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Conversion Master in IT Curriculum

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Digital innovation for business process redesign

Master's Thesis (15 ECTS)

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Abstract:

The focus of this thesis is the adoption of emerging digital technologies in the context of business process management. To better understand the ways in which technology can impact business process redesign, this thesis explores the capabilities of these technologies. This research presents a systematic literature review (SLR) with 26 academic articles (from 2017 to 2021) that describe case studies in which business process redesign is done with the introduction of new technologies. As a result of the SLR, six capabilities of digital technologies were derived and positioned beside 14 identified redesign heuristics. The main contribution of this research is a framework that can support practitioners and researchers in establishing how business processes can be redesigned through the capabilities of digital technologies.

Keywords: business processes, business process redesign, digital technologies, systematic literature review

CERCS: P170 Computer science, numerical analysis, systems, control

Digitaalne innovatsioon äriprotsesside ümberkujundamisel

Lühikokkuvõte:

Käesoleva lõputöö keskmes on tänapäevaste digitehnoloogiate kasutuselevõtt äriprotsesside juhtimise kontekstis. Lõputöös uuritakse nende tehnoloogiate võimekusi (*capabilities*), et paremini mõista viise, kuidas tehnoloogia mõjutab äriprotsesside ümberkujundamist. Uurimistöö meetod on süstemaatiline kirjanduse ülevaade, mis koondab 26 juhtumuuringut (avaldatud vahemikus 2017–2021) äriprotsesside ümberkujundamistest digitaalsete tehnoloogiate abil. Kirjanduse ülevaate tulemusel tuletati 6 digitaaltehnoloogia võimekust ning suhestati need 14 tuvastatud äriprotsesside ümberkujundamise heuristikuga. Magistritöö peamine panus on raamistik, mis aitab ja hõlbustab praktikutel ja uurijatel välja selgitada, kuidas äriprotsesse saab digitaaltehnoloogia võimekuste kaudu ümber kujundada.

Võtmesõnad: äriprotsessid, äriprotsessi ümberkujundamine, digitaaltehnoloogiad, süstemaatiline kirjanduse ülevaade

CERCS: P170 Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine (automaatjuhtimisteooria)

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1. Introduction

The "information revolution" has put immense pressure on companies to pursue digital innovation in order to stay competitive and adjust to changing work methods [1]. One of the significant drivers of innovation in organizations and businesses today is the emergence of new technologies and the subsequent digitalization and adoption of digital technologies in process innovation [2]. Digitalization encompasses "complex organisational change, where the physical and the digital are entwined and configured in new ways" [3]. Therefore, organizations need to understand the relationship between digital technologies, digitalization, and process innovation.

As Mendling et al. [4] put it, "digital innovation is the story about *how we change what we do* because of the digital technologies emerging around us". Since digital technologies are new and constantly evolving, it is not often clear how specific digital technologies impact the improvement and redesign of business processes. One of the main reasons companies are reluctant to adopt new technologies is not so much their lack of knowledge regarding different technologies as such but rather the scarcity of "approaches for classifying and assessing digital technologies" [5]. Lipsmeier et al. [5] see that one of the constructive steps forward is categorizing, classifying, and evaluating digital technologies.

This thesis is situated in the discipline of business process management (BPM) [6] and contributes to the issues of digital innovation and process innovation by concentrating on how business processes change with the help of digital technologies. The thesis aims to contribute to the topic of digital innovation by systematizing and aggregating knowledge about different digital technologies and their capabilities in the context of business process redesign. The thesis argues that change is not brought about by digital technologies as such but rather results from the ways in which they are used.

The thesis centers around two research questions (RQ): *RQ1. What are the capabilities of digital technologies that can be used to redesign business processes? RQ2. How can business processes be redesigned through the capabilities of digital technologies?* The thesis aims to understand how businesses adapt to changing circumstances by redesigning their business processes through the capabilities of new digital technologies. The research is based on a systematic literature review (SLR) where case studies that provide information about how business processes have been redesigned by implementing new digital technology are analyzed.

The goal is to discover how the capabilities of technologies allow to improve an existing process. Hence, the aim of this thesis is not to focus on the enablers or barriers of implementing innovative digital technologies nor to measure the (un)successfulness of digital transformation projects but instead to provide a general framework to assess digital technologies through their capabilities and offer an overview of business process redesign through the lens of these capabilities. BPM practitioners can benefit from this framework by using it as a practical decision-making tool in business process redesign projects.

The remainder of the thesis is structured as follows. Section 2 outlines the key terms and relevant contextual background. Section 3 presents an overview of research related to this thesis. Section 4 offers a detailed overview of the SLR process. Section 5 summarizes the results of the SLR. Section 6 presents and describes the results of this research as a framework that brings together process redesign and the capabilities of digital technologies. Section 7 summarizes the research and offers concluding remarks.

2. Background

This section defines what is meant by business process, gives a brief overview of business process management (BPM), and describes the redesign phase in the BPM lifecycle. The section also explains what is meant by redesign heuristics. Finally, what is meant by digital technologies and digital capabilities is specified.

2.1 Business process management

As Dumas et al. put it, processes are “chains of events, activities and decisions” that business process management as a discipline understands as something that organizations (public, private, non-profit) have to *manage* [6]. In other words, be it the steps from *quote-to-order*, *order-to-cash*, or *issue-to-resolution*, “business processes are what companies do whenever they deliver a service or a product to customers”[6]. Simply put, processes present a way to structure, explain, and explicate the activities performed in an organization.

According to Dumas et al., Business Process Management (BPM) is concerned with the alignment of performance objectives and business processes in an organization [6]. It deals with the analysis of the work performed by an organization and its outcomes to provide opportunities for improvement [6]. To sum up, BPM is a discipline concerned with researching and theorizing the nature of business processes and developing the discourse around how to talk about organizations in a process-based way to enable and facilitate continuous improvement.

BPM can be viewed as a “continuous cycle” – one that begins with the identification of a process that leads to the subsequent phases of discovery, analysis, redesign, implementation, and monitoring – that is known as the BPM lifecycle (Figure 1) [6]. Simply put, it is a circular model that conceptualizes different phases of business process management. This thesis is primarily focused on the *process redesign* phase.

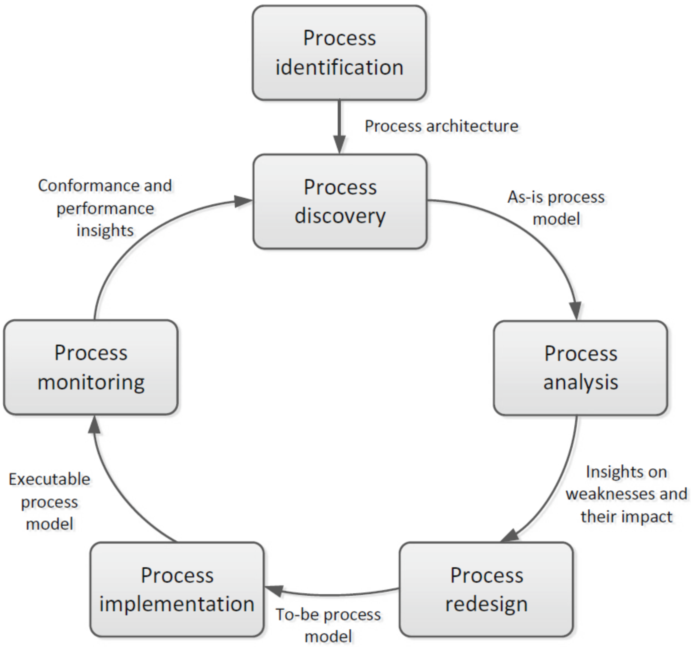

Figure 1. BPM Lifecycle [6]

The process redesign phase deals with the issues that have been elicited in the process analysis phase [6]. However, whereas the analysis phase raises the issues that need to be addressed, the aim of the redesign phase is to pick the "most promising change options" related to the issues at hand, and as a result, a to-be process model is presented that serves as a basis for the implementation phase[6]. The following section introduces the idea of best practices in business process redesign.

