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INNOVATIVE INTERACTIONS

EXAMINING STAKEHOLDER ROLES IN PROCUREMENT OF DIGITAL LEARNING TECHNOLOGIES IN DANISH HIGHER EDUCATION

BY
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AALBORG UNIVERSITY
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Innovative Interactions:

Examining Stakeholder Roles in Procurement of Digital Learning Technologies in Danish Higher Education

Ph.D. Dissertation
Eskil Olav Andersen

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Abstract

This thesis examines the procurement process of educational technology in Danish higher education institutions (HEIs) from a systems' perspective, exploring the involvement of different stakeholders (intermediaries, educational institutions, suppliers, and governments) and the implications of their participation for the development and implementation of these technologies. The study contributes to the understanding of how large public institutions incorporate services from private firms, how government initiatives impact technology integration in education, and the global phenomenon of technology integration in education. The thesis is structured around four articles that focus on different aspects of educational technology system development and procurement in the context of HEIs.

The thesis uses four related theoretical themes, namely, innovation system research in a transnational context, innovation intermediaries, public procurement of innovation, and collaborative innovation, to encapsulate the global phenomenon of procurement of technologies for teaching and learning in HEIs with specific local conditions. The thesis comprises four articles, each approaching a different aspect of EdTech system development, and procurement in HEIs.

The first article examines the transnational dimensions of innovation systems in educational technology procurement and implementation, providing an understanding of different subsystems supporting the development of a global EdTech innovation system, by analyzing the role of intermediaries in system formation. The second article focuses on the impact of public procurement of innovation on the development and implementation of educational technologies, specifically focusing on procedural innovation policies, or, how organizations can structure themselves to allow for innovation from third parties. The third article analyzes the role of collaborative innovation in the procurement process of educational technologies and its impact on technology implementation. This paper focuses on the supply side of public procurement policies, examining how providers engage with large public institutions in the development and implementation of services. Finally, the fourth article explores the perspectives of students as recipients of digital education. This study was set during the initial COVID-19 lockdowns of 2020, showcasing the consequences of pure online education.

The findings suggest that the procurement process of educational technology in Danish universities is complex, involving multiple stakeholders with different inter-

ests and goals. The involvement of intermediaries, such as consultants and alliances, can have positive effects on the innovation system, but their impact is highly dependent on the surrounding regulatory and strategical structures. Public procurement of innovation can facilitate innovation and drive development, but it can also create barriers to entry for smaller companies. Collaborative innovation can enhance the effectiveness and efficiency of the procurement process, but it requires trust and a shared vision among stakeholders, and from the findings of this thesis, collaborative innovation activities are relatively limited. Finally, the transnational dimension of innovation systems in educational technology procurement and implementation highlights the importance of context-specific factors, such as institutional culture and regulatory frameworks. Together, the articles in this thesis provides insights into the procurement process of educational technology in large public institutions, highlighting the roles of different stakeholders and their impact on the diffusion of such technologies. The thesis contributes to the literature on innovation system research, innovation intermediaries, public procurement of innovation, and collaborative innovation. The findings have implications for policy and practice, as they suggest ways to enhance the effectiveness and efficiency of the procurement process and promote innovation in educational technology.

Resumé

Denne afhandling undersøger anskaffelsesprocessen for uddannelsesteknologi på universiteter i Danmark fra et systemperspektiv, og undersøger involveringen af forskellige interessenter (mellemled, uddannelsesinstitutioner, leverandører og regeringen), og implikationerne af deres deltagelse for udviklingen og implementering af disse teknologier. Studiet bidrager til forståelsen af, hvordan store offentlige institutioner inkorporerer services fra private virksomheder, hvordan regeringsinitiativer påvirker teknologi-integration i uddannelse og den globale fænomen af teknologi-integration i uddannelse. Afhandlingen er struktureret omkring fire artikler, som fokuserer på forskellige aspekter af systemudvikling i uddannelsesteknologi og anskaffelse a teknologi til undervisning i konteksten af danske universiteter.

Afhandlingen bruger fire beslægtede teoretiske temaer, nemlig innovationssystemforskning (innovation system research) i en transnational kontekst, innovationsmellemled (innovation intermediaries), offentlig anskaffelse af innovation (public procurement of innnovation) og samarbejdsinnovation (collaborative innovation), til at indkapsle den globale fænomen af anskaffelse af teknologier til undervisning og læring i højere læreanstalter med specifikke lokale forhold. Afhandlingen omfatter fire artikler, som hver tager fat på et forskelligt aspekt af systemudvikling og anskaffelse af uddannelsesteknologi i konteksten af højere læringsanstalter.

Den første artikel undersøger de transnationale dimensioner af innovationssystemer i anskaffelse og implementering af uddannelsesteknologi og giver en forståelse af de forskellige subsystemer, der understøtter udviklingen af et globalt edtech innovationssystem, ved at analysere rollerne for forskellige mellemled i systemdannelsen. Den anden artikel fokuserer på virkningerne af offentlig anskaffelse af innovation på udviklingen og implementeringen af uddannelsesteknologi, hvor fokus er på procedurale innovationspolitikker, eller, hvordan organisationer kan strukturere sig selv for at facilitere innovation fra tredjeparter. Den tredje artikel analyserer rollen af samarbejdsinnovation i udbuddet af uddannelsesteknologi og dens indvirkning på teknologi-implementeringen i en stor offentlig virksomhed. Denne artikel fokuserer på forsyningssiden af offentlige anskaffelsespolitikker og undersøger, hvordan leverandører engagerer sig med store offentlige institutioner i udviklingen og implementeringen af tjenester. Endelig undersøger den fjerde artikel studerendes perspektiver som modtagere af digital uddannelse. Dette studie blev udført under de indledende COVID-19 nedlukninger i 2020 og viser konsekvenserne af ren online-undervisning.

Resultaterne indikerer, at indkøbsprocessen af uddannelsesteknologi på danske universiteter er kompleks og involverer flere interessenter med forskellige interesser og mål. Involvering af mellemled, såsom konsulenter og alliancer, kan have både positive virkninger på innovationssystemet, men deres succes afhænger ofte af de omkringværende regulatoriske og strategiske strukturer. Strategier for offentlige indkøb af innovation kan lette innovation og fremme udvikling, men det kan også skabe barrierer for mindre virksomheder. Samarbejdsinnovation kan forbedre effektiviteten og effektiviteten af indkøbsprocessen, men det kræver tillid og en fælles vision blandt interessenter. Endeligt fremhæver den transnationale dimension af innovationssystemer i indkøb og implementering af uddannelsesteknologi vigtigheden af kontekstspecifikke faktorer såsom institutionel kultur og regulative rammer.

Sammen giver artiklerne i denne afhandling indsigt i indkøbsprocessen af uddannelsesteknologi i store offentlige institutioner og fremhæver forskellige interessenters roller og deres indflydelse på udvikling og implementering af sådanne teknologier. Afhandlingen bidrager til litteraturen om innovationsystemsforskning, innovationsmellemled, offentlige indkøb af innovation og samarbejdende innovation. Resultaterne har implikationer for politik og praksis, da de foreslår måder at forbedre effektiviteten og gennemslagskraften af indkøbsprocessen og fremme innovation inden for uddannelsesteknologi.

Contents

Contents

Thesis Details

Thesis Title: Innovative Interactions: Examining Stakeholder Roles in Procurement of Digital Learning Technologies in Danish Higher Education
Ph.D. Student: Eskil Olav Andersen
Supervisors: Assoc. Prof. Roman Jurowetzki, Aalborg University
Prof. Chaoying TANG, University of Chinese Academy of Sciences

The main body of this thesis consists of the following papers.

[**??**] Eskil Olav Andersen, "System building in European EdTech: The role of intermediaries in market formation," In review at *Technological Forecasting and Social Change*, 2023.

[**??**] Eskil Olav Andersen and Roman Jurowetzki, "Procurement of innovation in large public institutions: The case of EdTech procurement in Danish universities," In review at *Journal of Public Procurement*, 2023.

[**??**] Eskil Olav Andersen, Primoz Konda, and Roman Jurowetzki, "Why is it so Complicated? A Supplier Perspective on Collaborative Innovation in Large Public Institutions," Submitted to *The Journal of Technology Transfer*, 2023.

[**??**] Eskil Olav Andersen, Hans Hüttel, and Dorina Gnaur, "Going Online: Student Perspectives in a Problem-Based Learning Environment during the Pandemic," *European Conference on E-learning (ECEL)*, vol. 20, pp. 42-50, 2021.

This thesis has been submitted for assessment in partial fulfillment of the PhD degree. The thesis is based on the submitted or published scientific papers which are listed above. Parts of the papers are used directly or indirectly in the extended summary of the thesis. As part of the assessment, co-author statements have been made available to the assessment committee and are also available to the Faculty. The thesis is not in its present form acceptable for open publication, but only in limited and closed circulation, as copyright may not be ensured.

Thesis Details

Preface

On December 15, 2019, I had my first day as a PhD student at Aalborg University Business School. I started this project with an interest in exploring the potentials for technology use in education. During the first months of planning, my supervisor and I developed a strategy to utilize the Danish-Chinese collaboration Sino-Danish Center (SDC), that I was hired as part of, to compare developments of artificial intelligence (AI) in education in China and Europe. We had planned for the first trip to China to happen in April 2020, but as fate would have it, something came up.

The spread of COVID-19 and subsequent lockdowns ruined many plans, including mine, and we had to rethink both goals and approaches to fit a new reality. As a silver lining to it all, however, (digital) technologies in teaching and learning suddenly became of utmost relevance, and different cases and approaches to research became available. At first, I was interested in the adoption and diffusion of novel technologies and solutions, especially in the light of developments within AI, machine learning (ML), and natural language processing (NLP). While I still remain deeply interested in these areas, as I researched, I became more and more aware of the many layers and different perspective to educational technologies (EdTech). Being positioned in innovation research, I increasingly steered the research towards an area that, in the midst of increasing EdTech interest, was strangely under-researched. Adoption and diffusion of novel technologies have interested researchers for a long time, and EdTech has been around for more than forty years as a practical and theoretical concept. However, few studies focus on the process of identification and purchase of novel solutions for the educational infrastructure.

The COVID-19 pandemic brought about unprecedented changes in the higher education landscape, as institutions were forced to quickly adapt to remote teaching and learning. This shift created a sudden and urgent need for new technologies and tools to support online instruction, leading to a surge in the procurement of EdTech solutions. Educational institutions had to quickly identify, evaluate, and purchase a myriad of privately developed services, with the aim of integrating them into their existing infrastructure, sometimes within a matter of weeks or even days.

This rapid adoption of new solutions presented numerous challenges. Institutions had to navigate complex procurement processes, negotiate with vendors, and ensure compatibility with existing systems. There was also a risk of creating a disjointed and fragmented digital environment, with different departments and units using different tools and systems. Additionally, there were concerns about the long-term sustainabil-

ity of these new technologies, as institutions had to balance the need for immediate solutions with the need for a more strategic and coherent approach to technology adoption.

Despite these challenges, the pandemic also created new opportunities for innovation and experimentation in EdTech. Institutions were able to explore new approaches to teaching and learning, leveraging technologies such as video conferencing, learning management systems, and online collaboration tools. Some institutions even developed their own solutions in-house, showcasing the potential for creativity and entrepreneurship in the EdTech space. As we emerge from the pandemic, it is clear that the role of technology in education will continue to evolve and expand. The lessons learned during this time can help to inform future strategies for technology adoption in education, with a focus on creating a more cohesive and sustainable digital ecosystem that supports effective teaching and learning.

As such, through this thesis, I argue that more research is needed on how procurement and procurement processes can be devised to enable creativity, entrepreneurship, and innovation in the EdTech space, to ideally benefit all stakeholders involved. The adoption and diffusion of novel technologies in education is a complex and multifaceted process that involves a range of stakeholders, including educators, administrators, policymakers, and vendors. Despite the increasing interest in EdTech, there is still a significant gap in the research on the process of identifying and purchasing novel solutions for the educational infrastructure.

One of the challenges in this area is the lack of standardized frameworks for evaluating and selecting new technologies. Educational institutions often have different priorities, resources, and constraints that influence their technology adoption decisions. For example, some institutions may prioritize cost-effectiveness, while others may prioritize functionality and user experience. Similarly, different departments within an institution may have different technology needs and preferences, making it difficult to find a one-size-fits-all solution. Another challenge is the need for effective communication and collaboration between educators and vendors. Educators need to be able to articulate their needs and requirements, while vendors need to be able to understand and respond to these needs in a timely and effective manner. This requires a certain level of technological and pedagogical literacy for educators, as well as an understanding of the educational context and culture for vendors.

Further, there are regulatory and policy considerations that can impact the adoption and diffusion of EdTech solutions. For example, some jurisdictions may have specific data privacy and security requirements that vendors must adhere to, while others may have specific funding mechanisms or procurement processes that institutions must follow. These factors can influence the availability and accessibility of different technologies, and can create additional barriers to adoption and diffusion.

The process of identifying and purchasing novel technologies for education requires careful consideration of a range of factors, including institutional priorities, technological and pedagogical needs, vendor capabilities, and regulatory and policy considerations. By examining this process in more detail, we can gain a more profound understanding of the challenges and opportunities of technology adoption in educa-

tion, and develop more effective strategies for supporting innovation and growth in the EdTech space.

In my thesis, the procurement of EdTech is explored in the context of Danish higher education institutions, providing a setting of highly autonomous large public institutions, set in regulatory boundaries of both Denmark and the EU. I hope my research can provide the reader with important insights regarding the challenges and opportunities for EdTech procurement, and open for new questions and avenues of research.

Preface

Acknowledgements

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Eskil Olav Andersen
Aalborg University, December 21, 2023

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Acknowledgements

Abbreviations

Abbreviation	Description
HEIs	Higher Education Institutions
EdTech	Educational Technology
IAs	Industry Associations
EU	European Union
OECD	Organization for Economic Co-operation and Development
EEA	European EdTech Alliance
IS	Innovation System (research)
PPI	Public Procurement of Innovation
PBL	Problem- and Project-Based Learning
AU	Aarhus University
AAU	Aalborg University
KU	University of Copenhagen
RUC	Roskilde University
SDU	University of Southern Denmark
ITU	IT University of Copenhagen
DTU	Technical University of Denmark
CBS	Copenhagen Business School
AI	Artificial Intelligence
VR & AR	Virtual and Augmented Reality
NLP	Natural Language Processing
BERT	Bidirectional Encoder Representations from Transformers
RoBERTA	Robust Optimized Bidirectional Encoder Representations from Transformers pretraining Approach
MOOCs	Massive Open Online Courses
LMS	Learning Management System
SaaS	Software as a Service

Abbreviations

Part I

Synopsis

1 Introduction

In an era marked by rapid digitalization, higher education institutions (HEIs) worldwide are at a crossroads, navigating the integration of new technologies in teaching and learning to remain relevant in the 21st century. This thesis examines the Danish higher education system's response to these global digitalization trends, particularly focusing on the procurement and implementation of educational technologies. The thesis explores how various stakeholders — institutions, intermediaries, end-users, and technology suppliers — participate in this process and the implications of their involvement. This approach not only offers insights into the intricacies of technology adoption in Danish universities but also contributes to a broader understanding of the dynamic between global trends and local institutional practices in the field of educational technology procurement (Weller, 2018; Williamson, 2021; Ryberg, 2016, 2021; Jeppesen and Havinga, 2021; Facer and Selwyn, 2021; Selwyn, 2010; Bond et al., 2018; Mohamed Hashim et al., 2022).

The onset of the COVID-19 pandemic has served as a catalyst in this regard, compelling educational institutions globally, and in Denmark, to rapidly embrace digital tools and platforms for remote learning and communication. This urgent shift has brought to the forefront the challenges and opportunities inherent in the adoption of digital technologies in education. The situation is further compounded by the emergence of generative artificial intelligence (AI), which poses new challenges and opportunities for educational institutions. This thesis situates the Danish HEIs within this backdrop, scrutinizing how their centralized and hierarchical systems cope with the pressures of digitalization and how their strategies and decisions in procuring educational technologies reflect a balance between innovation and tradition. The Danish experience, characterized by a concerted effort to integrate digital solutions amidst bureaucratic structures, provides a rich context for studying the broader European and global trends in higher education digitalization (Madsen et al., 2020; Haslam et al., 2020; Aristovnik et al., 2020; Reale, 2021; Baidoo-Anu and Owusu Ansah, 2023; Grassini, 2023). The institutional implementation of educational technologies have the potential to improve access to education, enhance the quality of teaching and learning, and increase the effectiveness and efficiency of education systems. However, the integration of technology in education also presents numerous challenges in terms of infrastructure, teacher training, digital divide, locally specific demands, and access to funding (Hillman, 2022; Bond et al., 2018; Facer and Selwyn, 2021; Ryberg, 2016).

1.1 Global context, local conditions

The advent of digitalization in higher education is not just a technological evolution but a transformative global phenomenon. Danish universities, characterized by their centralized and hierarchical management system, face change-related challenges and opportunities in this digital era. The necessity to adapt and innovate within these institutions mirrors a broader European trend towards exploring the integration of novel educational technologies (Wright, 2012; Ryberg, 2016, 2021; Mohamed Hashim et al., 2022).

In Denmark, the intersection of bureaucratic structures and the rapid advancement of digital solutions has created a distinctive scenario. The centralized management prevalent in Danish universities provides a streamlined approach to decision-making and policy implementation. However, this centralization also presents complications, especially when procuring and adopting new educational technologies. These complications are not unique to Denmark but resonate with global challenges in higher education – an aspiration to preserve educational quality while embracing technological advancements (Wright, 2012; Rolfstam, 2013; Hillman, 2022; Facer and Selwyn, 2021). This is explored in this thesis through the conceptualization of process intermediaries — entities within HEIs, managing the procurement of technologies for teaching and learning (Rolfstam, 2013; Rolfstam et al., 2011; Kivimaa et al., 2019a; Edler and Yeow, 2016).

The increasing reliance on digital solutions in Danish society, particularly in education, is not just a response to contemporary demands but also a strategic move towards future readiness. The economic pressures facing these institutions, coupled with the growing need for digital skills among students, underscore the urgency of effectively integrating technology into educational frameworks (Hillman, 2022; Bond et al., 2018; Sulaeman et al., 2019; Chen et al., 2022). This urgency aligns with Denmark's role as a digitally advanced nation, making it a fitting case for studying the broader impacts of digitalization in education.

This thesis situates the Danish higher education system within the larger context of transnational innovation systems (Binz and Truffer, 2017; Bergek et al., 2015; Lundvall, 1992). By doing so, it highlights how systemic intermediaries – entities that facilitate cross-border collaboration and knowledge exchange – are instrumental in the adoption and diffusion of educational technologies (Kivimaa et al., 2019a). The Danish case, therefore, provides, not only insights into local procurement challenges and strategies, but also into how these practices are influenced by and contribute to wider European and global trends. In this global context, Denmark's specific local conditions, with its largely homogenous societal structure and concentrated academic landscape, offer an opportunity to explore how large public institutions manage the incorporation of services from private firms in the realm of educational technology. This exploration is critical, as it sheds light on the nuanced interplay between global digital trends and local institutional practices, providing valuable insights into the procurement process's effectiveness and efficiency.

As such, this thesis aims to elucidate the specificities of the Danish higher education system's response to global digitalization trends. It examines the role of various stakeholders in this process, particularly focusing on the procurement of educational technologies, a subject of increasing relevance in the context of mission-driven innovation and collaborative efforts in public institutions (Mazzucato, 2013, 2018; Sørensen and Torfing, 2011; Rolfstam and Petersen, 2014; Hillman, 2022).

1.2 Digitalization as a political project

Digitalization in Danish higher education is not only a response to evolving technological landscapes but also a reflection of strategic political decisions. In recent years, Denmark has embarked on an ambitious digitalization strategy, underscoring its commitment to integrating digital technologies across various sectors, including education (Danish Regions, 2022; Danish Ministry of Finance, 2022). This strategy represents a significant political project, with implications that extend beyond mere technology adoption.

Central to this strategy is the Danish government's emphasis on innovation and collaboration between public and private sectors. This approach resonates with the concept of mission-driven innovation, where the focus is on addressing societal challenges through collaborative efforts (Mazzucato, 2013, 2018; Edler and Uyarra, 2013; Georghiou et al., 2014; Torfing, 2019; Rolfstam and Petersen, 2014). In the context of higher education, this translates into a concerted effort to procure and implement digital tools and platforms that not only enhance educational delivery, but also align with broader societal goals.

The pandemic has further accelerated this digital shift, prompting an urgent need for educational institutions to adapt rapidly (Mohamed Hashim et al., 2022; Haslam et al., 2020; Madsen et al., 2020). This urgency has highlighted the importance of agility and adaptability in public institutions, particularly in the procurement and integration of educational technologies. The shift towards remote learning and teaching methodologies necessitated by the pandemic underscores the critical role of digitalization in maintaining educational continuity and quality.

Furthermore, recent developments in AI and natural language processing (NLP) — including the rise of generative AI technologies, such as ChatGPT — presents new frontiers for digitalization in education. These technologies challenge traditional pedagogical approaches and evaluation methods, necessitating a reevaluation of procurement processes to incorporate innovative solutions that are both effective and ethically considerate (Wach et al., 2023; Marr, 2023; Rudolf et al., 2023; Chan, 2023; Grassini, 2023). These technologies offer new ways to enhance learning and teaching but also require careful consideration of ethical, pedagogical, and practical implications (Chan, 2023; Baidoo-Anu and Owusu Ansah, 2023). The procurement process, therefore, must be agile and responsive, capable of adapting to the rapidly changing technological landscape while staying true to the educational and institutional goals. This situation illustrates the dynamic interplay between technology, policy, and educational practices, further emphasizing the need for a strategic approach to technology adoption in universities.

