Lasting Impacts of COVID-19 on Software Development Projects in Public Sector

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ABSTRACT: This master thesis investigated the impacts of the COVID-19 pandemic on software development projects in the public sector. The pandemic has caused unprecedented disruptions in the workplace, forcing software development project-teams to shift to work in home office and adopt new technologies to support virtual collaboration. This master thesis aimed to explore how these changes have affected software development projects in the public sector and to identify lasting impacts of COVID-19 on software development projects in public sector. To achieve this, the study employs a mixed-methods approach, consisting of a Systematic Literature Review and semi-structured expert interviews with selected participants. The findings reveal that the pandemic has had a significant impact on software development projects, with many organizations experiencing delays, increased costs, and reduced productivity. However, the study also identifies several positive outcomes, such as increased flexibility and agility in project management, improved communication and collaboration, and a renewed focus on the role of digital transformation in public sector. The thesis concludes an overview of lasting impacts on software development projects in public sector.

1 INTRODUCTION

The global outbreak of COVID-19, which began in Wuhan, China, in December 2019, led to widespread disruptions across the world. The spread of the virus posed challenges not only to public health systems but also to various sectors of society. One of the areas significantly impacted was the workplace, where software engineers became increasingly crucial in developing and maintaining software systems for various industries.

Austria implemented a lockdown on March 16, 2020, forcing many businesses to swiftly transition employees to remote work to minimize exposure to the virus. Since then, numerous research studies have examined the challenges faced by software development projects during the COVID-19 pandemic, highlighting the virus's impact on productivity and efficiency within the industry.

Many studies have focused on the immediate challenges brought about by the pandemic, such as decreased productivity and difficulties in maintaining work-life balance. However, the long-term effects of COVID-19 on software projects remain unclear.

This master's thesis draws on an in-depth analysis of the organizational dynamics and operational strategies of a key public sector entity in Vienna, Austria. By focusing on this organization, the research aims to explore the complex interactions between public sector dynamics and software development projects.

Bezerra, C. I. et al. (2020) examined the impact of the COVID-19 on Brazilian software engineering teams, and focused on productivity issues. Researchers surveyed software professionals in Brazil, collecting data on factors such as work environment, team communication, leader-ship, and work-life balance, and then analyzed Analyze data to find correlations with productivity levels. Research shows that factors such as team communication, leadership, and work-life balance have significantly impacted development team performance during the pandemic. The study also highlights the importance of organizational support and re-mote working infrastructure to stay productive in times of crisis.

Neto et al. (2021) covered topics such as remote work challenges, changes in work pat-terns, impact on development processes, adoption of new tools and technologies in soft-ware

development area. The authors explore how the pandemic has affected the work pat-terns of software developers. For instance, developers had to adapt to new work schedules and timelines due to the disruption caused by the pandemic. They also highlight how the pandemic has accelerated the adoption of certain software development tools and tech-nologies such as cloud computing.

Several research articles have addressed the challenges software development projects face during the COVID-19 pandemic, including its impact on productivity and work-life balance. Although the research focused on the immediate challenges workers face, such as reduced productivity and difficulties in maintaining work-life balance, the lasting impact of COVID-19 on software projects is not yet fully understood.

2 RELATED WORK

Nolan, A. et al. (2021) examined the substantial changes in work patterns for software engineers brought the shift to work in home office. Their research investigated that the shift to remote work during the pandemic has posed challenges for software development teams, including maintaining social connections and trust building. Agile methodologies have adapted to remote work, but issues such as reduced collaboration and client meetings have been reported. Technology frameworks and project sizes impact productivity in a remote work setting.

Marek, K. et al. (2021) identified a few contributing factors to the problems, including lack of face-to-face communication, the need to adapt to working remotely, and difficulties main-taining team morale and motivation. However, research also shows that agile teams can adapt to new realities and find solutions to pandemic-related problems. The authors suggest that lessons learned during the pandemic could lead to improvements in agile practices, such as greater use of online collaboration tools and a greater emphasis on communication and computing. transparent. Their research provides valuable insights for Agile practitioners and organizations looking to im-prove their Agile methods in a post-pandemic world.

