step procedure for integrating case writing into a course from recruiting business mentors to on-campus workshops. The case writing assignment was also integrated in the assessment as it accounted for 20% of the final grade. The grading of the cases was based on evaluations made by business mentors, faculty consultants and course instructor. Criteria in the evaluation were initial case outline, final case study and accompanying teaching note, use of analytical skills, preparation at workshops, formal presentation, use of technology and agribusiness skills.

Bengtsson and Asplund [2002] reported on the experiences and outcomes from an experiment with case writing projects for last-year engineering students in Sweden. The results of the study confirmed the importance of the assessment as the most important element for the students learning strategies. In general the students were very positive towards case writing as part of the teaching and assessment. From a learning point of view the students rated case writing very high on multiple learning outcomes. The experiment verified the earlier reported advantages and positive outcomes of case writing in undergraduate and graduate education. The main new finding, in relation to earlier research, was the important role of the teaching note. A case writing assignment benefits greatly by including both the construction of the case as well as the teaching note.

Case writing in undergraduate and graduate education has received limited attention in the literature. However, a few studies have reported on the advantages of case writing [Hornaday, 1995] and the beneficial educational outcomes on a broad set of skills and knowledge [Lamont, 1998, Bengtsson and Asplund, 2002]. Moreover, two studies have proposed frameworks in undergraduate education for case writing development processes [Lamont, 1995; Sureshwaran and Hanks, 1998]. Thus, case writing in undergraduate education seems to have beneficial learning outcomes. At the same time Sureshwaran and Hanks [1998] notes that certain courses are probably better than others to use case writing in and probably demands more mature students like graduate students. Bengtsson and Asplund [2002] stress the importance of the teaching note, i.e., clear learning objectives and an understanding of the pedagogical context, for constructing good teaching cases. Of special interest for our study is Hornaday [1995] that asserts that it demands certain responsibilities from students, faculty and organizations for case writing to work in undergraduate teaching. Also Whitt et al [1991] stress the win-win situation in case writing in co-operation between business and university education. For the companies and organizations studied possible benefits include analysis of their own strengths and weaknesses by a third party, a source of help for specialised problems, a free look at possible future employees, and public recognition. However, the experiences and outcomes of case writing in undergraduate education for companies and organizations seem to have received limited attention in the literature.

DESIGN OF CASE WRITING PROJECTS

Our aim with the case writing projects was to give students incentive to adopt a deep-learning strategy thereby increasing the likelihood of knowledge retention as well as increasing the students' awareness of teaching and assessment issues. The more specific reasons for using case in our teaching were the following:

- The construction of a case fulfils the requirements for upholding the formal functions of assessment, i.e., diagnosis, motivation, and selection.
- By asking students to construct a case and teaching note for teaching purposes, as part of their assessment, the students were forced to think about learning and didactic issues.
- The major part of the course has a management perspective thus making decisions, in this course about technology strategies, a natural part of the course. Constructing cases would integrate and reinforce the decision-making perspective in the course.
- The intention was to give the students a deeper understanding of a specific and real management problem in order to convey the feeling to the students that issues taught in the course has a real-life meaning.
- It would generate contemporary cases from a context, i.e., Swedish industry, which the students are familiar with.
- The authors were aware of only a few studies in the area (see above). Thus, it would be interesting for teachers, course and program directors to take part of the authors' experiences.

The Course and the Design

In order to address the issues of decision-making and organization concerning technology and R&D the Lund Institute of Technology introduced a course on Technology Strategy in spring 2003. The overall purpose is to give the student a framework to identify the most important R & D questions especially concerning technology strategy and to find an appropriate organisation to conduct research and technology development projects in industry and at the university.

The course was an elective course given to last year (year four) engineering students. The course was assessed evaluating the constructed case (50%) and a written exam on concepts and models (50%).

The case writing process followed a ten-step process.

1. Instruction for case construction
2. Gaining access to a firm and a "technology challenge"-case
3. Round table sessions
4. Handing in case outline
5. Data gathering, compilation and writing of case and teaching note

6. Off-campus workshop
7. Presentation for company representatives and feedback from companies
8. Revision of case and teaching note
9. Handing in final case and teaching note
10. Grading and feedback to students

Instruction for Case Construction

The purpose of the assignment was to develop the students' understanding of the practice of technology strategy as well as to train the students' skills in areas like making research, applying theories, presenting, teaching and writing. The following instructions were given to the students concerning the final product of the assignment:

"The final product will consist of the following:

1. A written case, 5-8 pages, about a company in an interesting R & D or technology development decision making situation that has to be understood and solved by participants in different roles as internal and/or external consultants and/or managers. You decide focus and key questions to be addressed with the help of the course instructor and company contact person.
2. A teachers' note including:
   a) The case learning objectives for two target groups; engineering students and company personnel.
   b) How to use the case (one for each target group), including alternative ways of using it.
3. A short summary of the case including key case content and design. Finish with the key words that are addressed in your case.
4. The case is to be delivered, in two hard copies and word-document via e-mail attachment." (case writing instructions to the students)

Two lectures were held in the beginning focused on the construction of case and teaching note. The first lecture gave a general view of cases and its use as a learning tool. The Case Difficulty Cube framework by Erskine, et al [1998] which discussed three dimensions of case construction; the analytical, conceptual and presentation dimensions, was also presented. The second lecture focused more in depth on how to construct a case. Here the students learned for instance more about the target groups, the case as a learning tool with multiple uses and to focus on a decision maker. The class deconstructed a ready-made case. The students received checklists in order to help them work more independently.

Access to a Company and a Technology Challenge

The student groups (of three or four students) contacted a company of their own choice especially concerning interesting "technology" challenges. The student group was instructed to tell about their assignment and get permission to do a case study. The course coordinator sent a formal letter thanking the company for their co-operation and a short description of the case writing projects. The student group was then instructed to start with asking more basic questions in order to get a rich picture of the company in relation to the content of the course. Then they should focus on key issues that the group and the company considered to be the most interesting to understand, discuss and act upon more in depth. Finally time and dates for data collection, interviews and visits were made.

Round Table Sessions

The group made a briefing on the company and the technology strategy case in front of the other students and the course instructor. The other student groups and the instructor gave feedback and suggestions to the presenting group. The course director provided additional advice to those groups demanding it.

Handing In Case Outline

At a certain date the groups had to hand in a case outline to be approved or modified by the course director

Data Gathering, Compilation And Writing Of Case And Teaching Note

The student group collected data through collecting written material and interviews in the company relying on the contact persons advice and introduction. Then compiling of data and writing of case and teaching note.

Off-Campus Workshops

The student groups then organised an off-campus workshop, in order to present and test-teach the case. Before the presentation at the overnight stay the case was e-distributed to all students and faculty by the students themselves with the purpose of reading them before the presentation. After the test teaching of the case the other students, the course director and faculty consultant gave feedback to the presenting/teaching group.

Presentation For Company Representatives And Feedback From Companies

After the off-campus workshop the student groups sent their written case and teaching notes to the company contact persons asking for their comments and suggestions for the revision of the case and the teaching note. If possible the student group should meet face-to-face with the contact persons and get the feedback in a discussion.

Revision Of Case And Teaching Note

Based on the feedback and comments given at the workshop and from the companies the groups had five days to revise their cases and teaching notes.

Handing In Final Case And Teaching Note

Student groups handed in final written case and teaching note.

Grading And Feedback To Students

The course director and the faculty consultant graded the final case and the teaching note based on the following criteria: use of business and technology information, analytical skills/application of theory on case, trustworthiness, overall impression of process and final product. Course director communicated the evaluation of the case and the grade to the student groups.

Cases written by students in the Technology Strategy course

Idefix Consultants
Focus on the R & D decision making process in relation to the development of an administrative computer system to meet new public organizations needs
Ericsson Mobile Systems case 1
Focus on the evaluation of a special R & D project concerning wireless communication system.
Ericsson Mobile Systems case 2
Focus on the R & D microchip development process as a research dialogue between the executive group, research engineer group and human resource management group. One on the main issues is the question of outsourcing the production or not.
Höganäs
Focus on the product development and especially on the combination of material use to address the issue of sustainability and environmental considerations.
Perstorp
The case focuses on which overall computer system the company should invest in.
Semcon
Focus on the evaluation of the decision process and work methods as consultants where they try to introduce a new business model for other businesses. This is highlighted in a product development process of a dishwasher machine.

Gambro
Focus on the development of the packaging format in connection to product qualities when trying to increase the density of a kidney fluid liquid. This case illustrates the product and packaging development process in relation to customers needs.
QlikTech
Focus on the R & D process in relation to the upgrading of a software system in relation to customer needs. The challenge is how close should their system be in relation to the dominating systems in the market? Which direction of product development should be preferred?
C Technologies
Focus on the R & D process in connection to the development of the new version of a product. External barriers and internal barriers are highlighted in connection with the decision chain in the company.
Alfa-Laval 1
Focus on decision process when choosing between types of product strategy;
ready-made product strategy or b) self organizing strategy. This case also highlights the company responsibilities concerning the final installed product solution.
Alfa-Laval 2
Focus on the issues of how to better understand and address technology strategy issues from a management and communication point of view. Which methods and models could be used in order to address the R & D challenges?

EVALUATION FROM THE COMPANIES

Telephone interviews were conducted by the authors with the assigned contact persons in the case companies. Unfortunately not all contact persons could be reached in the case companies. Due to contact persons travels, vacations and general time pressure problems only five contact persons could be interviewed. The authors' judgement is that the five companies fairly well represent all the cases as they represent both successful as well as less successful case writing projects. The interview questions concerned the process and interaction between the company contact persons and the student group, their evaluation of the finished case, the possible use of the case for internal purposes, proposals for improving the co-operation, willingness to participate again and overall evaluation.

The answers to the questions are listed in short form in the following table.

TABLE 1 - OVERVIEW OF ANSWERS TO TELEPHONE INTERVIEW WITH COMPANY CONTACT PERSONS (CP=CONTACT PERSON)

	Perstorp	**Gambro**	**C Tech**	**Alfa Laval 1**	**Alfa Laval 2**
Contact persons	Vice president IT Project director	Vice president Corp Research, Project director	Vice President R&D Project director	Vice president R&D, Vice president HRM, product manager	Vice president R&D
First contact	Personal contacts	Personal contacts	Personal contacts	Contact through faculty	Contact through faculty
Formulation of case task	Case formulated by CP	Case formulated by CP	Historical case formulated by CP	Case formulated by CP and faculty	Case formulated by CP and faculty

Planning of work	Done in co-operation between CP and student group	Done in co-operation between CP and student group	Done in co-operation between CP and student group	Done in co-operation between CP, faculty and student group	Done in co-operation between CP, faculty and student group
Feedback	Yes, in written form and face-to-face meeting	Only partially, initial feedback but not on final case	Yes, written feedback on final case	Yes, in written form and face-to-face meeting	Only partially, some written feedback on final case. CP travelling a lot.
Evaluation of final case	Excellent	Not very good	Ok	Very good	Ok
Improvements	No proposals	Better instructions and information to the company, especially on aim of case writing projects	No	Contact and planning much earlier than now, need to integrate in internal plans	Contact and planning much earlier than now, need to integrate in internal plans
Participate again?	Yes and also in other parts of the company	Yes, if improvements are made	Yes, if relevant case could be formulated	Yes, but better planning	Yes, but better planning
Use in company	Maybe later	No	No	Yes, have already been used	Do not know
Overall evaluation	Very good, very positive	Not good	Ok	Very good	Not good
Main benefits for company	Good analysis of IT problem by third party, look at possible future employees, good citizen	Nothing in this project	Good citizen	Good analysis of IT problem by third party, internal educational material, look at possible future employees, good citizen	ook at possible future employees, good citizen

From the overview of the answers the following observations are made:

Two cases (Perstorp and Alfa Laval 1) worked very well and the contact persons in the companies were very enthusiastic about the project, the interaction with the students and the end result, i.e., the final case. They both wanted to participate again and Alfa Laval had already used for internal education purposes. Alfa Laval stressed that they needed to be contacted earlier in order to better plan the work with the cases. Perstorp wanted to get in contact with other types of students (e.g., other engineers, business students) in order to do similar projects with other parts of the university. Both companies said that the interaction with the students had been very good and that the work had progressed according to the initial plan. In the Alfa Laval case, one of the faculty, the course coordinator, had provided the contact and also been instrumental in informing the company and formulating the case task.

In two cases (Gambro and Alfa Laval 2) the process and the final case were considered to be less good. In Gambro, the project started well, but an early feedback from the contact person had been ignored by the students. Thus the contact person got irritated with the students and did not provide any more feedback. The main contact person also felt that she had not been sufficiently informed about the

case writing projects and the aim of the projects. In Alfa Laval 2 the student group had only one contact persons (most other groups had two or three contact persons in the company). In Alfa Laval 2 the contact person had to travel a lot in the second half of the project and became hard to contact for the student group. Consequently the group lacked supervision and support from the contact person in the later stages of the case. The case also concerned more abstract corporate R&D management issues, and not related to specific product development projects as was the case in several other groups, thus the need for company supervision was high.

In the last case, C Tech, the contact person was satisfied with the students but they considered the case study less interesting. While the other groups had been given on-going projects to study and write cases about, the C Tech group had been given a historic case. Thus the contact person and the company were less interested in the final case as they were now working with new projects. One reason for giving the students a historic case was the sensitivity, from a competitive perspective, of many of the projects that the company worked with. The contact person also remarked that future participation on their part depended on the formulation of more relevant (for them) case projects.

The main benefits for the companies ranged from public recognition (to be a good citizen, support higher education, get good reputation among students and faculty) to more relationship oriented benefits like getting free look at possible future employees and maintaining good relations with the engineering school. The two best cases (Perstorp and Alfa Laval 1) also stressed the benefits of getting a free analysis of difficult problem by a third party and getting perspective on their own thinking and reasoning. In one case, Alfa Laval 1, the case material was judged of so high quality that they had used it in internal education for managers.

CONCLUDING REMARKS - FROM CASE TO INTERVENTION

When the 2003 version of the technology strategy course was designed the authors focused especially on the improvement of the communication between the university/the students and the different eleven (11) companies/business units that was involved. This was also one of the implications when summarizing the previous course design [Bengtsson and Asplund, 2002].

The assumption was that if the purpose of the case and the case construction process was well understood by the company (as by the students) they could more connect the case projects to their ongoing value creation especially concerning current and earlier R & D projects and important issues in the area of technology strategy.

Another possible contribution was that if the students could get more authentic R & D issues to address during two months the course lasted, this would result in greater involvement and collaboration from the contact person (often the head of R&D) and their organization in solving the task. The authors assumed, if they understood this more elaborated learning method more deeply, this could mean that they could contribute more actively in the case construction process.

The efforts to involve the companies in a more substantial way were for some companies problematic. A combination of lack of motivation from the companies and their contact persons and the student groups sometimes in conjunction with problematic case construction processes resulted in less good co-operation and less good cases. These companies mostly participate because they fell obligated to do so. They feel it is their *obligation* to do so and do not want to give a bad impression on the students and faculty. Beyond keeping a good public image they do not see any benefits in participating in case writing projects.

A second group of companies seemed to involve themselves a bit more in the case writing projects. While they saw limited value in the actual case projects they did value the *relationships* with students, the faculty and developing a good public image. They also could get a free look at possible employees. Some of these companies recognised however that more value could be created if the process was managed differently, e.g., given longer notice of participation, better internal organization and so on.

The last group of companies was enthusiastic about the case writing projects and involved themselves heavily in the student groups' work. These companies recognised that not only could they maintain and develop the relationships (as the group above) with students and faculty, but they could also use the case studies for getting new perspectives on their own thinking and management practices. These companies seemed to use the case writing projects as possible *interventions* in their own practices.

In conclusion the companies could be differentiated according to the level of participation; 1) obligation level, 2) relationship level, and 3) intervention level. At the obligation level the main problem is motivation in the companies. Thus, more and better information about the case writing projects will not make these companies more active or better organised to participate in these projects. Here it is more an issue of selecting out such companies beforehand. Thus students and faculty need to be aware that some companies probably not should take part in case writing projects because of lack of motivation. Companies at the relationship level do have motivation but do not take part because of the case writing projects as such but rather because of the relationship qualities that come with these projects. These companies could probably benefit from more and richer information about the case projects both from faculty and from the students. This in order to become a company that operates at intervention level, i.e., see the value of the case projects in themselves and manage to organise internally in order to extract this value from the case projects. In relation to Whitt et al's [1991] discussion of benefits for the companies the authors think that faculty and students need to be aware of the interests of the companies. Thus while it is interesting to create more interactivity between the higher education area and the company arena [Leitch and Harrison, 1999] one need to understand the interests and capabilities of the companies. If the companies do not see the value in this interactivity, be it case writing projects or other teaching practices, and they do not know how to organise such an interactive strategy, little progress will be made. This paper has hopefully made some contribution to understand both the possibilities and the pitfalls of getting case writing projects to work in co-operation with companies.

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Paper II

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ORCHESTRATING CASE LEARNING: ON THE KEY IMPORTANCE OF THE TEACHING NOTE

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Abstract

The case method, using existing and student written cases in teaching, is relatively well researched [Christensen, 1981; Leenders, M. R. & Erskine, J.A., 1997; Bengtsson, 1999; Bengtsson and Asplund, 2002; Asplund and Bengtsson, 2005; Asplund and Jordan, 2006; Ross, Zufan and Rosenbloom, 2008]. By contrast, the use of the teaching note in undergraduate and graduate education has received relatively limited attention, with the notable exception of Cinneide [1998] and Ross, Zufan and Rosenbloom [2008]. There is little research concerning the use of the teaching note or experiences and outcomes of student case writing projects in university education.

In Bengtsson and Asplund [2002], the authors stressed the key importance the teaching note has in the student case writing process as well for designing the learning situation on universities' academic courses. Bengtsson & Asplund [2002] proposed that the students themselves can construct a teaching case to better describe and understand a company's technology strategy. In the case construction process the authors stressed the importance of the student writing of a teaching note in order to build and support new knowledge of content issues whilst at the same time creating an effective learning vehicle.

The purpose of this paper is three-fold: first, to present how the student written case process is designed and applied in a course at the Faculty of Engineering, Lund University, Sweden; second, to review the importance, role and design the teaching note has in orchestrating the entire learning process (i.e. before, during and after the case construction); third, to present the main findings from applying the teaching note in both academia and industry contexts.

KEYWORDS: Case learning and assessment, Student Written Case (SWC), teaching note, design of case and teaching note, learning process

INTRODUCTION

There is a broad, deep knowledge base concerning the writing and measurement of the learning effects of using business cases in education [e.g. Christensen, 1981; Leenders, M. R. & Erskine, J.A., 1997; Bengtsson, 1999; Asplund and Bjerke, 2008]. Several authors have examined how student-written cases can be used as both an advanced learning tool as well as for assessment [Bengtsson and Asplund, 2002, 2003; Asplund and Bengtsson, 2004, 2005; Asplund & Jordan, 2006; Herrlander, J and Lundberg, A-S., 2007].