2.2 Redesign heuristics

According to Dumas et al. [6], the redesign process ought to be methodological in order to limit the possibilities where "interesting redesign opportunities" are not considered. One of the redesign methods is the *heuristic process redesign* method, where "the emphasis is on the systematic consideration of a wide range of redesign principles" [6]. These redesign principles are also called *redesign heuristics* that "can be seen as rules of thumb for deriving a different process from an existing one" [6].

Table 1. Most popular best practices in business process redesign [7]

Best practice	**Definition**
1. Task elimination	Eliminate unnecessary tasks from a business process
2. Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks
3. Integral technology	Try to elevate physical constraints in a business process by applying new technology
4. Empower	Give workers most of the decision-making authority and reduce middle management
5. Order assignment	Let workers perform as many steps as possible for single orders
6. Resequencing	Move tasks to more appropriate places
7. Specialist-generalist	Consider to make resources more specialized or more generalist
8. Integration	Consider the integration with a business process of the customer or a supplier
9. Parallelism	Consider whether tasks may be executed in parallel
10. Numerical involvement	Minimize the number of departments, groups and persons involved in a business process

Mansar and Reijers [7] have defined a framework that consists of 29 best practices, out of which 10 have been further labeled as the most popular redesign heuristics. These are presented in Table 1. These rules of thumb are meant to serve as a guideline for business process redesign. In this thesis they serve as a theoretical background for the analysis of the case studies in section 5.2.

2.3 Digital technologies and capabilities

While it might seem straightforward that digital transformation happens when digital technologies and techniques are applied in certain organizational contexts [8], defining *digital technology* is a much more complex issue. As Lipsmeier et al. [5] offer a brief discussion about the semantic difficulties regarding terms such as *technology*, *technical problem*, and *digital technology*, they still provide a concise definition of *digital technology*, which is also the basis for this thesis. They see *digital technologies* as technologies that "comprise knowledge, skills and know-how for the creation, processing, transmission and use of digital data as well as systems and procedures for practical implementation"[5]. Moreover, they also offer a comprehensive list of digital technologies divided into eight classes: analytics, connectivity, fabrication, H2M interface, interactivity, sensoring, storage, and visualization [5].

In this thesis, however, the technology framework of Pousttchi et al. [8] serves as a guiding structure to classify digital technologies in the SLR. Similarly to Lipsmeier et al. [5], Pousttchi et al. [8] also offer a comprehensive framework of different technologies. The advantage of the latter model is that the three major areas of technology – communication and other enabling technologies; technologies combining hardware and software in intelligent systems; data technologies – are also supported by a comprehensive list of both characteristics and respective illustrative instances [8].

As Korhonen and Gill [9] note, there has been considerable interest among researchers and practitioners of digital innovation in the concept of *digital capability*. In general terms, this concept refers to the “capacity“ of enterprises “to integrate and utilize digital data and information technologies in its products, services, business processes, and organizational systems and practices to create added value to its constituents and beneficiaries” [9]. Discussing *digital capabilities*, Milani [10] notes that introducing and implementing new digital solutions in companies can be integrated either into existing capabilities (e.g., introducing digital marketing to marketing) or be wholly new digital capabilities (e.g., digital data analysis). On the other hand, Sandberg defines *digital capability* as a concept that frames the “organizational routines for strategizing in competitive landscapes where IT is a key driver of organizational change” [11].

While the terms *digital* and *capability/capabilities* are central to this thesis, it is not interested in studying the role of digital technology/technologies in organizations and companies through the concept of *digital capability*. Namely, the focus of this thesis is on the capabilities of *digital technologies* in the context of business process redesign. As Henriette et al. note [12] in their SLR on digital transformation, the boundaries and definitions of digital capabilities remain largely vague or unidentified. Still, they present six concrete digital capabilities based on their SLR – digitalization/dematerialization, internet technologies, analytics, mobility, social network, knowledge and skills – that they define as “a kind of IT capability” [12]. Following their example, this thesis brings together particular digital technologies and their capabilities in the context of business process redesign.

3. Related work

This section gives an overview of the related works that deal with the topics presented in this thesis: BPM, digital innovation, and digital technologies.

Starting with the latter, Ribeiro da Silva et al. [13] look at the factors that enable or prevent the implementation of digital technologies and "assist managers to more carefully and accurately design" implementation projects. Basing their research on digital manufacturing, they bring out three key points: a) the organizational culture that needs to be considered instead of trying to implement recipe-based changes; b) technology cannot be implemented without changing the product life cycle; c) change does not happen "periodically, it could be continuous or event driven" [13]. Their research explicates the critical and general issues that should be discussed while planning the implementation of digital technologies to allow for more adequately designed implementation projects. This thesis complements their research by focusing on the implications of particular technologies in the context of process redesign.

Whereas Ribeiro da Silva et al. [13] focus on the implementation of digital technologies in the context of Industry 4.0 at a general level, Ardolino et al. [14] look at how three digital technologies – the Internet of things (IoT), cloud computing (CC) and predictive analysis (PA) – impact manufacturing. The research is based on a literature review and four case studies, and the authors identify 11 digital capabilities for these three technologies. The authors are interested in "servitisation and the digital transformation of manufacturers" and explore the shifting from being an *equipment supplier* to taking one of the three service transformation paths – becoming an *availability provider*, a *performance provider*, or an *industrialiser* [14]. In a similar vein, Chen et al. [15] focus on IoT in the context of the manufacturing industry. They base their findings on a longitudinal study of one manufacturing firm, explore its "transformation towards servitization" and argue that IoT data can "generate valuable marketing insights and stimulate service thinking" [15]. While [14], [15] offer valuable insight into how the transformation from product-based to service-based logic in manufacturing is intertwined with digital technologies, this thesis is not interested in industry-specific issues and takes a broader and more encompassing view on digital technologies and process redesign.

Mikalef and Krogstie [16] focus on data technology and look at organizations' *process innovation capability* – innovation activities related to new processes – regarding the implementation of big data analytics (BDA) resources. They aim to understand the interplay between BDA resources, organizational aspects, and the business environment [16]. While Mikalef and Krogstie [16] take a cross-industry approach to Norway's largest companies, Babu et al. [17] consider artificial intelligence (AI) in the textile and apparel (T&A) industry. Based on their SLR and in-depth interviews with experts, they explore industry-specific opportunities and challenges of implementing AI as a *dynamic capability* – "a combination and reconfiguration of management processes, adaptability and resource capabilities" – to improve the agility of manufacturing practices [17]. By bringing together the notions of *process innovation* and *capabilities* with the implementation of particular technologies, the works of [16], [17] complement the discussion of the capabilities of digital technologies, which is one of the key concerns of the thesis. However, in contrast, this thesis focuses on a broader spectrum of technologies and follows a different notion of capabilities (see section 2.3).

While [14]–[17] discuss innovation on the *process* level, Karttunen et al. [18] take a multi-case-study and cross-domain approach to analyze what are the necessary operational capabilities needed for implementing IoT-based business *models*. Their main contribution is a framework that ties together necessary operational capabilities and offers empirical examples and practical guidelines related to implementing IoT-driven innovations [18].

One of the contributions of this thesis is to offer a framework that brings together the capabilities of digital technologies and business process redesign. Related studies that build frameworks for practitioners that help reduce complexity or support decision-making in process innovation offer multiple perspectives and help to understand the intention of this thesis better. For example, Denner et al. [19] ask “how organizations can systematically exploit the digitalization potential of their business processes”. Their answer is a practical four-step framework that deals with the complexity of activities, techniques, tools, roles, and outputs relevant to digitalization endeavors. The central aim of their framework is to “stimulate and structure consensus-oriented discussions among the business-, process-, and IT-related roles involved in process improvement to identify the most suitable digital technologies for the process in focus” [19].