Qahtani (2022) compared the process before and during the pandemic to identify challenges and measure its impact on the number of requirements completed and development project resources. The results showed that the pandemic changed requirement elicitation techniques, increased the number of completed requirements, and necessitated adjustments in human resources due to remote communication. Furthermore, the researchers have modeled the requirements engineering scenario, outlining the differences between the client's site and the vendor's site before and after COVID-19.

Neves de Souza et al. (2023) examine the impact of communication channels on software development teams, highlighting the importance of digital tools and the challenges encountered, particularly during the COVID-19 pandemic. They show how teams adapted to remote work by relying on digital tools like private chats for communication. However, the transition to remote work has not been without challenges. Teams face issues such as asynchronous communication, scheduling conflicts, and technical difficulties, which complicate collaborative efforts. The pandemic has also had mixed impacts on team communication. On the positive side, it has increased the availability for remote interactions, enabling more frequent communication.

Müller et al. (2023) focused on the challenges encountered by agile teams during the COVID-19 pandemic, particularly concerning distributed collaboration. The study emphasized the significance of trust and self-responsibility within these teams, addressed various collaboration challenges, and offered recommendations aimed at enhancing team satisfaction and productivity.

Bezerra et al. (2021) investigated the effects of working from home office on Brazilian software engineering teams during the COVID-19. The findings revealed that home office induced significant changes in work routines, notably an increased workload and extended working hours. Despite these challenges, the study observed that collaboration and communication within teams remained positive. Participants reported enhanced productivity and a general sense of satisfaction with the home office arrangement, highlighting the adaptability and resilience of the teams in navigating the new work environment. The researchers conducted a survey involving 67 participants to examine the tools used during work from home office and the frequency of meetings. The first graphic illustrates the various tools adopted by individuals to facilitate remote work, while the second graphic provides insights into how often these participants engaged in meetings.

Da Silva et al. (2023) highlighted that the communication, encompassing speaking and listening, is essential for effective collaboration within software development teams. The COVID-19 pandemic has led software developers to prioritize soft skills such as teamwork, fast learning, ethics, responsibility, problem-solving, and proactivity. While the pandemic has positively influenced developers' soft skills—enhancing flexibility, empathy, adaptability, and a willingness to learn—it has also adversely affected motivation and emotional resilience.

To clearly present this scientific research, an SLR is first the target of this thesis. Upon completing the literature analysis via SLR, it should identify and refine a set of core topics for the expert interviews. These main topics should be selected to address key research questions and to provide meaningful insights into the topic under investigation. With these main topics in mind, it should formulate a series of relevant and insightful questions to support the expert interviews. The questions are designed to probe deeply into the key themes and concepts identified during the literature review, with the aim of eliciting rich and nuanced responses from the interviewees. By carefully crafting the questions to align with the main topics, the interviews are structured and focused, facilitating the collection of valuable data that is critical in advancing our understanding of the subject matter.

3 RESEARCH QUESTIONS

The primary aim of this thesis was to investigate the long-term effects of COVID-19 on software development projects within the public sector. To achieve this objective, a series of research questions (RQs) were formulated. These RQs were intended to delve into the complexities of the topic, considering its various dimensions. The following key research question was identified:

- **RQ1:** What are the lasting impacts of COVID-19 on software development projects in public sector?

To explore the main research question of this thesis, it needs to be broken down into sub-research questions. This method helps achieve the overall objective by concentrating on specific aspects. It involves analyzing different time periods to evaluate the impact of COVID-19 on software development projects in the public sector.

- **RQ 1.1:** What was the initial situation of the software projects before the COVID-19 pandemic?
- **RQ 1.2:** How has the pandemic impacted the software projects?
- **RQ 1.3:** What effects are still present today regarding software development projects since the end of the pandemic?

The thoughtfully crafted research questions presented in this section guide the investigation and assessment of COVID-19's effects on software development projects in the public sector. These questions were designed to examine various facets of the topic, spanning the periods before, during, and after the pandemic.