Bengtsson and Asplund [2002] stressed the vital importance the teaching note has in the student case construction process, both as a support system in order to achieve deeper learning for the students

and as a vehicle for orchestrating learning situations at universities. They also proposed that the students themselves are able to identify and construct a business case in order to better understand a company's technology and business strategy. In the student case construction process, a focus was the importance of the construction of a teaching note to enhance the knowledge of the studied subject. This concerned both content issues and creating a good pedagogical vehicle for communicating knowledge to both industries and universities.

The purpose of this paper is three-fold: first, to present how the student written case process is design and applied in a course at the Faculty of Engineering, Lund University, Sweden, second, to review the importance, role and design the teaching note has in orchestrating the entire learning process (i.e. before, during and after the case construction), third, to present the main findings from applying the teaching note in both academia and industry contexts.

The teaching note is defined as follows: it communicates the multiple goals and learning challenges of a specific case in order to use it in educational situations in academia and industry. The teaching note can be designed in multiple ways. Before examining its design, it is useful to review how Leenders and Erskine [1989, p 74] describe the teaching note (or instructor's note) in order to get a deeper understanding of its function.

"For cases in their broadest sense, a teaching note could refer to any communication between the case writer and those who subsequently teach the case, as well as between various teachers of the case. Normally it is in a written form; although verbal communication between the originator of a case and the teachers using it is frequently extensive, especially between colleagues in the same institution…The intent is always to provide helpful information for those who wish to use the case. As notes become more detailed, samples of analysis, computations etc. are likely to be included".

This paper elaborates on the vital importance and function of the teaching note in both orchestrating the student learning process (three P model): presage, process and product [Asplund and Bengtsson, 2005] when writing cases, as well acting as a guide for sharing knowledge when applying these cases in different learning contexts. At the Faculty of Engineering in Lund, Sweden, the teaching note is designed for use in multiple contexts (i.e. academia and industry). Since 2004, the emphasis has been on designing and writing the teaching note *before* writing the complete case. Evidence from ten years of course evaluations clearly indicates that the preparation and articulation of the first case synopsis is also of utmost importance for the students. The synopsis guides/steers the students in their search for relevant sources, ideas and tools to address the case with. The quality and overall value of the student-written case is also higher where an iterative process exists between the case and teaching note. Applying this method has two distinct benefits. First, the student case teams develop a deeper knowledge base of the subject under study. Second, students are better able, through the development of their produced case, to apply their deeper knowledge to a learning situation in academia or industry.

This is supported by Cinneide [1998, p 1]:

"The teaching note's importance in case writing has been inadequately appreciated. While accepting that its role to date, i.e. in supporting classroom discussion on the case study, is extremely valid, it is suggested that if developed and formulated to its near final stage, the teaching note can provide an ideal template within which the planned case can be written."

This finding is also supported by Ross, Zufan and Rosenbloom, [2008, p 456] who state:
"Preparing the teaching note increased the understanding of course concepts."
Before examining the use of the teaching note, it is useful to review the student case writing process.

STUDENT WRITTEN CASES (SWC)

The many benefits of the case method in teaching and learning are well documented [Erskine et al, 1998; Mauffette-Leenders et al, 2001 and Ellet, 2007]. While the case method using professionally produced cases in teaching is relatively well researched and documented, the use of case writing in undergraduate and graduate education has received limited attention in the literature [Bengtsson & Asplund; 2002, 2003, 2004, 2005]. A few studies have reported on the main advantages of student case writing [Hornaday, 1995] and the beneficial educational outcomes on a broad set of skills and knowledge [Lamont, 1995, 1996; Bengtsson & Asplund, 2002; 2003; Asplund & Bengtsson, 2004]. Whitt et al [1991] stress the "win-win situation" in student case writing in co-operation between business communities and universities. For the studied companies and organizations, possible benefits include e.g. analysis of their

own strengths and weaknesses by a third party, a source of help for specialised problems, a free look at possible future employees, and public recognition. While some research has been conducted on using case writing in academic education [Hornaday, 1995; Barksdale-Ladd et al, 2001] the topic has not been systematically explored [Sureshwaran & Hanks, 1998]. For instance, the actual experiences and outcomes of student case writing in undergraduate education for companies and organizations seem to have received limited attention in previous research.

The educational program for engineering students at the faculty of engineering at Lund University has, for many years included the use of case studies especially in courses related to business and technology strategies. Existing cases in text books and distributed by e.g. case clearing houses are often set in a foreign (non-Swedish) - mostly American and British. To some extent that poses problems for the predominantly Swedish students. They may have difficulty in fully relating to the case and extracting the maximum learning outcomes. The greatest problem, however, with case studies in the technology strategy area, is the fast pace of technological change. This causes many cases to become rapidly outdated and therefore obsolete. This does not mean that such cases cannot be used at all, as historic cases can be useful to reflect on for example longer technological life cycles.

With this in mind, the authors decided to introduce student case writing in an academic course (2002) focusing on Technology Strategy at the Lund Institute of Technology for final-year engineering students. The main objective was (and still is) to influence and support the students' learning strategies towards using a broader set of skills and to understand technology strategy in a corporate and societal context. A second objective was also to generate more Swedish/Scandinavian technology strategy cases.

Case writing is carried out in close collaboration with Swedish companies that provide the topics and information needed in order for the students to accurately construct the cases. The best outcomes [Asplund and Bengtsson, 2005] both in terms of good quality cases and in terms of learning outcomes for the students and the companies were achieved in projects where the company managers were the most interested and most supportive of the case construction projects.

DESIGN OF STUDENT WRITTEN CASES (SWC)

In order to address decision-making skills in companies and public organizations, especially concerning technology, the Faculty of Engineering introduced a course on Technology Strategy (TS) in spring 2002. This course is an opening signature course within the programme of Industrial Management and Engineering that focuses on highlighting Business and Innovation specialisation. The overall purpose of the technology strategy course is to provide the participating students with the generic knowledgebase and management skills needed to identify and explain Technology Strategy concepts. Ford [1988, p 85] states: "A good starting point to understand Technology Strategy is to affirm that the core of a company is what it knows and what it can do rather than the products it has or the market it serves. Technology Strategy centres on this knowledge and these abilities. It consists of policies, plans and procedures for acquiring knowledge and ability, managing that knowledge and ability within the company and exploiting them for profit". In addition, the alignment of technology strategy and business model is emphasised.

The specific objectives of the course are:

1. To give a broad picture of technological development processes and their current knowledge base in Sweden and globally.
2. To explore and to clarify in depth the phenomenon of technology strategy in Small and Medium-sized Enterprises (SMEs) and public organizations
3. To discuss its implications for companies' overall business strategies, management and organization.
4. The course focuses on the three key elements in TS: the acquirement, management and exploitation (i.e. value creation) of TS in order to achieve and maintain a sustainable competitive advantage.

The course is an elective course given to final year (year four) engineering students.

The course is assessed using the student constructed cases (60%), which also include a student written teaching note as well as an individually written examination focusing on the main technology strategy concepts and models (40%). The student case writing process generally follows a twelve step learning process as follows [Asplund, 2010]:

1. 'Case school' - (introductory seminars) with basic instructions for the student written case method and its merits
2. Gaining access to an organization with an interesting and perceived (internally) "technology strategy challenge"
3. Deconstructing previous student-written cases. This learning event is conducted by former students.
4. First case synopsis drafted and delivered to the course faculty
5. Case synopsis presented and debated with other student teams. Round table sessions in order to debate the choice of company as well as the preliminary issues to address.
6. Data gathering, compilation and writing of the case and the teaching note
7. Off-campus workshop to test the case (version 1.0)
8. Instant feedback at the off campus workshop concerning both content & pedagogical issues. This is provided by the other student teams.
9. Revision of the case and the teaching manual by the faculty
10. Handing in the finished case and the teaching note (version 2.0)
11. Student-written case is presented, tested and debated with the partner company and contact persons, e.g. organising a company case seminar
12. Final grading and brief feedback to students by the faculty

Further details clarifying and elaborating on a selection of the main steps in the learning process are given below.

Gaining access to a company/organization with a perceived technology challenge

Ensuring that the company was well informed about the case construction project was a key success factor. Faculty representatives made a number of on-site company visits to develop their understanding of cases, case teaching and their role in this project. This selection and choice has, in since 2006, been self-governed by the student teams themselves in order to make them even more engaged in the specific technology challenge and the company under study.

The selected companies were chosen for their R&D/technology strategy intensive operations and their location in the Lund/Malmö region. In several cases there was a history of very positive working relations between Lund University and the particular company and/or manager. The company representative received information about the student's educational program, the Technology Strategy course and the case construction project through both personal contact and written information. They were also given an example of a student-written case delivered by students from the previous year. Ideas were discussed concerning an appropriate and useful situation that a case could be constructed around; some kind of "technology challenge" situation. In many cases it was possible to identify two or three possible alternatives that would be interesting for the company, which were also deemed appropriate for the course content and time available for the project. Finally, times and dates for initial student group visits were agreed.

Instructions for Case Construction

The purpose of the course assignment is to develop the engineering students' deep understanding of the theory and practice of technology strategy as well as to practise/improve their skills in areas such as carrying out research, identifying and applying theories & concepts, case writing, presenting and debating. The following instructions were given to the students concerning the final outcome (i.e. product) of the course assignment. The final "product" should consist of the following:

1. A written student case, 6-8 pages long, focusing on a company with an interesting "Technology Strategy issue(s)" that has to be understood, investigated and solved by participants in different roles as internal and/or external consultants and/or managers. The students decide on the focus areas and key questions to be addressed with the help of the company contact person and faculty.
2. The teaching note includes:
   a) The main case learning objectives for the two target groups - university and industry.
   b) How to apply the case (a minimum of one application method for each target group), including alternative ways of using it.

3. A short summary of the case including key case content and design. End with the key words that are addressed in the case.
4. The case and teaching note is to be delivered on a USB/flash drive to both the university and the managers in the companies.

A lecture and a tutorial were held at the start of the process, focusing on case construction and the teaching note. The lecture gave a general overview of cases, their use as a learning tool and some general advice on how to construct a case. The Case Difficulty Cube framework by Erskine, et al (1998) which discussed three dimensions of case construction; the analytical, conceptual and presentation dimensions, was also presented. The tutorial focused in more depth on how to construct a case and used a previous student-constructed case as learning material. The tutorial was run by the students that had constructed the particular case. Here the students learned more about the target groups, the case as a learning tool with multiple uses and how to focus on a decision maker. The former students could also give some good hints and advice on particular problems that they had experienced with the case construction process.

Round table sessions/debates

The student case teams first give a briefing on their technology strategy case in debates with the other students and the course faculty. The overall learning goals were a particular focus for the whole class. The other student groups and the faculty gave feedback and suggestions to the presenting group. The course director provided additional advice to those groups requiring it.

Handing in case synopsis

In week three the case teams handed in the case synopsis to be approved (and/or modified) by the course faculty.

Data gathering, compilation and writing of the case and teaching guide

The student group gathered data through collecting written material and conducting interviews in the company, relying on the contact persons advice and introductions. Date was compiled and the case and teaching notes were written.

Off-campus workshops

The student groups then organised an off-campus workshop, in order to present and test-teach (i.e. prototype) their written cases. Two days before the presentation at the off-campus location, cases were distributed to all students by the students themselves, with the aim of reading them before the presentation. After the test-teaching of the case the other students, the course director and faculty consultant gave feedback to the presenting/teaching group.

Revision of case and teaching note

Based on the feedback and comments given at the workshop and from the companies, each group had about five days to revise its case and teaching note.

Handing in final case and teaching note

Student groups handed in the final written case and teaching note.

Presentation and discussion of case at the company

The students had to present their written case and their findings in a case seminar/session with the company representatives. Some student teams chose to run the case as a case test. Other student groups gave an overview presentation of the case and teaching note, finishing with a discussion about the value for and potential use in the company. The case was also distributed beforehand to the company representatives for the purpose of preparation and to check the validity of the used data.

Final grading and feedback to students

The course faculty and the participating companies read and evaluated the final case 2.0 and the teaching note based on the following criteria: a) use of business and technology information, b) analytical skills/application of theory to the case, c) trustworthiness, and finally d) the overall impression of the case

learning process and final product (i.e. the case and teaching note) including its delivery to the company managers. The course director communicated the evaluation of the case and gave the grade to the student groups.

ON THE DESIGN OF THE TEACHING NOTE

One example of a suggested outline for an initial teaching note is given below [Cinneide 1998, p 29]. The author does not elaborate further than the main headings.

Teaching note content

1. Key-points.
2. Basic issues.
3. Immediate issues.
4. Medium/long term considerations.
5. Suggested student assignments, prior to class discussion.
6. Recommended additional readings/references.
7. Audio-visual/computing aids.
8. Prospective questions.
9. Suggested analysis which could provide answers to the above questions.
10. Suggested approaches to facilitate class discussion.

In order to promote the whole learning process (i.e. when the students write their own cases) the author developed the following detailed design/content instructions for the teaching note. Through evaluations/course feedback and review meetings with both students and managers, it was shown that that these instructions gave them a better understanding of how to approach and work in the case construction process.

This design was, therefore developed and distributed to both students and managers to help them understand the case learning method. This supported the learning situation in academia as well as in industry and built on the case design process presented in 2002. Confidentiality was a key issue for the organizations involved. They were assured (in writing) that the constructed case would not be used publicly until the company representative had approved it. In addition, due to the sensitive nature of R & D issues, it could be made anonymous.

FIGURE 1: CONTENT OF AND INSTRUCTIONS FOR THE TEACHING NOTE

Factual information

- Name of the case (hint: make it interesting/attention-grabbing and focus on the key issues in the cases)
- Year and date
- Company name and contact persons
- Case writers
- Academic tutor
- Please note: all produced cases are considered strictly confidential

1. Case summary "The case in a nutshell"

In the summary the whole case challenge and decision making situation is described with the main focus on Technology Strategy. The business situation is often included in order to put the technology in its context. Mention how the case can contribute to different learning outcomes in both academic research and industry.

2.The main use of the case at the company

In this part, the main purposes and use for the particular industry is highlighted so that the case can be used by the managers in their organization, both practically and theoretically, in the situation or situations that it was design for. Focus on understanding issues concerning the Technology Strategy and related areas such as business environments (review the literature for more ideas).

3.The main use of the case at the university
The other main purpose of the case is that it could also be used in the Technology Strategy course. Here the challenges are that the students understand both the course objectives and course design. They should formulate different learning scenarios so that the case can be used in, e.g. a certain module in the course. Here the focus is on both addressing and illuminating the case company's technology issues with the relevant theory, models and concepts.

4. Decision situation and main questions for the company
In this part the student describe which decision-making situations the case could be used in within the company. The case task can here be placed at different levels by the case level difficulty cube method [Leenders and Erskine, 1997]. Three to five questions/tasks (i.e. the analytical dimension) can also be assigned to the participants. The choice of questions is also justified and the potential solutions, which can be of various kinds, are also given here.

5. Decision situation and main questions for the university
In this part the student describe which decision-making situations the case could be used in within the company. The case task can here be placed at different levels by the case level difficulty cube method [Leenders and Erskine, 1997]. Three to five questions/tasks (i.e. the analytical dimension) can also be assigned to the participants. The choice of questions is also justified and the potential solutions, which can be of various kinds, are also given here.

6. Applied models and concepts.
In this section, which addresses the conceptual dimension, students fully justify their choice of key models and concepts (i.e. the conceptual dimension) derived mostly from the course literature focusing on Technology Strategy. The most important thing is that they are relevant to the case and that they are useful i.e. applicable for both stakeholders in helping to understand the questions (and task) they are addressing with the case.

7. Relevant learning formats (i.e. case pedagogy) for the company.
This part provides often a real challenge for the students. They need to suggest two (2) alternative pedagogical ways of managing the case learning situation in the company to generate new knowledge and competence. Justify these briefly. This should also be connected to the case difficulty cube and particularly the analytical dimension. Be creative and also ask the companies for ideas on how the work relates to company development and competence development.

There are a lot of alternative ways to pedagogically orchestrate the case learning process: debates, role plays, simulation and structured confrontations etc. Reflect on how the white board, the room and modern media might be used. The key thing here is to focus and be very precise in your instructions (see point 7) so that the participating managers understand and are able, in the near future, to independently apply your suggested pedagogical formats without your assistance.

You will get two chances to test the effectiveness of your teaching note (and of course the case) - at the pre-test and at the final case test with the managers. Please organise the final case test session well in advance. Company representatives often have very busy schedules.

8. Relevant learning formats (i.e. case pedagogy) for the university.
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9. References i.e. literature, relevant links and email addresses. In this final section you note all the articles and books that you used in the case. This shows the basic references and gives ideas to the instructors in industry and academia. You can recommend new literature that could also be used.
10. Appendix

MAIN FINDINGS

In this final section some findings are presented regarding the use of the teaching note in both the academic and industry contexts, when the students write and present their own cases.

First, we found, through evaluations and meetings with both students and managers, that the teaching note framework (Figure 1) that was distributed at the beginning of the course, provided the students with a thorough understanding of how to approach, manage, and work in the student written case (SWC) construction process. As the students had a basic knowledge of case methodology, this gave them an explicit framework for how to approach, design and steer the learning situation for the different stakeholders.

Second, the teaching notes also helped to communicate the case construction challenge to the participating managers and companies. Supported by deconstructing the challenges and producing a written case, this more abstract “knowledge creation process” became more understandable and tangible for them. This issue remains, however, the greatest challenge for us at the university in strengthening our collaboration with companies and public organizations.

Third, focusing attention on the framework and process of case construction greatly improves the end results. Students were strongly encouraged to discuss the first phases (especially parts 2 – 5 in the teaching note) before starting any writing. This provided a sound basis for creating relevant, useful cases and also helped students to avoid many typical pitfalls (e.g. focus not precise enough, weak links between theory and practice, lack of engagement). Fourth, early introduction of the teaching note also highlighted the importance of the key use and clear understanding of the case difficulty cube [Leenders and Erskine, 1989] for orchestrating case development and demonstrating the connection between the analytical and conceptual dimensions. In the student evaluations (2009), the students reflected on both what the concepts in the course literature meant, and how they can be effectively applied.

FUTURE STUDIES

In summary, these findings suggest that further research is needed into how students write and apply their own cases. Future studies could investigate students’ cognitive development in the SWC method as individuals and working in teams in comparison to traditional, generic case-based learning. More work is also needed on the interaction (and perhaps the phases) between the development of the teaching note and case. This could identify how professional educators can better design and orchestrate the overall learning using the student written case (SWC) method.

