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CENTRO DE CIÊNCIAS EXATAS E TECNOLOGIA
ESCOLA DE INFORMÁTICA APLICADA
CURSO DE BACHARELADO EM SISTEMAS DE INFORMAÇÃO

OS IMPACTOS DA PANDEMIA DE COVID-19 NO DESENVOLVIMENTO DE SOFTWARE: UM ESTUDO DE SÍNTESE TEMÁTICA

COVID-19 PANDEMIC IMPACTS ON SOFTWARE DEVELOPMENT: A THEMATIC SYNTHESIS STUDY

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Rio de Janeiro, RJ - Brasil
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Projeto de Graduação apresentado à Escola de Informática Aplicada da Universidade Federal do Estado do Rio de Janeiro (UNIRIO) para obtenção do título de Bacharel em Sistemas de Informação.

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Agosto de 2022

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Nesse 15 de agosto, quando é comemorado o dia da informática, encerro um ciclo. Na trilha até a chegada ao final dessa graduação nunca estive sozinho, cada um a ser citado teve parcela importante do meu crescimento como pessoa. Por conta de cada participação, devo prestar os devidos agradecimentos à:

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Todos os meus professores: desde o maternal e alfabetização; passando pelos ensinos fundamental, médio e superior; sem esquecer dos de línguas estrangeiras e das danças de salão;

Todos os profissionais da linha de frente, que abnegadamente colocaram as suas vidas em risco para proteção da coletividade;

Todos os pesquisadores, que em esforços coletivos conseguiram em tão pouco tempo desenvolver mais de uma vacina comprovadamente capazes de nos proteger contra a o terrível vírus que nos afligiu;

Ada Lovelace, mulher matemática, escritora e autora do primeiro programa de computador;

Alan Turing, ateu e homossexual, pai da ciência da computação.

Resumo

Contexto: A pandemia de COVID-19 acarretou uma quebra de paradigma nas relações de trabalho. Repentinamente, a maioria das categorias de trabalhadores teve que executar as suas atividades de forma online e de casa e essa mudança nas circunstâncias foi única devido à necessidade de uma rápida adoção. Foi a primeira (e esperamos que a única) vez que uma pandemia desse tamanho nos atingiu desde o advento da internet.

Objetivo: O propósito deste estudo é descrever como o desenvolvimento de software foi executado no contexto apresentado, particularmente interessado em como o processo de transição ocorreu, quais atividades puderam ou não serem migradas para o trabalho remoto, e quais aspectos relacionados ao trabalho foram impactados.

Método: Um Mapeamento Sistemático da Literatura foi executado para identificar os pontos críticos no processo de transição e durante o trabalho remoto. Isso inclui processos e atividades de desenvolvimento, as ferramentas utilizadas, outros aspectos do trabalho, assim como lacunas de conhecimento nesse contexto. Então uma Síntese Temática foi executada para compilar as principais ideias discutidas na literatura sobre o contexto apresentado.

Resultados: Nossa Síntese Temática revelou três temas principais: Interações; Organização do Trabalho; e Humano e Social. Associados a esses temas foram geradas 24 categorias e 179 códigos. A partir desses temas, as principais descobertas foram: a maioria das empresas ofereceu alguma forma de apoio aos desenvolvedores; a qualidade da comunicação e o trabalho em equipe foram afetados; a maioria das atividades puderam ser migradas para o trabalho remoto; novas práticas foram implementadas para manter o engajamento dos desenvolvedores; e alguns times ajustaram seus fluxos de trabalho ao novo contexto.

Conclusão: apesar de alguns desenvolvedores reportarem uma deterioração no bem-estar, a experiência no trabalho remoto foi, em geral, positiva. A maioria dos desenvolvedores deseja permanecer trabalhando de casa ao menos uma parte do tempo. Poucos estudos mencionaram atividades que não puderam ser migradas ao trabalho remoto. Levantamos, então, a hipótese de que a maioria das atividades puderam de fato ser migradas para o trabalho remoto. Conjecturamos também se o

trabalho remoto durante a pandemia tem diferenças em relação ao trabalho remoto praticado anteriormente, mas pouca informação nesse sentido foi encontrada.