4 METHODOLOGY

The methodology adopted for this study involves a multi-phase approach, beginning with a systematic literature review (SLR) followed by semi-structured interviews. The SLR aims to comprehensively explore existing literature to uncover insights of COVID-19 in software development projects. After conducting a structured analysis of existing literature, thematic input for semistructured interviews must be developed to capture relevant information. It involves identifying and integrating common themes from the literature, organizing them into coherent thematic areas based on careful consideration, and formulating interview questions that directly reference these themes. Structuring interviews around these themes allows for the gathering of comprehensive data that enhances understanding and meets research objectives effectively. Aligning

interview content with findings from the literature ensures relevance and meaningfulness for participants, thereby enriching overall research outcomes.

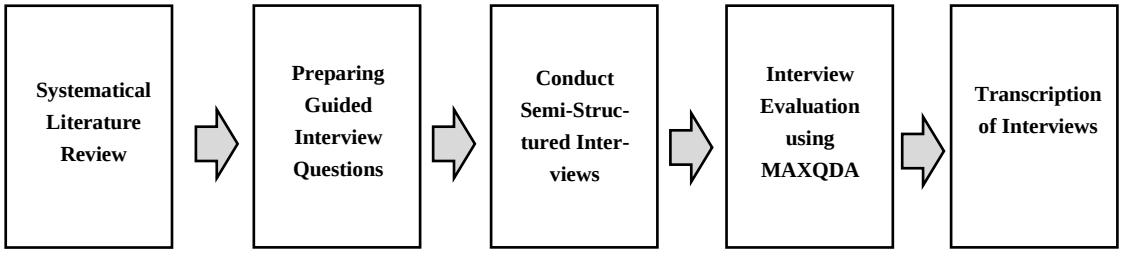

Figure 1: Process for Mixed-Methodology Research

4.1 *Systematic Literature Review based on Kitchenham and Charters*

Before conducting a systematic literature review (SLR), it the SLR research questions were defined as the first and foremost step, as pointed out by Kitchenham and Charters (2007).
The SLR research questions are formulated to achieve descriptive and content analysis objectives while identifying any po-tential research gaps. After defining the research questions, the next step is to create a review protocol. This protocol includes the motivation for conducting the SLR and the research questions once again. The protocol serves as a roadmap for conducting the SLR and ensures that the process is consistent and thorough. The following terms are searched in the appropriate databases such as IEEExplore, Springer, and ACM Digital Library.
The purpose of the systematic review is to address specific questions aimed at identifying and/or framing future research activities. The aim of this study is to examine lasting impacts of COVID-19 on software development projects in public sector. So, the research questions in this systematic review are found:

- **SLR_RQ1:** What is the state of research on the COVID-19-situation in software development and IT projects?
    - **SLR_RQ1.1:** What are the identified impacts of COVID-19 in software development and IT projects?
    - **SLR_RQ1.2:** What are the identified challenges of COVID-19 in software development and IT projects?
    - **SLR_RQ1.3:** What are the identified recommendations of COVID-19 in software development projects?

As outlined by Kitchenham and Charters (2007), the initial step in this review process involves determining whether a new review is necessary by identifying and examining any existing systematic reviews on the topic. Reviews covering the impacts of COVID-19 in software development projects were searched. So, the search string must include the following keywords:

- Impact or impacts. So: (“impact* of”)
- COVID-19, pandemic or epidemic. So: (“covid-19” OR “pandemic” OR “epidemic”)
- software development, software projects, ("software development" OR "software project*" OR "IT department*")

These keywords have to be searched in the title of papers to reduce noise in the results by searching string:

- ("impact*" AND (“covid-19” OR “pandemic” OR “epidemic”) AND ("software development" OR "software project*" OR "IT department*"))

4.2 *Thematic Areas for Interview Questions*

After conducting a structured analysis of existing literature, thematic input for semi-structured interviews must be developed to capture relevant information. This step is crucial for gaining deeper insights into the research problem. It involves identifying and integrating common themes from the literature, organizing them into coherent thematic areas based on careful consideration, and formulating interview questions that directly reference these themes. Structuring interviews around these themes allows for the gathering of comprehensive data that enhances understanding and meets research objectives effectively. Aligning interview content with findings from the

literature ensures relevance and meaningfulness for participants, thereby enriching overall research outcomes.