In addition, Executives’ use of SWCs should be further investigated. Such cases potentially represent a very valuable tool for internal development programmes. They could be re-used with trainees and new employees, providing a consistent, highly relevant resource. Further internal development of the specific cases could also take place, perhaps augmented by input from professional educators. Finally, the use of such cases may provide a useful benchmark for individual evaluation within an organization.

Given the strengthening links between academic research and industry, one key challenge is how to better engage industry representatives in educational collaboration. This kind of knowledge vehicle co-creation (student written case) has enormous potential, warranting more research into the processes that support it, such as the design and use of teaching notes.

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Knowledge spillover from Master of Science Theses in Engineering Education in Sweden

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ABSTRACT

Educational collaboration activities are generally under-researched part of the interactive learning between universities and industry. The study based on 529 Master of Science (MSc) theses from a major Swedish engineering school, the faculty of engineering LTH at Lund University, shows that MSc theses are a frequently used collaboration mechanism between university and industry in engineering education. Collaborating firms benefit mainly by recruiting students and the transfer of technological knowledge. Moreover, mainly regional large firms benefit from the educational collaboration and firms collaborate mostly on knowledge related to product innovations and in the early stages of the product innovation process. Small and medium-sized enterprises (SMEs) tend to relate to newer engineering disciplines, have relatively more MSc thesis projects related to product innovations and later process stages, specifically in prototype development and testing, than large firms have. The paper suggests a number of university actions to increase knowledge spillover to SMEs.

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Introduction

Master theses and project work in the students' education are according to Bramwell and Wolfe (2008) an important but in university-industry collaboration research often underestimated part of the knowledge spillover and interactive learning between universities and industry, especially for small and medium-sized enterprises (SMEs). Knowledge spillover (e.g. Andersson, Quigley, and Wilhelmson 2004; Audretsch and Feldman 1996; Agarwal, Audretsch, and Sarkar 2010) means that firms and organisations can benefit from the knowledge gained from university research and development (R&D) and education e.g. by engaging students in a bachelor or master thesis, recruiting the educated students as well as come in contact with research and teachers/researchers (Kunttu 2017).

University-industry collaboration is typically described as involving collaborative R&D, contract R&D, personnel mobility and educational collaboration (e.g. D'Este and Patel 2007; Perkmann et al. 2013). While educational collaboration activities with universities often are mentioned as potential sources of innovation knowledge for the industry, it has with few exceptions being empirically investigated (e.g. Bramwell and Wolfe 2008; Kunttu 2017). The topic of university-industry collaboration in engineering education has received some research interest but limited to identifying societal drivers, such as globalisation and speed of Information and Communication Technology (ICT) development and related challenges and opportunities for the engineering education (Korhonen-Yrjänheikki,

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Tukiainen, and Takala 2007). Research focusing on the actual impact and knowledge spillover to the industry from educational collaboration activities, in the engineering field, seems to be limited to four studies by Bramwell and Wolfe (2008), Kunttu (2017), Lucia et al. (2012) and Thune (2011). Bramwell and Wolfe's (2008) case study of University of Waterloo, a technical and natural science university in Canada, shows two main advantages for firms involving themselves in internships and master theses: (1) the companies will be able to more thoroughly observe, test and evaluate job candidates before possibly recruiting them, and (2) students transfers new knowledge, both explicit and implicit, to the firms. Two other case-based studies by Kunttu (2017) in Finland, and by Lucia et al. (2012) in Spain, corroborate these findings and show that in a European educational system the master of science (MSc) theses are one of the most commonly used knowledge spillover mechanism to the industry. However, none of these studies systematically researches the knowledge spillover from MSc theses to the industry.

Bramwell and Wolfe (2008) mostly discuss the benefits for SMEs while the studies by Kunttu (2017), Lucia et al. (2012) and Thune (2011) concern benefits for large firms. This poses the question to what extent knowledge from MSc theses spills over to large firms or to SMEs. On the one hand, we could expect SMEs, because of their more limited resource base, to more frequently use external sources of knowledge than large firms as prior research has indicated (e.g. Edwards, Delbridge, and Munday 2005). On the other hand, we could also expect SMEs to be a less frequent user of external knowledge sources than large firms are as they have access to fewer resources, smaller organisations and fewer people to commit to external knowledge exchange (Lee et al. 2010). The smaller resource base of SMEs also indicates that SMEs would need more assistance, e.g. intermediaries (Lee et al. 2010), to be able to utilise external knowledge in a more comprehensive way. Bramwell and Wolfe (2008) indicate that university-industry educational collaboration is particularly valuable to SMEs. By investigating the differences of knowledge spillover from MSc theses to large firms and SMEs we could increase knowledge on the current situation of knowledge spillover and its distribution to large firms or SMEs. In case of SMEs being disadvantaged, we could propose supportive components in the engineering education to better serve the needs of innovation-related knowledge for SMEs.

The lack of systematic research regarding university-industry educational collaboration in general and knowledge spillover from engineering students' master theses to the industry in particular has motivated us to do a survey study of MSc theses in engineering. We have studied the MSc theses at one of Sweden's major engineering schools, the Faculty of Engineering LTH[1] (from now on LTH), at Lund University in Sweden, situated in the most southern part of Sweden. LTH has roughly 9000 students (mostly engineering students but also students in architecture, industrial design etc.), some 700 engineering graduates and 500 MSc theses each year. This study intends to contribute to the university-industry educational collaboration by investigating the extent and form of innovation-related knowledge spillover from master thesis projects in engineering education and possible differences between large firms and SMEs. While there is also knowledge spill in from industry to university, e.g. from more research-oriented MSc theses, this study focuses only the knowledge spillover from university to the industry through MSc thesis projects. The research questions are:

- To what extent are master theses done in collaboration with industry in engineering education?
- What type of firms are involved in the theses, i.e. large firms or SMEs?
- What type of innovation-related knowledge spills from the master thesis projects to the firms and are there differences between large firms and SMEs?
- How can engineering education increase the innovation-related knowledge spilled to SMEs?

The rest of the paper is structured as follows. Next section will briefly review the research on knowledge spillover from an educational collaboration between university and industry. Thereafter we shortly present the method used in the study. In the third section, we present the results and then finish with concluding discussions of the results and implications for engineering education.

University-industry educational collaboration and knowledge spillover

Theories of knowledge spillover from university R&D to surrounding companies (e.g. Audretsch and Feldman 1996) generally base their reasoning on theories of knowledge-based (endogenous) economic growth (Romer 1986). Andersson, Quigley, and Wilhelmson (1996) found that innovative activity linked to R&D knowledge is geographically concentrated and that this concentration can be explained by proximity to highly educated labour, university R&D and firm R&D. However, the proximity to university R&D is for most firms less interesting than proximity to a pool of skilled labour and a constant flow of graduate students (Bramwell and Wolfe 2008; Kunttu 2017). Even for companies that have extensive R&D activities, higher education and access to a pool of educated labour often play a more important role than proximity to relevant university R&D (Andersson, Quigley, and Wilhelmson 2004).

There are several reasons why university-industry educational collaboration, relative to R&D collaboration, are and will be even more attractive for industry. In most developed economies, the service sector dominates the economy and particularly the knowledge-intensive service sectors are growing (OECD 2012), a sector that relies heavily on recruiting higher educated engineers. Moreover, the increasing globalisation and ICT development throughout almost all industries put a premium on young engineers with generally better language, cultural and ICT skills than previous generations of engineers (Korhonen-Yrjänheikki, Tukiainen, and Takala 2007).

In Bramwell and Wolfe's study (2008) point to two major advantages with student internships and thesis work; (1) Through internships and thesis work, companies are given the opportunity to more thoroughly observe, test and evaluate job candidates before hiring. (2) Students transfer new knowledge and skills, which means, among other things, that they educate employees in certain areas, such as qualified use of ICT. Kunttu (2017) corroborate these findings in her study of nine cases of educational collaboration activities, most of them with an engineering content, that master thesis projects are the most important forms of knowledge transfer for the industry. The firms involved in educational collaboration activities mostly appreciated the benefits of (1) recruiting student graduates with specific competences, (2) gaining skills and new information from the academic world, (3) facilitating industry to utilise new information from the university, and (4) deepened understanding of university research processes and collaborative practices.

The transfer of new skills and new information in educational collaboration is one source of external knowledge in firms' open innovation strategies (Lucia et al. 2012). The case study by Lucia et al. (2012) provides an example of how a large firm (Bosch and Siemens Home Appliance Group – BSH) collaborates with the University of Zaragoza in both research and education in order to develop the induction heating technology since 1990. Over the years, the collaboration has helped BSH to develop induction heating from an exclusive and bulky appliance to a built-in, efficient and mass-produced device (Lucia et al. 2012). The case study provides examples of the product as well as process innovations and involvement at various stages of the new product development process.

Thune (2011) reviews the research on R&D-based university-industry partnerships and identifies three categories of success factors (contextual, organisational, process factors) for such partnerships. The contextual factors are choice of partners and geographical and cognitive proximity. Organisational factors concern formal organisation of and top leadership commitment for collaboration activities. Process factors are how the partnerships are actually managed, i.e. project management, and how communication is handled in the partnership. In her four case studies, she checks the relevance of these success factors for educational collaboration in engineering. She finds that the three success factors are relevant also for educational collaboration albeit with a few differences in emphases. She finds that geographical proximity seems more important in educational collaboration and the cumulative manner of successful partnerships (prior successful collaboration leads to more collaboration) requires the universities to allocate resources to initiate and coordinate new partnerships by initiating small projects with new industrial partners.

In order to determine what type of innovation-related knowledge that is spilled we have chosen to define innovation according to OECD's definition (OECD 2005) based on Schumpeter's (1942) innovation definition. As we expect most master theses to be related to product innovations we have used Cooper's (2008) definition of the innovation process 'as a series of stages' and used six stages in this process, from screening to commercialisation, to position innovation-related knowledge spillover in the innovation process (for details see Box 1). As recommended by Cooper (2008) we have broadened the scope of the stage-gate process to include also other types of innovation projects, such as innovations in manufacturing, distribution, recycling and maintenance processes, by asking for development or adaptations in technologies, methods, concepts, and products (see Appendix A).

Box 1. Innovation definition and stages in the innovation process used in this study.

Innovation definition
'An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations'. (OECD 2005, 46)
Stages in the innovation process
'The innovation process can be visualised as a series of stages, with each stage comprised of a set of required or recommended best-practice needed to progress the project to the next gate or decision point'. (Cooper 2008, 214)
Stages used in this report are; screening of new ideas and technologies, scoping of ideas and technologies, development of a business case, development of a prototype, testing and validation, commercialisation.

Kunttu (2017), Lucia et al. (2012) and Thune (2011) all provide examples of large firm educational collaboration with the university. Laursen and Salter (2004) found that large firms dominate university-industry research collaboration, especially the large firms with access to R&D-capabilities and large firms with an open innovation strategy, i.e. firms that used many external knowledge sources in their innovation processes. Large firms have in general better access to R&D-capabilities than SMEs as well as a better capacity to search for new knowledge (Lee et al. 2010). Thus, we expect large firms to dominate also educational collaboration even though educational collaboration could be seen as relatively more valuable for SMEs (Bramwell and Wolfe 2008). Lee et al. (2010) propose that SMEs need of innovation-related knowledge is more oriented to the exploitation phase of innovation, e.g. development of prototypes, marketing, and commercialisation activities, rather than the exploration phase of innovation, e.g. technology development, ideation, the latter being more compatible with large firms' R&D-oriented innovation process.

Empirical context

The Swedish higher education system has generally limited interaction with industry as most of it is performed by state government funded and organised universities and higher education institutes (Jacob, Lundqvist, and Hellsmark 2003). However, the level of interaction between university and industry varies greatly between different faculties, i.e. applied sciences such as engineering having a much more frequent collaboration with industry in R&D and education than less applied sciences (Bengtsson 2011, 2013). Since the mid-1990s there have been national policy efforts to support research knowledge coming into use with a law specifying 'a third mission', education and research being the first two missions, for Swedish universities coming into effect in 1997 (Jacob, Lundqvist, and Hellsmark 2003). As part of this national policy to increase interaction between university and industry the Swedish state funds a regional system of university Technology-transfer offices (TTOs) connected to all Swedish universities focusing on university spin-offs (Bengtsson 2017). The national innovation agency, Vinnova, finances various university-industry innovation programmes, which requires co-financing from industry (Bengtsson 2017). However, there has been very limited attempts from the Swedish government to support university-industry educational collaboration programmes and projects (Bengtsson 2013).

In Sweden, compulsory internships are unusual in the higher education of engineering degrees. Instead, there is a tradition to finish the degree programmes, both at bachelor and master level, with an independent major study reported in a bachelor or master thesis. Some theses are done in collaboration with firms, public organisations, and non-profit organisations while others are more research-oriented. The knowledge spillover effects of these theses are, on a more systematic level, at least to our knowledge, not known. This research focuses on MSc theses completed at the end of five years of study at the Faculty of Engineering LTH at Lund University (LU). The faculty of engineering LTH is, in terms of a number of students, the largest faculty at LU, and mainly educate engineers in 16 educational programmes leading to an MSc degree in engineering. At LTH, thesis projects are the only systematic opportunity in the undergraduate and graduate degree programmes to offer the students contact with working life and practice their knowledge in cooperation with a company or other organisation over a longer time (30 credit points equivalent to one semester or approx 4.5 months for the MSc thesis). Either individual students (approx 60% of the theses) or maximum two students (40%) perform the MSc projects. The objective of the MSc theses at LTH is: *The aim of the degree project is for the student to develop and demonstrate the requisite knowledge and skills to work independently as an engineer* (LTH Course Syllabus for Degree Projects 30 credit points 2016). Of course, many students have contact with working life and firms through summer employment or part-time employment but this is not part of their educational programme.

Method

The lack of prior systematic knowledge on the extent and type of knowledge spillover from MSc theses in engineering education motivated us to use a quantitative method surveying all MSc theses at a major engineering faculty in one year. The sample consisted of all registered MSc theses in engineering at the Lund University engineering school, LTH, completed during the year 2016. We identified 529 MSc theses supervised at 16 LTH departments. We have coded all master theses on authors, subject, the title of theses, supervisors, external collaboration partner (if any) and connections to departmental research. A thesis was coded as 'collaborative' if the thesis contained a clear statement of being done in collaboration, or on commission with one (or in a few cases several) specific firm(s) or organisation(s) or had an external supervisor from a firm or organisation. In a limited number of theses, the collaboration firm or organisation was anonymous due to secrecy concerns from the firm or organisation. They were nevertheless coded as 'collaborative theses' but could then not be included in the second survey to the collaborating firms or organisations.

The second survey was conducted as a telephone interview to the external collaboration partners (firms, organisations) and the specific external supervisor or contact person mentioned in the master thesis. The questionnaire to the firms and organisations contained two sections of questions. The first section contained general questions, e.g. regarding the firm or organisation's general reasons to collaborate on MSc theses. The second section concerned questions specific to the master project the contact person had supervised, e.g. the thesis relatedness to the type of innovation and product development process stage (based on the definitions provided above in Box 1), implementation of results and recruitment of master students. The questions used in this study are listed in Appendix A.

339 of the 529 MSc theses (64%) were classified as collaborative theses. In 315 of the theses, the firm or organisation name could be identified and 280 of the theses specified at least one contact person. Thus, in 59 of the 339 theses of the company name and/or contact person were not disclosed leaving 280 theses to base the firm survey on. Of the 280 questionnaires sent to firms/organisations and their contact person, we received 139 responses giving a total response rate of 49.6%. We used only the large firm and SME responses as the public sector and non-profit organisations' responses were too few to use in statistical analysis, i.e. we used 124 responses in our analysis. We performed the statistical analysis using the data analysis tools in Excel.

Validity and reliability

The MSc-thesis survey contained all MSc-theses during one year, i.e. the whole population of MSc-theses in one year. Over time, MSc-theses may change in terms of collaboration frequency and type of partners, but we have no indication that the year 2016 was significantly different in this regard from previous years' MSc-theses. Two researchers coded independently from each other the collaborative and non-collaborative MSc-theses. In only four cases (of originally 343) they differed in coding, four of the anonymous MSc-theses, resulting in classifying these four theses as non-collaborative and ending up with 339 collaborative MSc-theses. Thus, interrater reliability is quite satisfactorily for the MSc-survey.

The overall response rate for the firm survey (49.6%) is satisfactorily and similar for both groups of firms, large firms (50.6%) and SMEs (45.7%), see Table 1 below. Concerning construct validity the questions regarding reasons to collaborate we based on the study by Bramwell and Wolfe (2008) and the questions regarding the phase of development and type of development are based on previously validated concepts and scales by Cooper (2008) and OECD (2005). Overall, we view external validity for LTH as good and, for reasons elaborated at the end of the paper, for the entire higher Swedish engineering education.

Results

In the following, we will report the results from the two surveys: the MSc thesis survey and the collaborating firm survey. Starting with descriptive results from the MSc thesis survey, we below list the distribution of the 529 MSc theses at LTH according to collaboration with different types of firms and organisations (Table 2). A clear majority of MSc theses at LTH are done in collaboration with firms/organisations.

The firms mostly involved in the collaborative theses are predominantly the large firms and especially Swedish multinational enterprises (MNEs), i.e. Swedish-based firms with international activity in at least six foreign countries. Most of these large firms have a regional presence, i.e. a head office or larger unit located in Southern Sweden, i.e. the region of Skåne.

A clear majority (72%) of MSc thesis projects collaborated with firms and organisations in the region. Knowledge spillover from educational collaboration tend to be absorbed primarily by regional firms (Bramwell and Wolfe 2008; Thune 2011), thus our survey confirms this pattern.

The distribution of MSc theses according to an engineering discipline, here we use LTH departments as an approximation of engineering discipline, show some interesting patterns (Table 3).

Looking at the distribution of collaborative MSc theses, engineering disciplines with a strong basic research profile, such as Physics, Immunotechnology, and Mathematics, have a limited share of collaborative MSc theses. At the other end of the distribution curve with high shares of collaborative theses, we have more applied engineering disciplines, such as energy sciences, mechanical engineering, and industrial management. Large firm oriented disciplines tend to be the older and more established disciplines such as Construction, Electrical, Chemistry, and Mechanical engineering. SME-oriented disciplines tend to be the 'newer' engineering disciplines, i.e. Computer, Biomedical, Food, and Design engineering.

Looking at the heavy users of MSc theses (Table 4), defined as firms with more than 4 master theses during a year, they are all Swedish MNEs (ABB, Axis, Ericsson, IKEA, Sandvik, Scania, Sweco,

Table 1. Response rates firm and organisation survey. Note that the responses from public and non-profit organisations are not included in this study.