Denmark's digitalization strategy presents a political project with profound implications for the procurement of educational technologies. It highlights the need for policies that foster innovation while ensuring alignment with educational objectives and societal values (Danish Regions, 2022; Danish Ministry of Finance, 2022). By focusing on collaborative innovation, Danish universities can navigate the challenges of integrating novel technologies, balancing the demands of rapid digital advancement with the need for thoughtful and strategic implementation.

1.3 Mission-driven innovation in higher education

In the realm of higher education, Denmark's approach to digitalization can be seen as a conceptualization of mission-driven innovation (Mazzucato, 2013, 2016, 2018). This concept, which emphasizes addressing societal challenges through strategic and collaborative efforts, is particularly relevant in the context of Danish universities. Here, the mission extends beyond mere academic excellence to encompass the broader objective of preparing students for a rapidly evolving digital world, while also contributing to societal development (Moore, 2018; vant Land et al., 2021; Rolfstam and Petersen, 2014).

This approach to innovation in higher education is not just about adopting new technologies; it involves a holistic understanding of the role that universities play in the societal ecosystem. Danish universities are not only educational institutions, but also key players in driving technological and social innovation. The procurement of educational technologies, therefore, is seen not just as a functional necessity but as a strategic endeavor that aligns with the larger mission of these institutions (Papadimitriou, 2020; Pinheiro et al., 2015; Shumar and Wright, 2016; Ørberg and Wright, 2019). In this context, the procurement process becomes a critical component of mission-driven innovation. Universities are tasked with identifying and integrating digital tools that not only enhance the learning experience but also align with broader societal goals, such as fostering digital literacy, promoting inclusive education, and supporting sustainable development (OECD, 2023b, 2019). This requires a nuanced understanding of the interplay between technology, pedagogy, and societal needs.

Furthermore, the involvement of various stakeholders in this process highlights the collaborative nature of innovation in Danish higher education. From government agencies setting the policy framework to private technology providers offering solutions, the procurement process encompasses a range of actors, each contributing their expertise to the collective mission. This collaboration is crucial in ensuring that the technologies adopted are not only advanced but also relevant and effective in the educational context (Mazzucato, 2013, 2016, 2018; Torfing et al., 2019; Torfing, 2019).

1.4 Danish universities as a case setting

Danish universities represent a compelling case setting for examining the procurement of educational technologies in higher education. As large public institutions, they are emblematic of the challenges and opportunities inherent in integrating digital solutions into established educational systems (Wright, 2012; Rolfstam, 2013; Danske Universiteter, 2022). Their distinct position within Denmark's societal and educational landscape provides valuable insights into how such integration can be managed effectively and strategically.

Firstly, the strong tradition of public education in Denmark, coupled with a high level of digital literacy and government support for digital initiatives, positions Danish universities at the forefront of educational innovation (OECD, 2021, 2019; Wright, 2012; UFM, 2020; Danish Regions, 2022; Danish Ministry of Finance, 2022). This environment provides a solid opportunity for exploring how digital technologies can be adopted in ways that align with both educational quality and societal needs. Ad-

ditionally, Denmark's focus on innovation and digitalization in the public sector, as part of its broader national strategy, offers a suitable context for understanding how universities navigate the procurement of new technologies. This context includes the balancing act between adhering to stringent public procurement regulations and embracing the flexibility required to integrate rapidly evolving digital solutions. Moreover, the centralized management structure of Danish universities provides a distinct perspective on decision-making processes related to technology procurement. It allows for an examination of how centralized policies and strategies are developed and implemented across different institutions, and how they interact with local needs and conditions. The Danish case offers valuable lessons on managing technology procurement in education that are relevant not only at a national level but also in a broader international context, providing insights that can inform practices in other countries facing similar challenges in integrating digital technologies in higher education.

Europe as a transnational boundary setting

Denmark's role in the European Union (EU) adds an essential transnational dimension to its approach to the procurement of educational technologies. As a member state, Denmark is influenced by EU-wide regulations, standards, and trends, which in turn shape its local educational policies and procurement practices (European Commission, 2021b,a). This relationship between the national and transnational levels offers an important perspective on the diverse adversities of technology procurement in higher education.

The EU's regulatory framework, particularly in the realms of digital innovation and public procurement, sets a standard that Danish universities must navigate. This framework emphasizes transparency, competitiveness, and innovation, guiding the procurement processes of member states. For Danish universities, this means aligning their procurement strategies not only with national policies but also with broader EU directives and regulations. This alignment is crucial in ensuring that the technologies procured are not only effective and relevant for Danish students and educators but also compliant with EU-wide standards.

Moreover, Denmark's participation in the EU opens avenues for collaboration and knowledge exchange with other European institutions. This collaborative environment fosters the development of best practices in technology procurement and facilitates the sharing of experiences and challenges (Rolfstam and Petersen, 2014; Rolfstam, 2013). Such transnational collaborations enrich the Danish approach to procurement of educational technology, allowing for a more comprehensive understanding of the opportunities and constraints within a broader European context. The EU's emphasis on digital education and innovation also influences Denmark's educational technology landscape. Initiatives like the European Digital Education Action Plan (European Commission, 2021a), set a strategic direction for digital education in Europe, encouraging member states to explore innovative ways to integrate technology into teaching and learning. Danish universities, in this context, become part of a larger European effort to harness the potential of digital technologies for educational advancement.

1.5 Procurement of technologies for teaching and learning as the case

The procurement of technologies for teaching and learning in Danish HEIs is the central focus of this thesis. This process is multifaceted, involving not just the selection and purchasing of digital tools but also their strategic integration into the educational framework. Educational technologies, also known as EdTech, refer to a wide range of tools, resources, and strategies that are used to enhance and support teaching and learning in educational settings (Selwyn, 2010; Facer and Selwyn, 2021; Ryberg, 2016, 2021; Williamson, 2021; Weller, 2018; Bond et al., 2018; Bond and Bedenlier, 2019). These technologies can include hardware and software, digital resources and platforms, online and blended learning programs, and other digital tools and materials. EdTech is used in this thesis to encapsulate the diverse applications and solutions implemented in the HEI teaching and learning structure. Some of the most common examples of EdTech usage are elaborated in table 1.

In Danish HEIs, the procurement of EdTech is influenced by a variety of factors: the rapidly evolving landscape of digital solutions, the diverse needs of students and educators, budgetary constraints, and compliance with both national and EU regulations (Ryberg, 2016, 2021; European Commission, 2021a,b; Hillman, 2022; Facer and Selwyn, 2021). Universities must therefore be adept at balancing these factors, selecting technologies that not only enhance the quality of education but also align with institutional strategies and values. This process involves more than just technical evaluation; it requires a deep understanding of pedagogical goals and the educational ecosystem. Danish universities are tasked with procuring technologies that can effectively support innovative teaching methods, foster student engagement, and provide access to quality education for all. This includes considering the scalability, accessibility, and sustainability of the solutions chosen.

Additionally, the procurement process in Danish HEIs is not conducted in isolation. It involves collaboration with a range of stakeholders, including technology providers, government agencies, and the academic community. This collaborative approach ensures that the technologies procured are not only providing innovative solutions, but are also practically viable and pedagogically sound.

Further, universities must stay informed of novel technological trends, evaluating their potential impact on teaching and learning. This includes considering ethical implications, data privacy concerns, and the need for digital literacy among students and staff.

Type	Description
Learning management systems (LMS)	Software applications designed to help manage and deliver educational content and resources, as well as track student progress and performance. An LMS can be used to create and administer courses, assign and grade assignments, communicate with students, and manage various aspects of the learning experience.
Virtual and augmented reality (VR & AR)	Immersive technologies that use computer-generated environments and sensory experiences to create a simulated reality or augment a real-world experience. Virtual reality creates a digital environment, while augmented reality overlays digital elements onto the real world.
Adaptive learning software	Educational software that uses data and algorithms to personalize the learning experience for individual students. Adaptive learning software analyzes student performance and adjusts content and activities in real-time to meet the needs of each student.
Online collaborative tools	Web-based applications designed to facilitate group work and collaboration in an online learning environment. Examples include video conferencing, chat and messaging apps, and shared document editing tools.
Interactive whiteboards	These are large digital displays that allow teachers and students to interact with content using a variety of input methods, such as touch or stylus. Interactive whiteboards can be used to create engaging and interactive lessons, as well as to display and manipulate educational materials.
Digital textbooks	These are electronic versions of traditional textbooks that can be accessed and read on digital devices such as tablets, laptops, or smartphones. Digital textbooks may include multimedia elements such as videos, interactive diagrams, and quizzes.
Learning analytics	The process of collecting, analyzing, and using data to inform and improve the learning experience. Learning analytics may involve tracking student progress and performance, analyzing engagement and behavior patterns, and using predictive modeling to identify at-risk students.
Artificial intelligence and machine learning	Technologies that use algorithms and data to simulate human intelligence and decision-making. In education, artificial intelligence and machine learning may be used to personalize the learning experience, identify patterns in student behavior, and provide insights to help educators make data-driven decisions.
Simulation and gaming technologies	Interactive digital environments designed to simulate real-world experiences or to create engaging games for educational purposes. Examples include virtual labs, educational games, and simulations that allow students to practice skills in a safe and controlled environment.

Table 1: Examples of EdTech solutions

1.6 Research focus

This thesis is centered on an examination of the procurement of educational technologies in Danish higher education. The focus is twofold: firstly, to understand how different stakeholders participate in this process, and secondly, to unravel the implications of their involvement for the innovation of technologies for teaching and learning in the educational space.

The relevance of this research is heightened by contemporary technological advancements, notably in digital and AI realms. Technologies like generative AI have begun reshaping the educational landscape, challenging traditional pedagogical methods and procurement strategies. This evolving landscape necessitates a deeper understanding of how educational institutions respond to and integrate novel technologies (Facer and Selwyn, 2021; Hillman, 2022; Ryberg, 2021, 2016; Chan, 2023; Baidoo-Anu and Owusu Ansah, 2023; Grassini, 2023).

Moreover, the COVID-19 pandemic has underscored the importance of digital agility in education. The sudden shift to online learning highlighted the necessity for robust and adaptable educational technologies, raising questions about the efficiency and effectiveness of existing procurement processes. This thesis seeks to explore how Danish universities work to navigate these unprecedented challenges, how they are adapting or changing their procurement strategies to meet urgent and changing educational needs, through the overarching research question:

How do different stakeholders participate in the procurement of innovation of educational technologies in Danish higher education, and what are the implications of their involvement?

This question guides the exploration across four articles, each addressing different dimensions of procurement in Danish HEIs. These articles collectively offer a comprehensive view of the procurement process, encompassing the perspectives of system- and process intermediaries, technology suppliers, and end-users. The specific research questions posed in each article are summarized in table 2.

Paper	Research question	Scope
Paper A	How do intermediaries contribute to system building in European EdTech?	Europe. Mapping of EdTech innovation system. Sets the boundaries in which EdTech procurement is studied.
Paper B	How do the roles and experiences of procurement intermediaries shape the procurement process of educational technologies in Danish universities?	Denmark. Direct focus on procurement processes in Danish higher education.
Paper C	How do private firms benefit or incur costs from collaborating with Danish universities in the technology services sector?	Denmark. Indirect focus on procurement in Danish higher education. Supplier perspective on procurement processes.
Paper D	How are students perceiving the transition to online learning during the initial lockdown of 2020 in terms of technology use and mental well-being?	Denmark. Indirect focus on procurement in Danish higher education. Student perspectives on consequences of procured technologies.

Table 2: Article research questions

By dissecting the multifaceted nature of technology procurement in education,

this thesis aims to contribute to a more profound understanding of the systemic, procedural, and collaborative dynamics in this domain. It seeks to provide insights not only into the challenges and opportunities encountered, but also into the strategic considerations that underpin successful technology integration in higher education. Through this research, it is the endeavor to offer valuable implications for policymakers, educators, and technology providers, aiming to enhance the synergy between educational goals and technological innovations. The findings and discussions presented herein are intended to inform and enrich the broader discourse on educational technology procurement, both within the Danish context and in the wider global educational arena. To encapsulate this, the thesis draws from four related theoretical themes, namely, innovation system research (IS) in a transnational context, innovation intermediaries, public procurement of innovation (PPI), and collaborative innovation.

Section 2 provides an overview of these theories, and conceptualizes them both in relation to each paper and to the broader research question regarding stakeholders' participation in the procurement of educational technologies in Danish higher education. The specific theoretical themes explored in each paper are linked to the overarching investigation of how large public institutions are managing the incorporation of services from private firms.

In section 3, the empirical context of Denmark and Danish universities is elaborated, situating the research within its specific socio-economic landscape. This section sets the stage for the in-depth examination of the subject across Papers A to D, drawing connections between the specific local conditions and the global phenomenon of technology procurement in higher education.

Methods and approaches are deliberated in section 4, detailing the research strategies and methodologies employed in each paper, while also linking them to the overall research question. This alignment ensures a cohesive understanding of the research design across all four papers.

The findings of each paper are discussed separately and together in section 5, integrating the individual insights from Papers A to D into a comprehensive analysis that directly addresses the research question. This synthesis enables a nuanced understanding of the implications of different stakeholders' involvement in the procurement process.

This section also includes a discussion of suggestions for future research, implications for policy, and final remarks. Here, the conclusions from each paper are consolidated, providing a rounded perspective on the challenges and opportunities in the procurement process in Danish higher education, in line with the research context and question.

The thesis is developed from four articles, attached as appendices after the synopsis, in Paper **??**, Paper **??**, Paper **??**, and Paper **??**. These appendices offer readers the opportunity to delve into each paper's detailed examination of the thesis's theoretical themes and empirical evidence.

2 Theoretical background

In the following sections, the theories applied – and their interconnections – will be elaborated. Section 2.1 provides an introduction to innovation system literature, and contextualizes the setting of the thesis. In section 2.2, the transnational perspective of this thesis is elaborated in the context of innovation systems research. Section 2.3 explains the concept of intermediaries and their roles within different aspects of innovation and procurement processes. Procurement of innovations in the public sector is elaborated in section 2.4, followed by insights on collaborative innovation in section 2.5. The interaction and cohesion of these theories are discussed in section 2.6, followed by a discussion of the theoretical context and contribution of each article in section 2.7.

2.1 Innovation system research

Innovation systems (IS) research is an interdisciplinary field that seeks to understand the factors that influence the innovation process in different sectors and regions (Lundvall, 1992; Nelson, 1993; Bergek et al., 2008; Markard and Truffer, 2008; Castellacci, 2008). It emphasizes the importance of understanding the interactions between various actors within an innovation system. While it is not the only theory to view innovation in systems, the IS research stream provides a well established framework for examining innovation across geographical or sectoral boundaries. IS research has developed through criticisms and convolutions to different research avenues focused on specific levels and aspects of innovation to, for instance – as conceptualized in this thesis – encapsulate transnational innovation dynamics (Markard et al., 2015; Binz and Truffer, 2017; Heiberg and Truffer, 2022). The following section will provide an introduction to central concepts within IS research, and explain its application in this thesis.

Evolutionary perspective in innovation systems

The evolutionary view of technological change is a central concept in IS research, offering insights into the clustering of groups of innovations and the temporal clustering of their economic impact (Dosi, 1982; Nelson and Winter, 1982; Schot and Steinmueller, 2018; Castellacci, 2007; Fagerberg, 2003).
In evolutionary theory, dynamics, process, and transformation are emphasized with learning and knowledge seen as fundamental to economic development. Individuals in society — or agents — act under *bounded rationality*, learning, searching, and experiencing in uncertain and changing environments. These concepts are intrinsic to the organizational or institutional context of educational institutions. Agents possess varying expertise and organization, leading to unique ways of performing tasks, mirroring the diversity of stakeholders involved in the procurement process within Danish higher education (Malerba, 2002; Metcalfe, 1998; Dosi, 1997).

  Three economic processes drive economic change in the evolutionary approach: processes of *variety creation* in technologies, products, firms, and organizations; pro-

cesses of *replication*, generating inertia and continuity; and processes of *selection*, reducing variety. These processes parallel how educational technologies emerge, are adopted, and become standard or discarded within HEIs (Nelson, 1997; Metcalfe, 1998). Localized learning and knowledge generation are vital components, with empirical findings recognizing that users often drive or initiate innovation (Kim, 1999; von Hippel, 1976). This user-centric view resonates within educational settings, where organizational and pedagogical needs spur technological advancements (Mishra et al., 2020; Bond et al., 2018).

The notion of individuals operating under bounded rationality is particularly interesting for educational institutions and technology providers. Institutional decision-makers must act on limited information, relying on localized and institutional knowledge (Hillman, 2022). Their decisions are grounded in existing competencies, organizational structures, and experiences, with the understanding that each institution may have distinct approaches to procurement (Ryberg, 2021).

The evolution of educational technologies intertwines with the users — students, educators, and administrators. The emphasis on users driving innovation aligns with findings suggesting that innovation often springs from feedback loops between research, development, and diffusion (Kline and Rosenberg, 1986; Schot and Steinmueller, 2018). Such loops in the educational context inform future technological developments, shaping pedagogical approaches. However, recent research indicates challenges regarding EdTech development, reflecting a lack of alignment of pedagogical needs and firm interests (Mishra and Koehler, 2006; Zawacki-Richter et al., 2019; Mouasher et al., 2016; Hillman, 2022).

Lastly, the three economic processes – variety creation, replication, and selection – are mirrored in the way educational technologies emerge, are adopted, or phased out. The complex decision-making processes within educational institutions, reflecting these evolutionary processes, provide insights into how large public institutions manage the incorporation of services from private firms.

As such, the evolutionary perspective in innovation systems provides a nuanced framework to explore the procurement process in Danish higher education. By elucidating the interplay between technology, users, institutions, and the broader economic processes, this view facilitates a deep understanding of the challenges and opportunities inherent in the identification, procurement, adoption, and diffusion of educational technologies.

Innovation system components

From this perspective on the rationality of societal agents and innovation processes, IS research has developed with a foundational assumption that innovation systems are usually comprised of *organizations*, their *networks*, and the *institutions* that shape and condition these organizations and interactions (Freeman, 1987; Lundvall, 1988, 1992; Nelson, 1993; Edquist, 1997; Chaminade and Nielsen, 2011). Organizations are understood as "formal structures that are consciously created and have an explicit purpose" (Edquist, 1997, p. 47). These organizations can take the form of various key

actors in an innovation system, such as firms, universities, technological centers, venture capital organizations, and public agencies involved in innovation development. Within this system, these actors partake in both formal and informal interactions, exchanging tacit and explicit knowledge, establishing network linkages, and consequently enabling innovation. The operating modality of these organizations, and the development of these relationships, are framed by institutional conditions. These are defined as a "set of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organizations" (Edquist, 1997, p. 49).

The relationships among these foundational components — organizations, networks, and institutions — not only shape the broad understanding of innovation systems but also serve as a basic lens through which the procurement processes in Danish higher education are examined in this thesis (Chaminade and Nielsen, 2011; Edquist, 1997; Lundvall, 1992). As visualized in fig. 1, and to be further elucidated in Paper A, these components offer a foundational entry point into understanding the specific configurations and dynamics that will be explored in the following sections.
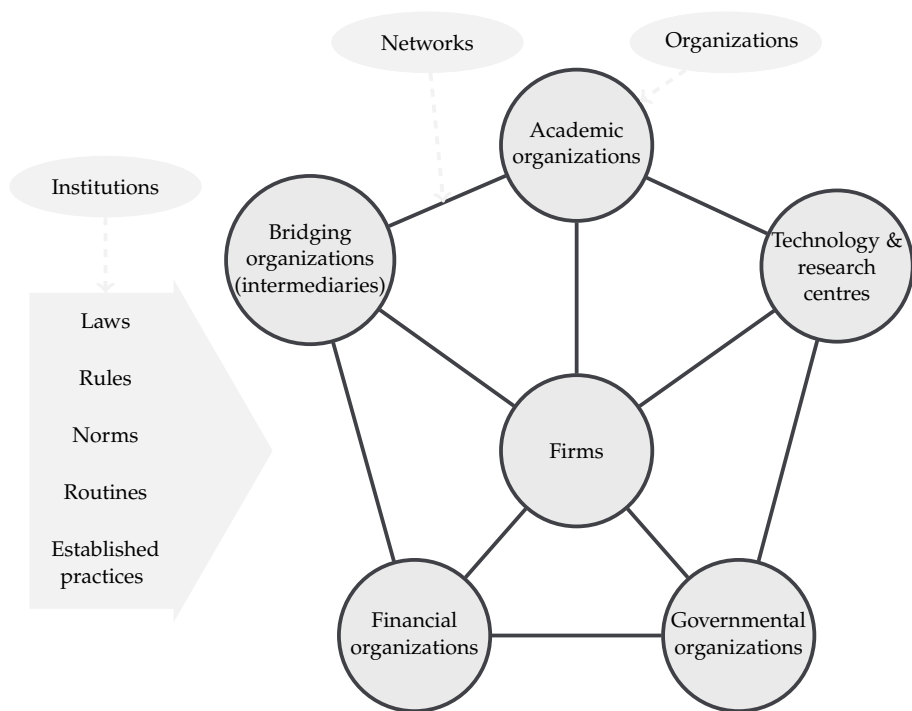

Fig. 1: Innovation system components (Chaminade and Nielsen, 2011; Edquist, 1997)

Configurations and developments of innovation systems

Building on the foundational elements presented above, it is essential to consider the configurations and developments that shape innovation systems at different scales. Research in innovation systems have evolved over time, with scholars adapting and expanding the concept to account for different levels and dimensions of innovation. Initially developed from the pioneering work by Lundvall and others, the focus was primarily on national innovation systems, which considered the innovation dynamics within a country (Freeman, 1988; Lundvall, 1992; Nelson, 1993). However, scholars soon recognized the need for more granular analyses, which has led to the exploration of regional innovation systems, sectoral innovation systems, and technological innovation systems.