Palavras-chave: COVID-19, pandemia, equipes distribuídas, trabalho remoto, home office, engenharia de software, desenvolvimento de software

Abstract

Context: The COVID-19 pandemic presented us with a paradigm break in work relationships. Suddenly most job categories had to execute their activities online from home. This change of circumstances was unique because of the necessity of rapid adoption. It was the first (and we hope the only) time a pandemic of this size has hit us since the advent of the internet.

Objective: The purpose of this study is to describe the software development process during the presented context. We are particularly interested in how the transition process took place, which activities could or could not be migrated to remote work, and what work-related aspects were affected.

Method: First, we have executed a Systematic Literature Review. This data collection intends to identify the critical points in the transition process and during the remote work period. This includes the development processes and activities, tools applied, other work-related aspects, and information gaps in this context as well. Then we executed a Thematic Synthesis to compile the main ideas discussed in the literature over the context presented.

Results: Our Thematic Synthesis revealed three main themes: Interactions, Work Organization, and Human and Social. Associated to those themes there were 24 categories and 179 codes. The most relevant findings were: that most companies offered their developers some sort of assistance; communication quality and teamwork were affected; most work activities could be migrated to remote work; new practices were implemented to keep developer's engagement; and some teams adjusted their workflows to accommodate the new context.

Conclusion: The remote experience was generally positive, despite some developers reporting deteriorating well-being. Most of them wish to keep working from home at least a part of time. There were few studies covering activities that could not be migrated to work from home. We raise the hypothesis that most activities could actually be migrated. We also conjecture whether the remote work during COVID-19 has differences to the remote work that was practiced before, but very little information in that regard was found.

Keywords: COVID-19, pandemic, distributed team, remote work, work from home, software engineering, software development

List of Tables

List of Figures

Summary

Chapter 1: Introduction

1.1 Motivation

The emergence of the COVID-19 pandemic has forced many workers, including software developers, to perform execute their daily work activities from their own homes. Companies that already had some remote teams had facilitating conditions for such a sudden shift to a work from home (WFH) environment (SMITE et al., 2021).

Remote working and remote software development are not new as they already existed long before COVID-19, but the pandemic brought a new context where WFH went from an option to some cases to becoming the only possibility of work available. SMITE et al. (2021) mentioned that "Most companies around the world were forced to send their engineers to work from home". Because of this location shift, the emerging WFH modality has gained a lot of importance due to the necessity of companies to remain active in their markets while respecting the context of sanitary safety protocols and strict collective protection regulations.

Several impacts came from this change, such as, but not limited to: teams experiencing communication difficulties and relationship issues, developers perceiving a decrease in their personal well-being experience, work organization undergoing many changes, including productivity gains or losses. RUSSO et al. (2021) mentioned that it is important to understand these impacts and the extension of those changes to elucidate how they are affecting software developers and their work, and what differences are being experienced in remote software development before and the after of the pandemic.

Considering that after the acute phase of the pandemic there are several primary studies investigating the matter; it is appropriate to compile and analyze those results through the means of secondary research, more specifically a Thematic Synthesis. To the best of our knowledge, there is a lack of comprehensive investigation about the pandemic and work-related effects due to the contemporaneity of the events that are still happening at the time of this study. Therefore, there is a need to put together all available information that is already produced, to comprehend the relation of the work-related changes and their impacts in the specific context in which they are happening.

1.2 Objective

The goal of this work is to qualitatively assess the identified challenges, practices and solutions applied to/by remote software developers during the pandemic period. To achieve this objective, our aim is to analyze the identified primary studies so there may be a comprehensive understanding about the themes found in the recent literature to provide a landscape about remote work due to the pandemic.