Survey to firms and organisations	Questionnaires sent	Responses
Large firms (250 or more employees)	172	87 (50.6%)
SMEs (1–249 employees)	81	37 (45.7%)
Public (state, regional, municipal), and non-profit organisations	27	15 (55.6%)
Total	280	139 (49.6%)

Table 2. Distribution of collaborative MSc theses according to type of organisation and region.

Type of organisation	Number of master theses in collaboration (percent of the total in collaboration)	Whereof in regional organisations (percent of collaborative theses for the type of organisation)
Public sector and non-profit organisations	28 (8%)	19 (19/28 = 68%)
SMEs (1–249 employees)	94 (28%)	67 (67/94 = 71%)
Large firms (250-or more employees)	193 (57%)	141 (141/193 = 73%)
Total nr of master theses where firm/ organisation is known	315 (93%)	227 (227/315 = 72%)
Organisation anonymous	24 (7%)	–
Total number of collaborating theses (in relation to total nr of collaborative theses)	339 (100%)	–

Table 3. Distribution of MSc theses according to LTH departments.

LTH Departments	Nr of MSC theses	Nr of collaborative MSC theses	Collaborative MSc theses (%)	(%) Large firm	(%) SME
Immunotechnology	5	0	0	0	0
Physics	30	6	20	50	17
Mathematics	17	6	35	100	0
Building & environm techn	63	32	51	56	28
Chemistry	27	14	52	86	7
Electrical and IT	46	25	54	64	28
Technology and Society	49	30	61	50	23
Chemical engineering	25	16	64	56	19
LTH Nr of MSc theses and means	529	339	64	57	28
Construction Sciences	15	10	67	90	10
Computer science	44	32	73	56	41
Biomedical engineering	37	27	73	56	30
Food technology	12	9	75	44	33
Design sciences	62	49	79	41	41
Industrial managem & logistics	51	43	84	60	21
Mechanical engineering	22	19	86	58	26
Energy sciences	24	21	88	52	33

Tetra Pak) or foreign-owned MNEs with Swedish subsidiaries (E.ON, WSP), except two regional firms (Kraftringen, Modelon), whereof only one firm (Modelon) is an SME. The 15 firms, heavy users, account for 31% of all collaborative theses while the remaining 69% of collaborative theses were related to 145 firms or organisations with three or fewer MSc theses. Overall, the results indicate that large firms dominate not only university-industry research collaboration (Laursen and Salter 2004) but also university-industry educational collaboration.

Turning to the collaborating firm survey we asked why the firm involved themselves in MSc thesis projects.

The major reasons are listed in Figure 1 below. As prior research has indicated (Bramwell and Wolfe 2008; Kunttu 2017) recruiting new employees, solving problems in the firm, get new technological knowledge and ideas and maintaining contact with the education and the school are the most important reasons. When comparing the means for large firms and SMEs with a t-test there were no statistically significant differences in the reasons to involve the firm in master thesis projects (see Table 5 below).

About half of the firms also gave a job offer to the students and most students accepted the job offer (see Figure 2). Giving a job offer and students accepting the offer was relatively more frequent for the large firms than SMEs. Some 40% of the firms reported that they had implemented the results of the master thesis project. SMEs tended overall to have relatively more use for the results, though differences were not statistically significant.

Table 4. Heavy users of MSc theses.

Collaborating firms/organisations involved in four or more master theses	Firm/organisation located in the same region as Lund University (regional), in rest of Sweden (national) or international	Number of master theses
ABB	Out of region, LF, Swedish MNE	4
Alfa Laval	In region, LF, Swedish MNE	4
Axis Communications	In region, LF, Swedish MNE	17
E.ON	In region, LF, Foreign MNE	8
Ericsson	In region, LF, Swedish MNE	7
IKEA	In region, LF, Swedish MNE	4
Kraftringen	In region, LF	5
Modelon	In region, SME	5
Sandvik	In region, LF, Swedish MNE	5
Scania	Out of region, LF, Swedish MNE	5
Skanska	In region, LF, Swedish MNE	6
Sweco	In region, LF, Swedish MNE	6
Tetra Pak	In region, LF, Swedish MNE	14
WSP	In region, LF, Foreign MNE	4
ÅF	In region, LF, Swedish MNE	4
Nr of 'heavy user' firms: 15	Nr of master theses	98

Thus, MSc thesis projects are a common mechanism for both large firms and SMEs to recruit engineering students and the majority of them, at least partly, implement the results. Again, the differences in means between the two groups, large firms and SMEs, were not significant (Table 5).

Innovation-related knowledge spill was defined as four different types of innovation according to the Oslo manual by OECD (2005) based on Schumpeter's (1942) innovation definition and six stages of the innovation process (Cooper 2008). For both type of firms product innovation-related knowledge dominates the MSc thesis projects. However, product innovation-related knowledge is relatively more frequent for SMEs than large firms (statistically significant), while process innovation is relatively more frequent for large firms than SMEs (not statistically significant, see Table 6). About 15% of the MSc theses could not be classified as related to any of the four types of innovations (Figure 3) indicating that some MSc theses have a broader focus, e.g. how an environmental law change may affect a firm's businesses.

Concerning the stages in the innovation process a majority of the theses were related to the initial phases of innovation, i.e. screening new technologies, especially for large firms, or scoping new

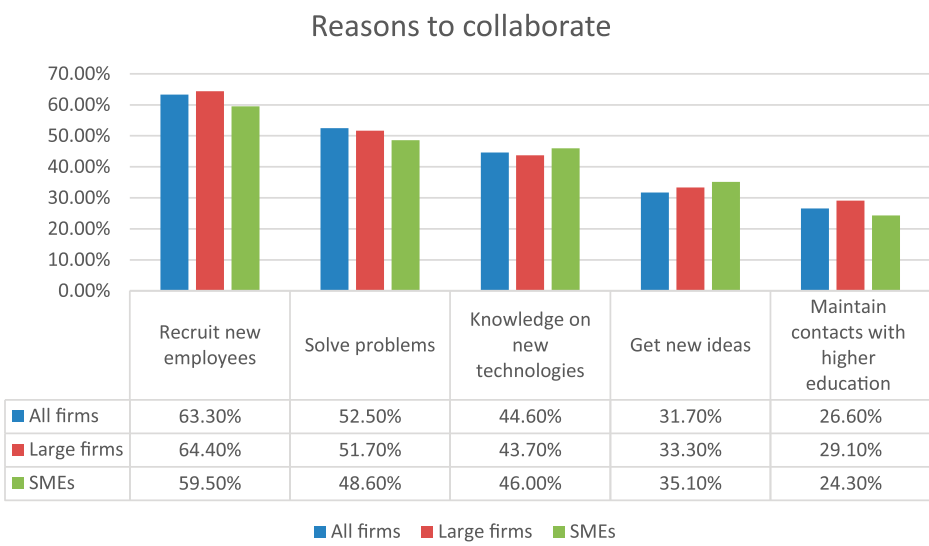


Figure 1. Five major reasons to collaborate according to firm responses.

Table 5. Standard t-tests of means, two-tailed, between large firms and SMEs regarding the reason for collaboration, job offers, and implementation. Statistically significant differences require a *p*-value at or below 0.05.

Variable	Large firms ($n = 87$) Mean	SMEs ($n = 37$) Mean	*t*-value	*p*-value
Recruit new employees	0.64	0.59	0.51	0.614
Solve problems	0.52	0.49	0.31	0.758
Knowledge new technologies	0.43	0.46	−0.23	0.819
New ideas	0.33	0.35	−0.19	0.849
Maintain contacts with school	0.29	0.24	0.54	0.586
Job offer	0.55	0.41	1.49	0.139
Results implemented	2.72	2.78	−0.24	0.808

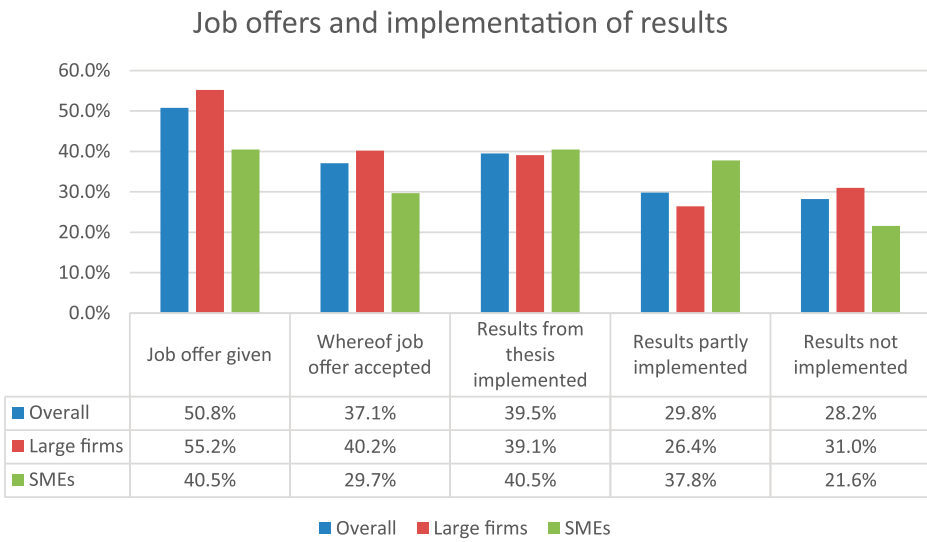


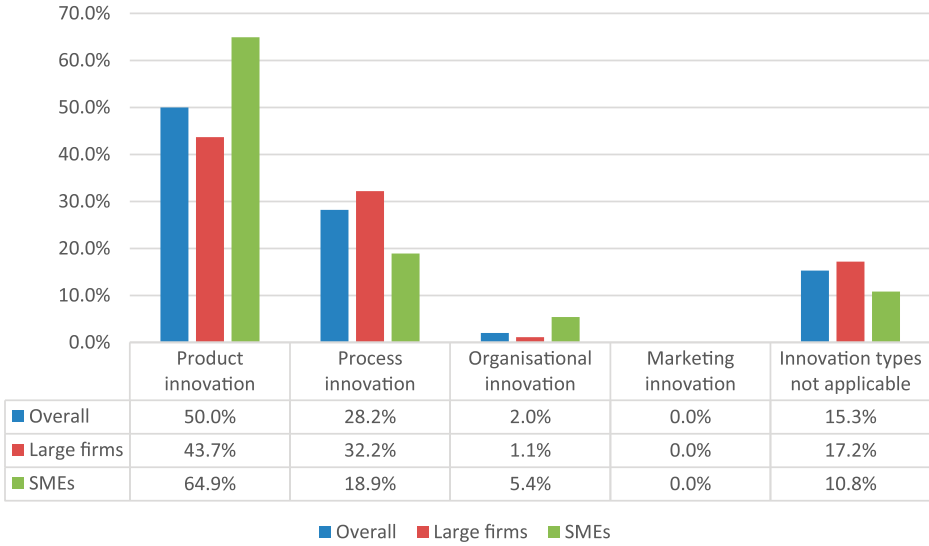
Figure 2. Job offers given to thesis students and implementation of thesis results according to firm responses

technologies to firm-specific purposes (Figure 4). The theses collaborating with SMEs were more frequently related to development and testing of prototypes. Overall, few theses concerned building a business case or development of commercialisation plans or actions. The difference between large firms and SMEs is here statistically significant, meaning that large firms tend to collaborate more

Table 6. Standard *t*-tests of means, two-tailed, between large firms and SMEs regarding type of innovation and innovation process stages.

Variable	Large firms ($n = 87$) Mean	SMEs ($n = 37$) Mean	*t*-value	probability
Product innovation	0.44	0.65	−2.21	0.030*
Process innovation	0.32	0.19	1.61	0.111
Organisational innovation	0.01	0.05	−1.08	0.286
Marketing innovation	0.0	0.0	–	–
Screening	0.60	0.38	2.27	0.026*
Scoping	0.23	0.24	−0.16	0.875
Business concept	0.05	0.03	0.53	0.592
Prototype development	0.01	0.14	−2.12	0.040*
Prototype test	0.01	0.19	−2.68	0.010**
Commercialisation	0.02	0.03	−0.13	0.898

*Indicates significant difference at *p*-value at or less than 0.05.
**Indicates significant difference at *p*-value at or less than 0.01.



	Product innovation	Process innovation	Organisational innovation	Marketing innovation	Innovation types not applicable
Overall	50.0%	28.2%	2.0%	0.0%	15.3%
Large firms	43.7%	32.2%	1.1%	0.0%	17.2%
SMEs	64.9%	18.9%	5.4%	0.0%	10.8%

Figure 3. Main type of innovation related to the MSc thesis

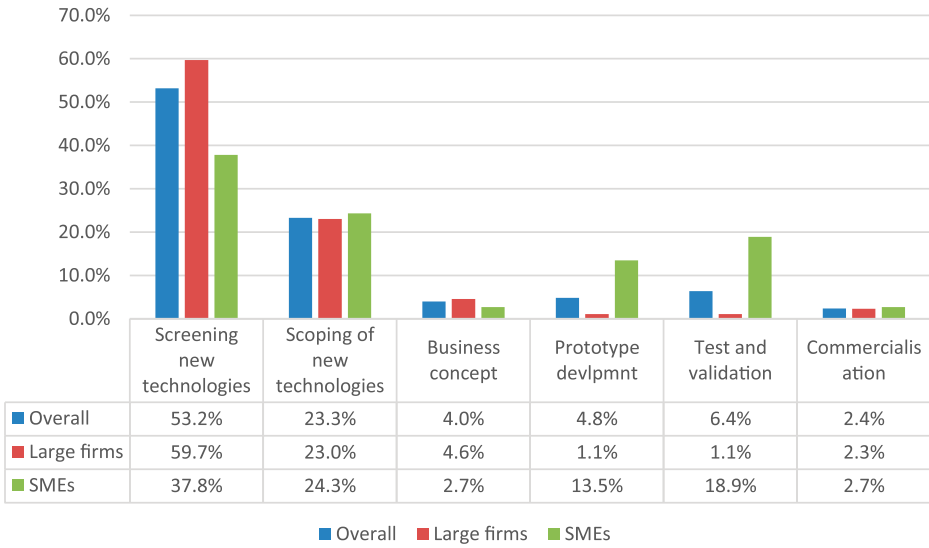
on the screening of new technologies while SMEs more on later stages of the innovation process, i.e. prototype development and testing (Table 6).

Overall, the typical MSc thesis deals with new to the firm technologies related to the development of new products or new processes in the firm in the early innovation stages. On the one hand, theses collaborating with SMEs tend to be relatively more oriented towards product innovations, prototype development, and testing than large firms. On the other hand, large firms' theses tend to concern process innovations, (though not a statistically significant difference) and screening of new technologies more frequently than SMEs.

Conclusions, implications for engineering education and further research

Our surveys of MSc thesis projects at LTH have empirically shown that: (1) MSc theses are a frequently used collaboration mechanism between university and industry in engineering education, (2) collaborating firms benefit mainly by recruiting students, (3) and by the transfer of technological knowledge. Moreover, (4) mainly large firms in the region benefit from the educational collaboration and (5) SMEs tend to be connected to newer engineering disciplines. Finally, we have shown that: (6) overall firms collaborate mostly on knowledge related to product innovations and in the early stages of the product innovation process, but (7) large firms tend to screen new technologies more than SMEs, and (8) SMEs tend to have significantly more MSc thesis projects related to product innovation and in the later product innovation process stages, specifically in prototype development and testing, than large firms have.

The empirical results confirm earlier research by Bramwell and Wolfe (2008) regarding the benefits (recruitment of students and transfer of knowledge) of master thesis projects, as well as the dominance of regional diffusion of knowledge. The dominance of large firms in educational collaboration is a new result, even though the pattern has been observed before in university-industry research collaboration (Laursen and Salter 2004). In addition, the results regarding knowledge spillover related to product innovations and early product innovation stages have not been reported before as well as the SMEs' thesis projects being significantly more focused on product innovations, prototype development and testing, while large firms' thesis projects focus significantly more on the screening of new technologies.



	Screening new technologies	Scoping of new technologies	Business concept	Prototype devlpmnt	Test and validation	Commercialisation
Overall	53.2%	23.3%	4.0%	4.8%	6.4%	2.4%
Large firms	59.7%	23.0%	4.6%	1.1%	1.1%	2.3%
SMEs	37.8%	24.3%	2.7%	13.5%	18.9%	2.7%

Figure 4. Main stage in the innovation process focused in the MSc theses.

Clearly, both large firms and SMEs seek to collaborate with engineering education for similar reasons and to a large degree, they also receive the benefits from the collaboration. Yet, the overwhelming dominance of regional large firms means that many SMEs might be disadvantaged in engaging in educational collaboration with engineering students (cf. Lee et al. 2010). How could engineering schools and their educational programmes provide more support to SMEs to compensate for these disadvantages? The results from the collaborating firm survey, specifically the profile of theses related to SMEs compared to large firms, i.e. mainly product innovations and prototyping support in product development, combined with Thune's (2011) success factors for educational collaboration, forms the basis for the following five recommendations to engineering schools and their managers in order to increase knowledge spillover to SMEs.

- Engineering school management should build and maintain long term networks with SMEs making better connections and interactive relations in education with regional SMEs a prioritised objective for the school signalling this priority to staff, students and the regional industry. For an example of a well-established university-SME network see Berglund, Birgersson, and Cederfeldt (2008). This may be especially important for the older established engineering disciplines.
- Engineering school management should instruct various internal units that work as intermediaries between university and industry, such as university-industry relational offices, career centres, and labs, to increase their efforts and services for SMEs in educational collaboration. This could include the establishment and promotion of an easy-to-use Internet-based service for SMEs to register their interest for a thesis project.
- Open up labs, equipment and facilities for no or low-cost use for SMEs in collaboration with students and teachers.
- Actively market the opportunities of thesis collaboration projects to regional SMEs, possibly sending them a voucher for an MSc thesis project to be 'cashed in' at the career centre or some other relevant university unit. Organising a fair specifically for SMEs could be another option (Granath 2012).
- Measure the educational collaboration activities and include key metrics for SME activity and follow-up progress over time.

Our results are based on the survey of 529 MSc theses in engineering at a major Swedish engineering faculty and a questionnaire to collaborating firms and organisations. Are these results generalisable to other Swedish and European engineering schools and faculties? The Swedish higher education system is uniform in the sense that it is state regulated and for the most part state organised and funded. Moreover, there are regular national quality assessments that focus mainly on the BSc and MSc theses, which have had a homogenising effect on thesis projects and reports throughout Swedish higher education institutes (UKÄ 2015). There might be differences between the larger Swedish engineering faculties and universities that are research oriented and smaller engineering universities and faculties where education dominates. The larger institutions have a significant proportion of MSc theses that are connected to their research. In our case regarding LTH, the proportion of research connected MSc theses was 20%. Still, the number of collaborative theses are much more frequent. At smaller engineering universities and faculties, where education dominates, the incidence of collaborative MSc theses might be even higher than for the larger institutions. Nevertheless, we believe our results are generalisable to the Swedish engineering educations. The external validity of the results of engineering education in other European countries is a question for further research.