Regional innovation systems address innovation processes at a sub-national level, focusing on the interactions and relationships between actors within a specific geographical region (Cooke et al., 1997; Schrempf et al., 2013; Schot and Steinmueller, 2018). For example, the Silicon Valley in the United States is often cited as an epitome of a regional innovation system where a synergy between academic institutions, venture capital, and technology companies drives innovation.

Sectoral innovation systems focus on the innovation processes within specific industrial sectors, irrespective of geographical boundaries (Pavitt, 1984; Malerba, 2002; Schrempf et al., 2013; Castellacci, 2008). For instance, Malerba's work on the pharmaceutical industry, which operates across national boundaries, exemplifies how sectoral innovation systems can be central to understanding the dynamics of specific industries (Malerba, 2002).

Technological innovation systems address the development, diffusion, and utilization of specific technologies. Unlike sectoral innovation systems, which focus on industries, technological innovation systems concentrates on the innovation processes around particular technologies, irrespective of the industry they are in. For example, the development of renewable energy technologies, such as solar or wind power, involves a technological innovation system that includes research and development, knowledge transfer, manufacturing processes, and market adoption, often cutting across various sectors and geographies (Carlsson and Stankiewicz, 1991; Hekkert et al., 2007; Bergek et al., 2008, 2015; Markard and Truffer, 2008).

2.2 Transnational innovation systems

As globalization intensified, innovation processes began to transcend regional or national boundaries. This led to the conceptualization of global and transnational innovation systems, which focus on cross-border interactions and collaborations. transnational innovation systems can be seen as a subsystem within the larger framework of global innovation systems, which encompass worldwide trends, international institutions, universal standards, and global supply chains (Bell and Giuliani, 2007; Binz and Truffer, 2017; Heiberg and Truffer, 2022). For instance, the European Union's Horizon 2020 program is a manifestation of transnational innovation, fostering innovation through transnational collaborations in research and technology development (European Commission, 2020). Studies on global and transnational innovation systems has

been particularly interested in sustainability transitions, but is in generally well suited for studies on innovation processes spanning borders and industries (Binz et al., 2020; Markard, 2018; Köhler et al., 2019).

Innovation systems, characterized by complex interactions between actors possessing complementary competencies within specific institutional settings, serve as the theoretical backbone of this thesis. The interactions between firms, universities, policymakers, and various intermediaries often give rise to positive externalities, which are critical but challenging to produce or control by any single actor, and are key to the innovation process (Lundvall, 1992; Nelson, 1993).

In this thesis, this innovation system conceptualization is used to identify key actors in the diffusion of educational technologies, set within a framework of transnational conditions for innovation of technologies for teaching and learning. The transnational perspective is particularly relevant in the European context due to shared objectives, regulations, and local conditions within the EU that create a unique transnational setting for innovation. In this setting, innovation systems evolve through cross-border interactions and collaborations (Binz and Truffer, 2017; Heiberg and Truffer, 2022).

Research on transnational innovation

Over the years, distinct variants of innovation systems have emerged, as described earlier, each marked by different system boundaries, research objectives, and methodological approaches (Lundvall, 1988; Cooke et al., 1997; Malerba, 2002; Carlsson and Stankiewicz, 1991; Bergek et al., 2008; Coenen et al., 2012; Binz and Truffer, 2017). Transnational innovation research has evolved from a focus primarily on multinational corporations driving global innovation to a more comprehensive view that emphasizes collaborative, network-based models of global and open innovation (Cantwell, 1995; Archibugi and Michie, 1997; Bathelt et al., 2002; Chesbrough, 2003; Coe and Bunnell, 2003; Bell and Giuliani, 2007). Such an approach acknowledges the reality that knowledge and innovation often transcend geographical and organizational boundaries, which aligns with the exploration of the procurement of educational technologies in the Danish higher education landscape.

Within the broad realm of transnational innovation literature, one perspective derives its insights from regional innovation systems, spotlighting innovations that originate in regions encompassing multiple nations (Chaminade and Nielsen, 2011; Coe and Bunnell, 2003; Bell and Giuliani, 2007; Moodysson and Jonsson, 2007). This perspective holds particular importance within the European context, especially given the numerous collaborations and partnerships formed post the inception of the European Union. Regions such as the Öresund (Sweden and Denmark) and the CENTROPE area (Austria, Slovakia, Czech Republic, and Hungary) exemplify such transnational innovation systems (Chaminade and Nielsen, 2011; Lundquist and Winther, 2006; Lundquist and Trippl, 2009).
However, while such regional perspectives contribute valuable knowledge, their inherent focus on defined regional or national borders might inadvertently omit some

activities and dynamics of networks and institutions that function at a supranational level. The challenge in the existing literature lies in achieving a shared understanding of the formation, significance, and varying impacts of these transnational connections across different industries and markets (Moulaert and Sekia, 2003; Coenen et al., 2012; Binz and Truffer, 2017).

Contrastingly, another approach in studies of global and transnational innovation is rooted in technological innovation system research. This perspective offers a different boundary conceptualization for innovation systems and identifies different dimensions for analysis. Labelled as "global innovation systems", this line of thought examines the various components that determine these systems' structure and function (Binz and Truffer, 2017; Heiberg and Truffer, 2022).

Aligning with the aim to understand the procurement process challenges for teaching and learning technologies within Danish higher education, the perspective from technological innovation systems seems particularly apt. The procurement of educational technologies, though global in nature, is uniquely influenced by specific local conditions. In this vein, Denmark's position within the European Union provides an additional layer of complexity. EU regulations and directives, especially those related to procurement, data protection, and technological standards, often create a broader transnational boundary that directly and indirectly affects local procurement decisions in Danish HEIs. These EU-driven parameters not only set the stage for which technologies can be considered, but also influence how Danish institutions navigate their procurement processes. This intertwining of local practices with EU-wide directives underlines the significance of a transnational innovation system perspective. Such a framework bridges the gap between global dynamics and local realities, encapsulating the complexity of the procurement landscape. As such, the term "transnational innovation system" is used in the thesis to signify this conceptualization of innovation. In Paper A, the development of a European alliance for EdTech development among multiple countries and entities, provides the empirical and contextual setting for exploring the role of intermediaries as actors in transnational innovation system development.

Components in transnational innovation systems

Similar to other IS research, actors within these transnational innovation systems encompass firms, research organizations, government departments, NGOs, and various intermediaries. These entities are seen not as isolated units but as integral parts of a broader network. Such a holistic view is essential for unraveling the complex stakeholder relationships within the educational technology procurement process in Danish institutions. This understanding is pivotal not just for multinational corporations, but is also insightful for other entities like research bodies and multilateral regulatory organizations (Binz and Truffer, 2017).

The complexity of transnational innovation systems also lies in the networks that actors form. These networks are not confined to regional, national, or international scales, but often blur these boundaries. They may involve various forms of governance, ranging from market exchanges to fully integrated hierarchies, and can span

geographical and non-geographical proximities. These trans- and international networks can take multiple forms, from formal organizations to loosely-coupled virtual and epistemic communities (Maskell et al., 2006; Coe and Bunnell, 2003; Gereffi et al., 2005; Crevoisier and Jeannerat, 2009; Musiolik et al., 2012; Binz and Truffer, 2017).

Institutions, both formal and informal, are – as in other IS constellations – an essential component of transnational innovation systems. They provide the regulatory framework within which these systems operate and include international policy regimes, treaties, and technology transfer mechanisms that set the boundary conditions for innovation processes. Because of Denmark's position as an embedded member, the EU provides an obvious boundary for innovation and procurement of educational technologies in Danish universities.

Specific institutions, like intellectual property rights (IPRs), procurement regulations, and digital privacy rights, play a significant role in the functioning of innovation activities at the transnational EU level and, consequently, at the local Danish level. Cognitive and normative institutions can develop validity beyond specific territorial contexts, influencing technological paradigms, professional cultures, and dominant rationalities (Gosens et al., 2015; Auerswald and Stefanotti, 2012; Boli and Thomas, 1997; Strang and Meyer, 1993; Binz and Truffer, 2017).

Transnational innovation systems, as conceptualized in this thesis, are thus constituted by multi-scalar actor networks and institutional contexts that either support or hinder the formation and diffusion of an innovation. They can be specific to certain territorial contexts or dependent on actor strategies, networks, and institutional dynamics that co-evolve between different parts of the world. The diverse combinations of organizational actors, networks, and institutions create an almost infinite array of system structures that can lead to similar performance characteristics (Bergek et al., 2008; Edquist, 1997; Binz and Truffer, 2017).

As such, analysis of transnational innovation systems incorporate the actors, networks, and institutional contexts involved in the creation and diffusion of innovation. Studies in this field seeks to understand the processes and mechanisms that stimulate, foster, and maintain global and transnational innovation processes.

System resources and structural coupling

A key focus within this approach is the formation and utilization of *system resources* within *subsystems* (Binz and Truffer, 2017; Heiberg and Truffer, 2022). These subsystems represent the networks and institutions involved in the generation of resources essential to the innovation process. The different aspects of system level resources are further discussed in Paper A. Subsystem boundaries are not strictly delineated by geographic territories; they often extend and overlap, transcending regional and national borders. For instance, legitimacy for an agricultural product sourced through fair trade could be a subsystem constructed among global NGOs, a transnational company, and farming collectives in various countries. These subsystems could be temporary, emerging at international conferences, trade fairs, or within dispersed communities of practice, such as the open-source software field (Binz et al., 2014, 2016; Ernst, 2002; Coenen et al., 2012; Bell and Giuliani, 2007; Lakhani and von Hippel, 2004).

Another crucial aspect of transnational innovation system research is *structural coupling*: the integration and interaction between different subsystems. This is where the foundational elements of an innovation system – organizations, networks, and institutions – come into play. For example, a multinational firm might couple knowledge resources from one region with market segments in another. Institutional couplings could be shaped by globally shared technology standards emerging from professional cultures, which enable economies of scale to be reaped in different markets. Network couplings often occur in international conferences, trade fairs, or in ongoing collaborative endeavors (as explored in Paper A) where information from different subsystems gets exchanged and recombined (Maskell et al., 2006; Binz et al., 2014; Sengers and Raven, 2015).

A transnational innovation system is characterized by multipolarity, fluidity, and contestation. The formation of system resources is asymmetrical; key resources may not be homogeneously available in a given region or within a single organization. Instead, strategic alliances and non-geographic proximities become important in accessing a full portfolio of resources. Concentrations of innovative activity often develop in hubs where actors from different subsystems interact, and these hubs can be physical locations, temporary events like conferences, or virtual spaces facilitated by global or transnational actors (Binz et al., 2016; Boschma, 2005; Bathelt et al., 2002; Larner and Laurie, 2010; Maskell et al., 2006).

In this multi-scalar approach to innovation systems, performance and development hinges on more than just the quality of resource formation within each subsystem. It equally depends on the ability of key actors to couple these dispersed activities into a coherent innovation trajectory at a global or transnational level. Hence, the system will perform well if different subsystems are well established, interconnected, and capable of mobilizing and recombining system resources for the development and diffusion of innovation (Binz and Truffer, 2017).

Technology for teaching and learning in a transnational perspective

In the multifaceted innovation systems surrounding technologies for teaching and learning, intermediaries often serve as essential drivers for innovation and development (Stewart and Hyysalo, 2008; Kivimaa et al., 2019a). These entities are capable of bridging gaps between various organizational actors, like firms, research institutions, and policymakers, operating across national borders. Their roles involve translating knowledge and aligning interests among these heterogeneous actors. In fact, the successful functioning of global or transnational innovation systems often depends on these intermediaries' ability to facilitate effective interactions and collaborations.

Paper A specifically delves into this topic by exploring how intermediaries contribute to the construction of the European EdTech innovation system. The study exemplifies how an intermediary, such as the European EdTech Alliance, aids in the establishment of common standards and guidelines for EdTech adoption and implementation. These standards facilitate the harmonization of practices across nations, making tech transfer and adaptation smoother in varied educational contexts.

While Paper A uses innovation systems as a theoretical backdrop, Papers B, C, and D delve further into the role of stakeholders from different perspectives, all centered around the procurement of technologies for teaching and learning in Danish higher education.

Paper B focuses on the procurement process itself, examining how the roles and experiences of process intermediaries shape this process within Danish universities. Paper C takes a supplier perspective, investigating how private firms benefit or incur costs from collaborating with Danish universities in the technology services sector. Lastly, Paper D offers a view on the consequences of procured technologies, exploring students' perceptions of the transition to online learning during the initial 2020 lockdown, especially in terms of technology use and mental well-being.

Given the critical role of intermediaries revealed in these studies, a comprehensive understanding of these entities within research is vital. This calls for an extensive review of the literature on intermediaries, elucidating their multifaceted roles within innovation systems and paving the way for a deeper examination of their involvement in the procurement process of educational technologies.

2.3 Intermediaries in research

In studies on innovation processes, intermediaries, also known as brokers, boundary spanners, or third parties, are entities that operate between or within organizations, fostering connections, and facilitating exchanges in various contexts (Bessant and Rush, 1995; Howells, 2006; Stewart and Hyysalo, 2008). In the sphere of innovation systems, they link disparate actors, enabling the flow of knowledge, resources, and technology, which amplifies innovative capabilities and strengthens the system as a whole (Stewart and Hyysalo, 2008; Howells, 2006; van Lente et al., 2003; Klerkx and Leeuwis, 2009; Watkins et al., 2015; Kanda et al., 2020; Lukkarinen et al., 2018).

These intermediaries may fulfill a range of roles, depending on the nature of the context and the specific needs of the actors involved. These roles include information brokers, bridging organizations, coordinators across geographical and institutional boundaries, and managers of intellectual property rights (Howells, 2006; Klerkx and Leeuwis, 2009; Kivimaa et al., 2019b). They bridge the 'valley of death' (Markham et al., 2010, p. 1), the gap between technology development and market adoption. The efficacy of intermediaries in these roles is influenced by various factors such as their credibility, legitimacy, access to networks and resources, and the governance the system in which they participate (Howells, 2006; Kivimaa et al., 2019a).

In the context of educational technology procurement in Danish higher education, intermediaries' contributions are multifaceted, from the management of procurement processes (Paper B) to the establishment and legitimization of a broader innovation system (Paper A). Their diversity of roles depends largely on the context. To delve deeper into this context-specific exploration, this thesis will concentrate on two intermediary roles that are central to this research: *systemic* and *process* intermediaries.

Intermediary typologies

In research on innovation, intermediaries have been studied in many contexts and settings, particularly within the context of large-scale and systemic change processes. A typology of intermediaries, as outlined in the work on sustainability transitions by Kivimaa et al. (2019a), provides a useful conceptualization for this thesis in the investigation of procurement of educational technologies in Danish higher education. The transition to educational technologies within HEIs represents a significant shift, encompassing changes in teaching practices, infrastructural upgrades, and behavioral modifications among educators and students. This transition is similar to those in sustainability transitions explored by Kivimaa et al. (2019a), where intermediaries play crucial roles in facilitating change. The typology delineates five intermediary types, each with a role in the transition landscape. The five intermediary types, along with HEI-specific examples, are detailed in table 3.

Type	Description	HEI example
Systemic intermediary	Operating on all levels (niche, regime, landscape), promoting an explicit transition agenda and taking the lead in aiming for change on the whole system level.	Act as facilitators of change across the education system, establishing connections among stakeholders and influencing policy to foster the widespread adoption of educational technologies.
Regime-based transition intermediary	Tied through, for example, institutional arrangements or interests to the prevailing sociotechnical regime but has a specific mandate or goal to promote transition and, thus, interacts (often) with a range of niches or the whole system.	Accreditation bodies ensuring digital competencies align with educational standards.
Niche intermediary	Typically working to experiment and advance activities of a particular niche, and trying to influence the prevailing sociotechnical system for that niche's benefit.	EdTech incubators at universities, with specific focus on advancements in areas like AI for learning, bridging the gap between research and practical application.
Process intermediary	Facilitates a change process or a niche project rather than broader niche (or IS) level; often without explicit individual agency or agenda, but in support of context-specific (project-based or spatially located) and/or external (niche, regime) priorities set by other actors.	Serve as catalysts for specific technology projects, guiding institutions through the adoption process and ensuring alignment with educational objectives and local contexts.
User intermediary	Translating new niche technologies to users and user preferences to developers and regime actors, qualifying the value of technology offers available.	Educators or related organizations translating technology capabilities into classroom applications, providing feedback to institution/developers.

Table 3: Intermediary typology - based on (Kivimaa et al., 2019a)

While the typology is expansive, this thesis chooses to focus on *systemic* and *process* intermediaries due to their direct relevance to the core research question concern-

ing the procurement process of educational technologies in Danish higher education. This focused approach is strategic, not implying that these types of intermediaries are more significant, but rather more pertinent to the scope of this research. Systemic intermediaries are instrumental from the perspective of innovation systems, as they embody the larger-scale transformation and development of educational innovation. Process intermediaries are integral to the specific procurement activities within HEIs, crucial for a granular understanding of the actual procurement and implementation challenges. Hence, their roles are emphasized to address the research question effectively and to provide an in-depth examination of the procurement process and its implications within the Danish higher education system. Despite being developed for sustainability transition research, the typology of intermediaries helps this thesis to conceptualize the different roles intermediaries can play in the procurement and diffusion of EdTech. The following section will elaborate on the theoretical conceptualization of systemic and process intermediaries, and relate it to the practical use throughout the thesis.

Systemic and process intermediaries

Systemic intermediaries take on the mantle of fostering innovation system-wide. They play a strategic role in supporting this transition, enabling the integration of educational technologies by championing change across the entire educational system, connecting diverse stakeholders, and influencing policy and decision-making. Their work aids in establishing educational technology systems, managing stakeholder expectations, and advocating for systemic adoption of novel educational and pedagogical practices. In this thesis, Paper A explores how systemic intermediaries contribute to the diffusion and legitimization of technologies for teaching and learning (van Lente et al., 2003; Klerkx and Leeuwis, 2009; Kivimaa et al., 2019a; Watkins et al., 2015).
Process intermediaries, conversely, operate at the tactical level, ensuring the seamless execution of procurement processes within institutions. Their role is essential for navigating bureaucratic procedures, ensuring compliance with procurement policies, and managing relationships with technology suppliers. These intermediaries facilitate the efficient acquisition and integration of educational technologies, thereby directly contributing to the practical aspects of the transition (Kivimaa et al., 2019a; Edler and Fagerberg, 2017; Tokumaru, 2022; Stewart and Hyysalo, 2008; Kivimaa et al., 2019b). In Papers B and C, It is explored how process intermediaries facilitate procurement processes within Danish HEIs.

It should be mentioned that, within the distinctions of transition intermediaries, presented by Kivimaa et al. (2019a), the lines can be blurred for the specific actors taking on the role of intermediaries across the innovation system. While these perspectives could be further scrutinized, the use of this distinction in this thesis, provides an understanding of two specific types of intermediaries, that are considered central for innovation system development and procurement processes for educational technologies. At a broader level, the system intermediaries explored in Paper A, works to legitimize and spread information and awareness of EdTech development, whereas the process intermediaries studied in Paper B and C are actors positioned within educational institutions, working to ensure innovation and diffusion of novel technologies

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for teaching and learning.

Differentiating between these two types of intermediaries enhances our understanding of their distinct roles within innovation systems. Throughout this thesis, the terms "systemic intermediaries" and "process intermediaries" will be used to delineate these functions and discuss the context and findings of the associated papers.

The development of innovation systems relies on the interaction and contributions of various stakeholders. Both systemic and process intermediaries play essential roles in this context, from the legitimization and diffusion of technology (Paper A) to facilitating collaborations and managing procurement processes (Papers B and C). In Paper B, specifically, the role of process intermediaries is explored through a lens of public procurement of innovation to provide a nuanced understanding of the ways HEIs manage the incorporation of services from private firms.

2.4 Public procurement of innovation

Public procurement of innovation (PPI) refers to the process by which public organizations, such as government agencies or large public institutions like universities, acquire goods and services from external providers. This process can involve a variety of actors and stakeholders, including suppliers, intermediaries, and government officials, and can have a significant impact on the development and diffusion of new technologies (Edler and Uyarra, 2013; Rolfstam et al., 2011; Yeow et al., 2013; Demircioglu and Vivona, 2021; Aschhoff and Sofka, 2009; Lember et al., 2014).

The existing literature delves deeply into the various challenges faced by buying organizations during the PPI process. Several factors, both internal and external to these organizations, have been identified as critical to the successful procurement and adoption of innovations in the public sector. Some of the major challenges include understanding market opportunities and what it could potentially offer, comprehending the organization's needs and the possible improvements through innovation, establishing incentive structures that balance risks and rewards, and implementing organizational changes necessary for the introduction and use of the innovation (Edler and Uyarra, 2013; Uyarra, 2013; Rolfstam et al., 2011).