The research questions of this study investigate the differences of remote work on software development before and during the COVID-19 pandemic:

- Research Question 1 has the objective of understanding the transition process from on-site to remote work. This process involved what companies did and offered to developers.
- Research Question 2 has the objective of listing activities that could not be migrated at all. We found that the majority of activities could be adapted and migrated. Those that could not be executed from home were cancelled or executed on premises. Pair Programming was an example of activity that at first was not executed from home, but as developers got used to this context they adapted and returned practicing it.
- Research Question 3 has the objective of inspecting the work-related aspects and is subdivided in two other questions that focus on (1) changes in activities and processes and (2) social aspects affected. Workweek schedules were adapted, developers had to do more overtime hours, and the one specific group perceived an increase in productivity; new practices were implemented and/or adapted to the work from home context, agile teams adjusted their ceremonies, project artifacts that underwent adaptations, and examples where shown of how remote Scrum frameworks can be more lightweight; Teamwork impacts as it was more difficult to contact colleagues, professional' well-being deteriorating and countermeasures; demographic groups that need special attention.

1.3 Methodology

This study was developed in two parts: first, a Systematic Literature Review (SLR); then a Thematic Synthesis.

The SLR aims to identify critical points during the transition and the remote work period. We have queried four of the most important digital repositories in the software engineering area. Those queries were looking for studies that: (1) presented empirical results; (2) or discussed challenges; (3) or that described the transition process to remote work.

The Thematic Synthesis compiled the main ideas discovered during the literature review. Twelve studies were completely read. Then text snippets were extracted from those studies and labelled into codes. Every code is related to at least one of our research questions. The codes were then iteratively analyzed and arranged into categories, which were then organized into themes. This part of the analysis was not guided by our research questions; thus, the categories and themes arose from the data itself.

Our study encountered three main themes: Interactions, Work Organization, and Human and Social. Those themes were associated to 24 categories and 179 codes. In terms of findings, the following were most relevant: most companies offered their developers some sort of assistance (either software, hardware or monetary); there was a decrease in communication quality and teamwork; almost all work activities can be handled remotely, few exceptions were found; a new set of practices was implemented to keep developers engaged; and there were some teams that adapted their workflows to accommodate the new environment.

1.4 Organization

This paper is organized in chapters, besides the introduction, as follows:

Chapter 2 presents the background related to the study such as telework, telework in software development, COVID-19 pandemic, and related work.

Chapter 3 describes the protocol of the Thematic Synthesis developed to identify, analyze, and report theme patterns previously found in those primary studies found with the qualitative research.

Chapter 4 presents the results of the Thematic Synthesis.

Chapter 5 discusses the results in relation to the posed research questions.

Chapter 6 presents conclusions, final considerations, known limitations and suggestions of following studies

Chapter 2: Background and Related Work

2.1 Work from home

The term telecommuting was introduced during the 1973 Petrol crisis, but the practice itself already existed before (NILLES, 1975). Telework is usually described as an agreement between employers and employees where at least a part of their work responsibilities is done outside the physical limits of the company with the help of information technology and tools to maintain a virtual presence (FAY; KLINE, 2012). This practice has seen a growth thanks to the rapid evolution in collaboration platforms like the Internet, personal computers, communication software and video conferences that allows professionals to fulfill their work tasks virtually from anywhere.

There are several other similar terms used to refer to this type of work, which are not limited to: *telework, remote work, distributed work, virtual work, flexible work, flexplace, distance work, and home office*. These terms, although overlaps in meaning, frequently indicate different concepts of telecommuting (ALLEN; GOLDEN; SHOCKLEY, 2015). Still, for the sake of this study all the previous terms are considered as synonyms.

2.2 Distributed Software Development

The popularization of the internet, emails and low-cost international communication has facilitated the development of remote teams, workgroups and global companies (CASEY, 2010). Because of that, we witness a growing number of software projects that are developed in geographically distributed environments.