We propose the following questions for further research:

(1) What is the incidence and character of collaborative MSc theses in engineering education in other European countries and how do they differ? Is there a pattern of older engineering disciplines connected to large firms and newer engineering disciplines connected to SMEs?
(2) How do engineering faculties and universities organise and facilitate MSc thesis projects for SMEs? Which measures are effective to increase SME thesis project activities?
(3) Given a more frequent use of the open innovation strategy (Lucia et al. 2012) in firms, how do firms organise and facilitate MSc thesis projects? How can engineering schools best facilitate firms' open innovation strategies?

This paper has focused on the knowledge spillover from MSc thesis projects to the firms and organisations. There are also knowledge flows in the other direction, so called 'knowledge spillins'. A final suggested research question is thus:

(1) What are the knowledge spillins to an engineering faculty/engineering department/educational programme/individual teachers from collaborative MSc theses?

Finally, as mentioned before, there are a number of reasons why educational collaboration may become relatively more important than research collaboration for engineering schools. The growth of the knowledge-intensive service sector and the ICT sector in particular and their need of higher educated engineers is one such important reason (Korhonen-Yrjänheikki, Tukiainen, and Takala 2007). These sectors show a lot of entrepreneurial and SME activity, i.e. new start-ups and many small firms (OECD 2012). In order for an engineering school to support this growth, to facilitate student transfer from study life to work life as well as the transfer of innovation-related knowledge, it may be prudent to organise educational collaboration activities accordingly.

Note

1. The acronym LTH stands for the Lund University engineering faculty's name in Swedish: Lunds Tekniska Högskola. In English, the faculty's formal name is Faculty of Engineering LTH.

Disclosure statement

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Notes on contributors

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Appendix A. Questionnaire to firms and organisations

Questions (response alternatives)

1. Which are the main reasons for your company or unit to engage students in master thesis projects (choose min 1 – max 3) Choose a maximum of three for the following reasons:
   - Solve a concrete problem (yes/no)
   - Get new knowledge about a new technology (yes/no)
   - Get an independent review of (parts of) our business (yes/no)
   - Recruit a new employee (yes/no)
   - Get new ideas (yes/no)
   - Need a market or customer survey (yes/no)
   - Maintain contact with the university and the education (yes/no)
   - Do not know (yes/no)
   - Other reason. Which? (open answer)
2. What stage of a developmental process did the thesis project mainly concern?
   - Investigation of new technologies / methods / concepts (or conditions for) that the company / organisation had not previously tested and not yet decided whether to use or not. (yes/no)
   - Development / adaptation of technologies / products / methods / concepts that the company / organisation decided to use. (yes/no)
   - Development of a business case for a new technology / product / method. (yes/no)
   - Development of prototype. (yes/no)
   - Testing/validation of prototype. (yes/no)
   - Measures to commercialise and implement the technology / product / method / process. (yes/no)
   - The above phases are not applicable in the thesis project. (yes/no)
   - Do not know. (yes/no)
3. What kind of development in your company / organisation was the thesis project related to?
   - Development of a new product / service or significant improvement of existing products / services. The product or service should be new or significantly improved with respect to its capacity, ease of use, components or sub-systems. (yes/no)
   - Development of a new or significantly improved process in the company / organisation. New or significantly improved methods of manufacturing goods or services, logistics, delivery or distribution methods, support activities such as maintenance systems, procurement, accounting or computer technology. (yes/no)
   - Development of the organisation, i.e. new method of organising business activities, including knowledge management, new organisation of the workplace or new organisation of external relationships not previously used by the company. (yes/no)
   - Development of marketing, i.e. significant change of aesthetic design, new product / service packing, new media and marketing methods, new product placements, sales channels, or new pricing method. (yes/no)
   - The above types of development are not applicable in the thesis project (yes/no)
   - Do not know (yes/no)
4. It is my view that the results of the maser thesis project have been used in the company or unit by influencing decisions or being implemented in the business.
5. (Strongly agree, agree, partly agree, disagree, strongly disagree, do not know)
6. We gave the master student a job offer in our company
   - Yes, and he/she accepted the job offer (yes/no)
   - Yes, but he/she declined the job offer (yes/no)
   - No (yes/no)
   - Do not know (yes/no)

Paper IV

Ivory Tower or Collaborative Innovation Platform? – Comparing MSc Theses in Engineering and Business Education

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Abstract

For the vast majority of firms and organizations the interest for university collaboration concerns education, i.e., educational collaboration, rather than R&D collaboration. The relative lack of prior empirical research regarding university-industry educational collaboration has motivated a study of Master of Science (MSc) theses in the business and engineering field. We surveyed all MSc thesis reports (n=945) in the year 2016 at Lund University in the business and engineering faculties, a survey of all collaborating firms (n=305) and follow-up interviews with study directors (n=14). Our main findings are: 1) MSc theses are frequently used as a collaboration mechanism between the university and industry in engineering education but very limited in business education, 2) collaborating firms in engineering education benefit mainly by recruiting students and by screening and scoping of new technologies, 3) collaborating firms in business benefit mainly by maintaining contact with school, 4) mainly large firms in the region benefit from educational collaboration, 5) the variation in incidence of collaborative MSc projects between the two faculties depends on the formal objectives of the master thesis (work life or research oriented), and 6) the character of the discipline at the department (applied or basic research).

Keywords: University-Industry Collaboration; Educational Collaboration; Knowledge transfer; Innovation;

Introduction

University-industry collaboration research encompasses various dimensions, including collaborative research and development (R&D), contract R&D, personnel mobility, and educational collaboration (D'Este & Patel, 2007; Perkmann et al., 2013). Bramwell & Wolfe (2008) emphasize that the interest in collaboration from industry extends beyond R&D collaboration and contract R&D, particularly within

small and medium-sized enterprises (SMEs) being more interested in educational collaboration activities. Educational collaboration manifests in diverse forms: collaboration with external stakeholders to develop curriculums (Fagrell et al., 2020), involvement in teaching and learning processes (Thune, 2011) and facilitating the transition between studies and working life (Thune & Stören, 2015). Regarding involvement in teaching, learning and transition to working life MSc theses and project work in collaboration with firms and organizations are important modalities (Kunttu, 2017). Despite often being undervalued, collaborative MSc theses and project work play a crucial role in facilitating knowledge trasnfer and interactive learning between universities and industry, especially for SMEs (Bramwell & Wolfe, 2008). From research on university-industry R&D collaboration we know that large firms dominate (Laursen & Salter, 2004) and SMEs do not see universities as technology partners but rater as teaching providers (De La Torre et al., 2018). University-industry educational collaboration might fit SMEs better than university-industry R&D collaboration as Bramwell & Wolfe (2008) suggest.

Educational collaboration activities with universities are acknowledged as potential sources of talented educated students and technical and innovative knowledge for the industry (Bramwell & Wolfe, 2008; Grimaldi et al, 2011; Perkmann et al., 2013). However, empirical investigations into this aspect remain limited, with few exceptions (e.g., Bramwell & Wolfe, 2008; Thune, 2011; Kunttu, 2017). Reviews of research on educational collaboration between university and industry highlight a scarcity of systematic studies on the knowledge transfer resulting from students' theses, including their transition to the workforce and knowledge transfer to established and new firms (Brandt et al., 2008; Thune, 2011; Bengtsson, 2013; Thune and Stören, 2015; Nsanzumuhire & Groot, 2020).

Previous research on university-industry R&D collaboration reveals an uneven distribution of interest, experience, and impact within universities (Goldstein, 2010; Nsanzumuhire & Groot 2020). Faculty members in engineering, medical science and natural science disciplines exhibit more favorable attitudes towards regional economic development, academic entrepreneurship, patenting, and licensing compared to those in social sciences and humanities (Goldstein, 2010; Compagnucci & Spigarelli, 2020; Nsanzumuhire & Groot 2020).

Given the paucity of systematic research on university-industry educational collaboration, our study aims to empirically investigate and compare the extent and patterns of educational collaboration activities between two major faculties at Lund University in Sweden – the engineering faculty and the business faculty. Specifically, we seek to answer the research questions: Is university-industry educational collaboration, in terms of collaborative MSc theses, more frequent in

the engineering faculty compared to the business faculty? Why do firms collaborate in education with universities? Which type of firm, large firms or SMEs and in region or out of region, are the most frequent educational collaboration partners in MSc theses? What are the main benefits for the collaborating firms in educational collaboration?

Our findings confirm the prevalence of a similar pattern in educational collaboration as observed in prior university-industry R&D collaboration research (Goldstein, 2010; Nsanzumuhire & Groot, 2020). Notably, there is substantial activity in the engineering faculty, while educational collaboration at business faculty remains limited. Moreover, university-industry educational collaborations in our study are dominated by large firms in the region. The knowledge transfer to industry is primarily in the form of student recruitment and transfer of technological knowledge in the early stages of the innovation process, i.e., screening and scoping of new technologies. The subsequent sections include a brief review of prior research on patterns of university industry research collaboration and educational collaborations, an overview of the empirical context and MSc thesis surveys, presentation of results, and a discussion thereof. The paper concludes with implications for university managers, as well as recommendations for future research on university-industry educational collaboration.

Theoretical background

Previous investigations into university-industry R&D collaboration have revealed significant variations in attitudes towards collaboration with industry and its impact across different faculties. Goldstein's (2010) comprehensive survey, encompassing 71 U.S. universities and eight distinct disciplines, identified engineering disciplines, such as Computer Science and Chemistry Engineering, as exhibiting the most favorable attitudes. These attitudes were particularly evident in issues related to the university's role in regional economic development, direct commercialization of research, and provision of start-up assistance. In contrast, social science disciplines (economics and political science) and humanities disciplines (English, History) displayed more critical attitudes towards various collaborative and entrepreneurial activities.

Bonaccorsi et al. (2013) extended this exploration to Italy, highlighting that universities specializing in applied sciences and engineering positively influenced regional new venture firm creation, particularly for service firms. However, social sciences and humanities had limited impact on new venture creation. While these studies did not explicitly focus on business schools and management research, they

included disciplines, such as economics and social sciences, that share similarities with business and management research.

The persisting difference in impact on firm innovation, entrepreneurial activities, and regional economic development between faculties may be attributed to various factors. Goldstein (2010) suggests that social sciences and humanities contribute less to entrepreneurial activities compared to engineering faculties. Differences in the ethics of open science, beliefs about university involvement in entrepreneurship, and perceived inefficiency in contributing to firm innovation and regional economic development may also play a role.

While university-industry R&D collaboration research primarily emphasizes the dominance of engineering and natural sciences, with social sciences and humanities playing a marginal role, empirical research on educational collaboration's actual impact and knowledge transfer to the industry is limited. Studies by Bramwell & Wolfe (2008), Thune (2011), Kunttu (2017), and Lucia et al. (2012) focus on the benefits of internships and MSc theses, with Bramwell & Wolfe (2008) emphasizing benefits for SMEs and the others discussing benefits for large firms. These studies confirm that university-industry educational collaboration activities mainly are associated with technical and natural science faculties. However, there is a lack of prior research specifically investigating MSc theses in different faculties and the nature of knowledge transfer in such educational collaborations (Thune, 2011; Nsanzumuhire & Groot, 2020).

In the context of industry collaboration partners in university-industry R&D collaboration, existing empirical research indicates a preference for large firms with R&D capabilities (Salter & Laursen, 2004). The typical university R&D partner is a large firm investing in R&D capabilities and adopting an open innovation strategy (Salter & Laursen, 2004). In terms of proximity in university-industry R&D collaboration studies suggests that knowledge proximity is more crucial than physical or geographical proximity (Thune, 2011). Large firms prefer collaborating on R&D with universities possessing similar or complementary R&D knowledge, even if geographically distant (Thune, 2011). This raises questions about knowledge transfer to small-and-medium-sized enterprises (SMEs) from educational collaboration. SMEs may leverage external sources of knowledge, especially if geographically close, but their limited absorptive capability could necessitate intermediaries' assistance such as universities (Bramwell & Wolfe, 2008; Thune, 2011) and especially in its teaching role (De La Torre et al., 2018; Compagnucci & Spigarelli, 2020).

In terms of benefits for the industry from educational collaboration extant research (Bramwell & Wolfe, 2008; Thune, 2011; Kunttu, 2017; Lucia et al., 2012; Nsanzumuhire & Groot, 2020) focus on two main benefits: 1) exposure to and

potential recruitment of educated students, and 2) technical support and transfer of innovative knowledge. Kunttu's (2017) is so far the only empirical study we have found specifically studying MSc theses, in nine cases of educational collaboration between a Finnish unievsrity and the R&D-function in industrial firms. She finds that MSc theses are an effective way to transfer practical academic knowledge, creates and strengthens relationships between the research group at the university and firm managers. She also finds that the easiest way to integrate the transfeered knowledge is to employ the graduate student.

In summary, extant research suggests that university-industry educational collaboration is likely to be dominated by projects related to engineering and natural science faculties, with a prevalence of collaborations involving SMEs in geographical proximity to the university. Benefits for the industry partner are likely to be opportunities to recruit graduate students and transfer of innovative knowledge. The nature of such innovative knowledge is however not known.

Empirical context

Since the mid-1990s, national policy initiatives have been in place to facilitate the dissemination of university R&D knowledge within the Swedish higher education system. This effort is grounded in a legislative provision known as the "third mission," introduced in 1997 for Swedish universities, emphasizing a commitment beyond education and research (Jacob et al., 2003). Aligned with the objective of enhancing interaction between universities and industry, the Swedish state has established a regional network of university technology transfer offices associated with all Swedish universities, primarily focusing on fostering university spin-offs (Bengtsson, 2017). Additionally, Vinnova, the national innovation agency, allocates funding for various university-industry innovation programs, requiring co-financing from industry participants and predominantly emphasizing R&D collaborations (Bengtsson, 2017). Notably, there has been limited governmental support for university-industry educational collaboration programs and initiatives in Sweden (Bengtsson, 2013).

In the context of higher education in business or engineering degrees in Sweden, compulsory internships are uncommon (Bengtsson, 2013). Instead, the prevailing practice involves concluding degree programs, both at the bachelor and master levels, with a comprehensive study reported in a bachelor or master thesis. Some theses entail collaboration with firms, public organizations, and non-profit entities, while others adopt a more research-oriented approach. However, the precise prevalence of collaborative MSc thesis projects and the distribution of industry partners by type remain undisclosed. This inquiry specifically centers on

MSc theses culminating at the conclusion of four or five years of study at the Faculty of Engineering (Lunds Tekniska Högskola) and the Faculty of Economics and Management (Ekonomihögskolan), both at Sweden's largest university, Lund University (LU).

The Faculty of Engineering stands as the largest faculty at LU, accommodating approximately 10,000 students and predominantly offering education in 17 programs leading to an MSc degree in engineering. The Faculty of Economics and Management is the second-largest faculty at LU, hosting around 5,000 students and featuring ten distinct master's programs leading to an MSc degree in economics and management. Within these faculties, thesis projects represent the principal and systematic avenue within undergraduate and graduate degree programs for students to engage with working life. It provides them with the opportunity to apply their knowledge in collaboration with companies or other organizations over an extended period.

Method

We have undertaken a comprehensive survey encompassing all MSc theses completed at the two faculties, engineering and business faculty, throughout the year 2016. The rationale behind surveying all MSc theses in a single year stemmed from the limited scope of prior research on educational collaboration, with the primary objective being to obtain a comprehensive overview of the extent and fundamental characteristics of this phenomenon. Given the resource-intensive nature of covering multiple years, focusing on a singular year was deemed appropriate for this initial exploration. Subsequent stages of research may involve a more nuanced and longitudinal approach to comprehend variations in knowledge spillover patterns and the underlying mechanisms influencing knowledge transfer to both firms and regions.

At the engineering faculty 529 MSc theses were identified across 17 departments (see table 1). At the business faculty, our investigation identified 416 MSc theses distributed across five different departments. In all our MSc thesis survey comprised 945 MSc theses. The coding process involved categorizing all MSc theses based on authorship, subject, title, supervisors, external collaboration partners (if applicable), and connections to departmental research. A thesis was categorized as "collaborative" if it explicitly indicated collaboration, commissioning, or external supervision involving one or more specific firms or organizations. In instances where collaboration firms or organizations preferred anonymity due to confidentiality concerns, they were coded as "collaborative

theses" but excluded from the subsequent survey targeting collaborating firms and organizations.

The second part of our research comprised telephone interviews with external collaboration partners, including firms and organizations, as well as the specific external supervisors or contact persons mentioned in the MSc theses. The questionnaire addressed two primary sections of inquiries. The first section encompassed general questions, exploring aspects such as the firm or organization's overarching motivations for engaging in collaborative MSc theses. The second section delved into queries specific to the MSc projects supervised by the contact person, addressing elements such as the thesis's relevance to innovation stages in the product development process, implementation of results, and the recruitment of master's students. We identified 280 colalborating companies and organizations connected to MSc thesis projects at the engineering faculty and 25 companies and organizations connected to MSc thesis projects at the business faculty. Overall 305 collaborating companies and organizations were contacted for a telephone interview.

The third part of our research focused on the directors of the graduate study programs at each department of the engineering and business faculty. Each department has a director of study programs that oversees the department's courses, as well as their BSc and MSc theses. Of the 22 directors (17 at the engineering faculty and 5 at the business faculty) we conducted personal interviews with 14 study directors (10 at the engineering faculty and 4 at the business faculty).

Results

The results will be described according to the three parts of our research. First the MSc thesis survey, then the collaborating firm and organization survey and finally the study director interviews.

MSc thesis survey

We have selected all master theses completed in the year 2016 from each faculty, 945 MSc theses in total. In tables 1 and 2 we list the distribution of the 529 master theses at LTH and 416 master theses at LUSEM and in specific disciplines, number and percentages of collaborative MSc theses as well as type of collaboration partner (percetages of large firms, SMEs or Public and nonprofit).

In table 1 the distribution of 529 MSc theses at the engineering faculty, LTH, is shown according to department and the the number (339 MSc theses in total) and percentages of collaborative MSc theses (64 % of all MSc theses are

collaborative). The list of departments are shown in the order of percentage of collaborative MSc theses, i.e., Energy sciences has the highest proportion of MSc theses (88 %) and Immunotechnology the lowest (0 %). Large firms (= more than 250 emploees) dominate as collaborating partners (57 %), while the proportion of SMEs (= 1-249 employees) is lower (28 %) and public and non-profit organizations are marginal as collaboration partners (8 %).