A central challenge in PPI is the interaction with suppliers. A previous survey, Uyarra et al. (2014), has shown that early interaction with the procuring organization is of paramount importance for encouraging PPI. Yet, many suppliers indicate a lack of such interactions, often emphasizing the challenges of dealing with public bodies that focus heavily on price or exhibit a limited understanding of the market. Additionally, internal fragmentation within buying organizations often complicates procurement processes. There's a notable absence of coordination between different actors involved, such as those responsible for the technical purchase, commissioning, service delivery, and actual use of procured solutions. This differentiation can further be intensified by "silo-budgeting" (Edler and Yeow, 2016, p. 418), emphasizing the misalignment between budgetary responsibilities and the locus of product benefits (Uyarra, 2013; Uyarra et al., 2014; Edler and Yeow, 2016).

Moreover, the level of organizational adaptation required by the buying organi-

zation when introducing an innovation can vary based on how disruptive the inno-vation is. More disruptive innovations often demand substantial changes, including new processes, routines, and significant internal coordination (Uyarra and Flanagan, 2009).

Lastly, public organizations may either respond to existing market innovations or trig-ger the development of entirely new solutions. Responsive procurement, driven by innovations present in the market, emphasizes assessing the business case for an in-novative solution and its added value. On the other hand, triggering an innovation necessitates clearly expressing future needs, stimulating market interest, and poten-tially co-producing the solution with suppliers (Allman et al., 2011; Miles et al., 2009; Prandelli et al., 2008; Von Hippel, 1986; Edler and Yeow, 2016).

Procedural dimensions of procurement policy

Public procurement, however, is not merely the act of buying goods, services, or works. Beyond the transactional layer of the acquisition, it embodies a strategic di-mension, manifesting as a sequence of processes that can function as a potent tool for policy execution and innovation. This strategic dimension is captured under the umbrella of *procedural* PPI (Demircioglu and Vivona, 2021; Edler and Yeow, 2016; Tokumaru, 2022).

At its core, procedural PPI refers to the sequence of operations, rules, guidelines, and methodologies that public entities utilize to cultivate innovation in their procure-ment processes. Contrasting with *substantive* PPI, which orbits around the tangible products or results of a purchase, *procedural* PPI places an emphasis on the "how" of procurement. This encompasses tender formulation, supplier engagement and selection, and contract management (Howlett, 2017; Demircioglu and Vivona, 2021; Howlett et al., 2018).

As articulated by the OECD (2023b), procurement is more than just an operational act of purchasing. It is a multifaceted administrative process comprising stages such as the conceptualization of public needs, design of the procurement contract, call for tenders, contract awarding, the procurement itself, and post-procurement evaluation (Demircioglu and Vivona, 2021; Lember et al., 2014; Osei-Tutu et al., 2014). These stages represent procedural aspects which, if optimized, can significantly impact the broader goals of innovation.

Starting from the 2000s, public managers began recognizing the strategic and sys-temic potential of procurement beyond the mere act of purchasing (Thai, 2001). Espe-cially in the European context, the European Commission has propagated the use of procurement not only to achieve economic goals but also to foster a more innovative, energy-efficient, and socially inclusive economy. This strategic shift in perspective has been towards viewing procurement as an explicit policy tool, emphasizing aims that might be secondary to the primary aim of procurement (Lember et al., 2014; Rolfstam and Petersen, 2014; Kattel and Mazzucato, 2018).

However, a noteworthy distinction between substantive and procedural policy tools emerges from the current literature. While substantive tools deal with policy mecha-nisms affecting production, consumption, and distribution in society, procedural tools

are more concerned with altering the machinery of a government's own functioning (Howlett, 2017; Howlett et al., 2018; Demircioglu and Vivona, 2021; Bali et al., 2021; Bali and Halpin, 2021). Research and insights on procedural policy tools, particularly in procurement, have garnered increasing attention from scholars as their significance in fostering innovation and enhancing government efficacy becomes more recognized (Edler and Yeow, 2016).

The main function of public procurement might be "substantive", i.e., purchasing goods and services affecting societal production, but procurement encompasses far more. A significant part of public buyer activities is procedural, aimed at refining internal stages of the procurement process. In the European context, for instance, there is a push towards improved and innovative procurement practices (Edquist and Zabala-Iturriagagoitia, 2012; OECD, 2023b; European Commission, 2021c,b).

Furthermore, innovation does not just originate from the private sector; public procurement can act as a demand-side tool. By harnessing its market-dominant purchasing power, governments can acquire off-the-shelf services and products that induce innovation (Demircioglu and Vivona, 2021; Edquist and Zabala-Iturriagagoitia, 2012; Edler and Yeow, 2016; Tokumaru, 2022). Most research on procurement has predominantly viewed it as a substantive tool, with the focus mainly on societal improvement via strategic purchases.

However, a perspective that's slowly gaining ground recognizes the potential of procurement as a procedural tool. This perspective underscores that public procurement not only can alter the exterior of an organization, such as by making private firms competitive, but can also influence the organization's inner workings. This shift focuses on how public-private interactions through procurement can foster interactive learning, knowledge generation, and consequently spur innovation within public organizations, and how procurement tools can be harnessed to kindle and assimilate innovations within public organizations (Howlett, 2017; Edler and Yeow, 2016; Demircioglu and Vivona, 2021).

In sum, PPI is more than transactional in nature, offering an avenue for collaboration, co-creation, and strategic policy implementation. By actively engaging diverse stakeholders in the procurement process, public institutions can pave the way for a culture of supportive development benefiting both supply and demand side in public procurement. The theoretical frameworks in this thesis delve into the multifaceted nature of public-private interactions during the procurement and development of innovations and services, with particular attention to the pivotal role of intermediaries. EdTech procurement in HEIs involves a complex web, where stakeholders and intermediaries, each with diverse agendas and perspectives, navigate to contribute to the surrounding innovation system at different levels. The challenge of establishing successful innovation lies in effectively aligning the goals and ambitions of these varied stakeholders. These interactions are explored in Paper B by focusing on process intermediaries involved in procedural PPI within a buying organization. In Paper C, the same context is explored from the perspective of private providers supplying technology for teaching and learning in Danish higher education. Further, Paper C employs a theoretical lens of collaborative innovation to explore the perceived costs

and benefits of supplying technology for teaching and learning to Danish HEIs.

2.5   Collaborative innovation in public procurement

Collaborative innovation emerges as a promising avenue for tackling public sector challenges and is central to the modernization of procurement processes. It entails the synergetic development and implementation of new products, services, or processes through partnerships among various organizations, including firms, universities, and government agencies (Sørensen and Torfing, 2011; Torfing, 2019; Hartley et al., 2013; Vivona et al., 2022). Collaborative innovation is characterized by the pooling of expertise and resources, aligning interests, and fostering an environment conducive to the co-creation of solutions tailored to address specific societal challenges.

Given the increasing demands of citizens and the quest to address wicked and unruly problems, the public sector is constantly in search of innovative solutions. The public sector's unique features, including the absence of competition and profit motives, differentiate its innovation conditions from those of the private sector (Halvorsen et al., 2005). Amid these conditions, hierarchical, competitive, and collaborative strategies emerge as potential routes for enhancing public innovation (Halvorsen et al., 2005; Roberts, 2000; Torfing, 2019).

Hierarchical strategies empower a select group of decision-makers to define problems and design solutions. Their strength lies in mobilizing existing knowledge and organizational resources swiftly. However, these strategies often fall short as they tend to rely too much on internal ideas and resources, missing out on the benefits of external knowledge sharing and mutual learning.
On the other hand, *competitive* innovation strategies engage numerous stakeholders in a zero-sum game. While competition can spur innovative solution searches, it often results in the wastage of resources in conflicts and redundant efforts. Moreover, knowledge sharing in competitive markets is hindered by intense rivalry (Teece, 1992; Roberts, 2000).
Contrastingly, *collaborative* strategies enable the exchange of knowledge, competencies, and ideas, stimulating mutual learning. This not only enhances problem understanding and solution creativity but also facilitates prototype testing, risk sharing, resource mobilization, and innovative idea diffusion (Sørensen and Torfing, 2011; Hartley et al., 2013; Torfing et al., 2019; Torfing, 2019). Collaborative innovation, therefore, engages diverse actors, from politicians to service users, in processes of creative problem-solving. This engagement disturbs established practices, inducing transformative learning, while building joint solution ownership. Such strategies considerably outperform hierarchical and competitive counterparts by exploiting the creative potential of sustained external actor dialogues.

Paper C delves into the challenges and opportunities of collaborative innovation within the domain of educational technology procurement in Danish HEIs. In these environments, the co-creation process between private firms and public institutions can be seen as not just a methodological choice, but a strategic necessity (Lamprini

and Brochler, 2018; Hillman, 2022; Morrison et al., 2015). It bridges the gap between technology developers and the actualized educational needs, ensuring that the digital tools and platforms are not only technologically advanced but pedagogically sound and aligned with educational objectives (as seen, for instance, with the company Edu-Flow in Paper C).

The synergy between diverse stakeholders — ranging from tech entrepreneurs and academic researchers to educators and policymakers — serves a dual purpose. Firstly, it engenders technologies that are inherently more attuned to the multifaceted nature of educational environments. Secondly, it fosters a shared sense of ownership and responsibility, crucial for the successful adoption and sustained use of innovative technologies in educational settings.

Moreover, in the Danish context, where mission-driven innovation policies underscore the pursuit of societal objectives, collaborative innovation is particularly pertinent. It allows for a concerted effort to meet educational goals that are increasingly intertwined with national development agendas. Such a focus on collaborative innovation aligns well with Denmark's policy environment, which encourages partnerships and collective problem-solving as catalysts for societal progress (Mazzucato, 2013, 2018; Torfing, 2019).

By centering on collaborative innovation, Article C highlights how such approaches in EdTech procurement can lead to more resilient and adaptive educational systems, better equipped to meet the challenges of the 21st century. Yet, alongside these promising prospects, collaborative innovation also entails an array of complexities and trade-offs that must be carefully managed (Vivona et al., 2022; Bommert, 2010).

Costs of collaborative innovation

Collaborative innovation, while bringing about numerous advantages, is not without its challenges. Such collaborations afford private firms unique insights and a chance to establish a reputation. However, they are also fraught with costs, including resource allocation for customization, time investments, and alignment of objectives. Paper C emphasizes the need for private firms to manage these costs strategically to ensure the success and sustainability of collaborations.

More specifically, Connelly et al. (2014) argue that the costs of collaboration – in terms of time, money, and effort – can sometimes outweigh its benefits. Worryingly, more than 50 percent of collaborative efforts do not yield the expected results (Gulati et al., 2012). This highlights a critical question: is it beneficial for organizations to innovate through specific cross-sectoral arrangements? Given the uncertain nature of innovation, it becomes challenging for organizations to assess the complete cost-benefit picture. This assessment is made more complex by three core reasons (Vivona et al., 2022; Bommert, 2010; Buehler et al., 2005; Gazley, 2008):

1. *Value attribution to collaboration*: There's a growing perception of collaboration as an inherent value (Sørensen and Torfing, 2011; Torfing, 2019; Voorberg et al., 2015). Often, collaboration is pursued not just as a means but as an end in itself. Although rooted in the uncertainties of innovation, the decision to col-

laborate should be based on pragmatic considerations rather than ideological ones (Bommert, 2010).

2. *Presumptive superiority of collaboration*: The prevailing notion is that collaboration naturally supersedes other methods in achieving strategic objectives. Such an assumption, however, is flawed as it overlooks the cognitive biases of actors, leading to possible underestimations of known costs. Collaboration could exacerbate fallacies in planning and result in over-optimistic project timelines (Buehler et al., 2005).

3. *Inevitability of collaboration*: Collaboration is often seen as the sole answer to complex innovation challenges (Edmondson, 2016; Head, 2019). Yet, innovation challenges can vary in complexity, and collaboration is a broad term encompassing a spectrum of arrangements, from formal to informal, and hierarchical to non-hierarchical (Gazley, 2008). Viewing collaboration as inevitable might limit the consideration of alternative solutions.

User innovation theory, introduced in Paper C, adds another dimension. It posits that while engaging with lead users (educational institutions in this context) can birth new innovations, it's vital to strike a balance between customization and scalability. This necessitates strong relational ties and perpetual adaptation (Von Hippel, 1986; von Hippel, 2005; Hienerth and Lettl, 2011).

Limitations of collaborative innovation in practice

While collaborative innovation theories paints an optimistic picture of synergy and mutual benefit, the reality in the context of EdTech procurement often falls short of these ideals (Luckin, 2015; Vivona et al., 2022; Hillman, 2022; Facer and Selwyn, 2021; Ryberg, 2021). This discrepancy becomes apparent when examining the interaction dynamics between universities (users) and EdTech companies (producers) in the Danish higher education sector.

1. *Asymmetric power dynamics*: Universities and EdTech companies often operate on different levels of power and influence. This imbalance can lead to a situation where the voice of one party, typically the universities, is less influential in driving the innovation process.

2. *Divergent goals and perspectives*: While universities are primarily focused on educational outcomes and pedagogical effectiveness, EdTech companies may prioritize technological innovation and market competitiveness. These divergent goals can lead to a misalignment in the collaborative process.

3. *Resource constraints*: True co-creation demands significant investment in terms of time, manpower, and financial resources. Both universities and companies may face constraints that limit their ability to engage deeply in the collaborative process.

As seen in both Paper B and C, even when insights and feedback are exchanged between universities and EdTech companies, implementing these into actionable innovation can be challenging. The process of translating educational needs and pedagogical insights into technological solutions is complex and often fraught with misunderstandings and misinterpretations (Luckin, 2015; Hollands and Escueta, 2017;

Ryberg, 2021; Williamson, 2021). Additionally, the fast-paced nature of technological development can outpace the slower, more deliberate pace of academic institutions, leading to a disconnect in expectations and outcomes.

In many cases, the collaboration is limited to specific projects or phases of development, rather than being a sustained, ongoing process (seen in Paper B and C). This episodic nature of collaboration hinders the development of a deep, continuous understanding of each other's needs and capabilities. As a result, the potential benefits of collaborative innovation are not fully realized.

The involvement of intermediaries can significantly enhance the effectiveness of the collaborative innovation process. For instance, process intermediaries can help ensure that the insights and feedback exchanged across multiple levels within the universities are not only heard but effectively integrated into the innovation process. This integration is critical for ensuring that the technological solutions developed are not only cutting-edge but also pedagogically relevant and practically applicable (Casabayó, 2022; Hollands and Escueta, 2017; Lamprini and Brochler, 2018).

In summation, the theory of collaborative innovation, while conceptually robust, encounters practical limitations. Paper C provides insights to kind of challenges experienced in the realm of EdTech procurement in Danish higher education. Through this thesis, the role of intermediaries emerges as a key factor in bridging these gaps, facilitating a more meaningful and effective collaboration between universities and EdTech companies. Recognizing and leveraging the role of intermediaries can thus be a crucial step in realizing the full potential of collaborative innovation in public sector procurement. This insight ties into the broader themes of transnational innovation systems, public procurement of innovation, and collaborative innovation explored throughout this thesis, highlighting the complex interplay of various stakeholders in shaping the educational technology landscape.

2.6 Theoretical context of articles

In this section, the theoretical frameworks established in section 2.1 to section 2.5 are applied to the articles constituting this thesis. The objectives are twofold: Firstly, to delineate the research gaps each article targets, thereby adding depth to the broader academic dialogue. Secondly, to outline how each article employs its theoretical framework, highlighting their unique contributions to scholarly discussions. The concurrence of theories across the articles and their relationship to the research questions are illustrated in table 4. This section is followed by a discussion and synthesis of the theories in section 2.7.

Paper A: System Building in European EdTech

Paper A sets out to address a significant research gap: the role of intermediaries in the rapidly evolving European EdTech market. While intermediaries are acknowledged for their importance in innovation systems, few studies have explored their role in the context of transnational systems, particularly those centered on education technology

Paper	Title	Main theories
Paper A	System Building in European EdTech: The Role of Intermediaries in Market Formation	Transnational innovation systems and innovation intermediaries
Paper B	Procurement of Innovation in Large Public Institutions: EdTech Procurement in Danish Universities	Public procurement of innovation and innovation intermediaries
Paper C	Why is it so Complicated? A Supplier Perspective on Collaborative Innovation in Large Public Institutions	Collaborative innovation and lead user innovation
Paper D	Going Online: Student Perspectives in a Problem-Based Learning Environment during the Pandemic	Problem-based learning and hybrid/blended learning modalities

Table 4: Summary of theoretical foundations in each paper

(Binz and Truffer, 2017; Heiberg and Truffer, 2022; Gosens et al., 2015).

The central research question of Paper A is: *"How do intermediaries contribute to system building in European EdTech?"*. This paper aims to fill the identified research gap by investigating the factors driving the development and adoption of EdTech in Europe, as well as scrutinizing how intermediaries facilitate innovation and technology adoption across national boundaries.

Paper A introduces a functional approach to study innovation systems, an angle not often emphasized in the existing literature on educational technology. The functional dynamics in innovation systems include a variety of activities and processes crucial for the system's development and prosperity, such as knowledge development, resource mobilization, and market formation (Bergek et al., 2008; Suurs and Hekkert, 2009). By mapping the roles of intermediaries to six specific system functions, the paper provides a nuanced analysis of their roles in system building. This approach not only enriches existing literature on the dynamics of innovation systems but also serves as an initial framework for examining educational technology through an IS lens. It offers insights into how system-level resources, such as information flow and knowledge diffusion, are developed and utilized to foster technological innovation.

Paper B: Public procurement in Danish higher education

Paper B investigates the role of intermediaries in large public institutions, specifically Danish universities, in the procurement of educational technologies. These universities are interesting to study due to their governmental funding and their autonomy in decision-making (Wright, 2012). While the broader role of public procurement in innovation is acknowledged in policy and academia, less attention has been given to *how* it functions in large public institutions (Edler and Yeow, 2016; Tokumaru, 2022). Paper B fills this gap by examining how Danish universities utilize PPI as a procedural policy tool to manage the acquisition of educational technologies. The central research question is: *"How do the roles and experiences of procurement intermediaries shape the procurement process of educational technologies in Danish universities?"*.

Paper B offers a comprehensive exploration into the complexities of public procurement in Danish universities, specifically focusing on PPI as a procedural policy tool. Situated within Denmark's mission-driven innovation policy and the growing focus on sustainability, efficiency, and innovation, the paper dissects PPI not as an end but as a process with multiple stages and actors (Aschhoff and Sofka, 2009; Lember et al., 2007; Rolfstam et al., 2011; Uyarra, 2013, 2010; Obwegeser and Müller, 2018; Rolfstam and Petersen, 2014; Mwesiumo et al., 2021; Uyarra et al., 2014). This nuanced approach extends existing literature by emphasizing the procedural dimensions of PPI in large public institutions, such as the Danish universities.

The article contributes to theory by identifying the crucial role of process intermediaries in shaping and managing procedural aspects of PPI. This fills an existing gap in literature that often focuses solely on end products or organizational structures, and rarely on the mediators enabling these complex transactions (Edler and Yeow, 2016; Tokumaru, 2022). By focusing on how internal process intermediaries facilitate procedural PPI — from need identification to final acquisition — the article provides valuable insights into procurement practices specific to educational technologies within the context of Danish higher education.

Moreover, the article's focus on "innovation" as not just breakthrough technologies but also as solutions that are novel to the specific organizational context adds a layer of complexity to our understanding of innovation in public procurement. This extended viewpoint is particularly relevant in HEIs, where the adoption of novel solutions can have far-reaching implications, both operationally and in alignment with broader mission objectives.

Paper C: Supplier perspective on collaborative innovation

Paper C aims to fill a research gap by shifting focus to the supplier's perspective in the collaborative innovation process, specifically within educational technology procurement in HEIs. This complements Paper B, which looked at the demand side by concentrating on public institutions.

The Danish context offers a compelling backdrop for this investigation. Denmark has been invested in integrating mission-driven innovation policies aimed at solving societal challenges, like education, into public procurement for multiple years by now (Mazzucato, 2013, 2018; Rolfstam et al., 2011; Rolfstam, 2013; Rolfstam and Petersen, 2014; Torfing, 2019; Ketchen et al., 2007; Sørensen and Torfing, 2011). This mission-driven focus, combined with a supportive regulatory environment, creates unique conditions for public-private partnerships. Such conditions are instrumental in shaping how private firms engage with public institutions, especially in the sector of educational technology.

Despite the emphasis on mission-driven innovation and public-private collaboration in policy and academia, there's a noticeable gap in research on how these collaborations affect the private sector (Vivona et al., 2022; Demircioglu and Audretsch, 2020). Paper C tackles this gap by scrutinizing the challenges, opportunities, and consequences for private EdTech firms in Denmark.

The central research question is: "*How do private firms benefit or incur costs from collaborating with Danish universities in the technology services sector?*" Paper C contributes

to the scholarly discourse by offering an exploration of the supplier's perspective on collaborative innovation. The focus on the Danish case allows for the exploration of how mission-driven policies and a particular national context can influence the dynamics of public-private collaborations.

The theoretical foundation lies in collaborative innovation, examining the modalities of interaction between private and public entities (Torfing, 2019; Rolfstam and Petersen, 2014; Vivona et al., 2022; Kobarg et al., 2019; Denicolai et al., 2016). It also draws on user innovation theory to shed light on how engagement with lead users, particularly within educational institutions, can serve as both a catalyst and a barrier in the innovation process (von Hippel, 2005; Hienerth and Lettl, 2011; Gram et al., 2013; Audretsch and Belitski, 2020; Gulati et al., 2012; Connelly et al., 2014).