Contributing to the dialogue regarding risks in digital innovation, van Looy [2] points out that the uncertainties are even more amplified when innovation involves immature or emerging technologies such as AI, IoT, and virtual reality. Based on expert interviews and case studies, the author builds a practical framework that supports decision-making in digital process innovation. The framework brings together environmental, strategic, and IT misalignments as well as employee resistance and management support and outlines practical solutions based on empirical material [2].

BPM is an essential background of the thesis. Hence the works that delve into discussions on the relationship between BPM and digital innovation allow for a better understanding of their (potential) synthesis, combination, and co-evolution. For example, Imgrund et al. [20] juxtapose BPM with the umbrella term *digitalization* to explore how the “methods, techniques, and systems” of BPM can (or should) be the “starting point for embarking on the journey of digitalization” in small and medium-sized enterprises (SME). More specifically, they demonstrate how BPM can help create a better understanding of the requirements of digitalization, such as facilitating the creation and digitization of process models, improving coordination, and connecting parts of an organization through process-oriented thinking [20].

Whereas Imgrund et al. [20] focus on digitalization, Mendling et al. [4] compare the research agendas of BPM and *digital innovation*. While the former takes a more practical approach, the latter offers a more nuanced discussion of the fundamental assumptions, objectives, and strengths of both research agendas. Regardless of the “methodological disjointness” of these research fields, Mendling et al. [4] nevertheless argue for their synthesis and offer two potential, mutually beneficial opportunities. First, they show how process mining technologies used in BPM could also be used to mine data generated from the usage of digital devices in order to understand patterns of behavior. Secondly, they argue that bringing computational methods from digital innovation to BPM and taking configurational approaches to digital innovation research allows for a better understanding of context [4]. While Mendling et al. [4] open up the (hidden) potential of combining the two paradigms, Ahmad and van Looy [21] analyze the “co-evolution” of BPM and digital innovation. Based on their comprehensive SLR and expert panel of practitioners, the authors outline seven “BPM-DI trends”. The relationship between BPM and digital innovation has also been analyzed by van Looy [1] from the perspective of “practitioners who combine

BPM with DI". The research offers insights into attitudes and (negative) perceptions and provides a contextual view of the relationship between BPM and DI [1].

Previously discussed works have focused on enablers and barriers of implementing digital technologies, organizational risks, and a broader meta-level discussion on the inter-play of BPM and digital innovation. In terms of process innovation, the final step is to evaluate the impact of an implementation project. An exemplary case is the work of Cho et al. [22] which focuses on the redesign phase of the BPM lifecycle. They develop a straightforward "tool to assess process redesign improvements" and calculate indicators that measure the success of a particular redesign project. Moreover, following the best practices of business process redesign (also discussed in section 2.2 of this thesis), their framework allows to assess process performance and the application of redesign best practices as well as to measure to what extent they have been employed [22]. This thesis contributes to their proposed method by offering a closer look at the impact digital technologies have on the redesign process before the success of a redesign project is assessed.

4. Systematic Literature Review

4.1 Planning and Motivation

This research aims to collect and structure knowledge about actual business process redesign case studies that are driven by the implementation of digital technologies. More specifically, the focus is on the capabilities of specific digital technologies and how introducing new digital technologies enables the business process's redesign across domains and industries. In this research project, the objective and motivation for deciding on SLR are to explore what digital technologies and which of their capabilities can be used to redesign business processes. SLR is particularly suitable in regard to the broad spectrum of digital technologies currently introduced in business process redesign projects in various industries. A systematic literature review (SLR) protocol is offered in the following sections.

This research follows the guidelines for SLR proposed by Kitchenham and Charters [23]. The process of SLR consists of three main phases – planning, conducting, and reporting, that each involves a number of specific stages. The planning phase is primarily associated with describing the need (or motivation) for a review, specifying the research questions, and writing the draft review protocol. The conducting phase involves identifying relevant research, selection of studies, and data extraction and monitoring. The reporting phase is associated with the dissemination and formatting of the report. However, as Kitchenham and Charters [23] note, the different stages of the review process are not necessarily sequential but can also be iterative. For example, the inclusion and exclusion criteria set in the draft protocol can be refined during the research process.

4.2 Research Questions

The two main research questions of the thesis are the following:

(1) **RQ1. What are the capabilities of digital technologies that can be used to redesign business processes?** The aim is to explore which specific digital technologies have been used in actual business process redesigns and are described in current research. More specifically, the aim is to focus on the actual digital technologies and their capabilities that were introduced in business process redesign and the motivation behind these (e.g., efficiency etc.).

(2) **RQ2. How can business processes be redesigned through the capabilities of digital technologies?** Once the digital technologies and capabilities have been identified, the next step is to look more into the redesign part and discover the ways in which different digital capabilities lead to different redesign outcomes. More specifically, if a certain capability of digital technology is introduced, what can be done with it in terms of business process redesign.

4.3 Search Strategy

The basis for the search strategy is the need to find relevant scientific studies in order to answer the research questions. According to Fink [24], after formulating the research question, the next main steps in the review are the selection of relevant databases and/or websites and deciding upon relevant search terms. These steps are followed by applying practical screening criteria. As described by Okoli [25], there are two main aims of the practical screen – decide on the inclusion criteria and evaluate the appropriate number of studies according to the restrictions of the research project.

As suggested by Kitchenham and Charters [23], the research strings that are used in the database search for literature should be based on, address and answer the research questions. The terms used for the search are the following:

(1) *"business process"* – the key term of the research that defines the foundation of the study.

(2) *"digital"* – the derived term from the research question as the research is interested digital technology.

(3) *"case study"* – the research is interested in search results where the implementation of digital technologies has been validated in a case study.

Based on the search terms, the following search string was formulated:

"business process" AND *"digital"* AND *"case study"*

Based on the coverage of papers in the field of computer science and the prominence of peer-reviewed content that can be accessed within the university domain, the following databases were used:

(1) Web of Science

(2) Scopus

4.4 Selection Criteria

In each SLR project, the researcher also needs to decide on inclusion and exclusion criteria. Establishing the selection criteria for the papers is part of the process of practical screen, as explained by Okoli [25] and Fink [24]. Selection criteria are most commonly expressed as inclusion and exclusion criteria. Examples of the criteria for inclusion/exclusion are for example language, date of the publication, type of the publication etc. [23]. In the current SLR, the exclusion criteria (EC) and inclusion criteria (IC) were the following:

(1) Exclusion criteria (EC):

   a. **EC1: Is the language of the study English?** All search results that are not available in English are omitted due to the limitations of the language skills of the reviewer.

   b. **EC2: Is the paper a duplicate?** Papers published with the same title by the same author(s) and/or with identical DOI-s are excluded.

   c. **EC3: Is it possible to identify a particular paper?** For example, whole conference review collections as such are not considered as papers for data extraction and analysis in the SLR because search results do not provide individual titles of particular papers, author name(s), and abstracts.

   d. **EC4: Is the paper accessible to the reviewer?** All papers that are not accessible through University Library's subscription nor freely accessible in full-text version are excluded from the review.

(2) Inclusion criteria (IC):

   a. **IC1: Does the paper explicitly discuss a particular digital technology in the context of business process redesign?** Papers that discuss at least one digital technology in the context of business process are included. Papers must provide enough information for data extraction.

b. **IC2: Has the implementation of digital technology been validated in a case study?** Case studies across fields and domains are included in the review.

c. **IC3: Was the paper published in 2017 or later?** This inclusion criterion is focused on identifying the most recent case studies.