LTH Departments	MSc the	Coll theses	Coll theses %	% Large firm	% SMEs	% Public/non
Energy sciences	24	21	88%	52%	33%	10%
Mechanical engineering	22	19	86%	58%	26%	0%
Ind mngmnt & logistics	51	43	84%	60%	21%	5%
Design sciences	62	49	79%	41%	41%	4%
Food technology	12	9	75%	44%	33%	0%
Computer science	44	32	73%	56%	41%	0%
Biomedical engineering	37	27	73%	56%	30%	11%
Construction Sciences	15	10	67%	90%	10%	0%
Chemical engineering	25	16	64%	56%	19%	25%
Technology and Society	49	30	61%	50%	23%	23%
Electrical and IT	46	25	54%	64%	28%	4%
Chemistry	27	14	52%	86%	7%	7%
Building & env techn	63	32	51%	56%	28%	12%
Mathematics	17	6	35%	100%	0%	0%
Physics	30	6	20%	50%	17%	33%
Immunotechnology	5	0	0%	0%	0%	0%
Total MSc theses	529	339	64%	57%	28%	8%

Table 1. MSc theses from engineering faculty at Lund University in 2016.

Table 2 reveals that collaboration with a company or organization with the business faculty's MSc thesis projects is not a very common phenomenon, only 7 %. Many MSc theses at the business faculty are based on case studies of companies and organizations, but they do neither involve the formulation of a project with the company or organization, nor feedback or dialogue with companies studied, only collection of data. Thus, we do not regard them as collaborative and not leading to any knowledge transfer to the case firms or organizations. Direct knowledge transfers from MSc theses to both firms and organizations are marginal. Roughly half of the collaborative MSc thesis projects concern large firms (14/29=48 %) and 24 % (7/29) being with SMEs. One of the SME-collaborating MSc theses concerns a startup. Collaborative MSC thesis projects at the business faculty is almost exclusively performed at the Department of Business Administration.

LUSEM – Departme	MSc theses	Coll theses	% Coll theses	% Large firm	% SMEs	% Publ/non-p
Business Adm	201	28	14%	46%	3%	14%
Economics	111	1	1%	100%	0%	0%
Economic History	71	0	0%			
Informatics	16	0	0%			
Business Law	17	0	0%			
Total MSc theses	416	29	7%	48%	24%	14%

Table 2. MSc theses from business faculty at Lund University in 2016.

A clear majority (72 %) of MSc thesis projects at the engineering and business faculties (table 3 below), collaborated with firms and organizations in the region (= located in the same county as Lund Unversity). Differences between different types of organizations were marginal. In line with prior research (Bramwell and Wolfe, 2008; Thune, 2011) knowledge transfer from educational collaboration, such as MSc theses, tend to be absorbed primarily by regional firms. However, not primarliy by SMEs as indicated by Bramwell & Wolfe's study (2008), but primarily by large firms.

Type of organization	Number of master theses in collaboration (percentage of the total in collaboration)	Whereof in regional organizations (percentage of collaborative theses for the type of organization)
Public sector and non-profit organisations	32 (9 %)	23 (23/32 = 72 %)
SMEs (1-249 employees)	101 (30 %)	73 (73/101 = 72 %)
Large firms (250-or more employees)	207 (61 %)	152 (152/207 = 73 %)
Total nr of master theses where firm/organisation is known	340	245 (245/340 = 72 %)
Total number of collaborating theses (in relation to total nr of collaborative theses)	368	-

Table 3. Distribution of collaborative MSc theses according to the type of organization and region.

Collaborating firms and organizations survey

Not all 368 firms or organizations were known to us. Some of them (28) remained anonymous and in 35 MSc theses we could not identify a contact person, giving us 305 firms or organizations that we distributed our telephone survey to. The survey to collaborating firms yielded 150 answers collaborating with engineering and business students (150/305 = 49.2 % response rate), i.e., 139 responses from firms collaborating with engineering students (49.6 % response rate) and 11 responses from firms and organizations collaborating with business students (44.0 % response

rate). As the group of respondents was few from the collaborating companies realted to the business faculty some of the statistical analyses did not seem meaningful to separate between the two faculties, especially when we present the results concerning the characteristics of knowledge transfer. Moreover, the responses from the public sector were also limited, so we have here focused on the answers from the large firms and SMEs. Turning to the collaborating firm survey we asked why the firm involved themselves in MSc thesis projects. The major reasons are listed in figure 1 below. As prior research has indicated (Bramwell & Wolfe, 2008; Thune, 2011; Kunttu, 2017; Lucia et al., 2012; Nsanzumuhire & Groot, 2020) recruiting new employees, solving problems in the firm, get new technological knowledge/management knowledge and ideas and maintaining contact with the education and the school are the most important reasons. For collaborating firms related to the business faculty the most common responses were to get new ideas and maintain contacts with the school. These companies had much lower expectations to recruit or learn something new through MSc thesis projects compared to the collaborating companies related to the engineering faculty.

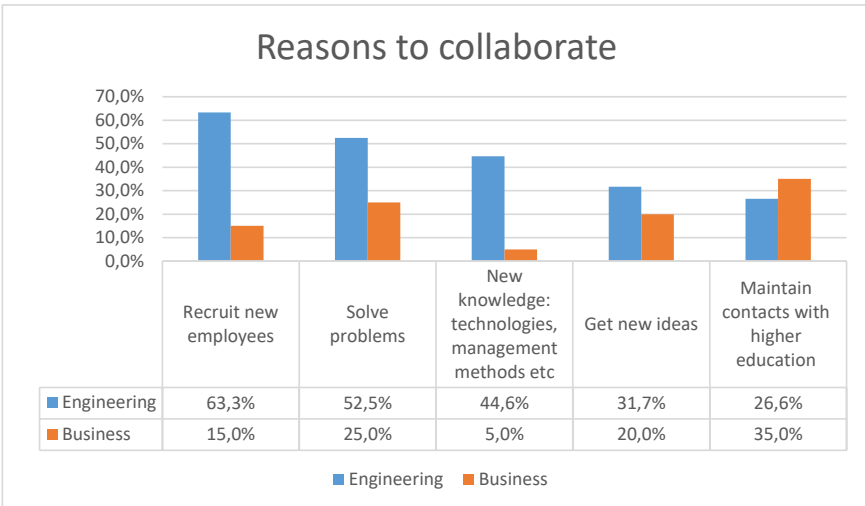
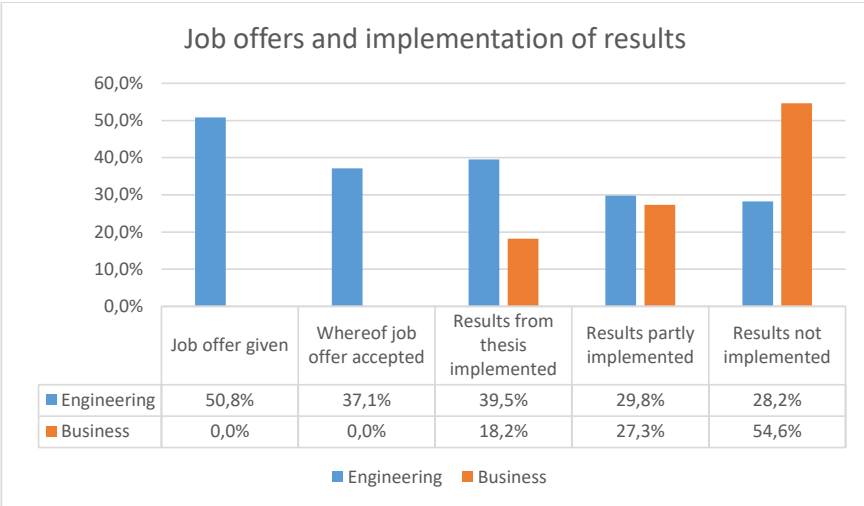


Figure 1. Five major reasons to collaborate according to firm responses.

About half of the firms collaborating with the engineering students also gave a job offer to the students and most students accepted the job offer (see figure 2). None of the firms related to the business faculty gave a job offer. Some 70 % of the

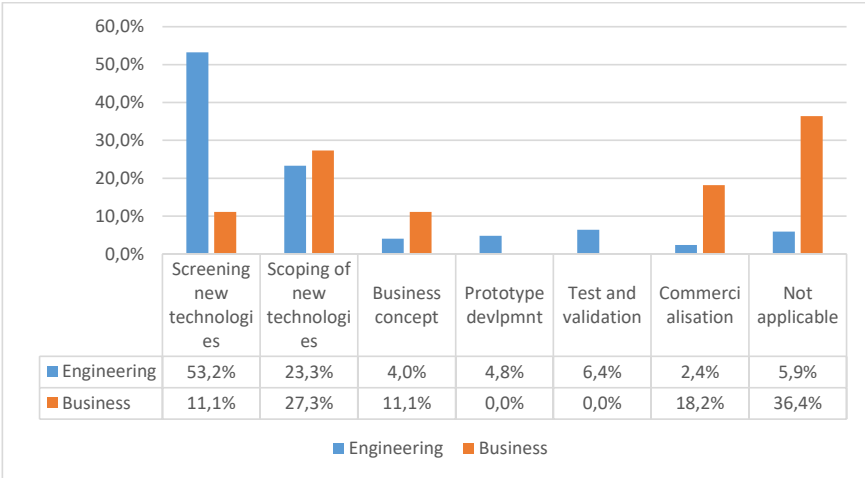
engineering faculty firms and 45 % of the business faculty firms reported that they had implemented the results, at least partly, of the MSc thesis project. SMEs tended overall to recruit relatively less than large firms and have relatively more use for the results, though differences were not statistically significant. Thus, MSc thesis projects are a common mechanism for both large firms and SMEs to recruit engineering students and the majority of them, at least partly, implement the results. This is not the case for firms collaborating with business students.



	Job offer given	Whereof job offer accepted	Results from thesis implemented	Results partly implemented	Results not implemented
Engineering	50,8%	37,1%	39,5%	29,8%	28,2%
Business	0,0%	0,0%	18,2%	27,3%	54,6%

Figure 2. Job offers given to thesis students and implementation of thesis results according to firm responses.

Concerning knowledge transfer we used a framework of the innovation process called the stage-gate process (Cooper, 2008) dividing the innovation process into six stages: screening of new technology/methods/concepts, scoping of new technology/methods/concepts, development of business case or concept, prototype development, test and validation and commercialization. A majority of the engineering theses were related to the initial phases of innovation, i.e., screening new technologies/methods/concepts and scoping new technologies to firm-specific purposes (see figure 3). Large firms tended to collaborate more on projects screening new technologies compared to SMEs and SMEs tended to collaborate more on prototype development and testing. For business faculty theses the most common stage was scoping of new technologies/methods/concepts, even though most respondents had trouble with the applicability of these stages in relation to the thesis projects.



	Screening new technologies	Scoping of new technologies	Business concept	Prototype devlpmnt	Test and validation	Commercialisation	Not applicable
Engineering	53,2%	23,3%	4,0%	4,8%	6,4%	2,4%	5,9%
Business	11,1%	27,3%	11,1%	0,0%	0,0%	18,2%	36,4%

Figure 3. The main stage in the innovation process focused in the MSc theses.

In line with prior research (Bramwell and Wolfe, 2008; Thune, 2011) the collaborating firm survey showed that the major reasons for firms to collaborate are to recruit graduates, to solve problems and transfer new knowledge. To a large extent job offers are also given by the collaborating firm and results implemented from the MSc theses connected to engineering faculty. This is, however, only true for the engineering faculty MSc theses. For the business faculty theses the major reason to collaborate is to maintan contact with the university. Concerning transfer of innovative knowledge the collaborating firm to the engineering faculty mostly focus projects screening of new technologies, this is especially the case for large firms. SMEs tended to collaborate more on the practical parts of the innovation process such as prototype development and testing. The respondents from the business faculty collaborating firms had trouble answering this question, finding it mostly not applicable. However, if they found it applicable the most common project focused on the scoping of a new technology, method or concept.

Interviews with study directors

The telephone interviews with the directors of study programs at the departments aimed to validate our findings regarding incidence of collaborative MSc theses as well as investigating the objectives for MSc theses, quality issues and support for collaborative MSc theses. We contacted all 22 study directors at the engineering

and business faculty and 14 study directors agreed to a telephone interview (10 study directors in engineering and 4 in business faculty giving 64 % response rate).

Regarding the question of their view on the incidence of collaborative MSc theses at their department the answers correlated well with the incidence of collaborative MSc theses in our survey (see table 1 and 2) above. The study director at the department of Energy Sciences responded that virtually all (100 % - 88 % in our survey) of their master theses were done in collaboration with companies or organizations. At the other end of the spectrum at the engineering faculty the study director at department of Immunology responded that no MSc theses (0 % - 0 % in our survey) were done in collaboration. Over all the study directors at both the engineering and business departments had a good overview of the incidence pattern of collaborative MSc thesis projects and aligned well with the results in our survey.

The question regarding objectives related to master thesis projects resulted in two groups of answers. Almost all study directors at engineering departments referred to the formal course syllabus stating the objective for degree projects at all engineering programs as :"*The aim of the degree project is for the student to develop and demonstrate the requisite knowledge and skills to work independently as an engineer*." This objective opens up for both more work life and company related projects as well as research oriented MSc thesis projects. The difference in incidence of collaborative MSc thesis projects between departments had according to the study directors to do with the character of the discipline (mostly applied research or mostly basic research) and the orientation of the specific research that was done at the department. Thus, departments with a lot of basic research, such as Physics and Mathematics, had a low incidence of collaborative MSc thesis projects, while other engineering departments with mostly applied research, such as Industrial Engineering and Management and Design Sciences, had a high incidence of collaborative MSc thesis projects.

The study directors at the business faculty also mentioned the formal objective of the course syllabus which states: "*The main objective is to develop students' ability to conduct an independent scientific study that includes developing relevant research questions, and to design and conduct a study that addresses the research questions based upon appropriate methodological considerations and relevant theories within the areas covered by the masters program."* This aim makes collaborative MSc thesis projects difficult, especially projects which entails only one company's or organization's problem. Problems or research questions which are shared among several companies and/or organizations might still be possible as well as new phenomena that might be tied to individual companies, but then motivated by research needs. Thus, most departments at the business faculty had none collaborative MSc thesis projects. The study director at Business

Administration department, mentioned that some sub-disciplines such as marketing and entrepreneurship and innovation, had a highly applied and practical character which made it more natural for the teachers to accept collaborative thesis projects. The study director at the Economics department mentioned that the sub discipline of Development Studies had an applied character which also made such collaborative projects more natural.

The study directors were also asked if a potential increase in collaborative MSc thesis projects would affect the overall quality of the MSc theses. Nine of the 14 study directors (7 at engineering and 2 at business) thought it would increase the overall quality, but some added that it depended on the supervisors and nature of project. The rest, 5 of the study directors, did not wish to increase the level of collaborative thesis projects, as they thought the current situation was well balanced. However, all study directors thought that student motivation would increase if more students were allowed to do collaborative MSc thesis projects.

In terms of support for collaborative MSc thesis projects, six study directors, all at the more collaborative intensive engineering departments, said they worked actively with facilitating contacts between firms/organizations and master students, as well as increasing the exposure of the finished master thesis projects both internally and externally.

In summary, the study directors confirmed the variation of the incidence of MSc thesis projects between the engineering and business faculty as well as the variation within the engineering faculty. The variation in incidence depends on the formal objectives of the MSc thesis (work life or research oriented), the character of the research at the department (mostly applied or mostly basic research), and the facilitation or not for contacts with firms and organizations.

Discussion

Our surveys of MSc thesis projects at the engineering and business faculty at Lund University have empirically shown that: 1) MSc theses are a frequently used collaboration mechanism between university and industry in engineering education and very limited in business education, 2) collaborating firms in engineering benefit mainly by recruiting students and by the transfer of technological knowledge, 3) collaborating firms in business benefit mainly by maintaining contact with school. Moreover, 4) mainly large firms in the region benefit from educational collaboration. Finally, we have shown that: 5) the variation of collaborative master thesis projects depends on the formal objectives of the master thesis (work life or research oriented), 6) the character of the discipline at the department (applied or basic research), and 7) the presence of facilitation activities or not for contacts with

companies and organizations.

Overall, our research confirms the relative high educational collaboration activity related to the engineering sciences, and the relatively limited activity in university-industry educational collaboration for social sciences, in this case the business faculty, observed earlier in the university-industry R&D-collaboration research (Goldstein 2010), increasing our understanding of the limited impact and knowledge transfer effects on regional development (Bonaccorsi et al 2013) from social sciences. Moreover, the empirical results confirm prior findings by Bramwell & Wolfe (2008) and Kuntuu (2007) regarding the benefits (recruitment of students and transfer of knowledge) of MSc thesis projects in engineering, as well as the dominance of regional diffusion of knowledge (Bramwell & Wolfe, 2008; Thune, 2011). The dominance of large firms in educational collaboration is a new result, in contrast to Bramwell & Wolfe's (2008) and Torres et al's., (2018) assertions that educational collaboration might fit SME's better than R&D collaboration. Another new finding, in relation to prior research, are the results regarding innovative knowledge transfer related to innovation stages, where screening of new technologies, is the most common type of knowledge transfer. The type of innovative knowledge transfer did however differ between large firms and SMEs with SMEs preferring projects involving more "hands-on" innovation knowledge, i.e., support with prototype development and testing.

Conclusions and implications for universities

There are several reasons why educational collaboration may become relatively more important than R&D collaboration for universities such as the general growth of the knowledge-intensive service sectors and the ICT sectors in the OECD economies (Korhonen-Yrjänheikki et al. 2007; OECD, 2012). Increased levels of project work in multidisciplinary teams, networking with other organizations, global work places and rapid technological development requires development of so called soft skills, e.g., communication and collaboration skills (Korhonen-Yrjänheikki et al. 2007; Caeiro-Rodríguez et al., 2021). Many of these skills can be trained in various ways in collaborative projects with firms and organizations (Caeiro-Rodríguez et al., 2021).

For universities that wish to support educational collaboration, to facilitate student transfer from higher education studies to work-life as well as the transfer of innovation-related knowledge, university managers may wish to facilitate collaborative MSc thesis activities and overall educational collaboration activities further. Obviously, if our findings in this study are valid for other universities, the business faculty and other less collaboration intensive faculties have more work to

do than engineering faculties.

The findings of this study forms the basis for the following five recommendations to universities and their managers to increase knowledge spillover through collaborative MSc theses to industry, both large firms and SMEs.

1) If necessary, change the syllabus of the MSc thesis project to allow students to work on projects related to working life, professional development and management issues.