By focusing on the specificity of the Danish context, Paper C not only contributes empirically, but also enriches the theoretical frameworks of collaborative innovation and public procurement. It offers insights into how such collaborations can be optimized for mutual benefit and provides a deeper understanding of how policy and national context can influence the dynamics of collaborative innovation.

Paper D: Student perspectives on technology use during COVID-19

Paper D, while being primarily an empirical report, complements Papers A, B, and C by providing a ground-level perspective on the implications of technology use in education, and how rapid adaptation in crisis situations can provide insights into the dynamics of collaborative innovation in educational settings. The article explores the impact of technology use on Problem-Based Learning (PBL) environments, specifically during the initial COVID-19 lockdown of 2020 among students at Aalborg University, Denmark. This paper not only focuses on the utilization of technology but also examines the psychological effects on students who were suddenly required to participate in education digitally. This sudden shift underscores the need for innovation through technology to overcome educational challenges, as highlighted in Papers A, B, and C. Moreover, it emphasizes that novel technologies need to be adaptable and sensitive to the specific educational conditions set by individual institutions (Williamson, 2021; Ryberg, 2016, 2021).

Building on insights from studies on blended or flipped learning, Paper D highlights the potential of digital solutions in education but also elucidates the unintended consequences of increased technology use. The research question for Paper D is: "*How are students perceiving the transition to online learning during the initial lockdown of 2020 in terms of technology use and mental well-being?*".

Research on blended, hybrid, and flipped learning environments has experimented with various approaches to integrating technologies in classrooms. These studies have implications for the kinds of collaborations and innovations discussed in Paper C and the manner in which technology is procured and implemented as discussed in Papers A and B.

PBL, central to Paper D, is a pedagogical approach that inherently relies on collaboration and problem-solving, making it particularly relevant to discussions on innovation. In PBL, students engage in self-directed learning in small groups to address

practical problems. In this setup, technology can be an invaluable asset for facilitating collaboration and aiding the learning process, echoing themes from Paper C on collaborative innovation. Additionally, the role of tutors in PBL is to guide rather than to instruct, which is reminiscent of the collaborative efforts where various stakeholders come together to co-create solutions, as explored in Papers B and C. The PBL environment, therefore, serves as an educational exemplar of the kind of collaborative processes that can be vital in navigating the challenges of an increasingly complex and uncertain world, as the COVID-19 pandemic has highlighted.

Under the COVID-19 lockdowns, educational institutions were thrust into a microcosm of the modern world's inherent unpredictability and rapid change. The need for swift adaptation and innovation during the lockdowns mirrored the characteristics of an increasingly volatile and uncertain global environment. In this setting, Paper D provides an important view into the effects and challenges of such rapid innovation and adaptation in response to unforeseen disruptions. The experiences of students at Aalborg University during the initial COVID-19 lockdown, as explored in Paper D, offer practical insights into the outcomes of institutional decisions and collaborations in a time of crisis. The article highlights the importance of resilience, adaptability, and innovation in education, qualities that are vital in today's fast-evolving and uncertain world. By examining the interplay between technology use and psychological well-being among students in a problem-based learning environment during this disruptive period, Paper D underscores the complexity of implementing educational innovation under pressure and illuminates the challenges and opportunities that are likely to arise in an increasingly unpredictable and fast-paced global landscape.

In essence, while Paper D is rooted in an empirical investigation, it serves as a natural extension and practical examination of the themes explored in Papers A, B, and C. It sheds light on the lived experiences of students and the immediate effects of technology integration and innovation in education, enriching the overall understanding of how collaborative innovation and technology procurement can shape educational environments and outcomes.

2.7   Discussion and synthesis

Concluding the exploration of the theoretical underpinnings of the articles, the following section provides a discussion that accentuates the critical role of intermediaries in the fabric of this thesis. This is done to show how these theories are actualized in practical contexts, particularly in the realm of educational technology in Danish higher education. The core research goal of this thesis – to unravel the complexities of the procurement process of educational technologies and its implications – is deeply intertwined with the functioning of intermediaries. They are not peripheral agents but central figures who navigate, influence, and shape EdTech development in the interplay of innovation systems, public procurement processes, and collaborative innovation. The ensuing discussion delves into this, unraveling how intermediaries can act as catalysts, bridging theoretical insights with practical implementations. This focus on intermediaries thus serves as a vital link in connecting the theoretical frame-

works outlined in the preceding sections with the pragmatic realities encountered in the adoption and diffusion of educational technologies, thereby aligning with the overarching research goal of this thesis.

In the confluence of innovation system research and transnational innovation, intermediaries emerge as critical enablers. These entities, adept at transcending geographical and sectoral boundaries, embody the essence of innovation in the context of educational technology. Their facilitation of knowledge transfer and resource mobilization within transnational settings exemplifies the interconnectedness of modern innovation systems. Systemic intermediaries, thus, act as pivotal conduits for cross-border collaborations, ensuring that diverse insights and capabilities are harnessed to foster holistic development in educational technologies.

Within the realm of public procurement, especially in the domain of educational institutions, process intermediaries undertake a significant role. They navigate the complications of conjoining procurement strategies with innovation objectives. This role is particularly salient in ensuring that technological acquisitions are not merely advanced, but are in congruence with the pedagogical imperatives of educational institutions. In doing so, intermediaries transcend the traditional transactional nature of procurement, aligning it with strategic educational and innovation goals.

Collaborative innovation, a cornerstone in the advancement of educational technologies, necessitates a concerted effort from diverse stakeholders, including educational institutions, technology providers, and policymakers. While Paper B demonstrates how process intermediaries are deeply involved in the diffusion of EdTech, Paper B and C both provide insights into the complicated nature of procurement in Danish HEIs, where intermediation on both sides (within both university structure, and within private companies) can serve to mediate strategies, aligning the disparate goals and facilitating communication channels. Through these articles, it is highlighted how intermediaries can help both educational institutions and private companies in developing and diffusing EdTech. With the right institutional structures and strategies for EdTech procurement, process intermediaries can be instrumental in addressing inherent collaborative challenges such as asymmetrical power dynamics and divergent objectives. Their role is crucial in forging environments conducive to mutual benefit and co-creation, involving needs from students, educators, institutions, and companies alike.

The investigation across various papers within this thesis highlights the indispensable role of intermediaries in different contexts and layers of analysis – from system building in the European EdTech market (Paper A) to the nuances of procurement processes in Danish universities (Paper B), and the balancing act in collaborative innovation from a supplier's perspective (Paper C). Intermediaries act as the anchor that effectively integrates these diverse yet interconnected theoretical frameworks. Their multifaceted roles, ranging from bridging agents in innovation systems to facilitators and mediators in procurement and collaborative processes, underscore their strategic importance.

This synthesis of the role of intermediaries across different theoretical frameworks

within the thesis sheds light on the complexity and dynamism inherent in the procurement, development, and implementation of educational technologies. The nuanced understanding of intermediaries' roles offers practical insights for policymakers, educational institutions, and technology providers. Future research could further explore the evolving nature of these intermediary roles, especially in the face of rapidly changing technological landscapes and educational needs. Additionally, the exploration of intermediary efficacy in different cultural and institutional contexts could provide a more global understanding of their impact on educational technology innovation.

In conclusion, intermediaries stand at the forefront of facilitating innovation in the realm of educational technologies. Their strategic positioning and multifunctional roles are crucial in navigating and bridging the theoretical landscapes of innovation systems, public procurement, and collaborative innovation. Recognizing and leveraging the potential of intermediaries can significantly enhance the effectiveness and efficiency of educational technology initiatives, particularly within the framework of Danish higher education. The theoretical exploration of intermediaries in educational technology, as discussed, establishes a foundation for understanding their critical role in the innovation ecosystem. This theoretical grounding paves the way for an empirical examination of how these concepts manifest in the specific context of Danish higher education. The empirical section of this thesis, therefore, shifts focus from the broad theoretical underpinnings to a more concentrated analysis of the practical applications and real-world implications of these theories. By examining the role of intermediaries within Danish universities, this thesis aims to bridge the gap between theoretical constructs and their tangible impacts in the realm of educational technology. The following section delves into the Danish higher education landscape, exploring how the theoretical themes of intermediaries, public procurement of innovation, and collaborative innovation are actualized in the practical setting of Danish universities, thereby offering a nuanced understanding of the interplay between theory and practice in the development and adoption of educational technologies.

3 Empirical context

Denmark and its higher education institutions provide the primary context for this thesis. Paper B, C, and D all use data collected from Danish universities, whereas Paper A conceptualizes transnational development of EdTech in a European context. The transnational context alludes to the understanding that, while national EdTech development is dependent on local structures and incentives, the development is not an isolated incident, but rather a subsystem of a global EdTech phenomenon. This section provides insights into the Danish setting, specifically focusing on universities as large public institutions and their role and position in Danish society.

3.1 The case of Denmark

Denmark is considered one of the most prosperous and egalitarian countries in the world, and also one of the most digitized, with most of its public institutions pro-

viding services in the digital space (OECD, 2023a; The World Bank, 2023). In 2022, Denmark had a population of around 5.9 million residents. Denmark has a large urban population, with most people living around the capital region or one of its other large cities spread across the country (Statistics Denmark, 2023). The Danish economy is export-oriented and knowledge intensive, supporting a strong well-fare state with high tax rates and a large public sector. The biggest industries in Denmark are related to trade and manufacturing, with only a small percentage involved in agriculture and fishing (Statistics Denmark, 2023; Globalis, 2022). However, the services sector has been increasingly important to the Danish economy, with many small- to medium-sized enterprises developing in the space. The growing service sector in Denmark is increasingly being utilized to solve public service challenges to support growth, innovation, and changing conditions (Statistics Denmark, 2023; Globalis, 2022; Mazzucato, 2013; Rolfstam and Petersen, 2014; Sørensen and Torfing, 2011; Torfing, 2019).

In general, the small country of Denmark values a highly skilled workforce, and public investments and incentives usually reflect that. For instance, Denmark has always invested heavily in education, and educational access for its population (Danske Universiteter, 2022; UFM, 2020). Most educational institutions in Denmark are public and free to attend, including its higher education institutions. About 42 percent of the Danish population between ages 25-64 have a higher education, with around 14.7 percent having received a master's degree or higher. In a European context, Denmark is considered average in terms of education levels among its people. Politically, there has been a clear goal that the percentage of people with a higher education should increase in Denmark. In 2011, the government set a target for 2020, where 60 percent of a cohort should complete a higher education, of which 25 percent should complete a long-term higher education (Danske Universiteter, 2022).

3.2 Universities in Denmark

All Danish universities are public institutions, and due to the strong prevalence of university education, coupled with a national interest in education, public investment enables the universities to remain tuition-free. Additionally, the state provides financial support for most students during their studies (OECD, 2021; UFM, 2020). There are currently eight universities spread across Denmark. The oldest, University of Copenhagen, was established in the fifteenth century, while the rest have been established primarily during the twentieth century. Across the Danish universities, around 150,000 students attend an education, with around 33,000 employees and a yearly turnover of more than 30 billion Danish crowns (Danske Universiteter, 2022). Five of the of these universities have their main campuses in the capital region, the rest at some remaining bigger cities in Denmark, Aarhus (AU), Aalborg (AAU), and Odense (SDU). In addition to their main campuses, several of the universities have branch campuses spread across the country, as visualized in fig. 2.

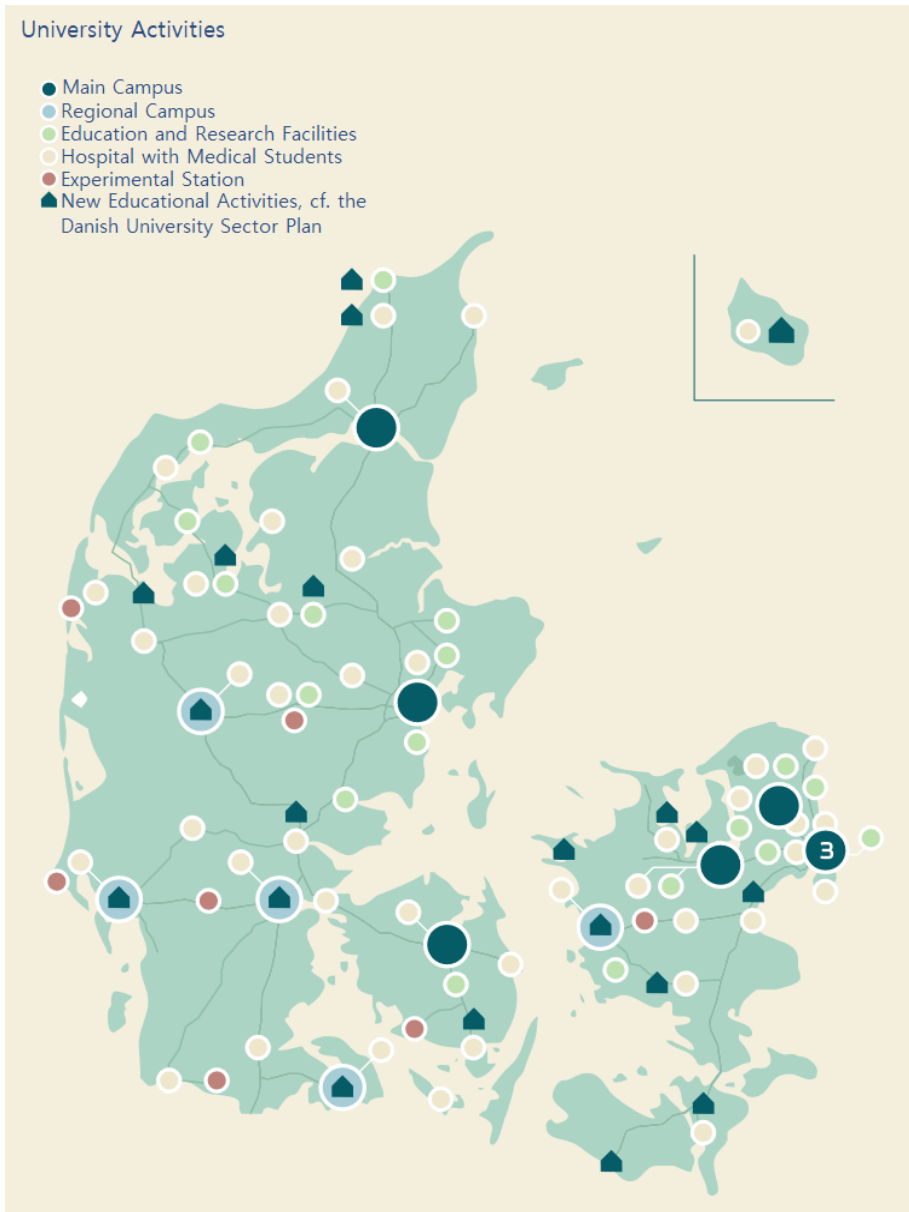**Fig. 2:** Map of university activity in Denmark (Danske Universiteter, 2022)

Among the eight universities, five have a general university profile, covering all main scientific disciplines, Aarhus University (AU) Aalborg University (AAU), University of Copenhagen (KU), University of Southern Denmark (SDU), and University of Roskilde (RUC). The last three, Copenhagen Business School (CBS), Technical Uni-

versity of Denmark (DTU), and the IT University of Copenhagen (ITU) are more specialized towards specific disciplines, for instance Business and IT (Danske Universiteter, 2022). The distribution of students across the eight universities is visualized in table 5.

University	Est.	Humanities	Social Sciences	Health Sciences	Technical Sciences	Natural Sciences	Total
AU	1928	9,243	11,315	4,664	4,253	3,187	32,662
AAU	1974	3,136	6,495	1,460	6,330	2,076	19,497
CBS	1917	150	14,903	0	0	0	15,053
DTU	1829	0	0	0	13,414	0	13,414
ITU	1999	0	0	0	0	2,271	2,271
KU	1479	8,705	10,720	7,847	0	9,625	36,897
RUC	1972	2,577	2,960	179	676	726	7,118
SDU	1966	4,425	6,390	4,698	3,576	2,007	21,096

Table 5: Number of students at Danish universities, 2021 (Danske Universiteter, 2023)

The Danish University Act

The Danish University Act of 2003 governs the organization and operation of universities in Denmark and has been revised several times since its initial enactment in 2003 (Wright, 2012; Danish Government, 2003). It sets out the legal framework for HEIs in Denmark, including the roles and responsibilities of universities, the rights, and obligations of students and staff, and the rules for the awarding of degrees and diplomas. Additionally, the law establishes the criteria for the accreditation and quality assurance of HEIs and programs. The Danish University Act of 2003 grants universities in Denmark a high degree of autonomy and self-governance (Wright, 2012; Carney, 2006). This means that universities are legally independent institutions, with the power to make many of their own decisions without interference from external authorities. Under the Act, each university is governed by a board of directors, which is responsible for the overall management of the institution. The board is composed of members who are appointed by the government, as well as representatives of the academic staff, students, and other groups associated with the university. The board has a high degree of autonomy in decision-making, including the power to determine the institution's strategic direction, allocate resources, and appoint senior managers and faculty members (Carney, 2006).

In addition to the board of directors, each university also has a number of academic councils and committees, which are responsible for overseeing the institution's academic programs and research activities. These bodies are composed of academic staff and students, and have a high degree of autonomy in decision-making related to academic matters. The Danish University Act of 2003 provides universities in Denmark with a great deal of independence and self-governance, which is intended to promote academic freedom, innovation, and excellence in higher education. This autonomy is also viewed as a key factor in maintaining the high standards of education and research that are associated with Danish universities (Danish Government, 2003;

Carney, 2006; Wright, 2012). As large public institutions, the Danish universities have multiple responsibilities relating to, among other things, research, education, and university-industry interactions, as outlined in table 6.

Definition	Description
Providing research-based education	Universities in Denmark are expected to provide education that is based on the latest research in their respective fields. This means that universities are expected to conduct research and produce new knowledge, which can then be integrated into their educational programs.
Promoting innovation and entrepreneurship	Universities are expected to foster innovation and entrepreneurship among their students and staff. This means that universities are encouraged to collaborate with businesses and other organizations to help develop new products and services that can benefit society.
Providing continuing education	In addition to traditional degree programs, universities are also expected to provide continuing education programs that can help people upgrade their skills and knowledge throughout their careers.
Promoting internationalization	Universities in Denmark are encouraged to promote internationalization by collaborating with other institutions around the world, attracting international students and staff, and offering programs that have an international focus.
Contributing to society	Universities are expected to contribute to society in a variety of ways, such as by providing research-based advice to government and other organizations, engaging in community outreach programs, and promoting the development of a more sustainable society.
Quality assurance	Universities are required to establish systems for quality assurance and evaluation of their academic programs, research activities, and overall performance. This includes conducting regular assessments and reviews of the institution's activities, and taking steps to improve areas that need attention.
Student rights and services	The Act sets out a range of requirements related to student rights and services, including access to information, academic support services, and accommodation. Universities are also required to establish procedures for dealing with student complaints and grievances, and to ensure that their services are accessible and inclusive for all students.

Table 6: University responsibilities (Wright, 2012; Carney, 2006; Danish Government, 2003)

Digitalization strategies at Danish universities

Danish universities provide an interesting setting for procurement in large public institutions because, while they are public institutions, they have a large degree of autonomy on how to implement government strategies, as for instance in the case of digitalization. Each university devises and implements their digitalization strategies, that reflect how they approach the use, diffusion, and procurement of digital solutions across the university infrastructure. As such, each university functions as a case with individual approaches, strategies, and considerations, nested in a similar societal context. In developing their digitalization strategies, Danish universities have had to consider a range of factors, including their current technological infrastructure, staff expertise, student needs, and financial resources. The strategies have typically included plans for the use, diffusion, and procurement of digital solutions across the university infrastructure, ranging from learning management systems (LMS') and online assessment tools to virtual classrooms and educational games (Aarhus Universitet, 2021; AAU, 2016; CBS, 2021; Københavns Universitet, 2014; SDU, 2018). These strategies have enabled universities to improve the quality of their education and research, while also enhancing their competitiveness in the global knowledge economy. However, the autonomy of universities in implementing their digitalization strategies has also presented challenges, particularly in terms of coordination and collaboration between universities. Without a coordinated national strategy, there is a risk of duplication of efforts, inefficiencies, and missed opportunities for collaboration and knowledge sharing. The digital infrastructure of universities comprises many tools and solutions in varying sizes, both internally developed and externally sourced. This thesis focuses on the procurement of these tools and solutions in the context of the teaching and learning environment at Danish universities.

4 Methodological considerations

This section outlines the methodology employed in the thesis, grounded in a pragmatic research approach, and is aimed at addressing the research questions of each article. It starts with an exposition on the multi-level analysis framework, setting the stage for a comprehensive methodological exploration. Following this, section 4.1 explores the research approach, elaborating on the inquiry process. Section 4.2 provides an overview of the methods utilized, and section 4.3 discusses the primary data sources. A more thorough investigation of methodologies, including steps for ensuring validity and replicability, are elaborated in the individual papers. The section culminates in section 4.5 and section 4.6 with a discussion on the research limitations and the potential generalizability of the findings.