4.3 *Semi-Structured Interviews Based on Mayring*

In addition to the SLR, semi-structured interviews were conducted with key stakeholders from the digital department of a Viennese public organization. These interviews aimed to gather in-depth, context-specific experiences and perspectives on the lasting impacts of COVID-19 on software development projects in the public sector.

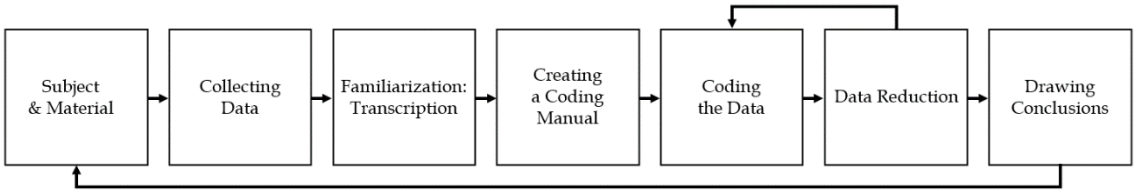

Figure 2: The Steps applied from Mayring's Method (2014)

The following steps outline the application of this method:

Subject & Material: In this step, the focus of the evaluation was determined: the lasting impacts of COVID-19 on software development projects in the public sector. The primary material for the analysis consisted of the interview transcripts.

Collecting Data: Data was gathered through semi-structured interviews with experts from the public sector involved in software development projects. These interviews were conducted in the form of video conferences via Google Meet and were recorded using Google Meet Recording. They provided rich, qualitative insights into how COVID-19 has impacted their work and the adaptations made in response.

Familiarization – Transcription: After the interviews were conducted, the recordings were transcribed using the transcription tool, Cockatoo. Creating a coding manual: The third step is to create a coding manual that will guide the analysis of the interview's transcription. This manual should be based on the research question and should include a set of codes or categories that will be used to analyze the data.

Creating a Coding Manual: Then, a coding manual was developed to standardize the process of data analysis. Three main dimensions of COVID-19 times were established to examine the insights, particularly focusing on the impacts of COVID-19 on software development projects in the public sector.

Coding the data: During this phase, the interview data was systematically coded in alignment with the categories established in the coding manual. This process entailed tagging specific text segments with codes that corresponded to various themes pertinent to the impacts of COVID-19 on software development projects. The transcripts in Englisch were imported into MAXQDA, where it was organized and coded under the main categories.

Data Reduction: After Coding 10-50% of data, a data revision was employed to filter redundancy in codes. The data reduction also involved summarizing and condensing the coded data to focus on the most relevant information.

Drawing conclusions: Finally, conclusions were drawn based on the analyzed data. This involved interpreting the patterns and themes identified through the coding process to understand the lasting impacts of COVID-19 on software development projects in the public sector, and how these insights contribute to the broader research objectives of the thesis.

5 RESULTS

5.1 *Result 1 – State of Research on the COVID-19-Situation in Software Development and IT Projects*

The SLR_RQ1 focused on the current state of research regarding the impact of COVID-19 on software development and IT projects. In the figure below, the findings have been systematically

categorized into three main thematic areas: Impacts, Challenges, and Recommendations. Each category has been assigned specific IDs for clarity and organization.

Impacts were identified with Ix codes, such as I1, I2, I3, etc., representing the various ways in which the COVID-19 pandemic has affected software development and IT projects. (Addressing SLR_RQ1.1)

Challenges are denoted with Cx codes, including C1, C2, C3, etc., which specify the difficulties and obstacles encountered due to the pandemic. (Addressing SLR_RQ1.2)

Recommendations were marked with Rx codes, such as R1, R2, R3, and so forth, representing the suggested actions and strategies proposed to address the identified impacts and challenges. (Addressing SLR_RQ1.3)