2) University management should facilitate the building and maintaining of long term networks with firms and organizations making better connections and interactive relations in education with regional firms and organizations.

3) University management should instruct various internal units that work as intermediaries between university and industry, such as university-industry relational offices, career centers, and labs, to increase their efforts and services especially for SMEs in educational collaboration.

4) University management should facilitate the active marketing of the opportunities of thesis collaboration projects to mainly regional firms, possibly sending them a voucher for an MSc thesis project to be "cashed in" at the career center or some other relevant university unit.

5) Measure the educational collaboration activities and include key metrics for large firms and SME activity and follow-up progress over time.

Limitations and further research

Our results are based on one year's MSc theses in engineering and business at a major Swedish university, a questionnaire to collaborating firms and organizations and an interview study with departmental study directors. Are these results generalizable to other Swedish, European or other countries' business and engineering faculties? We believe our results are generalizable to the Swedish higher education system as it is rather uniform in the sense that it is state-regulated and for the most part state-organized and funded. Moreover, there are regular national quality assessments that focus mainly on the BSc and MSc theses, which have had a homogenizing effect on thesis projects and reports throughout Swedish higher education institutes (UKÄ 2015). The external validity of the results to business and engineering education in other countries is a question for further research.

MSc theses are only one form of educational collaboration. Other forms of educational collaboration, such as student written cases (Asplund & Bengtsson

2008), student projects (Kuntuu, 2007), internships (Cook et al., 2004), jointly organized courses (Kuntuu, 2007) and open innovation centers (Lucia et al., 2012), may also be important educational collaboration forms with industry. To increase our knowledge of university-industry educational collaboration future studies should include more forms of educational collaboration. This is particularly important for countries and universities that do not offer MSc theses in their curriculum. This study is based on one major university in Sweden and MSc theses completed in one year (2016). Collaboration patterns may vary across time but we have no indication, from discussions with experienced supervisors, that 2016 was very different from other years in regards to collaborative MSc theses.

Similar studies should be performed in more countries to verify our results. We have not specified the causal mechanisms between collaborative MSc thesis projects and company impact. Even though our firm survey gives some insights here, these are partial and do not provide a good understanding of if and how companies use and utilize MSc thesis projects in their operations and innovation processes. This would require more fine-grained and longitudinal case studies, which we recommend for future studies.

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Paper V

Submitted to Industry and Higher education for review.

Three stages of university-industry educational collaboration

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Abstract

While scholarly attention has predominantly focused on university-industry research collaboration, university-industry educational collaboration remains comparatively underexplored within academic discourse. This is particularly noteworthy given the significant scale of educational programs administered by numerous universities and higher education institutions, with enrollments often numbering in the thousands or tens of thousands. Despite the prevalence of research-intensive universities, the majority of European institutions exhibit a pronounced orientation towards education. Furthermore, from the perspectives of companies, public organizations, professions, and students alike, the primary value derived from universities is primarily derived from educational activities.

In this paper we ask how higher educational institutions can work with and organize university-industry educational collaborations in order to reap the benefits of such collaboration. The aim of this paper is to develop a model of the university-industry educational collaboration process from a university department perspective. The key contribution in the paper is a model of three university-industry educational collaboration stages viewed from the perspective of the university department. The model specifies the corresponding capabilities, typical educational activities, resources, potential effects and key success factors for each stage.

Introduction

While scholarly attention has predominantly focused on university-industry research collaboration, university-industry educational collaboration remains comparatively underexplored within academic discourse (Zhuang et al., 2024; Zhuang & Shi, 2022; Bengtsson, 2013; Thune, 2011; Bramwell & Wolfe, 2008). This is particularly noteworthy given the significant scale of educational programs administered by numerous universities and higher education institutions, with enrollments often numbering in the thousands or tens of thousands. Despite the prevalence of research-intensive universities, the majority of European institutions exhibit a pronounced orientation towards education (Davey et al., 2018). Furthermore, from the perspectives of companies, public organizations, professions, and students alike, the primary value derived from universities is primarily derived from educational activities (Borah et al., 2021; Davey et al., 2018; Bramwell & Wolfe, 2008; Mowery & Sampat, 2005).

Within university education, practical relevance assumes significant importance, particularly within undergraduate and graduate programs leading to professional careers in fields such as engineering, management, psychology, law, or medicine. It is challenging to conceive of professional degree programs that do not prioritize or seek practical relevance. While many higher education instructors may proficiently articulate the practical applications of textbook and research knowledge, achieving heightened levels of relevance for students necessitates active engagement in educational collaboration with businesses, organizations, and public entities, as well as their managerial representatives (Zhuang & Shi, 2022; Borah et al., 2021; Davey et al., 2018). Moreover, research indicates that educational programs offering internships or collaborative student projects often yield tangible benefits such as increased job opportunities, expedited employment, enhanced learning outcomes, and improved understanding (Asplund & Bengtsson, 2020; Bramwell & Wolfe, 2008; Hurts & Good, 2010; Franco et al., 2019; Fielding et al., 2014).

From the standpoint of companies and organizations, collaboration with university education not only provides insights into potential future employees but also offers ancillary advantages such as third-party assessments of strengths and weaknesses, assistance with specialized issues, augmentation of domain-specific and generic competencies, and enhanced public recognition (Zhuang & Shi, 2022; Borah et al., 2021; Asplund & Bengtsson, 2020; Bramwell & Wolfe, 2008; Bengtsson & Asplund, 2008).

Although research on university-industry educational collaboration remains limited, extant literature predominantly corroborates the positive impacts of collaborative initiatives, such as internships and project work, on student enrollment rates, educational satisfaction, and post-graduation employment rates compared to programs lacking such collaborative components (e.g., Zhuang & Shi, 2022; Borah et al., 2021; Hurst & Good, 2010). For educational institutions, which rely on student enrollments and uphold a reputation for quality teaching and research, the strategic significance of educational collaboration becomes paramount (Zhuang et al., 2024; Bramwell & Wolfe, 2008). Moreover, heightened demands for universities to demonstrate societal impact, as

evidenced by initiatives like the Research Excellence Framework in the UK (HECFE, 2014) and increased attention from policymakers within the EU (Davey et al., 2018), further underscore the strategic imperative of university-industry educational collaboration for both academic institutions and regional stakeholders such as companies and public entities.

In this paper we ask how higher educational institutions can work with and organize university-industry educational collaborations in order to reap the benefits of such collaboration. How do educational collaboration and corresponding capabilities develop as the educational collaboration process unfolds? The aim of this paper is to develop a model of the university-industry educational collaboration process from a university department perspective.

To construct our model, we draw upon two distinct bodies of research literature. Firstly, we leverage existing scholarship on university-industry educational collaboration (Zhuang et al., 2024; Zhuang & Shi, 2022; Borah et al., 2021; Bengtsson, 2013; Thune, 2011; Asplund & Bengtsson, 2008). Secondly, we incorporate insights from stage-based models that elucidate organizational characteristics and the requisite changes in practices needed to advance through various developmental stages (Greiner, 1972; Miller & Friesen, 1984), as well as capability life cycles (Helfat & Peteraf, 2003), which offer a dynamic and stage-based perspective on organizational capability theories (Teece, 2007). Stage-based models of organizational capabilities highlight the dynamic nature of capability development, underscoring the notion that deficiencies in organizational capabilities can impede the progression of the educational collaboration process (Helfat & Peteraf, 2003).

The primary contribution of this paper lies in the proposed stage model delineating three distinct stages of educational collaboration, accompanied by corresponding university departmental capabilities. This model describes typical activities, processes, resource allocations, outcomes, and key success factors at each stage. To the best of our knowledge, such a systematic depiction of educational collaboration stages has not been previously been developed in extant research literature. Furthermore, we employ these stages to deliberate upon the risks and advantages associated with university departments engaging in more advanced collaborative stages.

Theoretical framework

University-industry educational collaboration

Collaboration activities between universities, industry and public sector organizations take place in many different forms and varies depending on the country, region, type of university, and discipline (e.g., Zhuang et al., 2024; Zhuang & Shi, 2022; Borah et al., 2021; Davey et al. 2018; Thune, 2011; Mora, Detmer, and Vieira, 2010). A common classification is according to universities main tasks: research collaboration, educational collaboration and service- and consultancy-collaboration (Mora-Valentin, 2002). Here we will focus only on educational collaboration which takes place in undergraduate and graduate educational programs (bachelor and

master level) excluding collaborative activities in postgraduate programs (PhD-programs) and executive education. Common objectives with educational collaboration are (Thune, 2011):

- develop the students' work-relevant competencies and skills,
- make students' more employable,
- increase their entrepreneurial attitudes and mind sets,
- increase knowledge transfer across sectors and,
- develop new networks.

These objectives are generally valid also for the university. However, from the university perspective common objectives to engage in educational collaboration are generally closer tied to their educational mission and to some extent also to their research mission (Zhuang et al., 2024; Borah et al. 2021; Bengtsson, 2013), i.e.:

- strengthen quality of education
- develop attractive educational programs
- increase reputation to attract new students
- support research activities to attract new PhD-students and external grants

Research on educational collaboration has identified three main types of collaborative activities (Zhuang & Shi, 2022; Fagrell, 2020; Thune, 2011; Brandt el al, 2008): 1) Collaboration activities concerning development of new or revision of existing educational programs, 2) collaboration activities focused on teaching and learning concerning issues such as involvement of firms in teaching, thesis advice, student project works and master thesis projects, and 3) collaboration activities concerning the transfer between studies and work life involving issues such as internships, career fairs, trainee programs, mentoring or other career advice.

Impact of educational collaboration activities could be categorized according to the common objectives above but more generally as effects on the three main educational collaboration actors (Bengtsson, 2013; Thune, 2011):

- Impact on the collaborating firms concerning recruitment of competence and skills in the short and long term, transfer of knowledge and expertise e.g., increasing the firm's innovation capabilities, and increased image and visibility towards students, academic teachers and the society at large.
- Impact on the university includes factors such as increased quality of teaching, more attractive educational programs, increased student enrollment, better visibility towards industry and public organizations, and increased opportunities of research financing.
- Impact on the students includes factors such as quality and relevance of the education, motivation for studies, increased possibility of employment and jobs according to qualification, and entrepreneurial skills.

The majority of research concerning collaborative endeavors in the realm of education demonstrates favorable outcomes for both universities and companies (Davey et al., 2018; Bramwell & Wolfe, 2008), as well as for students (Asplund & Bengtsson, 2004; Thune, 2011). This observation is drawn from comparative analyses of educational programs and institutions with and without collaborative engagements, or through pseudo-experimental designs introducing varying collaborative activities within programs (Mason et al., 2009). However, despite the anticipated benefits, empirical evidence suggests that the prevalence of such collaborative activities falls below anticipated levels, as evidenced by findings from a comprehensive European survey on university-industry collaboration endeavors (Davey et al., 2018).

Furthermore, collaborative efforts within educational contexts often rely heavily on the individual enthusiasm and personal networks of educators, rather than being firmly institutionalized (Zhuang & Shi, 2022; Thune, 2011). Consistent with findings in the broader literature on collaboration, be it in business settings such as strategic alliances (Larsson et al., 1998), or within educational spheres (Thune, 2011), it is evident that collaborations involving two or more independent organizational entities often encounter challenges and may yield outcomes that fall short of expectations.

Nevertheless, research has identified several key success factors that contribute to the efficacy of organizational collaboration in general (Larsson et al., 1998), collaborative endeavors within universities as a whole (Rybnicek & Königsgruber, 2019), and specifically within educational contexts (Zhuang & Shi, 2022; Thune, 2011). These factors, as indicated by extant literature, exert a positive influence on the outcomes of collaborative educational activities.

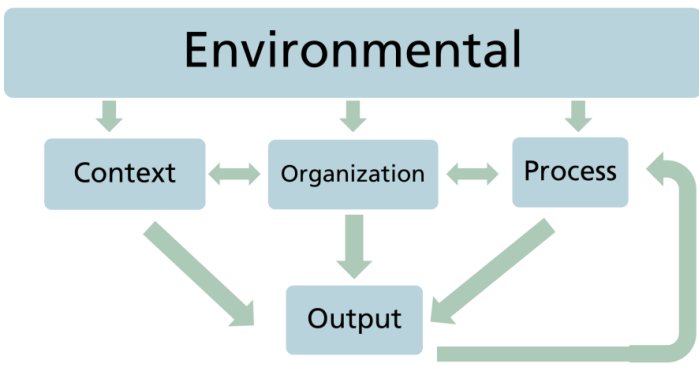

Figure 1 Success factors in Educational collaboration

The initial set of success factors encompasses environmental factors, which represent aspects of the broader context capable of exerting influence on university-industry educational collaborations across diverse dimensions. These factors encompass governmental support, legal regulations, and market conditions (Rybnicek & Königsgruber, 2019; Bengtsson, 2013). Specifically, governmental

funding initiatives, tax incentives, and policy directives have the potential to foster favorable conditions conducive to the inception and expansion of collaborative endeavors (Rybnicek & Königsgruber, 2019; Bengtsson, 2013). Conversely, issues related to intellectual property rights, including professorial prerogatives or university ownership, may present obstacles to effective collaboration (Bengtsson, 2017). Moreover, fluctuations in regional demand for specific educational profiles, such as in different fields of engineering, can create dynamic shifts in interest towards collaborative initiatives (Bengtsson, 2013).

The subsequent set of success factors pertains to contextual factors, which predominantly influence the selection of collaborative partners and the establishment of collaborative frameworks. A viable collaboration partner is one characterized by synergistic objectives, overlapping expertise, and prior collaborative engagements (Rybnicek & Königsgruber, 2019; Mora-Valentin et al., 2004; Larsson et al., 1998). Contextual variables encompassing university size, disciplinary focus, institutional nature (public or private), degree of industrial integration, and research intensity levels may either facilitate or impede collaborative formation and outcomes (Borah et al., 2021). Notably, geographical proximity emerges as a salient contextual determinant unique to educational collaborations, distinct from its research-oriented counterpart, underscoring the significance of physical proximity for effective communication and interaction (Rybnicek & Königsgruber, 2019; Drejer & Ostergaard, 2017; Thune, 2011; Bramwell & Wolfe, 2008).

The third set of success factors revolves around organizational factors, encompassing incentives for collaboration within both university and industry spheres (Zhuang & Shi, 2022), formalization of collaborative arrangements through contractual agreements, and securing commitment from key stakeholders within academia and industry (Rybnicek & Königsgruber, 2019; Zhuang & Shi, 2022). Additionally, the allocation of dedicated resources and budgetary provisions for collaborative activities emerges as a critical organizational imperative (Zhuang et al., 2024; Rybnicek & Königsgruber, 2019; Thune, 2011).

The fourth set of success factors pertains to process-oriented factors, emphasizing effective project management practices encompassing the delineation of expectations, project planning, resource allocation, and progress monitoring (Zhuang & Shi, 2022; Rybnicek & Königsgruber, 2019; Butcher & Jeffrey, 2007). Furthermore, fostering open communication channels between collaborative entities emerges as pivotal (Zhuang & Shi, 2022; Rybnicek & Königsgruber, 2019; Thune, 2011), alongside cultivating trust, confidence, and mutual respect, which serve to mitigate the need for extensive monitoring while fostering a climate of goodwill and cooperation (Zhuang & Shi, 2022; Rybnicek & Königsgruber, 2019; Thune, 2011).

The final category of success factors pertains to output factors, specifically delineating the nature and magnitude of outcomes stemming from university-industry collaborations (Rybnicek & Königsgruber, 2019). The extent to which these outputs align with predefined objectives is typically instrumental in determining the longevity or cessation of collaborative endeavors, particularly over protracted durations (Rybnicek & Königsgruber, 2019; Larsson et al., 1998). Effective knowledge and technology dissemination assumes paramount importance within the realm of university-industry collaboration, a sentiment echoed across scholarly discourse (Rybnicek & Königsgruber, 2019). This imperative is particularly pronounced within knowledge-intensive sectors of industry (Fernandes & Ferreria, 2013; Bengtsson, 2013), extending to encompass educational collaborations between universities and industries as well (Zhuang et al., 2024; Bramwell & Wolfe, 2008).

Stage-based models

Stage-based models, often referred to as life-cycle models, have been fundamental in organizational and management research for several decades (e.g., Greiner, 1972; Normann, 1971). These models elucidate the developmental trajectories of organizations, delineating prolonged periods of stability punctuated by intermittent phases of profound transformation, as exemplified in the punctuated equilibrium model of organizational change (Romanelli & Tushman, 1994). They provide insights into the organizational characteristics, as well as the requisite changes in capabilities and practices, necessary for advancing to subsequent developmental stages (Greiner, 1972; Miller & Friesen, 1984).

Contemporary research on organizational change and transformation, particularly within the purview of dynamic capabilities theory, underscores the imperative for organizations and management to continually innovate and adapt (e.g., Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Teece, 2007; 2018). However, organizational cultures, structures, and capabilities often exhibit path dependency, inertia, and resistance to change (Hannan & Freeman, 1984).

While scholars of dynamic capabilities theory typically emphasize a continuous process of change rather than discrete stages (e.g., Teece, 2007; 2018), Helfat and Peteraf (2003) introduce the concept of capability lifecycles to describe the evolution of organizational capabilities. The inception of a capability occurs when individuals organize to establish a capability aimed at achieving a specific objective, such as the development of a capability to facilitate collaborative projects with external organizations, including master thesis projects and internships, matching students with appropriate opportunities, and overseeing the execution of these projects. In the developmental stage, the capability is refined and expanded, with the team gradually developing routines and structures to support a broader scope of activities, such as establishing career centers to manage larger-scale internship programs and project engagements.

As the capability matures, it becomes embedded within the organizational fabric, with its execution becoming increasingly entrenched. Over time, the developmental trajectory of a capability may become tacit, ingrained within the organizational ethos and operational practices, colloquially

referred to as "the way things are done here" by employees and managers. In the context of educational collaboration with external entities, such as internships and master thesis projects, this institutionalization may manifest in the integration of these activities within academic curricula, with external partners anticipating and facilitating student engagements as regular components of educational collaboration initiatives (cf. Bramwell & Wolfe, 2008).

The trajectory of capability development is subject to the influence of various internal and external factors. External factors encompass shifts in demand, such as instances where organizations encounter challenges in accommodating interns and master thesis projects due to adverse economic conditions or significant internal restructuring efforts, as well as advancements in technology, such as the advent of improved communication and monitoring technologies facilitating more efficient supervision and mentoring of students in remote settings, and governmental policies, such as incentive schemes aimed at encouraging universities and organizations to participate in hosting internships or student projects (Helfat & Peteraf, 2003).