4.5 Search Procedure

The formulated search string was used to execute searches in two databases – Web of Science and Scopus. The search results are shown in Table 2. The search result lists from both databases were downloaded and merged into a single list composed of 260 publications.

Table 2. Papers identified per source

Source	**Papers identified**
Web of Science	79
Scopus	181
Total	**260**

The selection procedure was conducted in accordance with the selection criteria. The steps included: removing duplicates, removing papers not written in English, removing papers with no author, filtering by paper abstract, and finally, filtering by reading the entire paper. The results of the selection procedure are shown in Table 3.

Table 3. Results of the selection procedure

	Search 1	
Selection Criteria	**Number of papers found**	**Number of papers left**
Search results	260	
Filtering out duplicates	40	220
Filtering non-English papers	6	214
Filtering out results where a particular paper is not identifiable	23	191
Filtering by paper abstract	108	83
Filtering by reading the full paper	70	13
Backward referencing	13	
Total		**26**

(1) **Filtering out duplicates**. Since the exact search string was applied to two databases, some papers naturally occur in both search results. The duplicates were identified by matching titles and authors as well as identical DOI-s. The first step was to remove the duplicates from the list, which resulted in the removal of 40 papers, leaving 220 papers.

(2) Filtering non-English papers. Search results written in other languages besides English were removed from the list. As a result, six papers were removed, resulting in 214 papers.

(3) Filtering out results where a particular paper is not identifiable. Publications that had no author name available were identified, and as a result, 23 conference reviews with no author were removed, leaving 191 papers for the next round of filtering.

(4) Filtering by paper abstract. The rest of the papers were filtered in regard to the abstract matching the research topic, research questions, and selection criteria. If the paper clearly did not match the selection criteria, it was removed from the list. If it was unclear from the abstract whether the paper matched the selection criteria, it was moved on to the next filtering stage. As a result, 108 papers were removed in this stage, resulting in 83 papers making it to the final round of the filtering.

(5) Filtering by reading the full paper. Based on the selection criteria IC1, IC2, and EC1, EC4, 70 papers were filtered out. As a result, the final list of the search consisted of 13 papers.

(6) Backward referencing. Additionally, 13 papers were added in the process of backward referencing. The final list of papers for this SLR is composed of 26 papers.

4.6 Data Extraction Strategy

A critical step in the SLR procedure is the extraction of data. To ensure that the data extracted is based on the research question(s) and is also extracted in a systematic manner, Okoli [25] recommends designing a data extraction form. The data extraction form in this study consists of three categories of data:

(1) **Identification data.** Data that allows to identify the paper: paper title and authors. In addition, each paper is labeled with a unique identifier to enable referencing in the analysis.

(2) **Study context.** Data that lays out the context of the case study, giving information about the main contours (abstract, main technology, As-Is process).

(3) **Process redesign.** Data that describes the redesign of the business process (To-Be process, what changed, how technology enabled the change, digital capability, redesign heuristic).

The data extraction form is presented in Table 4.

Table 4. Data extraction form

Identification Data	
ID	Unique identifier of the paper
Title	Title of the paper

Author(s)	Authors of the paper
Study context	
Abstract	Abstract of the paper
Main technology	Specific technology implemented in the case study.
As-Is Process	Process before the implementation of digital technology in the case study.
Process Redesign	
To-Be process	Process after the implementation of a digital technology in the case study.
What changed	Which elements of the process were transformed.
How technology enabled the change	Describes the particular impact of the digital technology on the process redesign.
Digital capability	Indicates the specific capability of the digital technology that was introduced.
Redesign heuristic	Describes in which way the process was redesigned.

4.7 Data Synthesis and Reporting

Following the data extraction, the next part of SLR was to synthesize the data according to the central research questions, key terms and concepts that are business process redesign, digital technologies and capabilities, and redesign heuristics. The data extraction table served as a basis for the analysis.

While one of the guiding examples for identifying different capabilities was the work of Henriette et al. [12], the final list of capabilities stems from the case studies. Thus, the capabilities discovered result from combining inductive and deductive approaches to data analysis.

Mansar and Reijers [7] have defined a framework of redesign heuristics that consists of 29 best practices which Dumas et al. [6] have further developed by providing concrete examples and discussing various aspects of said heuristics. These heuristics served as a basis for data analysis regarding the best practices for business process redesign.

4.8 Overview of Publications

This section presents an overview of the papers included in this research. The complete list of 26 papers included in this SLR is presented in Table 5.

Table 5. Papers included in the SLR

ID	Article Title	Authors	Year
P01	The effect of digital technologies adoption in healthcare industry: a case based analysis	Laurenza, E; Quintano, M; Schiavone, F; Vrontis, D	2018

P02	Digitalization in the sea-land supply chain: experiences from Italy in rethinking the port operations within inter-organizational relationships	Di Vaio, A; Varriale, L	2020
P03	Supporting Process Innovation with Lightweight IT at an Emergency Unit	Ovrelid, E; Halvorsen, MR	2018
P04	The Use of Robotic Process Automation (RPA) as an Element of Smart City Implementation: A Case Study of Electricity Billing Document Management at Bydgoszcz City Hall	Sobczak, A; Ziora, L	2021
P05	Modeling and analysis of a quality traceability framework for phosphate extraction process: evidence from Morocco	Lafquih, H; Elhaq, SL; Krimi, I; Berquedich, M	2021
P06	Multitier digital twin approach for agile supply chain management	Shevtshenko E., Mahmood K., Karaulova T., Raji I.O.	2020
P07	A workflow for building site digitalization	Di Giuda G.M., Marcandalli G., Sanvito L., Schievano M., Paleari F.	2021
P08	Self service system for library automation: Case study at Telkom university open Library	Karna N., Pratama D., Ramzani M.	2019
P09	Analysis of Digitalization in Healthcare: Case Study	Gavrilov G., Simov O., Trajkovik V.	2020
P10	Achieving Trust, Relational Governance and Innovation in Information Technology Outsourcing Through Digital Collaboration	Vaia G., DeLone W., Arkhipova D., Moretti A.	2020
P11	Human-in-the-Loop Control Processes in Gas Turbine Maintenance	Barz, M; Poller, P; Schneider, M; Zillner, S; Sonntag, D	2017
P12	The effect of islands of improvement on the maturity models for industry 4.0: The implementation of an inventory management system in a beverage factory	Barbalho S.C.M., Dantas R.F.	2021
P13	The Role of Industry 4.0 and BPMN in the Arise of Condition-Based and Predictive Maintenance: A Case Study in the Automotive Industry	Fernandes, J; Reis, J; Melao, N; Teixeira, L; Amorim, M	2021
P14	Developing and Implementing a Process-Performance Management System: Experiences from S-Y Systems Technologies Europe GmbH—A Global Automotive Supplier	Josef Blasini, Susanne Leist, and Werner Merkl	2018