Distributed work has become the standard for software development. In particular, the number of locations is directly related to work complexity (JOHRI, 2011). This increased complexity demands make it more critical the use of effective strategies for organizing the work environment (LAMERSDORF, 2011).

It is important to consider that distance affects coordination mechanisms. ESPINOSA et al. (2002) points that "Team interaction in distributed contexts tends to be less frequent and less spontaneous, affecting member's ability to coordinate through communication". Also, LANUBILE (2009) mentions that "distance has an impact on the three main forms of cooperation within a team: communication, coordination, and control." Then, JOHRI (2011) points out in his study that new self-emerging

communication practices could be of crucial importance for the success of the global software development.

2.3 The COVID-19 pandemic

As the year of 2019 was coming to an end, news from China reported a new and highly transmissible respiratory disease. Evidence indicated that this disease was transmitted by a virus pertaining to the Corona family (Coronaviridae), which is the same family of SARS and the MERS viral strains. In March 2020, considering the rising number of infected populations and the geographic spread of the illness around the globe, the World Health Organization (WHO) declared the state of pandemic. Despite the precautions taken, the lethality rate was approximately 3% of those who tested positive, the high transmissibility and subsequent ICU admissions have rapidly exhausted the medical facilities around the world.

During the first phase of the pandemic, there were no vaccines such as that became available between the end of 2020 and the beginning of 2021 and there is still (as the time of writing this study) no treatment by pharmaceuticals that has proven effective against the disease; what was left for governments and societies were the attempts to prevent and mitigate further infection through the use of social distancing policies and the use of masks, several hygiene rules, and restrictions against social, business and community agglomerations, quarantine procedures - social isolation and the closing and restricted use of study and work places where infections were detected.

On-site software development teams were among the group of professionals affected by the social distancing measures, these professionals were obliged to migrate from a presential worksite to a WFH condition.

2.4 Related work

No secondary studies were found revising, aggregating, and synthetizing data on the specific research subject. The lack of secondary studies was expected because they can only be developed after primary studies are conducted, considering that the pandemic is a very recent event.

Given the absence of secondary studies, we cite the primary studies (below), that have more comprehensive analysis and findings, which make them more related to what is intended in this research

SMITE et al. (2021) applied a longitudinal case study in two companies focusing on Remote Pair Programming during the pandemic. They executed three rounds of interviews and surveys during the transition to WFH ranging from March 2020 until January 2021. Then they reviewed written notes and transcriptions with a qualitative data analysis software to create a group of codes and categories, but they did not specify the name of the analysis approach. Their findings indicate that some interviewed developers were not pairing for almost a year, but that Pair Programing has regained importance with the use of special tools and that it has been used also as a form of social practice.

BEZERRA et al. (2020) developed a Grounded Theory (GT) based on a survey among 56 Brazilian developers to understand the relationship of the factors of influence on their respective productivity in the middle of the pandemic. In their conclusions they cite that the majority of the participants consider their productivity good or excellent, and that they are motivated and have good communication with co-workers.

There are important differences among this and the two studies above. First, they are primary studies while this one is a secondary study, the second is the data analysis methodology. Even though they applied similar qualitative analysis, there are differences between the GT and the Thematic Synthesis: One of them is that in the GT the data collection and analysis occur simultaneously while they are executed in different steps in a Thematic Synthesis. In common, the theories (from the GT) and the themes (from the Thematic Synthesis) will emerge from the data.

Chapter 3: Study Planning

The methodology used to conduct this study consists in a SLR protocol composed of the sections or phases:

- Objective and Research Questions;
- Research Strategy and Source Selection;
- Selection criteria and Primary studies selection;
- Selection Procedure;
- Information Extraction Strategy;
- Quality Evaluation;
- Data Analysis and Synthesis.