Conversely, internal factors may stem from managerial decisions to curtail or expand specific activities, including those related to educational collaboration endeavors. The augmentation or diminution of these factors can precipitate transformations in organizational capabilities. A weakening factor poses a threat to the viability of the capability, potentially rendering it obsolete, whereas a strengthening factor engenders opportunities for the capability to evolve and mature (Helfat & Peteraf, 2003). Weakening factors may prompt managers to phase out or discontinue the capability, whereas strengthening factors may incentivize managers to rejuvenate, replicate, reallocate, or reconfigure capabilities within the organizational framework.

Educational collaborative capabilities

To our knowledge there is no specific research on university-industry educational collaboration capabilities. However, the research literature on open innovation (e.g., Chesbrough, 2003) that has described capabilities related to transfer and integration of knowledge from external actors or stakeholders (Kazadi et al. 2016). Specific suggestions in extant research are networking capabililties (e.g., Kazadi et al. 2016), relational capabilities (e.g. van Lancker et al. 2016) and desorptive capabilities (e.g. Behnam et al. 2018). Networking capabilities are the ability to attract and involve external actors in the focal organization's project (Kazadi et al. 2016), relational capabilities are the ability to manage relationships with external actors to build a development and innovation network (van Lancker et al. 2016), and desorptive capabilities are the ability to select, engage and align internal actors with external actors in the focal organization's projects (Behnam et al. 2018), especially aligning with the management of the focal organization (Ahn 2020).

In this study, we use the framework of capabilities life cycle to create a stage-based model of the development of educational collaboration from the university department perspective. The presence and strength of relevant capabilities determine the speed and extent of renewal and reconfiguration of capabilities in response to external and internal proposals to engage in university-industry educational collaboration. Conversely, the absence or weakness of such

capabilities will hinder or slow down the educational collaboration process. Stage based models of educational collaboration processes are, to our knowledge, lacking in extant research.

The model of educational collaboration stages

The theoretical frameworks described in the preceding section serve as the foundation for our conceptualization of three distinct stages of educational collaboration. Effective educational collaboration does not materialize abruptly; rather, it is a protracted process necessitating the commitment of dedicated personnel and university management, as borne out by our empirical observations. These three stages encapsulate the evolutionary trajectory through which a university department attains increasing proficiency and adeptness in collaborative educational endeavors with external stakeholders.

The three stages of educational collaboration are as follows: the Distant stage, the Relational stage, and the Interactive stage. At the outset, the Distant stage represents the rudimentary phase of educational collaboration, while the Interactive stage represents the most sophisticated and advanced stage of collaborative efforts. The Relational stage occupies an intermediary position between the initial Distant stage and the ultimate Interactive stage.

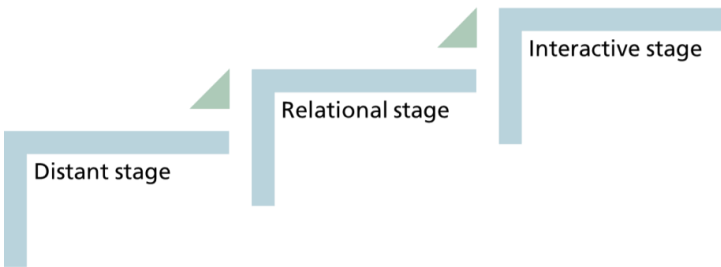

Figure 2 The three educational collaboration stages

The three stages and their typical activities, resource needs and resource complexity, potential effects for students, university and collaborating firms as well as key success factors are summarized in the table below.

Collaborative stage	**Distant**	**Relational**	**Interactive**
Organizational capabilities needed to sustain stage	Limited, mainly individual networking and relational capabilities	Networking and relational capabilities	Networking, relational and desorptive capabilities
Type of activities	Guest lectures, study visits, minor student projects	Internships with weak relation to study program, Live cases in class, Advisory board Project work,	Internships related to study programs, Collaborative project work, MSc thesis projects,

		Case competitions, MSc thesis projects	Service learning programs, Projects related to research collaborations Manager/Entrepreneur on campus Advisory Board Professor of Practice, professional experts
Resources needed and level of resource complexity	Small, mostly utilizing teachers' personal network and time	Moderate complexity, commitment from stakeholders, administrative routines, some organizational arrangements, some funding and time allocation	High complexity, goal congruence, managing expectations, commitment and budgets, project leaders needed, dedicated teachers and managers, dedicated organizational units. Funding and mobility of employees and teachers
Potential effects of collaboration for students	Small, creating first contacts between companies and students	Effects on students exposure to business dynamics, work related competences, creating individual networks, some facilitation of transfer to work life	Stronger exposure for students on business dynamics, work related competences, creating networks,
Potential effects for university	Small, mostly maintaining relationships, mostly at individual level	Networks becoming institutionalized, some knowledge transfer,	Strategic collaboration company and university, profile and image of university, co-branding, stronger push for enlarging collaboration to both education and research
Potential effects for companies/organizations	Small, personal contacts, some recognition	Some knowledge transfer, third-party problem solving, look at potential employees, more recognition	Co-branding, public recognition, exclusive meetings with top researchers and top students
Key success factors	At least not very negative or hostile towards individual level collaboration	Contextual, Organizational, Process factors	Organizational, Contextual, Process, and Output factors

Table 1. Three educational-collaboration stages.

Distant stage

The model assumes, in line with prior research, that collaborative activities in education often are based on individual teachers' enthusiasm and personal network (Zhuang & Shi, 2022: Thune, 2011), that a usual start of educational collaboration activities at a university department are based on individual teachers' initiatives. This requires very little of relevant organizational collaborative capabilities, instead it is individual level networking and relational capabilities that are required in this stage. Educational activities are mostly in the form of guest lectures, study visits and student projects. The effects, for the university department, the collaborating firm or organization and the students are small and localized to the involved teachers, the specific courses and students, and the specific employees and managers at the collaborating partner. Unless the university department's management and/or colleagues are or become hostile or very negative towards such individual level educational collaboration this stage may continue as long as the active teachers remain at the department. The distant stage is probably a fair description of a majority of higher education departments as a rather recent EU-wide survey shows that 75 % of the academics have no collaborations with companies (Davey et al., 2017).

A couple of cases from the authors' own experience of educational collaboration projects may serve as illustrations of the distant stage and the transition to the next stage, the relational stage.

Alfa Laval is a large multinational engineering company developing and selling heat exchangers and separators. The head office and large parts of its R&D is located in Lund, Sweden. It regularly recruits engineering students from the engineering school at Lund University. The geographical proximity, longstanding involvement in research collaborations with Lund University, and regular need of new engineers makes it an obvious collaboration partner, particularly for the engineering school at Lund University. The educational collaboration with Alfa-Laval is one of the longest we have established and started some two decades ago. It started by coincidence when one of the authors met the head of the Alfa Laval R&D in an executive education program. A contact was established and the first activities consisted of some highly appreciated guest lectures on how Alfa Laval worked with product and process development. This was followed by study visits to the Alfa-Laval R&D, production and distribution-facilities using the value-chain as a pedagogical tool to illustrate and explain the different Alfa-Laval activities.

Some years later a new master level course on Technology strategy started at the engineering school as part of innovation management minor for the engineering students taking the engineering degree in Industrial engineering and management. Now we complemented the guest lectures with students writing their own innovation cases (Bengtsson and Asplund, 2004) based on product development data from Alfa Laval and other collaborating engineering companies. The experiences were almost entirely positive both from Alfa Laval and other collaborating companies as well as from teachers and students.

The established relationships between different teachers and course directors and different company managers resulted in new forms of activities in other courses in the program such as consultancy projects and master thesis projects. The good relations between Alfa Laval and six other companies resulted in the sponsorship of a new professorship in technology strategies and business models as well as the establishment of an advisory board connected to the research area and the professorship in Industrial engineering and management. To a large extent this advisory board is used for advice on educational development issues as well as to coordinate different educational collaboration activities. The function of the advisory board is also to get new insights, for both parts, about emerging issues/needs that can be turned into new research projects.

Tetra Pak is another large multinational engineering company with its global head office and much of its R&D located in Lund, Sweden. It is a company focused on providing packaging solutions for liquids and food. The educational collaboration case with Tetra Pak is similar to the one of Alfa Laval. The collaborative activities with Tetra Pak have however taken on a somewhat different form than for Alfa Laval.

Just as with Alfa Laval the collaborative activities for several years included guest lectures, study visits, students writing case studies of different innovation projects and student projects. In 2006, some students expressed a large interest in learning more about the case method so one of the authors to this paper together with a student representative launched a Swedish case competition inviting other engineering schools in Sweden to compete. The case competition became known as the iCaseChallenge in 2008. For the case competitions we need case material for the students to solve. Here we have worked in close collaboration with the management group at Tetra Pak producing cases on for instance sustainability challenges for Tetra Pak. The case competition has been hosted by Tetra Pak head office were both the responsible management members, faculty members have served as the judges. Involvement in the Swedish case competitions have resulted in more student contacts for Tetra Pak, higher visibility towards the engineering students, as well as knowledge transfer and second opinions on some strategic issues.

This Swedish case competition also made our students better prepared for international case competitions such as TIMES- the tournament in management and engineering (www.estiem.org). Times is a pan-European case study competition for Industrial Engineering and Management students and attracts about 250 teams every year. Tetra Pak has just as Alfa Laval involved themselves in more courses, student consulting projects, master thesis projects and also joined our advisory board. Tetra Pak's special involvement in the student case competition shows that a specific educational collaboration partner can develop specific and unique educational activities which will differentiate itself from other educational collaboration partners.

The relational stage

As the case illustrations of Alfa Laval and Tetra Pak collaborations with the engineering school at Lund University indicate, the relational stage is characterized by the institutionalization of collaborative activities in organisational structures and routines, such as involvement in regular

events such as student competitions or participating in organizational bodies such as advisory boards. The number of teachers involved in such collaboration activities grows in this stage.

The transition from the distant stage to the relational stage may happen by the initiatives of individual teachers, students and/or managers at the collaborating partner. Environmental factors may play role for such initiatives, such as an increasing demand for engineering students at particular companies or government funding for such activities. No matter the cause of the initiatives the university department needs to develop organizational collaborative capabilities to sustain collaborative activities at this stage, otherwise the initiatives will soon be back to an individual level, i.e., to the distant stage.

In the relational stage the university department needs to develop networking and relational capabilities. Networking capabilities could be to create routines, structures and allocate competence, time and budgets for educational events which will interest external actors, develop communication channels and media with external actors with focus on educational activities and students, market educational events and activities to alumni or other organized networks, and so on. Once the development of networking capabilities starts to pay off in terms of interest and attendance to events and activities, relational capabilities have to be developed to maintain and expand the network of collaboration partners. This might include routines for regular communication and dialogue, creation of organizational bodies for planning and dialogue, assignment of contact persons or contact points, including contact points with student organizations and programs.

In the relational stage the effects for all stakeholders increases. The teachers and the department may develop its teaching material and didactics. Students may be more motivated by being exposed to organizational and business dynamics as well as learning more about work related competences including domain specific competences. Firms and organizations can market themselves as interesting employers as well as getting a chance to take a closer look at individual students as potential employees.

The interactive stage

In the interactive stage the educational collaboration activities may increase even more compared to the relational stage, but the main difference is that educational collaboration activities will, from university department perspective become strategically focused, i.e., aligned with the university departments strategic objectives and priorities. This should include not only strategies for the educational part of the university department but also the research part. To accomplish this, the university department needs to develop desorptive capabilities, i.e., the ability to select, engage and align internal actors with external actors to achieve the strategic objectives. As an example Lucia et al. (2012) describes the collaboration between University of Zaragoza's, specifically the Department of Electronics Engineering and Communications and the Bosch and Siemens Home Appliances (BSH) group in the field of domestic induction heating appliances over a 15-year period. This collaboration entails both educational and research activities in induction heating-

related knowledge areas such as power electronics, digital control and magnetic components design. The education activities include lecture sessions on specific induction heating issues, training sessions, technical conferences, company visits, internships, and an annual innovation award. Research includes direct collaboration in research projects by master students (master theses) and PhD-students (doctoral dissertations). Over a 15-year period the number of published academic papers, master theses, doctoral dissertations and job placings of students have steadily increased.

The development of a desorptive capability consists of several components, most importantly to have internally accepted and well-diffused strategic objectives and priorities, to be able to select suitable and engaged external stakeholders in collaboration. The aligning of objectives, between the collaboration partners, requires closer contacts and communication than in the relational stage. This would be realized by more co-planning and co-executing activities as well as sharing of personnel, i.e., adjunct professors, visiting scholars, and visiting managers (manager on campus). Trust levels have to be maintained at high levels, as sensitive company or organization information is bound to be exposed.

In the interactive stage the effects for the university department's teachers and researchers, as well as students and the collaborating firms and organizations and their managers are very visible. For teachers and researchers they include funding, higher research activity, curriculum and course development, and professional development. For students they include development of many specific skills, generic work related and domain-specific, early career development making them better professionals at the time of finish of their studies being able to propose new ideas and business solutions. For companies, organizations and their managers they include a source of creative ideas, as well as a well-trained workforce.

The down-side of such a collaboration program described by Lucia et al. (2012) is the dependence on rather narrow technological focus and one large company. Thus, it makes sense to select several collaborating partners, including SMEs, to reduce dependence.

Concluding remarks - Educational collaboration – Organizing for impact

The three collaborative stages implies that educational collaboration may evolve from largely being an individual effort between teacher and a company manager to a much more encompassing and institutionalized collaboration. The relational and the interactive stages of educational collaboration is a more collective effort from both the university and partner organizations involving more people and collaboration in-between several department units and partner organization units as well as several programs and courses. The teaching and learning in such more advanced collaborative stages becomes significantly different from the teaching and learning in the distant stage. The interactive stage implies that there is a strategic dimension on educational collaboration. It is about selecting collaboration partners and investing in relationships and organizational structures that will increase quality of teaching, make the university department more attractive for students, teachers, and collaborating external partners as well as make a more

visible impact on society. Seen from a strategic perspective educational collaboration efforts should be put into the overall and longtime development agenda both at the university and the collaboration partners. In the interactive stage the university department develops a desorptive capability, to sustain such strategic collaboration efforts. At the interactive stage we see the largest potential risks with educational collaboration, i.e., to select less good partners and/or partners that decrease their commitment over time in the partnership activities due to changed strategic intentions or financial problems. This especially the risk when you collaborate with large companies or public organizations. In addition there are risks that the curriculum and courses over time might become too company-or organization specific, deterring other companies or SMEs from collaboration activities.

While we personally have a positive view on and experiences from working with more advanced collaboration modes the risks of decreasing commitment and changed strategic agendas need to be taken seriously. Above all, the selection of collaboration partners, the mix of partners as well as projects chosen (and project management) becomes very important issues to handle. Collaboration with SMEs might require specific development of networking, relational and desorptive capabilities as they generally have less resources, less time and less competences to devote to educational collaboration (Asplund & Bengtsson, 2020).

Educational collaboration is a key signature process for the modern and proactive university to excel in. In order to proactively educate our students (during their education) - we have to move towards more institutionalized collaboration, applying more advanced educational collaboration stages that links into the value creation for students, organizations and companies.

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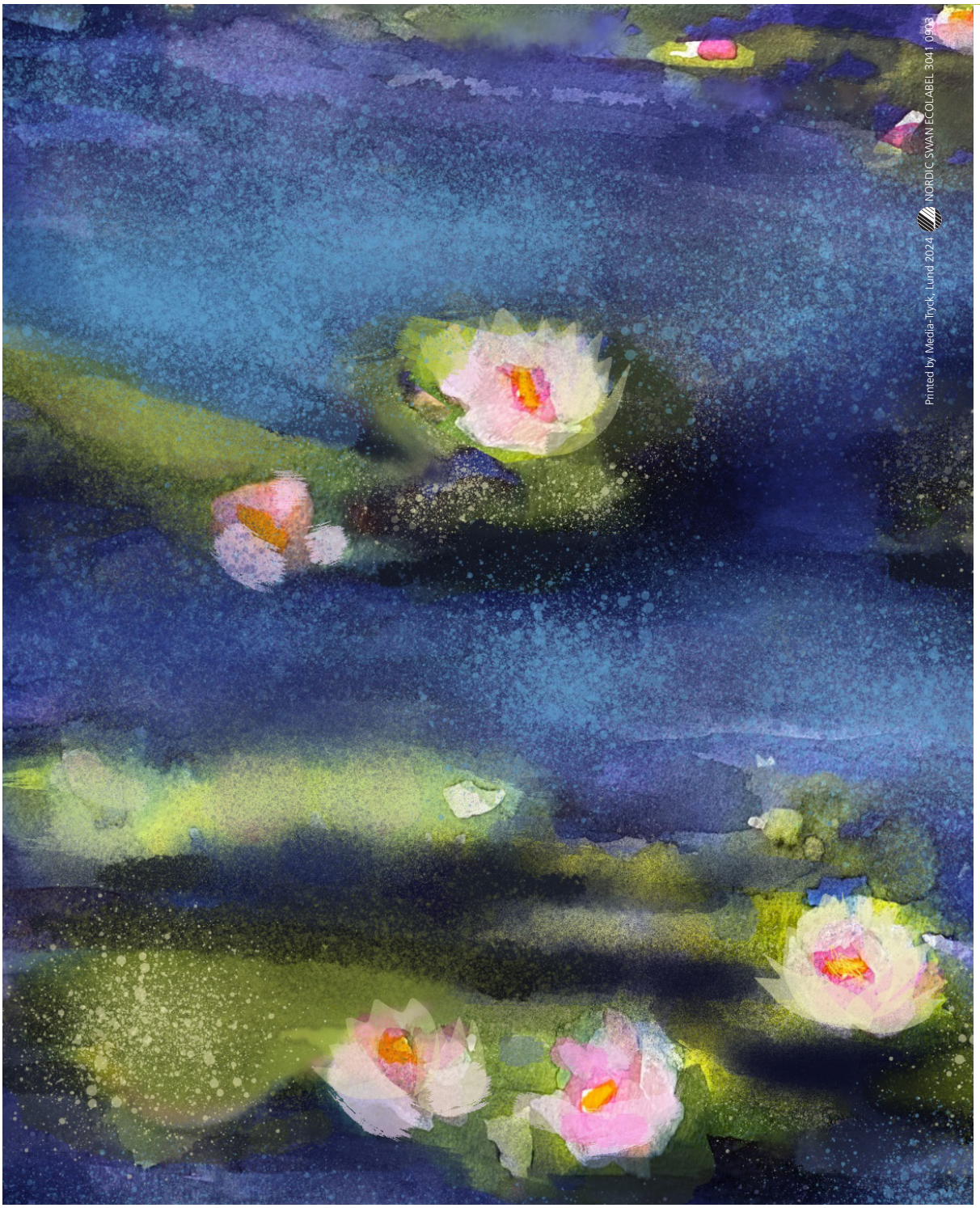

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