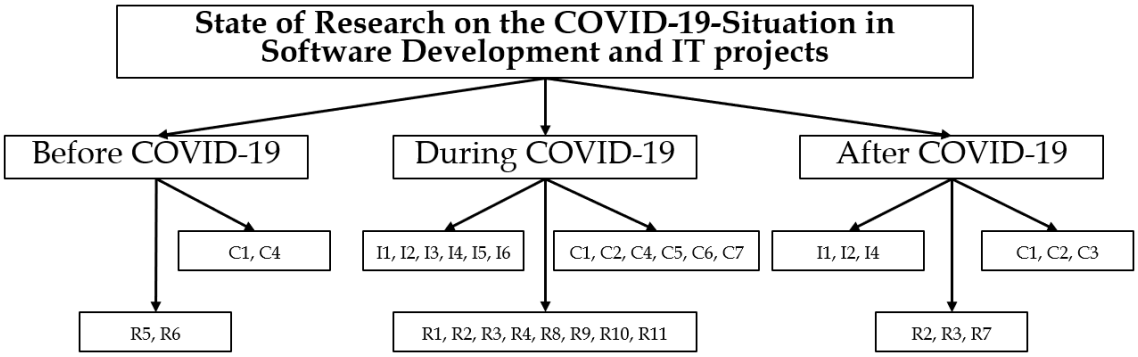

Figure 3: State of Research on the COVID-19-Situation in Software Development and IT projects

The impacts were emerged from the SLR. As a summary, these impacts are presented in the following table. This table presents the impacts along with their names. Each impact is assigned an ID, such as Ix:

Name of Impact	ID
Home Office	I1
Productivity	I2
Demand on Cloud Solutions	I3
Requirements Engineering	I4
Impacts on Corporate Business	I5
Team Management	I6

Table 1: Mapping of Impacts of COVID-19 on Software Development Projects

In the following paper are the challenges identified through the SLR. This table shows the challenges' names. Each challenge has been assigned an ID, such as Cx:

Name of Challenges	ID
Adopting to Remote Work	C1
Collaboration and Management	C2
Work-Life Balance	C3
Navigating Budget Constraints	C4
Remote Work on Development	C5
Businesses	C6
Digital Transition on Well-Being	C7

Table 2: Mapping of Challenges of COVID-19 on software development projects

The recommendations identified through the SLR are summarized in the table below. This table lists the recommendations along with their names. Each challenge has been assigned an ID, such as Rx:

Name of Recommendations	ID
Adapting Agile Practices	R1
Implementing Training Programs	R2
Adopting Remote Communication Tools	R3
Improving Development Process Transparency	R4
Corporate Support for Remote Work	R5
Short Breaks and Clearly Separating Work Time from Personal and Family Time	R6
Adaptation, Communication, and Collaboration	R7
Future-Proofing for Business Continuity	R8
Enhancing Organizational Agility to Quickly Adapt to Change	R9
Asynchronous Scrums and Unified Backlogs for Efficiency	R10
Limiting Meetings to Enhance Well-Being	R11

Table 3: Mapping of Recommendations of COVID-19 on software development projects

5.2 *Result 2 – Interview Results: Lasting Impacts of COVID-19 in Research Area of the master thesis*

This chapter addresses the evaluation results of transcripts with MAXQDA Analytics Pro, and evaluating the data related to the enduring effects of COVID-19 on software development projects in the public sector. It emphasizes a systematic and thorough approach to data analysis, grounded in Mayring's framework.

These thematic areas were carefully crafted through a SLR creating an interview guideline. The guideline used in the interviews was designed to uphold objectivity and avoid influencing the responses. It was organized into four main blocks: Project Management, Home Office, Requirements Management, and Corporate Business and Team Management.

A bridge was established between the pre-, during- and post-COVID-19 periods. This bridging highlighted 10 lasting impacts of COVID-19 on software development projects in the public sector. The figure below outlines the high-level process and results of the semi-structured interviews.