Analytical levels

The study of procurement processes for educational technologies within Danish higher education can be approached in myriad ways, each with its unique merits. In this thesis, the decision to adopt a multi-level analytical approach stems from a recognition that understanding such a complex system benefits from a panoramic perspective.

This is not to undermine the value of more singular, in-depth explorations; rather, it acknowledges the significance of seeing the forest and the trees.

At the systemic level, educational technologies in higher education exist within an expansive network of increasingly globalized innovation and technology development interactions. Paper A delves into the role of systemic intermediaries, mapping out the nuances of larger innovation systems and their interplay with Danish procurement intricacies.
The organizational level, as explored in Papers B and C, unpacks the operational dynamics of these procurement processes. By exploring the role of process intermediaries in Paper B, and by probing into the actual procurement practices and offering a supplier's lens in Paper C, these articles underscore the practical challenges and strategies that underpin decision-making within institutions.
Shifting focus to the micro-level, Paper D examines student experiences and interactions with the procured technologies, shedding light on the immediate pedagogical and experiential outcomes.

In addressing the central research question, this thesis melds these various analytical layers. This synthesis is rooted in the belief that a well-rounded exploration offers a unique vantage point, allowing the study to interconnect global trends, institutional decision-making, and micro-level perspectives. The approach adopted here provides a coherent yet intricate perspective on the procurement landscape, offering a textured understanding of the innovation system for educational technology in Danish higher education, as an increasingly digitized society and modern innovations, such as generative AI, are challenging the role and composition of educational institutions.

4.1   Research approach

To do this, the thesis applies a pragmatic research approach to explore procurement in HEIs. Pragmatism is a research philosophy that emphasizes practicality, usefulness, and applicability of knowledge (Kelemen and Rumens, 2011; Silverman, 2019). It is rooted in the idea that knowledge is dynamic, ever-changing, and context-dependent, and that the best way to gain knowledge is by actively engaging with the world and testing theories through practical experimentation. Pragmatism is focused on practical problems rather than philosophical, in the sense that, pragmatic research is concerned with solving concurrent and contemporary challenges in society by looking at all aspects of social phenomena that have practical relevance for investigation (Silverman, 2019). There is an inherent "fallibalist" view on science, indicating that all knowledge is temporary, and rather than aiming for knowledge for the sake of knowledge, the aim is to develop practical and useful insights that can be applied temporally in a given context (Silverman, 2019). Pragmatic research is usually considered from the pragmatist maxim stating: "Consider what effects, that might conceivably have practical bearing, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (Peirce, 1878, p. 293). This relates to the social constructivist world-view in pragmatism, also related to the more famous Thomas theorem: "If men define situations as real, they are real in their

consequences" (Thomas and Thomas, 1928, p. 571). Pragmatist research is concerned with solving practical societal challenges, while still recognizing that solutions and challenges might change over time, the most central aspects summarized in table 7. In this positioning, it is assumed that social science research must be guided by the questions of relevance rather than methodological preconceptions (Silverman, 2019; Kelemen and Rumens, 2011).

Definition	Description
Focus on problem-solving	Pragmatic researchers are primarily concerned with solving practical problems and improving the human condition
Plurality of methods	Pragmatists believe that there is no one "right" way to conduct research and that a variety of methods can be used to address a research question
Socially constructed reality	Pragmatists recognize that knowledge is socially constructed and that it is shaped by the social, historical, and cultural context in which it is produced
Value-laden research	Pragmatists acknowledge that research is never neutral and that it is always influenced by the values and interests of the researcher

Table 7: Pragmatist research summarized (Silverman, 2019; Kelemen and Rumens, 2011)

The subsequent application of pragmatism within this thesis bridges the gap between theoretical discourse and real-world practice. It poses questions aimed at deciphering the complexities of EdTech procurement in Danish higher education. For instance, Paper A investigates the market formation of EdTech in Europe, not through conventional metrics like patents, which are often ill-suited to the fast-evolving nature of educational technologies as discussed by Watters (2016), but through the lens of intermediary roles, a topic that has gained prominence in recent innovation system research (Binz and Truffer, 2017; Tziva et al., 2021; van Lente et al., 2003; Musiolik et al., 2020).

Pragmatism in action

Paper A provides a pragmatic lens to the overall development of an EdTech market by posing the question: "How do intermediaries contribute to system building in European EdTech?". This inquiry is grounded in the operational realities of the European EdTech market and seeks to uncover the practical implications of intermediary activities.

The article's primary goal is to identify and map how intermediaries at a system-wide level interact and influence the procurement and deployment opportunities of educational technologies from a transnational perspective. Further, insights gathered aim to inform and refine policymaking and multilateral strategies for identifying and integrating EdTech innovations.

By investigating the specific roles of systemic intermediaries, the research directly engages with the pragmatic mandate to determine *what works* in system building (Silverman, 2019). The outcomes are intended to inform both theory and practice, by

contributing to the scholarly understanding of intermediaries in innovation systems, and by offering insights that could enhance the interaction between technology producers, educational institutions, and users across national boundaries.

Paper B continues the pragmatic exploration by examining the influence of procurement intermediaries in Danish universities, addressing the question: "How do the roles and experiences of procurement intermediaries shape the procurement process of educational technologies?". The study delves into the intricacies of procurement management, enriching the discourse on intermediary roles and providing insights to streamline procurement processes, with potential benefits for all stakeholders involved.
This paper aims to move beyond a descriptive account, seeking to comprehend the challenges procurement intermediaries face and the consequent institutional impacts, thereby guiding stakeholders toward more efficient technology adoption practices (Silverman, 2019).

Paper C poses an inquiry into the collaboration between private firms and universities, asking: "How do private firms benefit or incur costs from collaborating with Danish universities in the technology services sector?". It concentrates on the concrete outcomes of these partnerships, exploring the potential for structured, mutually beneficial interactions that support effective technology procurement and integration. The investigation in Paper C is aimed at uncovering the direct effects of such collaborations. It seeks to understand how these interactions can be structured to be mutually advantageous, thus supporting the effective procurement and integration of educational technologies.

Paper D complements the pragmatic framework by probing student experiences with the transition to online learning, with the research question: "How are students perceiving the transition to online learning during the initial lockdown of 2020 in terms of technology use and mental wellbeing?". It stresses the import of student feedback in guiding technology procurement to meet their needs and wellbeing, thus enriching the procurement process with end-user insights (Silverman, 2019).

Together, these studies reinforce the thesis's commitment to pragmatism, addressing relevant issues and contributing practical insights for the challenges inherent in the procurement process of Danish higher education. This approach allows for a nuanced understanding of procurement, offering knowledge that is not only contextually rich but also actionable for stakeholders (Silverman, 2019; Kelemen and Rumens, 2011).
Methodologically, the articles utilize the most suitable approaches for the data at hand, employing a mixed-methods framework. Papers B and C focus on qualitative data, providing rich and complex insights, allowing for more inductive realizations in the data collection and analysis process (Kvale and Brinkman, 2009; Bryman, 2016). While Paper B relies purely on qualitative analysis, Papers A, C, and D combine qualitative insights with computational methods to enhance analysis. Steady development in computational capabilities, for instance in natural language processing (NLP), has

resulted in the emergence of novel methods and methodologies, allowing for different and more profound insights to be collected from text data. Pragmatic research philosophy is an inclusive and flexible approach that emphasizes the importance of practicality, usefulness, and relevance in research, thereby being ideal for exploring the potentials of novel methodologies and approaches (Bryman, 2016; Silverman, 2019).

4.2   Methods

The data sources for this research were chosen for their relevance in addressing the research questions and providing a comprehensive analysis of the procurement process in Danish higher education. These included both primary and secondary data. Primary data was collected through interviews with stakeholders involved in the procurement process, such as educators, administrators, and suppliers, to understand their perspectives and experiences. Secondary data included documents, reports, and digital communication related to the procurement process, and in the case of Paper A, for the overall development of an EdTech innovation system.

The methods employed for data collection and analysis were designed to capture the complexity and multi-faceted nature of the procurement process. Interviews were conducted and analyzed qualitatively and supported by computational methods, such as NLP, to gain in-depth insights into stakeholder experiences. Similarly, computational methods were used to enhance document analysis to understand the formal processes and policies surrounding procurement and innovation system formation.

Developing from established methods

While NLP driven methodologies have been instrumental in analyzing data, it's equally important to elaborate on the established social science methods applied in this thesis. The most central methods applied through the thesis are qualitative analysis, document analysis, and network analysis.

To be more specific, *qualitative analysis* involves analyzing non-numerical data like interview transcripts, notes, or any text to explore meanings and insights. Qualitative analysis is fundamental in research for its ability to capture detailed descriptions and interpretations of social realities (Bryman, 2016; Kvale and Brinkman, 2009; Meyer, 2001; Yin, 2009; Castañeda and Williamson, 2021). In the context of this thesis, qualitative analysis is used to understand the perspectives and experiences of the stakeholders involved in the procurement process. Paper B stands alone as purely qualitative; interviews with management, consultants, and IT involved in the procurement of EdTech within Danish HEIs were analyzed without computational support.

Used in conjunction with computational methods, it is possible to enrich qualitative data analysis by adding context, depth, and interpretative insights. In Paper C, for instance, a combination of qualitative analysis, sentiment analysis, and extractive summarization is employed to examine the costs and benefits of collaborative innovation for firms providing software services to Danish universities. Furthermore, in Paper D, qualitative analysis is utilized with topic modeling and semantic searching to explore student experiences with technology during COVID-19 lockdown conditions.

Document analysis is one of the established methods used to interpret and ana-
lyze textual documents. It involves evaluating documents in various formats, such
as print and electronic, to extract meaningful data. Document analysis is crucial in
understanding formal processes, policies, and recorded communications which are
often central to procurement processes and innovation system formation. When used
alongside — or enhanced by — NLP techniques, document analysis can provide a
more grounded and contextualized interpretation of text data (Bowen, 2009; Asdal
and Reinertsen, 2022; Bryman, 2016). For instance, in Paper A, document analysis is
used to examine the roles and responsibilities of intermediaries, their activities, mis-
sions, goals, and their support for the development and diffusion of EdTech systems.
In Papers B and C, document analysis supplements qualitative interpretation of inter-
views by providing insights into public and internal documents of the organizations
involved.

Network analysis is a method used for understanding the structure and dynamics
of networks, where networks are comprised of nodes (entities such as organizations or
individuals) and edges (relations or interactions between these entities). This method
can reveal patterns and structures in the relationships and interactions among the net-
work's members (Wasserman and Best, 1994; Hagberg et al., 2011; Aynaud, 2022). One
common technique within network analysis is the assessment of centrality measures
to understand the importance or influence of nodes within the network (Barthélemy,
2004; Bloch and Jackson, 2021; Porter et al., 2009). In this thesis, network analysis
is particularly employed in Paper A to explore the structure and interactions within
the European EdTech Alliance, focusing on internal clusters and the identification of
intermediaries involved in the formation of the transnational EdTech system.

Novel methodologies in social science

Recent advancements in NLP and computational methods, particularly the develop-
ment of transformer models like Google's BERT (Bidirectional Encoder Representa-
tions from Transformers), have significantly enhanced social science research (Devlin
et al., 2018; Tenney et al., 2020; Grootendorst, 2020). These models, through attention
mechanisms, enable nuanced and context-rich analysis of textual data, far surpassing
traditional methods (Clark et al., 2019; Michel et al., 2019).
The accessibility of Python and user-friendly libraries in social science research has de-
mocratized these advanced methodologies, making them more accessible to a broader
audience. Libraries and frameworks, designed with simplicity and accessibility in
mind, have made it possible for researchers to leverage advanced NLP tools like trans-
former models without needing deep technical expertise in programming or compu-
tational linguistics (O'Reilly Editorial Team, 2021). Python's simplicity and the emer-
gence of specialized packages have simplified previously complex tasks, expanding
the analytical capabilities available to researchers and encouraging more comprehen-
sive analyses.

Building upon these foundational advancements, this thesis employs several trans-
formerdriven NLP techniques, including topic modeling and extractive summariza-
tion. These methodologies enhance analytical depth and process efficiency, enabling

sophisticated interpretation of complex datasets. While the emergence of generative AI postdates the data collection of this thesis, its development and challenges presented to educational institutions worldwide form an important backdrop to this study. These advances in AI and computational linguistics have informed the methodological approach of this research, exploring novel approaches to the analysis of social science data.

Topic modeling is one such technique that allows for the detection of latent topics and themes in text data. It operates by analyzing the co-occurrence and relationships of words within documents to identify clusters of words that are likely to appear together and are representative of underlying themes. Essentially, topic modeling is a form of unsupervised machine learning where algorithms, such as latent Dirichlet allocation (LDA), are used to group words into topics and documents into mixtures of topics. By utilizing the contextual analysis capabilities of transformer models, topic modeling can gain an even deeper understanding of the semantic relationships between words and topics (Sievert and Shirley, 2015; Grootendorst, 2020). In social science, this technique allows researchers to identify prevalent discourses, ideologies, and concerns within a dataset without prior assumptions. This is highly beneficial for exploratory research and is integral to studies focusing on social trends and emerging phenomena.

Another transformative NLP technique is *extractive summarization*. In social science research, engaging with extensive textual data such as reports, transcripts, and articles is common. Extractive summarization becomes an invaluable tool, as it condenses lengthy documents into concise summaries by extracting key sentences and phrases. The contextual understanding provided by transformer models improves the quality of these summaries, enabling more accurate representations of the original documents (Miller, 2019). For researchers, this is particularly beneficial as it provides a quick overview of the content, aiding in the decision-making process on which sources warrant a deeper investigation. In addition to facilitating efficient navigation through voluminous data, extractive summarization helps in identifying key themes and concepts that are essential for hypothesis formation and research direction. Moreover, it assists researchers in the comparison of content across multiple sources, making it easier to understand varying perspectives and narratives.

Sentiment analysis has evolved from basic categorizations of text into positive, negative, or neutral sentiments to more fine-grained analysis. Modern sentiment analysis can recognize a spectrum of emotions such as joy, anger, sadness, and more. Further, developments in NLP have enabled sentiment analysis to understand the intensity of these emotions and detect sarcasm, irony, and context-specific sentiment expressions. Transformer models, in particular, have been pivotal in enabling this fine-grained analysis by understanding the context and nuances of text (Demszky et al., 2020). This enhanced capability of sentiment analysis is vital for research, as it provides deeper insights into the emotional and psychological states of individuals and groups.

Semantic similarity search, often referred to as *semantic searching*, is an advanced

computational technique that enhances the capability of traditional keyword-based searches. Unlike conventional searches that rely solely on matching keywords, semantic searching delves into the contextual meaning and relationships between words and phrases. This is achieved by leveraging NLP algorithms, especially transformer models, which are trained to understand the semantic relationships between words in a given corpus (Reimers and Gurevych, 2019; Devlin et al., 2018; Liu et al., 2019). By utilizing semantic similarity search, it is possible to extract more relevant and contextually-rich information from large datasets.

In the context of preparing qualitative data for analysis, *auto-transcription* has shown great potential for research involving interviews. Utilizing advanced speech recognition algorithms, auto-transcription services like Whisper.ai (used primarily in this thesis) convert spoken language into written text (OpenAI, 2022). This is especially beneficial for transcribing interviews, which can be labor-intensive and time-consuming when done manually. Whisper allowed for the rapid conversion of oral data into a format that could be easily analyzed and integrated with other textual data sources.
Auto-transcription was especially valuable for Paper C and for background interviews (interviews not used empirically, but for context and development of research interest, more in section 4.3), where it was used to efficiently transcribe, facilitating an in-depth analysis of stakeholders' perspectives in the procurement process in Danish higher education. Moreover, sentiment analysis and extractive summarization in Paper C provided nuanced insights into the emotional dimensions of stakeholders' communications and responses.
While services like Whisper have seen significant improvements over earlier auto-transcription software, it is important to note that these transcriptions can still contain errors or inaccuracies. As such, manual review and correction are necessary to ensure the accuracy and reliability of the transcribed data.

This holds true in general for the application of novel methodologies. While NLP-fueled text-summarization and emotion-detection have the ability to optimize analytical insights, reality have shown on multiple occasions that such software is also highly capable of being wrong (Marr, 2023). In Paper C, the relatively small data-size allowed for thorough scrutiny of, for instance, emotions portrayed by respondents, but in large sample-sizes, where these methods are ideal, it can be harder to verify findings. So, while these types of software or services can greatly improve the transcription and analyses processes, it is still vital to critically review automated feedback to identify and correct any discrepancies, ensuring that the output accurately reflects the actual content and maintains the integrity of the data.

Despite the need to be critical and careful using applications in the ongoing development and refinement of ways to computationally understand text and language, the integration of advanced NLP techniques, underpinned by the groundbreaking capabilities of transformer models, represents novel opportunities in conducting social science research. These methodologies provide researchers with unprecedented levels of depth and granularity, enabling the exploration of complex social phenomena

in ways that were not previously possible. In the context of this thesis, these NLP methodologies played a crucial role across various articles. For instance, topic modeling was instrumental in understanding the formation of the EdTech market in Europe in Paper A. In Paper D topic modeling aided in the development of latent themes for qualitative analysis, which was further augmented through semantic searching.

Together, combining novel computational methodologies with established methods like qualitative analysis, document analysis, and network analysis creates a robust and holistic approach. This integration not only ensures that the research is grounded in traditional methodologies, but also takes advantage of modern advancements in data analysis to produce comprehensive and actionable insights.

As the field of data science continues to evolve, there are new opportunities and tools emerging that have the potential to further improve analytical capabilities in other research fields. The combination of traditional and novel methods, as exemplified in several of the thesis' articles, serves as a testament to the adaptability and the continuous development of research methodologies that cater to complex and multidimensional datasets.

4.3 Data sources

The efficacy of these integrated methodologies is intrinsically linked to the quality and relevance of the data sources employed. In this thesis, the data serves as the empirical foundation for examining the various stakeholders involved in the procurement and diffusion of technologies for teaching and learning in Danish HEIs. The following section shifts focus from the methodologies applied to the nature of the data itself, detailing the types of data collected, their acquisition timelines, and their significance to each component of the study. This detailed examination of the data sources not only underpins the methodological approach but also highlights the empirical basis that drives the research inquiry. The sources of data, outlined in table 8, range from primary data collected through interviews and surveys to secondary data from existing literature and reports, each playing a crucial role in shaping the findings of this thesis.

The rationale for selecting the diverse data sources in this thesis lies in the need to triangulate different perspectives. Interviews with administrators, procurement intermediaries, and private firms provide a broad view of the procurement landscape. While traditional documents like policy briefs and reports are analyzed to obtain institutional perspectives, the use of interviews, network analysis, and computational methods to enhance insights, helps in understanding the underlying structural intricacies.

Paper	Data Type	Time Frame	Data Details
Paper A	Public Data	01/04-2021 - 01/11-2022	European EdTech Alliance (EEA). 25 industry associations, 612 identified stakeholder partners
Paper B	Interviews / Documents	01/06-2021 - 01/12-2021	22 interview respondents (12 interviews). across Danish universities Internal and published digitalization strategies, roadmaps
Paper C	Interviews / Public Data	01/07-2022 - 15/09-2022	4 companies supplying software for teaching and learning in Danish HEIs Web page information, published reports and documents
Paper D	Survey	01/10-2020 - 01/11-2020	AAU student survey, 2.190 respondents across 5 faculties and 5 semesters
Background	Interviews	01/06-2021 - 01/12-2021	12 educators at AU, KU, and AAU. Focus on potentials and challenges of using EdTech in teaching and learning environments

Table 8: Article research questions

Background interviews: Building from educator insights

While not directly contributing to the empirical analysis in any of the articles, interviews with educators in Danish HEIs have been essential in shaping the research questions and focus of this thesis.

Originally, an article was planned that would integrate the perspectives of internal procurement intermediaries with those of educators. However, as the research progressed, it became clear that this would result in an unwieldy and overloaded article, unable to do justice to the richness of the insights collected. Hence, the decision was made to focus on data from administrators for Paper B.

The insights from educators illuminated the practical challenges and complications that arise when implementing technologies in teaching and learning environments. These practical considerations significantly influenced the framing of subsequent interviews with administrators and industry stakeholders. The educators' insights, frustrations, and identified challenges were instrumental in crafting the questions and discussion topics for the ongoing thesis research.

Moreover, educators' views on the utility of various technologies and their experiences in trying to align institutional goals with ground-level educational practices provided a critical layer of context. This context motivated not just the questions asked in later stages, but also contributed to the nuanced understanding of the implications of technology procurement and integration in educational settings.

Therefore, although these interviews did not contribute directly to any article's empirical analysis, their influence is woven throughout the thesis, underpinning the major research points, key interests, and framing of questions.

4.4 Methodological application in articles

Having established the significance of various data sources and their diverse roles in shaping the research, the following sections will describe how the methodological foundations and data sources were applied in each Paper to explain how the methods complement the data and are effectively applied to answer the research questions addressed in each article.

Paper A: The European EdTech Alliance

This study investigates the role of intermediaries in shaping the European EdTech innovation system by focusing on the European EdTech Alliance (EEA) — a not-for-profit organization bridging industry associations, incubators, and venture capital in Europe. Methodologically, the paper employs two primary analytical techniques: document analysis and network analysis. Document analysis is applied to data gathered from EEA member webpages to examine roles, activities, and goals of intermediaries within the system. The framework of functional analysis is used to classify actions and objectives of intermediaries contributing to system-level development and diffusion of EdTech.