P15	Enabling Flexibility of Business Processes Using Compliance Rules: The Case of Mobiliar	Thanh Tran Thi Kim, Erhard Weiss, Christoph Ruhsam, Christoph Czepa, Huy Tran, and Uwe Zdun	2018
P16	People-Centric, ICT-Enabled Process Innovations via Community, Public and Private Sector Partnership, and e-Leadership: The Case of the Dompe eHospital in Sri Lanka	Wasana Bandara, Rehan Syed, Bandula Ranathunga, and K.B. Sampath Kulathilaka	2018
P17	Managing Environmental Protection Processes via BPM at Deutsche Bahn	Ingo Rau, Iris Rabener, Jürgen Neumann, and Svetlana Bloching	2018
P18	Business Process Management in the Manufacturing Industry: ERP Replacement and ISO 9001 Recertification Supported by the icebricks Method	Jörg Becker, Nico Clever, Justus Holler, and Maria Neumann	2018
P19	Adoption of RFID Technology: The Case of Adler—A European Fashion Retail Company	Roland Leitz, Andreas Solti, Alexander Weinhard, and Jan Mendling	2018
P20	Integrate Your Partners into Your Business Processes Using Interactive Forms: The Case of Automotive Industry Company HEYCO	Bernhard Schindlbeck and Peter Kleinschmidt	2018
P21	Leading 20,000+ Employees with a Process-Oriented Management System: Insights into Process Management at Lufthansa Technik Group	Mirko Kloppenburg, Janina Kettenbohrer, Daniel Beimborn, and Michael Bögle	2018
P22	Process Automation at Generali CEE Holding: A Journey to Digitalization	Jan Marek, Kurt Blümlein, and Charlotte Wehking	2021
P23	Sensor-Enabled Wearable Process Support in the Production Industry	Stefan Schönig, Andreas Ermer, and Stefan Jablonski	2021
P24	Enabling Financing in Agricultural Supply Chains Through Blockchain	Luise Pufahl, Bridie Ohlsson, Ingo Weber, Garrett Harper, and Emma Weston	2021
P25	Digital Transformation of Global Accounting at Deutsche Bahn Group: The Case of the TIM BPM Suite	Fabian Ludacka, Jean Duell, and Philipp Waibel	2021
P26	Adoption of Globally Unified Process Standards: The Case of the Production Company Marabu	Klaus Cee, Iris Bruns, Andreas Schachermeier, Lena Franziska Kaiser	2021

5. Systematic Literature Review Results

In this section, the results of the SLR are presented. First, the capabilities of digital technologies are discussed (RQ1). Then, the redesign heuristics are presented (RQ2).

5.1 Capabilities of digital technologies

This section presents the capabilities of digital technologies that can be used to redesign business processes. As noted in section 2.3, digital capability can be seen as "an enterprise's capacity to integrate and utilize digital data and information technologies" [9]. In this thesis, the capability of digital technology is understood as a specific capacity of technology to enable business process redesign. Since this thesis focuses more specifically on business processes and the redesign phase in the BPM lifecycle (described in section 2.1), the capability of digital technology cannot be separated from the notion of process redesign.

The aim is to show how different kinds of capabilities emerge and impact process redesign in a specific way. The resulting capabilities stem from the cases analyzed in the SLR and relate to the introduction of digital technologies. Six different capabilities of digital technologies were identified in the literature review. These capabilities are not exclusive since the cases show that one technology can have several capabilities. The main results, along with the definitions of each capability, are presented in Table 6.

Table 6. Capabilities of digital technologies

Capability of digital technology	Definition of capability	Digital technology	References
Digitalization/dematerialization (15 cases)	Transforming paper-based activities into digital information processing by introducing new digital devices, applications, systems and/or replacing manual labor and physical contact with digital tools, platforms, or environments.	Digital platform, electronic whiteboards and smart mobile phones, robotic process automation (RPA) tools, web application, document management system platform, radio frequency identification (RFID) based self-service system, electronic service, smart pen technology, health management IT system, BPMS web application, RFID, interactive forms, BPM platform, blockchain, digital process automation software	P02, P03, P04, P05, P07, P08, P09, P11, P16, P17, P19, P20, P22, P24, P25
Knowledge management (13 cases)	Providing standardized information and data management such as sharing documents and quick access to information and creating transparency and a secured data system among people, processes,	Web portal, digital platform, web application, document management system platform, digital collaboration tool, health management IT system, BPMS web application, web-based modeling environment, process-oriented management system web application, BPM platform, block-	P01, P02, P05, P07, P10, P16, P17, P18, P21, P22, P24, P25, P26

	organization(s).	chain, digital process automation software, quality management (QM) system software	
Analytics (11 cases)	Collecting and analyzing immediate/real-time/automatic data, organizational behavior, and processes and/or enhancing control or traceability.	Multitier digital twin, smart pen technology, inventory management system, real-time monitoring system, process performance management (PPM) dashboard, adaptive case management (ACM) technology, health management IT system, web-based modeling environment, process-oriented management system web application, BPM platform, wearables	P06, P11, P12, P13, P14, P15, P16, P18, P21, P22, P23
Communication (5 cases)	Enabling effective communication through a more dynamic flow of information and social collaboration among stakeholders/employees.	Electronic whiteboards and smart mobile phones, digital collaboration tool, ACM technology, digital process automation software, QM system software	P03, P10, P15, P25, P26
Visualization (5 cases)	Allowing the visualization and graphic representation of business processes and/or automatically collected process data.	Multitier digital twin, smart pen technology, real-time monitoring system, BPM platform, wearables	P06, P11, P13, P22, P23
Mobility (1 case)	Affording movability and portability in operational business processes and their improvement.	Wearables	P23

The first capability is *digitalization/dematerialization*, which was identified in 15 out of the 26 cases. These cases can be divided into (a) moving from paper-based activities to digital information processing [P02, P16, P22], (b) introduction of new digital devices [P03, P11], and (c) replacing manual labor and physical contact with digital tools, platforms, or environments [P04, P05, P07, P08, P09, P17, P19, P20, P24, P25]. For example, building a digitized health management information system in a hospital previously running their daily lives largely on paper [P16], introducing electronic whiteboards and smart mobile phones to digitize communication at a hospital [P03], replacing manual data processing with robotic process automation tools [P04].

The second capability is *knowledge management*, which was identified in 13 out of the 26 cases. These cases deal with standardized information and data management, such as sharing documents and quick access to information [P01, P02, P07, P17, P18, P21, P22, P25] and providing stakeholders' transparency and a secured data system [P05, P10, P16, P24, P26]. For example, introducing a web-based modeling system to enable knowledge-sharing [P18] or building a digital platform based on blockchain technology to facilitate knowledge about financial transactions in the agri-supply chain [P24].

The third capability is *analytics*, which was identified in 11 out of the 26 cases. These cases deal with immediate/real-time/automatic data collection and analysis [P11, P13], analyzing organizational behavior and processes [P06, P14, P15, P18, P21, P22], and providing control or traceability [P12, P16, P23]. For example, introducing smart pen enabled incident reports that allow immediate digitization and integration into a central knowledge base [P11], introducing a Process Performance Management (PPM) dashboard to measure performance [P14] or an inventory management system that enables automatic inventory control [P12].

The fourth capability is *communication*, which was identified in 5 out of the 26 cases. These cases describe how digital technology makes communication more effective and allows for a more dynamic flow of information [P03, P15, P25] and social collaboration [P10, P26] among stakeholders/employees. For example, replacing e-mail as a means of communication with a new central digital system for accounting [P25] or introducing a Quality Management (QM) system to enhance global communication between subsidiaries of an international enterprise [P26].

The fifth capability is *visualization*, which was also identified in 5 out of the 26 cases. These cases deal with visualizing whole business processes [P06, P22], incidents [P11], or current process data [P23], as well as enabling graphic representation of data collected by sensors [P13]. For example, providing a graphical representation of processes after introducing a BPM platform [P22] or offering a clear picture of electronically searchable incidents enabled by smart pen technology and digitized incident reports [P11].

The sixth capability is *mobility*, which was identified in 1 out of the 26 cases. This case describes the capability of mobile technologies such as wearables to reduce the time to obtain information and intervene at the production line of a plant [P23].

5.2 Business process redesign

This section presents the ways in which business processes can be redesigned through the capabilities of digital technologies. Out of the 29 heuristics proposed by Mansar and Reijers [7], 14 were identified from the literature review. These heuristics are not exclusive since the cases show that one process can be redesigned in several ways. These heuristics fall under different categories depending on the focus or aspect of the redesign regarding the business process. Table 7 gives a general overview of the heuristics and opens up the ways in which processes were redesigned in the case studies analyzed. In the table, the categories, heuristics, and definitions are based on Mansar and Reijers [7].