3.1 Objective and Research Questions

Starting from the Goal-Question-Metric paradigm described by BASILI (1992) the objective of this study is defined as:

Analyze the remote software development

with the purpose of characterize it

in relation to adaptations and changes of software technologies (tools and techniques) and procedures (processes activities and social aspects)

from the point of view of the software developers

in the context of software project developments executed during the COVID-19 pandemic event.

Thus, the research questions related to this objective are the following:

RQ1) How was the transition process from on-site to remote teams?

RQ2) Which activities could not be migrated to remote work?

RQ3) What work related aspects were affected?

RQ3.1) Which changes were implemented in organizational activities and processes?

RQ3.2) Which social aspects were affected?

Considering companies were forced to do a sudden transition to remote work due to the pandemic, RQ1 aims to understand the way the transition evolved. Even with the

necessity to do most of the WFH, it is possible that some activities could not be migrated at all – RQ2 examines those activities. Social isolation altered the forms of relations between people, including with coworkers – RQ3 explores changes in those aspects.

3.2 Research Strategy and Source Selection

A SLR strategy specifies the process concerned with how knowledge relevant to a particular research topic will be gathered, investigated, and summarized. (CRUZES et al., 2015)

Table 1 shows the digital repositories that were selected for this research. The queries in these digital repositories were done in two stages. First, in an ad hoc manner, by using the following terms related to software development, remote work, and pandemic to identify papers: 'software development', 'software engineering', 'home office', 'remote work', 'pandemic' and 'COVID'. From this initial stage, OLIVEIRA et al. (2020) and BEZERRA et al. (2020), were found, from which additional keywords were extracted for the next stage. The new keyword set was applied in the second stage, in a systematic manner, with the objective of finding the primary studies for the systematic review.

Electronic Database	**Search terms matched with**	**Web address**
Engineering Village	Subject, Title, abstract	http://www.engineeringvillage.com
IEEE	Title, Abstract, Index Terms	http://www.ieee.org/web/publications/xplore
Scopus	Title, Abstract, Keywords	https://www.scopus.com/home.uri
Web of science	Title, Abstract, Keywords	http://www.webofknowledge.com

Table 1: Digital databases included in this SLR

The search string contains the following keywords:

("software development" **OR** "software engineering" **OR** "software project" **OR** "programming team" **OR** "programming teams" **OR** "Software company" **OR** "software team" **OR** "software teams") **AND** ("home office" **OR** "remote team" **OR** "remote teams" **OR** "remote work" **OR** "telecommuting" **OR** "work-from-home" **OR** "work from home" **OR** "Remote environment") **AND** ("pandemic" **OR** "COVID" **OR** “corona virus” **OR** “coronavirus”)

The specific search strings for each of the selected digital repositories are listed in Appendix A.

3.3 Selection criteria and Primary studies selection

In accordance with the study’s objectives and research questions, all primary studies should meet at least one of the following criteria:

- Report analytic of empirical results over remote software development during the pandemic; or
- Discuss challenges in remote software development during the pandemic; or
- Propose models for remote software development during the pandemic; or
- Describe the transition process of organizations that did not work remotely before to the WFH configuration.

Exclusion criteria include the following:

- Not written in Portuguese nor English; or
- Not related to remote software development in the context of the pandemic; or
- Duplicates; or
- Not available to download; or
- Not a primary study; or
- Preface, book, editorial or summary.

Table 2 shows the surveyed repositories and the quantity results found in each of them:

Repository	**Result quantity**
Scopus	18
Engineering Village	12
IEEE	07
Web of Science	04
Total	41

Table 2: Digital databases and respective quantity of articles found

After the duplicate removal 25 distinct articles were able to be submitted to the next phase: the Selection Procedure, when inclusion and exclusion stages are executed.

3.4 Selection Procedure

We performed the following steps for the selection procedure to filter primary studies:

1. Keyword queries at Scopus repository.
2. Inclusion criteria executed based on article's Title, Abstract and Keywords.
3. Research string adjustments do add new relevant synonyms.
4. New query on the four selected repositories with the adjusted research string.
5. Exclusion criteria executed based on abstract.
6. Exclusion criteria executed based on full reading.
7. Full reading of articles.