It highlights the key steps involved, leading to the identification of 10 lasting impacts. These impacts are clearly shown on the right side of the figure:

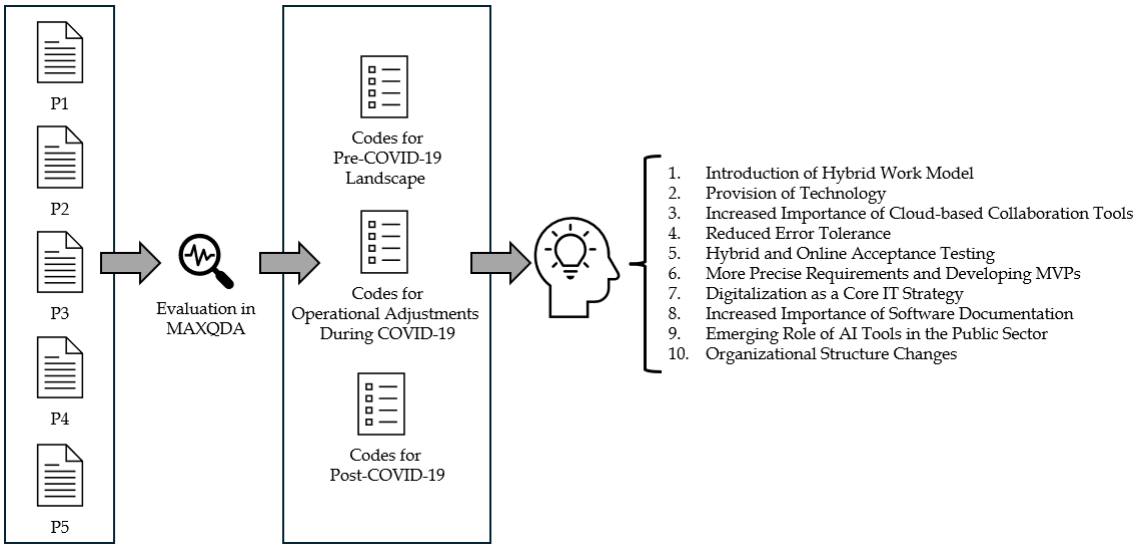

Figure 4: Lasting Impacts of COVID-19 on Software Development Projects in Public Sector

6 CONCLUSION

The COVID-19 pandemic drastically altered life across the globe, leading to widespread illness and potentially long-term impacts on human organizations. This period also supposed significant impacts for software development projects in public sector. To explore these impacts in detail, this master's thesis employed a (SLR) methodology, as outlined by Kitchenham and Charters (2007).

The study began by developing a search string focused on the "impacts of COVID-19 in software development projects." The identified papers were systematically reviewed, and data from these papers were extracted into a structured template. The results of the SLR provided a mapping of impacts, challenges, and recommendations, categorized into three distinct time periods: before-, during-, and after COVID-19. Based on the identified impacts from the SLR, an interview guideline for semi-structured interviews was developed.

Interviews were conducted with five experts from software development projects within the public sector. The interviews were transcribed in German using, manually reviewed for accuracy, and subsequently translated into English. In conclusion, the predetermined thematic areas from the guidelines were discussed in the context of the periods before-, during-, and after COVID-19.

The findings were presented in relation to the research questions, revealing the lasting impacts of COVID-19 on software development projects within the public sector. These insights underscore the significant and enduring changes brought about by the pandemic in this field.

The lasting impacts of COVID-19 on software development projects in the public sector include the introduction of hybrid work models, enhanced provision of technology, a greater emphasis on cloud-based collaboration tools, reduced error tolerance, hybrid and online acceptance testing, more precise requirements and developing MVPs, the digitalization of core IT strategies, changes in organizational structures, increased importance of software documentation, and the emerging role of AI tools.

Extending the study to encompass industries, like businesses, healthcare or education could give a broader perspective on the effects of COVID-19 on software development in different fields. This comparative method could reveal challenges and adjustments specific, to each sector.

Potential future research could be directed toward the identification of the patterns and creation of the guidelines and policies for best practice models based on the results of the present research. This would assist organizations within the public sector and others to establish and/or fine-tune strategies that could be used to manage software development projects especially within the lens of the existing and emerging disruptions.

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