Table 7. Redesign heuristics (based on [7])

Category	**Heuristic name**	**Definition**	**References**
Technology	Integral technology	Try to elevate physical constraints in a business process by applying new technology	P01, P02, P03, P05, P06, P07, P08, P09, P10, P11, P12, P14, P15, P16, P17, P18, P19, P21, P22, P23, P24, P25, P26
	Task automation	Consider automating tasks	P04, P13, P19, P20

Category	Heuristic name	Definition	References
Customers	Integration	Consider the integration with a business process of the customer or a supplier	P01, P02, P24, P26
Operation view	Order-based work	Consider removing batch-processing and periodic activities from a business process	P03
	Task elimination	Eliminate unnecessary tasks from a business	P04, P05, P08, P09, P11, P13, P15, P16, P19, P20, P22
Organisation: structure	Centralization	Treat geographically dispersed resources as if they are centralized	P07, P25, P26
	Numerical in-volvement	Minimize the number of depart-ments, groups and persons in-volved in a business process	P08, P23, P25
	Flexible assign-ment	Assign resources in such a way that maximal flexibility is pre-served for the near future	P18
Organisation: population	Specialist-generalist	Consider to make resources more specialized or more generalist	P15
External environment	Interfacing	Consider a standardized interface with customers and partners	P10, P17, P26
	Trusted party	Instead of determining information oneself, use results of a trusted party	P24
Information	Control addition	Check the completeness and cor-rectness of incoming materials and check the output before it is sent to customers	P12, P14, P17, P19, P21
Behavioral view	Resequencing	Move tasks to more appropriate places	P16, P23
	Parallelism	Consider whether tasks may be executed in parallel	P19

Based on the heuristics presented in Table 7 and the capabilities discussed in section 5.1, a detailed case-by-case description of redesign outcomes is available in Appendix I. However, a general overview of the most important results is presented in the remainder of this section.

Since this thesis focuses on cases where digital technologies are introduced, all the papers analyzed fall into the category of technology. In the framework of Mansar and Reijers [7], the two heuristics in this category are *integral technology*, which is the introduction of a new technology, and *task automation*, which deals with automating tasks.

The redesign outcomes related to the capability *digitalization/dematerialization* involve replacing manual, paper-based activities with ones that are digital, automated, or based on self-service systems. The name of the capability consists of digitalization and *dematerialization* because the purpose of digitalization is often to dematerialize parts or whole business processes and enable fundamental transformations of previously physical objects, mediums, and/or employees central in the process. In terms of process redesigns, *task elimination* – which deals with change on the operational level and is concerned with improving the process through eliminating unnecessary elements or activities – is one of the most common best practices.

The redesign outcomes related to the capability *knowledge management* involve digital innovations regarding documents, documentation, and documenting. This means both documentation inside the organization, between organizations and/or between the customer and organization. In terms of process redesign, prominent best practices are *integration* of customers and suppliers and *interfacing* with customers and partners. When the emphasis of the redesign is more on the digitalization of knowledge management, the best practices for redesign include *centralization* of organizational resources, *control addition* within the flow of information, and relying on a *trusted party* to establish the trustworthiness of the information.

The redesign outcomes related to the capability *analytics* concern digital innovations that improve the ability to make sense of business processes on various levels and from different perspectives. The best practice in these cases is *control addition*. However, analytics differs from knowledge management in the sense that the question is not so much about improving document management processes but enabling the transformation of information-related processes through valuable insights provided by data (analysis). When the emphasis of the redesign is both on *knowledge management* and *analytics* capabilities of digital technology, the outcomes are structural and allow for a more *flexible assignment* of resources in an organization.

The redesign outcomes related to the capability *visualization* invariably occur in conjunction with *analytics*, adding an extra layer to process data analysis. In terms of process redesign, when combined with the capability *mobility*, this also translates into flexible and decentralized ways of working, such as *resequencing* tasks on a behavioral level. As a result, the outcome of the redesign also allows for the reduction of human resources, i.e., *numerical involvement* in the organization.

The redesign outcomes related to the capability *communication* exist in combination with previously mentioned capabilities. On an organizational level, when resources become more *specialized* or *generalized*, the change is supported by technology that allows the redistribution of work tasks based on its analytic capability and facilitates efficient communication between employees, which also results in *task elimination*. When communication couples with knowledge management, the redesign outcomes are more effective internal and external document-related processes supported by common environments (*interfacing*), economically assembled resources (*centralization*), and improved consistency in the *integration* of customers and/or suppliers into the business process.

As an example of how a capability enables redesign, the adoption of RFID technology in a retail company [P19] is discussed in the remainder of this section. The main focus of the process improvement project [P19] was to address repetitive manual labor and inefficient working methods. Before introducing RFID, the item handling process – from receiving the goods in the stock room to check-out on the sales floor – relied on manually scanning barcodes for each item with a hand-held scanner and unhandy anti-theft tags. The scanning of items was repetitive and had to be done one by one in the stock room as well as at points of sale. As distinguishing between the location of items would have required time-consuming manual scanning of each item every time it was moved between the stock room and the sales floor, the location of items was not known. There was no complete overview of the items since anti-theft tags were attached to only 20% of the items, and it was not possible to obtain accurate information about stolen or lost items. At the cash desk, the employee needed to scan the items manually, remove the anti-theft tags and engage with the customer as separate tasks, which resulted in a slow check-out process.

In the case study [P19], the capability digitalization/dematerialization of RFID, an auto-identification system (see Table 10), was used to redesign the process of inventory management. The redesign involved five best practices: integral technology, task elimination, task automation, control addition, and parallelism. First, manual labor and physical contact with the goods were reduced throughout the process by integrating RFID tags into the items. Secondly, in the redesigned process, batch-scanning of items was made possible, thus removing a large proportion of unnecessary repetitive labor. Moreover, it was no longer necessary to manually remove the anti-theft tags at the cash desk. Thirdly, the tracking of items was automated, allowing for automatic identification of the item's location. Fourthly, over 90% of the items were equipped with RFID, enabling more accurate information about available stock. Fifthly, the check-out process became more efficient – item scanning and de-activating the anti-theft tag, which were previously consecutive, became parallel activities that could be executed while engaging with the customer.

In conclusion, the redesign outcomes depend on the expected results of the redesign project, the process being redesigned as well as the technologies that are introduced (see section 6). While the capabilities offer a way to talk about the expected outcome, the redesign heuristics try to capture how the process was redesigned on a practical level. In other words, the aim of discussing the capabilities of digital technologies in conjunction with redesign heuristics is to demonstrate and explicate the nuances of the redesign process rather than focus on particular technologies as such. An overview of the introduced capabilities and digital technologies is presented in Table 6.

6. Discussion

This section assembles the results of the research together in a framework which is presented in Table 8. The primary purpose of the framework is to summarize and categorize business process redesign through the capabilities. Moreover, it also brings together all the central elements and issues – capability, technology, and redesign – with references to the cases included in the SLR to answer the research questions (RQ1, RQ2) of the thesis.

As the framework brings together several different aspects and perspectives, it is supported by Table 6 (detailed overview of capabilities), Table 7 (definitions of redesign heuristics), and Table 9 (overview of the redesign outcomes). These tables provide a complementary structure and more detailed definitions or descriptions that the overarching framework presented in Table 8 does not focus on in detail. In other words, the framework offers a synthesized view where the cases are dispersed across capabilities. Furthermore, the framework is complemented by Table 10, which divides the digital technologies based on the technology areas and characteristics to offer a complementary perspective of technology classification.

Although the focus of the thesis is on capabilities and redesign, the framework can be approached from different angles. For example, suppose the starting point for the reader is interest in a particular technology. In that case, the reader can observe the capabilities related to the technology and the ways in which the process can be redesigned when introducing these capabilities. In another instance, when the reader's focus is on the redesign, the framework shows how the outcomes of the redesign vary in relation to different capabilities. Thus, the framework offers the reader solutions based on the current focus or problem.