Network analysis is applied to further understand the interactions within the EEA. Collaborations are identified from stated partnerships on member webpages and subsequently confirmed through email correspondence (further elaborated in Paper A). Community detection algorithms map these collaborations to reveal internal clusters and central stakeholders. Further, closeness centrality metrics are utilized to identify key stakeholders that act as important nodes within the transnational EdTech network. (EEA, 2019; Jeppesen and Havinga, 2021; Grunspan et al., 2014; Friedkin, 1991; Bloch and Jackson, 2021; Hagberg et al., 2011) The methodology of this study is focused on combining functional analysis with network analysis to explore how intermediaries are contributing to system building in European EdTech.

Paper B: Procurement intermediaries in Danish universities

Paper B initiated with an exploratory lens, probing into the procurement of EdTech in Danish HEIs. The investigation began with an emphasis on identifying challenges and operational bottlenecks via a thematic analysis that was guided by the pre-defined themes within the interview guide (available in Paper B, **??**).
However, as the study progressed, our analytical perspective developed. While initial findings were categorized through thematic analysis, the discovery of PPI as a significant factor in the literature prompted a methodological shift. This transition was not merely a change in coding technique but a refinement of the analytical lens, focusing on the procedural aspects of PPI, thus enriching our research narrative.

The analysis, which started with a broader thematic approach, became more structured around PPI, offering a dual advantage: it remained true to the grounded insights from data while also engaging with the broader conceptual framework of PPI. This methodological evolution is an example of how the research remained flexible

and responsive to emerging themes, ensuring that the study's findings are both empirically grounded and theoretically informed (Strauss and Glaser, 1967; Eisenhardt, 1989; Kvale and Brinkman, 2009). For an in-depth view of the coding process and how the themes were developed and refined, further information is available in the full article and its appendix.

Paper C: Technology Providers in Danish University Teaching and Learning Environments

While Paper B focuses on the procurement process from the universities' perspective, Paper C turns the lens toward technology providers. Specifically, the study explores the experiences, challenges, and opportunities that suppliers face when working with large, complex institutions like Danish universities.

To gather empirical data, interviews were conducted with key figures—executives, managers, and sales representatives—from four types of technology companies. Each company was strategically selected to reflect diverse business models, geographical locations, and levels of interaction with HEIs. These interviews followed a standardized semi-structured guide to ensure consistent data collection (Kvale and Brinkman, 2009).

Unlike in Paper B where interviews were mainly coded manually, Paper C leverages computational methods for data analysis. All interviews were transcribed using Whisper, an open-source auto-transcription algorithm, trained locally (GDPR-safe) and validated qualitatively (OpenAI, 2022). Further data enrichment came from applying machine learning techniques like sentiment analysis and extractive summarization on the interview transcripts. A transformer-based model was employed to automate this process (Devlin et al., 2018; Tenney et al., 2020; Michel et al., 2019). For more insights to the coding and analysis process, see Paper C appendices for context.

The study's analytical framework combines qualitative insights with semantic and sentiment analyses. It captures a range of emotional responses from the interviewees, providing a nuanced view of the costs, benefits, and strategic considerations associated with supplying technology solutions to HEIs. In essence, Paper C utilizes a multidimensional approach to better understand the collaborative dynamics between technology providers and universities, situating these findings within the larger context of public procurement and innovation in the higher education sector.

Paper D: Student Experiences at Aalborg University Amidst Lockdown

While Papers A, B, and C predominantly focus on systemic and institutional dimensions, Paper D shifts the attention toward end-users—the students. This paper aims to understand the impact of sudden technological shifts and online teaching methods on students at Aalborg University (AAU) and AAU Business School during the COVID-19 pandemic lockdown.

To provide a broad overview of student experiences, a large-scale survey was administered across five semesters and faculties, garnering over 2,000 responses. The survey employed a multi-method approach combining Likert-scale, multiple-choice, and open-ended questions. While quantitative responses were gathered for initial analysis, the research's focal point lay in the qualitative examination of open-ended responses.

For the qualitative analysis, computational methods were deployed to analyze 2,189 cleaned and pooled textual responses. Topic modeling techniques were used to identify recurring themes and related issues. Specifically, BERTopic, a topic modeling framework that utilizes pre-trained BERT and transformer embeddings, was employed for this purpose (Grootendorst, 2020).

The modeling for this paper utilized Facebook AI's RoBERTa model, trained on a 160 GB dataset, substantially larger than the original BERT model. This state-of-the-art transformer model offered optimized outcomes for topic visualization and text analysis (Liu et al., 2019). Importantly, this modeling approach permitted responses to be associated with multiple topics, providing a nuanced and layered understanding of student experiences.

Thus, Paper D successfully merges computational qualitative analysis with traditional survey methodologies. It offers a comprehensive view of how students navigated the technological and pedagogical shifts induced by the pandemic, validated through a combination of quantitative and qualitative data. This paper supplements the institutional perspectives offered in Papers A, B, and C by adding a user-experience dimension, thereby providing a well-rounded view of technology procurement and utilization in Danish higher education. The methodologies utilized in the thesis' articles are summarized in table 9.

Paper	Methodology	Data sources
Paper A	Network analysis, geographical plotting, document analysis	European EdTech Alliance public member information, published reports
Paper B	Qualitative analysis, document analysis	Procurement intermediaries, consultants, IT personnel Semi-structured and focus group interviews, published reports
Paper C	Semantic analysis, extractive summarization, document analysis	Software providers for teaching and learning Semi-structured interviews, auto-transcription, NLP
Paper D	Statistical analysis, topic modeling, document analysis	University students Survey with qualitative responses

Table 9: Summary of methods and research settings

4.5   Limitations

This research was conducted within a dynamic and unprecedented context due to the COVID-19 pandemic, which influenced the methodological choices and the scope of data collection. The limitations encountered are acknowledged not as shortcomings, but as inherent aspects of the research process under the given circumstances.

Data limitations

The study of the EEA in Paper A was based on a methodological framework that combined document and network analysis to elucidate the role of intermediaries within the European EdTech innovation system. While this approach yielded significant insights into the system's structure and stakeholder roles, it is acknowledged that the reliance on publicly available data and the absence of direct stakeholder engagement beyond confirmation emails may limit the depth of interaction analysis. Furthermore, focusing exclusively on the EEA as the empirical foundation means that additional collaborative activities outside this coalition were not considered. Future research could benefit from direct engagements with key stakeholders to explore the broader EdTech ecosystem and to deepen the understanding of the roles of systemic intermediaries and the dynamics of their interactions in transnational innovation processes.

In Paper B, the thematic analysis initially lacked a specific theoretical anchor, beginning broadly without a pre-defined focus on the procedural aspects of PPI. This methodological openness, while allowing for flexibility and responsiveness to emerging themes, also meant that the data collected was not always optimally aligned with the PPI framework subsequently adopted. The interviews, conducted across five distinct Danish universities, revealed diverse procurement practices reflective of their autonomy. While the study offers insights into common challenges and bottlenecks, it also highlights the heterogeneity of procurement approaches, which is a characteristic of the decentralized nature of these institutions. Future research might explore the individualized procurement strategies in further detail to fully understand the nuances of each institution's approach, and the potential effects of centralization versus decentralization of EdTech procurement in Danish HEIs.

In Paper C, the engagement with industry representatives was insightful but limited to four interviews. This sample, while offering valuable perspectives, represents an area where future research could seek broader engagement within the industry. Despite the apparent small scale, these interviews were strategically sourced to encompass a diverse array of entry points within the higher education EdTech ecosystem. The sample's diversity mitigated the limitation of its size, as it captured a cross-section of the industry, from startups to established companies, each providing a different perspective on collaboration with higher education. Thus, within the confines of this study, the range of industry views was effectively canvassed, offering a nuanced glimpse into the complex interplay of stakeholders within the HEI EdTech ecosystem.

Moreover, the staggered timing of data collection across the papers introduced variability, with Paper B's data gathered in 2021 and Paper C's in 2022. This temporal

difference is recognized as a factor that may have influenced stakeholder perspectives, serving as an impetus for ongoing research to monitor these evolving views.

Paper D provides an insightful snapshot of student experiences during the initial COVID-19 lockdown at Aalborg University, based on a substantial survey response. Despite its focused scope on a single university and the time-bound context of the pandemic's onset, the study offers valuable data on the immediate impacts of the transition to online education. While the survey design and its integration into the broader thesis theme may have room for refinement, the wealth of responses adds a significant dimension to the understanding of end-users' adaptation to technological shifts in education.

Overall research limitations

The initial research design envisioned a comprehensive comparative study incorporating insights from a year-long research stay in China — a plan that was integral to the thesis due to the funding structure. However, the constraints imposed by the pandemic required a strategic pivot away from international fieldwork, leading to a refocusing of the research questions and methodology. The omission of the comparative study with the Chinese educational system represents a significant adaptation, yet this change in direction is reflective of an agile research approach tailored to an evolving global situation.

While each paper within this thesis faced its own set of limitations, from the reliance on publicly available data to the diversity of procurement strategies across institutions, these constraints have been met with a strategic and discerning research design. The insights developed have been shaped by these conditions, and thus, the findings should be interpreted within this context.
Looking ahead, the limitations underscored in each paper do not merely highlight areas for future research but also demonstrate the potential for further in-depth exploration and application of the studies' outcomes. As delineated in section 5.3, the proposed future research directions are poised to enhance the current body of work, expanding upon the empirical and theoretical contributions made by this thesis.

4.6 Generalizability

One of the central concerns of any research is the extent to which the findings can be generalized beyond the specific context in which the study was conducted. The research approach adopted in this thesis is pragmatic, which places a particular emphasis on practicality, usefulness, and applicability of knowledge. Pragmatism is a research philosophy that recognizes the dynamic and ever-changing nature of knowledge and emphasizes the importance of actively engaging with the world and testing theories through practical experimentation. As such, the approach is well-suited to research that aims to provide practical and relevant insights that can be applied in a given context.

4. Methodological considerations

The studies in this thesis were conducted in the specific context of procurement of EdTech in Danish higher education. Yet, the findings may have relevance for other contexts and settings. For example, the study in Paper A explored the role of intermediaries in developing system-level resources towards building a transnational EdTech innovation system in Europe. While the specific context of the European EdTech Alliance was the focus of this study, the findings may have implications for the development of similar innovation systems in other regions and contexts, especially in relation to the role of intermediaries in system building.

Similarly, the studies in Papers B and C explored the procurement of EdTech in Danish higher education and the challenges and opportunities associated with providing technology solutions for large public institutions. The setting of Danish universities is in many ways unique due to the structure of education in Denmark, but many universities experience similar complications in how to measure the impact and relevance of procuring technologies for teaching and learning. As such, the findings may have implications for how universities, private as well as government funded, develop procurement policies. Despite the specificity of the Danish university setting, HEIs often experience similar challenges, both in Denmark and in other countries. For instance, public tender for digital solutions is broadly becoming recognized as a central complication for innovative capabilities in HEIs, and a more profound understanding of these processes could impact multiple sectors, public and private.

The study in Paper D explored the experiences of students with online learning during the initial lockdown of 2020. While the specific context of Aalborg University was the focus of this study, the findings may have implications for other HEIs that have shifted to online learning due to the COVID-19 pandemic. During this period, many studies were developed with similar intent, and with similar findings, and especially universities with PBL or similar approaches, argued for the maintained relevance of received education in a physical format, ideally enhanced through technology, rather than replaced.

It is important to note, however, that the extent to which the findings of each study can be generalized beyond the specific context in which it was conducted will depend on a range of factors. These may include differences in institutional structures, cultural factors, and variations in the implementation of procurement processes or online learning initiatives. As such, the findings of each study should be interpreted within the specific context in which it was conducted and should be viewed as a starting point for further research in other contexts and settings. While the studies in this thesis were conducted in specific contexts, the pragmatic approach adopted in the research places a strong emphasis on practicality, usefulness, and applicability of knowledge. As such, the findings of each study may have implications for other contexts and settings, but the extent to which they can be generalized will depend on a range of factors specific to each context. Further research is needed to explore the applicability of the findings in other contexts and to develop a more nuanced understanding of the factors that may influence the generalizability of the findings.

5 Conclusion

This thesis is grounded in a comprehensive exploration of the procurement of EdTech in Danish HEIs, specifically probing how different stakeholders participate in this process, through the overarching research question: *How do different stakeholders participate in the procurement of innovation of educational technologies in Danish higher education, and what are the implications of their involvement?*

Through the thesis work, the findings suggest that the procurement process of educational technology in Danish universities is complex, involving multiple stakeholders with different interests and goals. The involvement of intermediaries, such as consultants and alliances, can have positive effects on the innovation system, but their impact is highly dependent on the surrounding regulatory and strategical structures. Public procurement of innovation (PPI) can facilitate innovation and drive development, but it can also create barriers to entry for smaller companies. Collaborative innovation can enhance the effectiveness and efficiency of the procurement process, but it requires trust and a shared vision among stakeholders, and from the findings of this thesis, strategies for collaborative innovation activities are relatively limited for both supply and demand side. Finally, the transnational dimension of innovation systems in educational technology procurement and implementation highlights the importance of context-specific factors, such as institutional culture and regulatory frameworks. Together, the articles in this thesis provides insights into the procurement of educational technology in large public institutions, highlighting the roles of different stakeholders and their impact on the diffusion of such technologies.

In the following sections, The aim is to cohesively integrate the diverse insights from each paper, reflecting on how they collectively respond and contribute to the broader discourse on innovation systems, intermediaries, and public procurement of innovation in the field of educational technology. Section 5.1 and provides a discussion of findings and contributions of each article in the thesis, with key thesis insights expanded in section 5.2. This discussion is broadened in section 5.3, where the theoretical underpinnings and empirical findings are collated to elaborate on the implication of the thesis research. Section 5.4 explores possible avenues for future research, with potential policy implications in section 5.5.

5.1 Article findings

The ensuing summary revisits the key findings of each paper, aligning them with the central themes of the thesis. From the role of intermediaries in the European EdTech system (Paper A) to the challenges and opportunities of procurement processes in Danish higher education (Papers B and C), and the examination of technology use and its impacts on students during the pandemic (Paper D), the summary bridges the methodological foundations with the theoretical and practical implications of the study.

Paper A: System building in European EdTech

Paper A explores the formation of a European EdTech innovation system, focusing on the EEA and its member associations. In the context of transnational innovation systems, this paper illustrates how systemic intermediaries like the EEA are important in navigating the dynamic landscape of educational technology across national borders. The study's findings align with the theoretical underpinnings of innovation systems (IS) research, particularly the evolutionary perspective and the role of systemic intermediaries in fostering cross-border collaborations and knowledge exchanges.

The paper highlights the EEA's role in supporting entrepreneurship, knowledge development, resource mobilization, and legitimizing new technologies in the field. This aligns with the notion of transnational innovation systems where intermediaries act as key facilitators, bridging gaps between various actors and aligning interests across different institutional contexts. The EEA's efforts in establishing common standards and guidelines for EdTech adoption exemplify the process of system level resource formation and structural coupling in transnational innovation systems.

However, the study also identifies barriers to the widespread adoption and diffusion of these technologies, such as limited financial resources, educators' reluctance to test novel solutions, and the unique local specificities of educational institutions. This resonates with the challenges outlined in transnational IS research, emphasizing the complications associated with harmonizing practices across different national and institutional contexts.

The paper's contribution extends beyond the empirical findings. It provides a conceptualization of the role of intermediaries in developing and sustaining transnational innovation systems, particularly in the context of European educational technology. This contributes to the broader discourse on transnational innovation by illustrating how systemic intermediaries operate within and shape these systems, especially in sectors marked by rapid technological change and diverse stakeholder interests.

In conclusion, Paper A not only sheds light on the specific dynamics of the EdTech sector in Europe but also contributes to a deeper theoretical understanding of the roles and challenges of systemic intermediaries in transnational innovation systems. This enhances our comprehension of how large public institutions, such as HEIs, manage the incorporation of services from private firms within a multilateral and multilayered transnational context.

Paper B: Public procurement in Danish higher education

Paper B delves into the intricacies of PPI within Danish HEIs, examining the procurement processes for educational technologies. This paper situates itself within the broader theoretical framework of PPI, emphasizing the strategic role of process intermediaries in navigating these changing technological procurement landscapes.

The study in Paper B underscores the challenges faced by HEIs in the procurement and integration of EdTech, with a distinction between EdTech systems and tools, highlighting the procedural dimensions of procurement policy. It identifies several key challenges, such as understanding market opportunities, managing internal coordination, and aligning organizational needs with innovative solutions. These challenges

resonate with the broader literature on PPI, which emphasizes the multifaceted nature of procurement beyond mere transactional exchanges.

Central to Paper B's findings is the role of process intermediaries, whom are highly important to managing the procurement processes within institutions, ensuring seamless execution, compliance with policies, and effective supplier engagement. The paper illustrates how these intermediaries navigate bureaucratic procedures, bridge communication gaps between different institutional actors, and facilitate the acquisition and integration of educational technologies.

This paper contributes to the understanding of procedural aspects of PPI within public institutions. It sheds light on the internal workings of HEIs as they engage in the procurement of innovative solutions, highlighting the strategic importance of process intermediaries in facilitating these efforts. The paper's insights into the interaction with suppliers and the management of procurement processes provide insights on the challenges and opportunities in public procurement.

Moreover, Paper B's exploration of the role of intermediaries in PPI aligns with the broader discourse on innovation systems, particularly the need for effective coordination and communication within these systems. By focusing on the tactical level of procurement, the paper offers a granular understanding of how public institutions, like universities, navigate the incorporation of services from private firms, balancing innovation with organizational constraints and policy requirements.

As such, Paper B enriches the theoretical and empirical landscape of PPI research, particularly in the context of educational technology within higher education. It highlights the critical role of process intermediaries in bridging the gap between innovative technologies and their successful adoption in public institutions. This paper's insights contribute to a more comprehensive understanding of the procurement dynamics in HEIs, offering valuable lessons for both practitioners and researchers in the field of public procurement and innovation management.

Paper C: Supplier perspective on collaborative innovation

Paper C examines the challenges and opportunities of collaborative innovation in the procurement of educational technologies within Danish HEIs, focusing on the perspectives of technology providers. This paper situates itself within the broader context of collaborative innovation in public procurement, addressing the complications and dynamics between universities and EdTech companies.

The study in Paper C delves into the process of co-creation between public institutions and private firms. It highlights the potential of collaborative innovation to produce pedagogically sound and technologically advanced solutions. However, it also uncovers the practical challenges, including asymmetric power dynamics, divergent goals, and resource constraints, that often impede the realization of these collaborative efforts.

Central to the findings of Paper C is the understanding that collaborative innovation, while offering numerous advantages, is fraught with hidden cost and challenges.

The paper emphasizes the strategic necessity of managing these challenges, particularly for private firms involved in the collaboration.

The paper explores the roles of intermediaries in facilitating these collaborations. It underscores how process intermediaries help ensuring that collaborative innovation is not only initiated, but also sustained and effectively integrated into the procurement process. These intermediaries are key in bridging the gap between the fast-paced technological development of EdTech companies and the slower, more deliberate pace of academic institutions.

Paper C contributes to our understanding of the practical realities of collaborative innovation in the context of EdTech procurement. It provides a perspective on the interaction dynamics between HEIs and technology providers, highlighting the challenges of translating educational needs into technological solutions. The paper's insights into the episodic nature of collaboration and the role of intermediaries in enhancing the effectiveness of the collaborative process offer valuable lessons for both practitioners and researchers in the field of public procurement and innovation management.

Paper C enriches the theoretical and empirical landscape of collaborative innovation research, particularly in the context of educational technology within higher education. It underscores the potential pitfalls and costs associated with collaboration between public and private sectors, highlighting the critical role of intermediaries in bridging gaps and facilitating effective partnerships. This paper's insights contribute to a more comprehensive understanding of the procurement dynamics in HEIs, offering valuable insights into how collaborative innovation can be more effectively managed and realized in public sector procurement.

Paper D: Students' perceptions on online education during COVID-19

Paper D investigates how students reacted to the first COVID-19 lockdown in 2020. The article is concerned with technology use for online education, and the mental well-being of students during this period. The study found that the transition to online learning during Covid-19 highlighted the diverse structure of the student body and confirmed that what works for one student may not work for another. Some students thrived in the distance learning setting, while others struggled with the diminishing social aspect of learning. Recorded lectures were almost exclusively positively received, as they allowed for flexibility and the ability to revisit key information. The study also found that universities that already had digital infrastructure in place were more successful in transitioning to online learning.

Comparing the findings of this study with similar studies conducted globally, it is evident that online learning has highlighted the psychological, social, and emotional perspectives of learning that have suffered through the transition. It is important for universities to consider the mental health aspect of higher education environments in the process of digitalization, as some students' motivation and mental wellbeing were heavily impacted by the transition to online learning and the isolation of being in lockdown (Aristovnik et al., 2020; Dodd et al., 2021; Khan et al., 2021; Raza et al., 2020; Khan et al., 2020; Selvanathan et al., 2020; Ali et al., 2020; Biber et al., 2021;

Bartolo et al., 2020; Haliwa et al., 2021). While online learning cannot fully replace traditional learning modalities, it has the potential to support physical learning environments, rather than replace them. Studies of blended/hybrid learning formats can gain a better understanding of how various technological or digital applications can be combined with physical learning environments to develop optimal settings for teachers and students to thrive. Ultimately, universities must balance the benefits of online learning with issues of motivation, social engagement, and mental health among students, which may be subject to a wider societal concern (Bryson and Andres, 2020; Pal and Vanijja, 2020; Alam and Parvin, 2021; Alam and Asimiran, 2021; Triyason et al., 2020; Buheji and Buheji, 2020; Raes et al., 2020a).