All the above steps were executed by the author and revised by the advisor. Step 5 was done in two sub steps: firstly, the author and the advisor applied the exclusion criteria separately; then they reunited to compare their evaluations and to discuss those studies that received diverging ratings (when the author accepted, but the advisor excluded the primary study, or vice-versa) to agree in a final decision.

Once the exclusion criteria were applied to the abstract step, 17 articles remained to the full reading selection. In that step five were excluded, the remaining 12 articles were subjected to the data extraction, analysis, and synthesis phases.

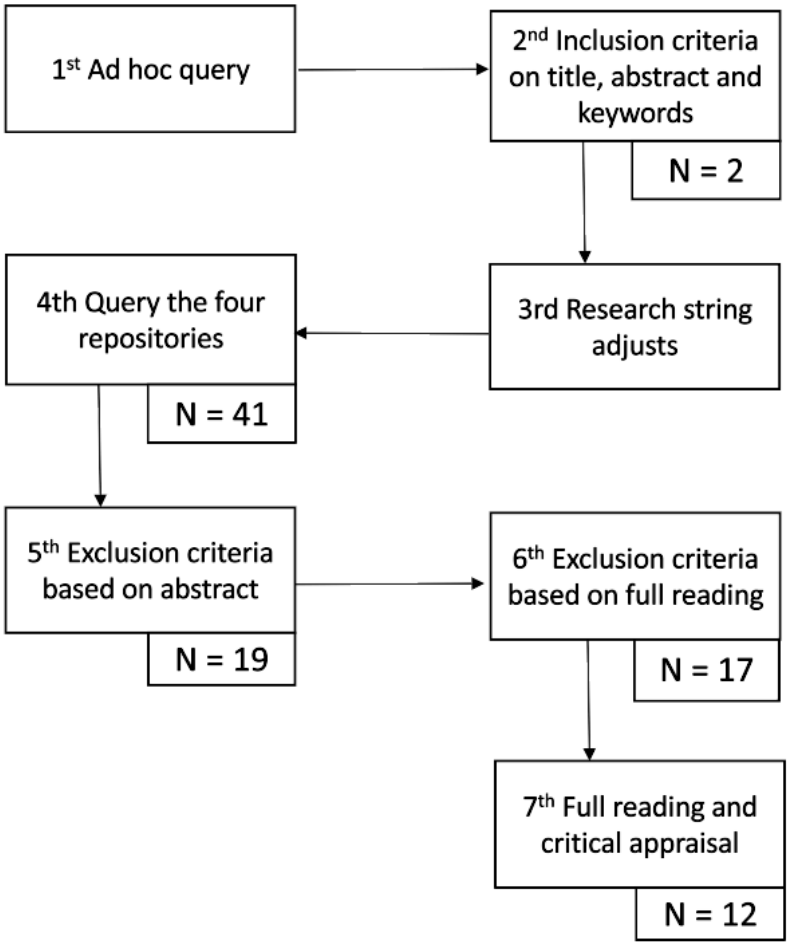

Figure 1: Selection procedure and the number of selected studies in each step

Figure 1 shows the 7 steps of the selection procedure and the number of studies in each stage. The 1st, 2nd, 3rd, and 4th steps were executed in September 2021. The 5th stage was executed in October 2021, then the 6th and 7th stages were executed from October 2021 to February 2022.

3.5 Information Extraction Strategy, Data Analysis and Synthesis

In a SLR, the data extraction process identifies the relevant information that must be extracted from each paper to answer the research questions.