Redesigning business processes involves various desired and potential outcomes, actors, and steps. It requires understanding industry-specific issues and challenges as well as grasping the role of and reasoning behind new technology in business processes redesign. Thus, one of the desired contributions of the framework is to support practitioners and researchers in their discussions around these issues on a common ground. The remainder of the section presents the framework for digital innovation for business process redesign (Table 8).

Table 8. Digital innovation for business process redesign

Capability of digital technology	Redesign heuristics	Redesign example	Technology	Reference
Digitalization/dematerialization ***Transforming paper-based activities into digital information processing by introducing new digital devices, applications, systems and/or replacing manual labor and physical contact with digital tools, platforms, or environments.***	Integral technology	New RFID-based process	RFID	[P08, P19]
		New e-service	Electronic service	[P09]
		New digital platform	Digital platform	[P02]

		New database	Blockchain	[P24]
		New web application	Web application	[P05]
		New document management system	Document management system platform	[P07]
		New BPMS web application	BPMS web application	[P17]
		New lightweight IT devices	Electronic whiteboards and smart mobile phones	[P03]
		New digital process automation software	Digital process automation software	[P25]
		New information system	Health management IT system	[P16]
		New smart pen technology	Smart pen technology	[P11]
		New BPM system	BPM platform	[P22]
	Task automation	Automated invoice processing	RPA tools	[P04]
		Automated item scanning process	RFID	[P19]
		Automated data entry process	Interactive forms	[P20]
	Task elimination	Removed manual loan order processing	RFID	[P08]

		Removed paper-based manual invoice processing	RPA tools	[P04]
		Removed paper-based certificate handling	Electronic service	[P09]
		Removed manual purchase order confirmation handling	Interactive forms	[P20]
		Reduced manual labor in stock handling	RFID	[P19]
	Numerical involvement	Reduced workforce due to self-service	RFID	[P08]
	Control addition	Improved transparency and accuracy in inventory management process	RFID	[P19]
	Parallelism	Introduced parallel activities in sales floor and stock room processes	RFID	[P19]
Knowledge management ***Providing standardized information and data management such as sharing documents and quick access to information and creating transparency and a secured data system among people, processes, organization(s).***	Integral technology	Introduced a web portal for healthcare processes	Web portal	[P01]
		Introduced a web-based modeling environment to create a comprehensive process documentation	Web-based modeling environment	[P18]
		Replaced a PDF-based process documentation with	Process-oriented management system web	[P21]

		a process-oriented management system	application	
		Replaced informal communication channels with a common digital tool	Digital collaboration tool	[P10]
		Introduced QM system software to standardize processes	QM system software	[P26]
		Replaced paper-based process documentation with digital process documentation in a BPM system	BPM platform	[P22]
	Integration	Consolidated professional knowledge among medical professionals	Web portal	[P01]
		Improved data exchange among port users (traders and control authorities)	Digital platform	[P02]
		Facilitated financial transactions among the supply chain participants	Blockchain	[P24]
	Task elimination	Replaced manual complaints handling reporting with streamlined information flows	Web application	[P05]
		Replaced manual health data	Health management IT	[P16]

		management processes with a customer-centric service model	system	
		Replaced paper-based business process documentation and multiple systems with a single platform	BPM platform	[P22]
	Centralization	Created a shared working environment for construction management to reduce documentation errors	Document management system platform	[P07]
		Centralized a previously decentralized e-mail-based reporting process to increase transparency in accounting	Digital process automation software	[P25]
	Interfacing	Enabled access to both internal and external parties to handle compensation obligations	BPMS web application	[P17]
	Trusted party	Increased trust and security among producers and buyers of agricultural produce	Blockchain	[P24]
	Control addition	Ensured data quality for compliance management	BPMS web application	[P17]
	Resequencing	Replacing disorganized, and siloed healthcare pro-	Health management IT system	[P16]

		cesses with a customer-centric service model		
Analytics *Collecting and analyzing immediate/real-time/automatic data, organizational behavior, and processes and/or enhancing control or traceability.*	Integral technology	Replaced an erratic, ad-hoc inventory management process with a digital inventory management system	Inventory management system	[P12]
		Introduced a PPM dashboard to enable process monitoring	PPM dashboard	[P14]
		Introduced ACM technology to enable transparent workflow management	ACM technology	[P15]
		Introduced a digital twin to increase transparency of operational processes	Multitier digital twin	[P06]
		Introduced wearable technology to display current process data	Wearables	[P23]
		Enabled access to performance reports and inventory data provided by a new information system	Health management IT system	[P16]
		Enabled business data extraction from the workflow system	BPM platform	[P22]
	Task automa-	Automated machine data	Real-time monitoring	[P13]

	tion	collection in real-time	system	
	Task elimination	Removed data collecting and analyzing process in physical space	Real-time monitoring system	[P13]
		Replaced paper-based incident reporting with smart pen technology	Smart pen technology	[P11]
	Flexible assignment	Enabled continuous improvement based on digital process models	Web-based modeling environment	[P18]
	Control addition	Increased control and traceability in inventory management	Inventory management system	[P12]
		Traced and reduced errors based on PPM dashboard data	PPM dashboard	[P14]
		Ensured compliance with requirements based on a process-oriented management system	Process-oriented management system web application	[P21]
Communication ***Enabling effective communication through a more dynamic flow of information and social collaboration among stakeholders/employees.***	Integration	Improved transparency and collaboration between subsidiaries and parent company through a common system	QM system software	[P26]
	Order-based work	Improved logistics related interactions in healthcare	Electronic whiteboards and smart mobile	[P03]

			phones	
	Task elimination	Replaced employee communication with IT department with adaptable process	ACM technology	[P15]
	Centralization	Improved collaboration between geographically dispersed parent company and its subsidiaries	QM system software	[P26]
	Specialist-generalist	Supported adaptable task assignment and increased employee flexibility	ACM technology	[P15]
	Interfacing	Shared information on standardized processes across departments and units in a common digital environment	QM system software	[P26]
		Fostered transparent, traceable, and documented client-supplier relations through a common digital tool	Digital collaboration tool	[P10]
	Numerical involvement	Reduced workforce by eliminating unnecessary phone-calls and meetings	Digital process automation software	[P25]
Visualization *Allowing the visualization and graphic representation of busi-*	Integral technology	Visualized business processes	Multitier digital twin	[P06]

ness processes and/or automatically collected process data.		Visualized current business process data	Wearables	[P23]
		Visualized incidents	Smart pen technology	[P11]
		Enabled business data visualization	BPM platform	[P22]
	Task automation	Enabled automatic visualization via dashboards	Real-time monitoring system	[P13]
Mobility ***Affording movability and portability in operational business processes and their improvement.***	Integral technology	Introduced wearable technology in manufacturing	Wearables	[P23]
	Numerical involvement	Enabled flexible production monitoring in manufacturing	Wearables	[P23]
	Resequencing	Enabled decentralized production monitoring in manufacturing	Wearables	[P23]

For instance, suppose a continuous improvement manager responsible for developing processes in an organization is given the task of improving internal communication with the help of new technology. Looking at the task of the manager through the framework, a technological solution that enables effective communication and social collaboration among employees should be considered. The manager could then use the framework as a reference point regarding how the internal communication process could be redesigned with the capability of communication. After consulting the framework, the manager could conclude that integration, order-based work, task elimination, centralization, specialist-generalist, interfacing, and numerical involvement are potential ways the process can be redesigned when this capability of digital technology is involved.

Analyzing the possible ways how technologies have been used in process redesign can be helpful in planning, evaluating, and achieving future redesigning goals. Since all the cases analyzed in the thesis were chosen for the SLR because they used a particular digital technology to redesign their process, the framework simultaneously serves as a tool for thinking and a snapshot of a specific point in time. As the research brings together case studies from the last five years, it can offer a starting point to analyze the same technology in five years and compare how the capabilities of a particular technology have changed. In other words, together with the development and improvement of technologies, their capabilities also change.