Summarily, the research focus and findings of each paper are visualized in table 10.

Paper	Research focus	Findings
Paper A	Role of systemic intermediaries in European EdTech system development	EEA's significant role in EdTech market formation, systemic intermediaries bridging gaps across borders, and challenges in harmonizing practices due to local specificities. Contribution to understanding of systemic intermediaries in transnational innovation systems.
Paper B	Impact of process intermediaries in EdTech procurement within Danish HEIs	Challenges in EdTech procurement highlighting strategic importance of process intermediaries in facilitating procurement and integration. Contribution to understanding of procedural aspects of PPI and the role of intermediaries in innovation systems.
Paper C	Dynamics of collaborative innovation between HEIs and EdTech companies	Exploration of co-creation challenges and the critical role of intermediaries in bridging gaps for effective partnerships. Insight into practical realities of collaborative innovation in EdTech procurement.
Paper D	Students' perceptions of online education and mental well-being during COVID-19	Diverse student responses to online learning, highlighting the importance of mental health in digitalization processes. The need for balanced online and physical learning environments to support different student needs.

Table 10: Summary of findings and contributions

5.2 Key insights

This section emphasizes the article contributions in their collective capacity to advance understanding of EdTech procurement and adoption in higher education, by providing an overview of four key theoretical insights, along with a central methodological insight, developed from the thesis work.

The first key insight emerging from the thesis is in regard to the conceptualization of EdTech in HEIs. From Paper A and B emerges a distinction between EdTech tools, and EdTech systems, providing an understanding of the different types of technologies being implemented in the space. Systems, for instance LMS', are large, encompassing solutions, that enable institutions to move their operations into the digital space. Tools, on the other hand, are smaller software or solutions, developed to solve specific

complications within the educational environment. This distinction further allows for more granular understanding of the procurement process, as larger systems entail public tender processes, and formalized procurement processes, whereas the area for tool procurement is exemplified by much more exploration and ad hoc implementation. As such, this distinction can allow future research to investigate procurement of EdTech in a more specialized manner, fitting the investigation to the type of EdTech being procured, diffused, or implemented.

The second insight relates to the conceptualization of transnational innovation systems in relation to digital innovation. Throughout the thesis, the complexities of innovation and procurement of EdTech are highlighted at different layers and levels. Local institutions, working under multilateral regulations, procuring software from multinational organizations, all with differing interests and goals for the directions of development. Paper A utilizes a functional approach, drawn from technological IS research, to map out the role of intermediaries within this transnational system. While this approach provide valuable insights from this endeavor, the limitations of the study also highlight the need for more development of methodologies to study transnational innovation system in primarily digital innovation processes, such as EdTech. With digitalization increasingly becoming a globally transformative phenomenon, it is important to develop the tools available to measure this type of transnational innovation. Without providing any viable solutions, this central insight from the thesis provides a foundation for further research in EdTech innovation, and for similar technologies operating in the digital space.

The third key insight is the role of intermediaries within innovation systems. While existing research has highlighted the importance of innovation intermediaries within innovation systems, this thesis goes a step further and introduces a variety of different intermediary types operating at different levels and areas. In terms of system building, especially in the context of transnational innovation, the thesis research highlights the importance of actors, operating between the main components of the innovation systems, bridging differences, aligning interests, and facilitating cooperation, within and across institutional boundaries. In this thesis, systemic and process intermediaries are central actors being investigated, but the research further alludes to different types of intermediaries likely being equally essential to strong system development and maintenance. These findings indicate that further research on intermediaries in innovation systems could be beneficial for strong innovation capabilities. In EdTech, where multiple interests and goals need to be aligned, and with development spanning borders and disciplines, it can be instrumental to expand the understanding of intermediary roles at different sections of the innovation process.

The fourth key insight is related to procurement, and specifically procedural aspects of PPI. Paper B expand on the existing research on procedural procurement processes, by investigating the role of process intermediaries in EdTech procurement in Danish HEIs. This research highlights the challenges associated with procurement and diffusion at an institutional level, navigating strategic policies, EU regulations, and educator needs and frustrations. This is further complicated by a lack of proper

overview of possible and available EdTech solutions. While existing research has highlighted the importance of managing the procedural aspects of procurement, this thesis' research illuminates the need for procedural innovation policies to understand and navigate the multilateral, institutional, and micro-level conditions, process intermediaries work under.

A final, methodological insight also needs to be mentioned. A driving interest in developing this thesis, has been the use of novel and untested methodologies to gain interesting insights for the research. Exploring qualitative data through NLP-driven computational methods has provided new opportunities for more granular and in-depth research to be made. Much of the thesis research, has been developed as a testing ground for various methodologies, to enhance insights. While not necessarily apparent on the pages of the thesis, many approaches and interesting methodologies were tried and tested. In social science research, this type of research is still considered novel, and much more knowledge is needed to realize which methods are more apt than others, what works, and what still needs development to be properly applicable in social science contexts. Paper C presents several opportunities available from computational methodologies, such as semantic searching, and sentiment analyses. For instance, while a limitation for the study, the small quantity of text, made thorough comparison between human and computational estimates of sentiment simpler. The research done in this thesis, promotes the increased used of computational methods in social science research, especially as programming languages are being simplified and democratized, data science communities are becoming more entwined and collaborative, and generative AI and similar technological developments, increases the availability, even for non-quantitative researchers.

5.3   General discussion

The thesis is focused on understanding procurement in large public institutions, specifically focusing on EdTech procurement in Danish HEIs, exploring the role of intermediaries involved in the procurement and legitimization of EdTech. The research highlights the pivotal role of intermediaries in the procurement and legitimization of EdTech. A key theme emerging from the findings is the importance of collaboration among intermediaries, educational institutions, and private firms in developing and adopting new technologies in the EdTech sector.

Intermediaries in EdTech diffusion

Intermediaries, serving as brokers or boundary spanners, play a critical role in facilitating this collaboration (Howells, 2006; Klerkx and Leeuwis, 2009; Stewart and Hyysalo, 2008; van Lente et al., 2003; Bessant and Rush, 1995). The thesis illuminates the diverse types of intermediaries involved in the development and diffusion of EdTech, and how different intermediaries, operating at various levels, can significantly impact the procurement process. This includes both systemic intermediaries, who foster innovation across the entire educational system, and process intermediaries, who are crucial in managing the granular aspects of procurement and imple-

mentation within HEIs.

Systemic intermediaries, as discussed in Paper A, are instrumental in legitimizing and disseminating information about EdTech development, thus aiding in the formation and sustenance of a broader innovation system. These intermediaries operate at a macro level, connecting stakeholders across borders and influencing policy decisions, which are vital for the systemic adoption of new educational technologies and practices.

Conversely, process intermediaries, explored in Papers B and C, operate at a micro- and meso-level within the educational institutions themselves. They navigate the bureaucratic intricacies of procurement, ensuring policy compliance, and managing supplier relationships. Their role directly impacts the efficiency and effectiveness of the acquisition and integration of educational technologies within HEIs. While borrowed from transition literature (Kivimaa et al., 2019a), and still in early stages of conceptualization, the distinction between systemic and process intermediaries provides an understanding of their diverse yet complementary roles in the innovation system. It highlights the multifaceted nature of intermediary involvement in the procurement process, emphasizing how their varying functions and levels of operation can influence the successful adoption and diffusion of EdTech in higher education.

Collaboration in procurement of EdTech

Further, while the research highlights the importance of co-creation and user collaboration for companies developing services for teaching and learning, it also reveals the challenges and costs inherent in such processes (Vivona et al., 2022; Torfing, 2016; Torfing et al., 2019; Torfing, 2019; Torfing et al., 2021; Sørensen and Torfing, 2011). The collaborative innovation process, involving institutions, end-users, and service providers, is crucial for ensuring relevance and effectiveness of the solutions. It enables iterative development based on user feedback, fosters strong relational ties, and builds trust and quality in relationships. However, this is not without significant challenges.

In Paper C, several obstacles are highlighted, such as adapting to the local contexts of universities, overcoming barriers in networking and communication, and navigating bureaucratic procurement processes. These factors can impede the seamless interaction necessary for effective collaborative innovation. Paper C particularly looks into the costs incurred by service providers when interacting with HEIs. These costs are not just financial, but also involve substantial time and effort in aligning with the unique requirements and constraints of educational institutions. The expectation of HEIs, intermediaries, and educators to be involved in the co-creation of services, as highlighted in Paper B, adds to the complexity.

The optimistic view, often expressed in research on collaborative innovation, sometimes overlook these practical challenges. In reality, collaborative efforts in HEI procurement can be laden with issues such as asymmetric power dynamics, divergent goals between educational institutions and technology providers, and substantial resource constraints. This often leads to a misalignment between the pedagogical needs of institutions and the technological solutions offered by providers. The process of

translating educational requirements into viable technological solutions is fraught with misunderstandings, leading to innovations that may not fully meet the intended educational objectives.

Moreover, the episodic nature of such collaborations, typically project-based or phase-specific, can hinder the development of a sustained and deep understanding between universities and EdTech companies (Gulati et al., 2012; Connelly et al., 2014; Vivona et al., 2022). This limits the potential benefits of collaborative innovation, preventing the realization of a continuous, mutually beneficial partnership.

In essence, while collaborative innovation presents a promising avenue for developing and adopting new technologies in the EdTech sector, it comes with its own set of challenges and costs. Recognizing and effectively managing these aspects is crucial for realizing the true potential of collaborative innovation in the context of HEI procurement. This insight is important to understand the dynamics of EdTech procurement in higher education, emphasizing the need for a more nuanced approach that accounts for the multifaceted nature of stakeholder interactions and the realities of implementing collaborative innovation.

Multilateral collaboration opportunities

The research underscores various barriers and challenges in the adoption and diffusion of new technologies in the EdTech sector, including limited financial resources of educational institutions, fatigue among students and educators in testing novel solutions, the unique local specificities of educational institutions, and a general lack of specified demands for novel solutions. These challenges indicate an opportunity where a collaborative, multilateral approach could effectively address them.

Drawing from the insights in Papers A and B, one innovative solution is the development of a transnational EdTech platform. Such a platform, operating within a transnational innovation system, offers a promising avenue for co-creation between diverse stakeholders: EdTech providers, educational institutions, end-users, and policymakers. This platform would not only facilitate collaborative innovation but also enhance transparency and regulation in the procurement process (Yakob and Tell, 2011; Fu et al., 2018; Komljenovic, 2021, 2022; Williamson and Komljenovic, 2022).

A transnational EdTech platform aligns with the concepts of multilateral collaboration and systemic intermediation, as it transcends national borders and leverages the diverse competencies of stakeholders spread across different countries. This approach is particularly relevant in the European context, where shared objectives, regulations, and educational challenges create a unique transnational setting for innovation (European Commission, 2021a,b,c; OECD, 2019, 2023b). Such a platform could serve as a fertile ground for testing, developing, and procuring educational technologies, integrating local specificities with broader EU-driven directives and standards.

Moreover, this platform could mitigate some systemic challenges identified, such as financial constraints and innovation fatigue, by pooling resources, sharing best practices, and creating economies of scale. The platform's role in legitimizing and disseminating information about EdTech development could also help align the varied pedagogical needs of institutions with the technological solutions offered by providers,

addressing the issues of misalignment and misunderstandings. While this solution will likely bring a myriad of novel and unforeseen challenges, a transnational EdTech platform can potentially encapsulate the spirit of a transnational innovation system, where the formation of system resources and structural coupling among different subsystems can lead to more robust and sustainable educational technology solutions. This concept not only aligns with the theoretical underpinnings of transnational innovation systems but also addresses the practical challenges of EdTech procurement in a holistic and collaborative manner.

The importance of end-user insights

Finally, Paper D, while tangentially related to the core themes of procurement explored in Papers A, B, and C, provides insights into the practical use of technologies in teaching and learning. Specifically, it highlights the impact of the COVID-19 pandemic on the adoption of online learning technologies and the mental well-being of students. This exploration complements the earlier discussions by emphasizing the end-user perspective, particularly the students' experiences and challenges in a rapidly evolving digital learning environment.

The transition to online learning, as necessitated by the pandemic, underscores the importance of aligning technological procurement with actual user needs and educational outcomes. Paper D's findings that online learning can supplement but not fully replace traditional learning modalities support the broader themes of balance and alignment discussed throughout the thesis. This insight reinforces the need for educational institutions to not only focus on procuring innovative technologies, but also to consider the broader pedagogical implications and the well-being of students (Mishra and Koehler, 2006; Zydney et al., 2019; Porter and Graham, 2016; Baloran, 2020; Raes et al., 2020a).

Moreover, the experiences during the pandemic highlight the significance of flexibility and adaptability in educational technologies, further enhancing the argument for more collaboration across institutional and national boundaries. The mental well-being of students, along with their motivation and social engagement, emerge as critical factors that should inform the development, procurement, and implementation of EdTech solutions. This perspective aligns with the earlier discussions on the necessity for a more nuanced and user-centered approach in the procurement of educational technologies, emphasizing the interplay between technological innovation and its practical, pedagogical applications. As such, Paper D enriches the general discussion by providing a user-centric lens, a reminder that the ultimate goal of EdTech procurement and innovation is to enhance the educational experience and learning opportunities of students. This addition to the discussion creates a more holistic view of the EdTech landscape, connecting the procurement processes and intermediary roles with the actual utilization and impacts of these technologies in an educational setting.

5.4   Potential Avenues for Future Research

Building upon the findings of this thesis and grounded in the conceptual framework of transnational innovation systems, several promising avenues for future research emerge, particularly in the context of EdTech procurement in Danish higher education. The studies within this thesis have highlighted the challenges and opportunities of this procurement, underscoring the roles of intermediaries, collaboration, and the distinct procurement practices for different types of technologies. These insights pave the way for further exploration into how the dynamics of transnational innovation systems can enhance the procurement and diffusion of educational technologies across borders.

1. **Optimizing procurement practices through transnational collaborations:** The distinction between the procurement of smaller tools and larger systems in Danish higher education opens up a critical research gap. Future studies should investigate how transnational innovation systems can optimize these procurement practices. This involves understanding how cross-border collaborations and EU-wide directives influence both the development and procurement of these technologies, taking into account local practices and regional specificities (European Commission, 2021b; Hillman, 2022; OECD, 2023b; Smith, 2019; Morrison et al., 2015). A central tenet across the research has been the challenges related to public tender processes. Especially for system procurement, this is an area that could benefit from more insights on how to improve the process institutionally, nationally, and trans-nationally. Conversely, EdTech tools is an area ripe for research, in terms of procurement, development, and diffusion alike.

2. **Interdisciplinary research on EdTech lifecycle:** With the increasing global interest in EdTech, especially post-COVID-19, there is a need for interdisciplinary research that encompasses the entire lifecycle of EdTech solutions – from development to diffusion. This research should also consider the influence of transnational innovation systems, examining how global trends and international collaborations impact local procurement processes (Casabayó, 2022; Hollands and Escueta, 2017; Facer and Selwyn, 2021; Williamson and Komljenovic, 2022; DuPont, 2021; Weller, 2018; Granić, 2022). For product development especially, insights on innovation sourcing could be beneficial for companies in the EdTech space, to optimize collaborative innovation opportunities (Tranekjer and Søndergaard, 2013; Zahoor and Al-Tabbaa, 2020; Ek and Sörhammar, 2022)

3. **Balancing digital and physical spaces in education:** The potential of digital technology in education, particularly in transcending traditional barriers, must be researched in tandem with the importance of physical spaces and collaborative activities. While much research has already been exploring how educational institutions can balance technology-enhanced learning with the need for physical interaction, more research is needed to encapsulate and evaluate the potentials and challenges of EdTech in institutions developing education in physical spaces with digital and hybrid learning environments (Mishra and Koehler, 2006; Raes et al., 2020b; Porter and Graham, 2016; Allan et al., 2019; Triyason et al., 2020; Hilli et al., 2019).

4. **Evaluating EdTech solutions in diverse contexts:** The proliferation of EdTech

solutions necessitates research on their effectiveness and practicality in various educational contexts, particularly considering the risks associated with their implementation. Education can be approached wildly differently across the world, and with the ongoing digital and AI developments, educational practices can potentially be immensely affected by the goals and intentions of these novel technologies. This research should evaluate the effectiveness of these technologies within a transnational setting, acknowledging the diverse educational needs and cultural specificities across countries (Hollands and Escueta, 2017; Ryberg, 2021; Renz et al., 2020; Cui, 2019; Daniluk, 2019; Jeppesen and Havinga, 2021; Chen, 2021; Thomas and Nedeva, 2018).

5. **Platform delivery of EdTech and transnational innovation:** The idea of a platform for EdTech delivery, as suggested in Papers A and B, presents a significant research opportunity. Investigating the potential benefits and challenges of such a platform within a transnational innovation system could provide insights into standardizing and diffusing educational technologies across different educational contexts (EEA, 2021; Pangrazio et al., 2022; Tian et al., 2022; Komljenovic, 2021; Torfing et al., 2021; Singh et al., 2020; Adner, 2017; Yakob and Tell, 2011; Fu et al., 2018).

6. **The role of intermediaries in transnational innovation systems:** Given the importance of intermediaries revealed in this thesis, further research is essential to understand their functions within transnational innovation systems. This includes exploring how system intermediaries like the European EdTech Alliance facilitate cross-border collaborations and the establishment of common standards, contributing to the harmonization of practices in varied educational contexts, and how process intermediaries within educational institutions mitigate EdTech procurement. Further, as argued in the thesis, other types of intermediaries likely impact EdTech diffusion, but more research is needed to explore the specifics of their impact (Kivimaa et al., 2019a; Tokumaru, 2022; Edler and Yeow, 2016; Binz and Truffer, 2017; Lukkarinen et al., 2018; Musiolik et al., 2020; Villani et al., 2017).

As we transition from exploring the potential avenues for future research, it is important to recognize how these avenues not only advance academic understanding but also have tangible implications for policymaking in the field of educational technology. The insights and findings of this thesis, while opening new horizons for research, also lay a foundational basis for practical policy considerations. The exploration of EdTech procurement, the role of intermediaries, and the dynamics of transnational innovation systems in Danish higher education, as discussed, informs a spectrum of policy strategies at various organizational and governmental levels.

5.5   Policy implications

The diverse insights developed from this thesis not only enrich academic discourse but also offer pragmatic guidance for policy formulation in the realm of educational technology. The findings underscore the necessity for multifaceted policy approaches that cater to the unique dynamics of EdTech procurement, the integral role of intermediaries, and the complexities inherent in transnational innovation systems.

1. **Institutional-level policymaking:** Danish universities, operating autonomously within the public sector, must navigate the evolving landscape of digitalization with agility and foresight. Policymakers at the institutional level should focus on crafting policies that enhance the efficacy of EdTech procurement processes, taking into account the dual nature of EdTech as both tools and systems. Such policies could involve developing frameworks for assessing the pedagogical and technological alignment of EdTech solutions, thereby ensuring the meaningful integration of these technologies into educational settings. Additionally, there is an opportunity for institutional policies to foster an environment conducive to testing and adopting innovative EdTech solutions, balancing the risks and rewards inherent in embracing new technologies.

2. **National government involvement:** The research highlights the potential for national governments, particularly in the Nordic context, to play a catalytic role in fostering EdTech innovation. Governments should consider policies that not only support the development of robust digital infrastructure but also encourage the formation of collaborative innovation ecosystems. This might involve providing incentives for public-private partnerships in EdTech, facilitating knowledge exchange between educational institutions and technology providers, and supporting initiatives that promote user-centric EdTech development. Moreover, national governments can play a pivotal role in shaping the regulatory landscape to ensure that EdTech procurement is transparent, equitable, and conducive to fostering innovation.

3. **Supranational policy recommendations:** At a broader, supranational level, entities such as the European Union can significantly influence the development of a global EdTech innovation system. The EU's role in standardizing EdTech procurement practices and fostering a common regulatory framework can lead to more efficient and effective adoption of educational technologies across member states. Policymakers at this level should consider revisiting and potentially streamlining public tender processes to mitigate the complexities currently associated with procuring EdTech solutions. By doing so, they can alleviate barriers to innovation, fostering a more dynamic and competitive EdTech market that benefits all stakeholders, including educational institutions, technology providers, and ultimately the end-users – the students.

This thesis not only provides an understanding of the EdTech procurement landscape in Danish higher education but also aims to provide insights for informed policymaking. It underscores the need for policies that are responsive to the nuances of technology adoption in educational settings, cognizant of the transnational nature of innovation, and supportive of collaborative efforts among various stakeholders. As we look to the future, the insights from this research can help guide policy decisions, ensuring that the procurement, adoption, and diffusion of EdTech in educational institutions are aligned with the overarching goal of enhancing educational outcomes and experiences.

The potential of digital technology in breaking barriers of time and space in education is significant. However, striking a balance between technology-enhanced learning and preserving the importance of physical spaces and collaborative activities is crucial. More research is needed to understand the impact of technology adoption on edu-

cational institutions and to explore how they can co-exist with technology providers without compromising educational quality.

In closing, it is imperative that future research continues to explore the procurement, adoption, and diffusion of EdTech in educational institutions to create an environment that fosters innovation, transparency, and collaboration among stakeholders. Ultimately, the pursuit of optimal solutions in EdTech will contribute to the betterment of education and the advancement of learning experiences for students, educators, and institutions alike.

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