7. Conclusion

This thesis aimed to identify the capabilities of digital technologies and explore how business processes can be redesigned using these capabilities. This was done by conducting an SLR that included academic publications from the last five years. As technologies are always used in a particular setting, the notion of capability is inseparable from the way the current situation is perceived (as-is) and what is expected from the outcome of the redesign (to-be). Since the research aimed to analyze the process of redesign, these capabilities were formulated based on how technology enabled the change and defined in the process of data extraction. The redesign aspect was captured by looking at what changed using the notion of redesign heuristics. A set of 29 previously defined heuristics served as a basis for analyzing the redesign outcomes. Basing the analysis on a widely used and methodic framework allowed for a structured evaluation of redesign outcomes.

As a result of the SLR, six capabilities were identified: digitalization/dematerialization, knowledge management, analytics, communication, visualization, and mobility. Simply put, these capabilities refer to different things that can be done with digital technologies. In the course of close reading and data extraction from the case studies included in the SLR, 14 heuristics were identified: integral technology, task automation, integration, order-based work, task elimination, centralization, numerical involvement, flexible assignment, specialist-generalist, interfacing, trusted party, control addition, resequencing, parallelism. While the capabilities describe the inter-relations between process and technology implementation, the heuristics categorize the ways in which processes are redesigned. The results of the analysis of real-life case studies are brought together and presented in a digital innovation framework that can support decision-making during the process redesign phase of the business process lifecycle and helps to capture how innovation can happen.

Several further research perspectives stem from this thesis. First, while this thesis was based on the analysis of previous case studies, the next phase of the research could be to gather first-hand information for further validation and elaboration of the framework. For example, the framework could be adjusted to serve as a tool in redesign related workshops that involve BPM practitioners and industry experts. Secondly, SLR-s that are interested in certain areas of technologies could provide more detailed insights into the capabilities of a certain group of technologies. For example, as countries are adopting 5G, one focus field could be the implementation of 5G related technologies that combine hardware and software, such as IoT, and the capabilities these technologies entail in process redesign. Thirdly, conducting an SLR that focuses on adapting to changes during the pandemic would offer ways to better understand how certain social, political, or environmental cataclysms also expand the evolvement of new capabilities of digital technologies.

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Appendix

I. Process redesign outcomes

The table presents the full list of process redesign outcomes that are arranged according to the capabilities of introduced digital technologies.

Table 9. Process redesign outcomes

Capability of digital technology	Process redesign outcome	Redesign heuristics
Digitalization/dematerialization	Creating a new RFID-based self-service process to reduce order processing time, workforce and enable 24/7 availability [P08]	Integral technology, task elimination, numerical involvement
	Replacing a paper-based process with an electronic service [P09]	Integral technology, task elimination
	Automation of a paper-based manual process [P04]	Task elimination, task automation
	Replacing manual data entry process with automatically processed interactive forms [P20]	Task elimination, task automation
	Introducing RFID to reduce manual labor and enable a more accurate, transparent, and automatic inventory management process [P19]	Integral technology, task elimination, parallelism, control addition, task automation
Knowledge management	Introducing a web portal to centralize information flow among participants and increase the efficiency of the service [P01]	Integral technology, integration
Analytics	Replacing an erratic, ad-hoc inventory management process with a digital inventory management system to increase control and traceability [P12]	Integral technology, control addition
	Introducing a Process Performance Management (PPM) dashboard to trace and	Integral technology, control addition

Capability of digital technology	Process redesign outcome	Redesign heuristics
	reduce errors [P14]	
Knowledge management, analytics	Introducing a web-based modeling environment to create comprehensive process documentation to enable continuous improvement [P18]	Integral technology, flexible assignment
	Replacing PDF-based process documentation with a process-oriented management system web application to ensure compliance with requirements [P21]	Integral technology, control addition
Knowledge management, communication	Replacing informal communication channels with a common digital tool to foster transparent, traceable, and documented client-supplier relations [P10]	Integral technology, interfacing
	Introducing QM system software to standardize processes, improve transparency and increase collaboration between the parent company and its subsidiaries [P26]	Integral technology, integration, centralization, interfacing
Digitalization/dematerialization, knowledge management	Replacing a paper-based process with a new digital platform for data exchange and connect users of the service [P02]	Integral technology, integration
	Replacing a manual reporting with a web application to streamline information flows [P05]	Integral technology, task elimination
	Introducing a document management system to create a shared working environment to reduce errors [P07]	Integral technology, centralization
	Replacing paper-based compliance management with a BPMS system that enables access to both internal and external parties [P17]	Integral technology, interfacing, control addition
	Introducing a digital platform based on blockchain technol-	Integral technology,

Capability of digital technology	Process redesign outcome	Redesign heuristics
	ogy to increase trust, provide secure asset registries, and facilitate payment and financing transactions among the supply chain participants [P24]	integration, trusted party
Digitalization/dematerialization, communication	Introducing lightweight IT devices to improve logistics and interactions within an organization [P03]	Integral technology, order-based work
Digitalization/dematerialization, knowledge management, communication	Replacing a previously decentralized e-mail-based reporting process with a digital process automation software to increase transparency and reduce workforce [P25]	Integral technology, centralization, numerical involvement
Analytics, communication	Introducing Adaptive Case Management technology (ACM) to support adaptability and flexibility of processes and employees [P15]	Integral technology, task elimination, specialist-generalist
Analytics, visualization	Introducing a digital twin to increase the transparency of operational processes and visualize business processes [P06]	Integral technology
	Introducing a real-time monitoring system to allow for automated data collection and visualization via dashboards [P13]	Task automation, task elimination
Analytics, visualization, mobility	Introducing wearables to move from fully centralized information and equipment control to flexible, decentralized production monitoring [P23]	Integral technology, resequencing, numerical involvement
Digitalization/dematerialization, knowledge management, analytics	Replacing disorganized, manual, and siloed processes with a customer-centric service model enabled by a new information system [P16]	Integral technology, task elimination, resequencing
Digitalization/dematerialization, analytics,	Replacing pen and paper-based incident reporting with smart pen technology to au-	Integral technology, task elimination

Capability of digital technology	Process redesign outcome	Redesign heuristics
visualization	tomate incident reporting [P11]	
Digitalization/dematerialization, knowledge management, analytics, visualization	Introducing a BPM system to move from paper-based to digital process documentation and enable business data extraction and visualization through a single platform [P22]	Integral technology, task elimination

II. List of identified technologies

Table 10. List of identified technologies (technology area and characteristics based on [8])

Communication and other enabling technologies	
Technology characteristic	**Digital technology**
Application software	Web portal [P01]
	Digital platform [P02]
	Web application [P05]
	Document management system platform [P07]
	Electronic service [P09]
	Digital collaboration tool [P10]
	Inventory management system [P12]
	ACM technology [P15]
	BPMS web application [P17]
	Web-based modeling environment [P18]
	Interactive forms [P20]
	Process-oriented management system web application [P21]
	BPM platform [P22]
	Digital process automation software [P25]
	QM system software [P26]
Auto-identification systems	RFID based self-service system [P08]
	RFID [P19]
Technologies combining hardware and software in intelligent systems	

Technology characteristic	Digital technology
Mobile devices	Electronic whiteboards and Smart mobile phones [P03]
	Wearables [P23]
Internet of things	Multitier digital twin [P06]
Human-computer interface	Smart pen technology [P11]
Data technologies	
Technology characteristic	**Digital technology**
Artificial intelligence	RPA tools [P04]
Big data	Real-time monitoring system [P13]
	PPM dashboard [P14]
IT infrastructure	Health management IT system [P16]
New database technology	Blockchain [P24]

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