"A key part of systematic reviews is data extraction, in which essential text and data from the primary studies are obtained in an explicit and consistent way according to a defined extraction strategy." (CRUZES; DYBA, 2011)

The Thematic Synthesis is the synthesis strategy chosen for this study. CRUZES; DYBA (2011) propose a 5-step Thematic synthesis process. This procedure includes

the following processes: Initial reading of data/text, identify specific segments of text, label the segments of text, reduce overlap, and translate codes into themes, and create a model of high-order themes.

The codes identified during the Thematic Synthesis process capture the richness of the phenomenon (E. BOYATZIS, 1998). By encoding relevant information, we can identify and develop themes from the data. According to E. BOYATZIS (1998) a theme consists of "a pattern in the information that at minimum describes and organizes the possible observations and at maximum interprets aspects of the phenomenon".

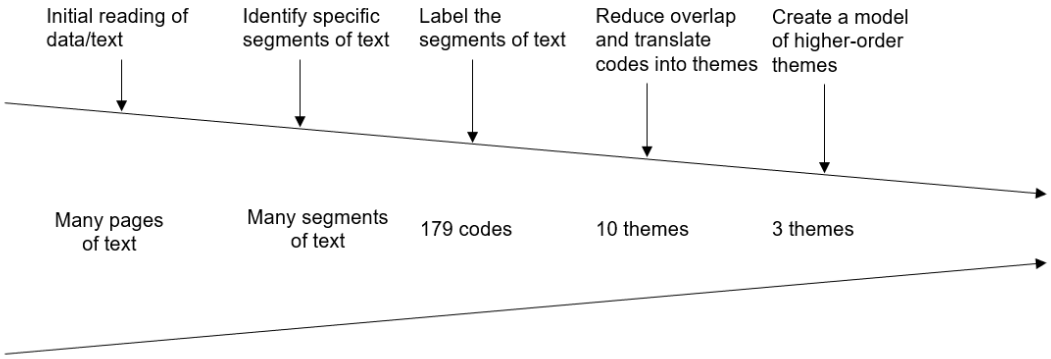

Figure 2: Thematic synthesis process once instanced

Figure 2 lists extraction steps suggested by CRUZES; DYBA (2011) and shows an execution overview of the synthesis process. In each step of this process the abstraction level increases.

- Initial reading and identifying segments of text: The two first steps were executed in parallel. First, the author read the papers highlighting every text snippet that were related at least to one of the research questions' concerns, including contextual information. As the text reading and segment identifying was executed in parallel the two steps were unified for the information extraction.

- Label the segments of text: codes were assigned to the text snippets using a qualitative analysis software[1]. Codes are descriptive labels that have a name and a reference to the snippet itself. The author thoroughly examined and organized the extracted data of each paper to identify the key points in the findings. Whenever needed, the original papers we referred to clarify the understanding and to get back to the context of discussion. The author and the advisor iteratively revised, merged, and defined new codes during this phase of our analysis.
- Reduce overlap and translate codes into themes: all the codes were reviewed and sorted into potential themes (e.g., communication or process).
- Create a model of high-order themes: The author and the advisor reunited weekly to discuss the theme organization. High-order themes were identified based on the codes and themes previously identified disregarding the research questions to the maximum extent possible. The idea is that the themes emerged from the data and not from prior understandings or biases. The fourth (search for themes) and fifth (reviewing and naming themes) steps were executed iteratively.

Table 3: Theme synopsis shows a preview of the themes that emerged from the analysis.

High-order Theme	**Theme**
Interactions	Collaboration
Interactions	Communication
Interactions	Engagement
Human and Social	Environment
Human and Social	Human
Human and Social	Social
Human and Social	Wellbeing
Work Organization	Laboring
Work Organization	Process

Table 3: Theme synopsis

[1] **QDA Miner lite.** Available at https://provalisresearch.com/products/qualitative-data-analysis-software/freeware/. Access in August 08, 2022

3.6 Codification process sample

This section exemplifies the labeling part of the Thematic Synthesis.

Figure 3 Text snippet highlighted in Adobe PDF shows one of the text segments that were identified during the initial reading of one study.

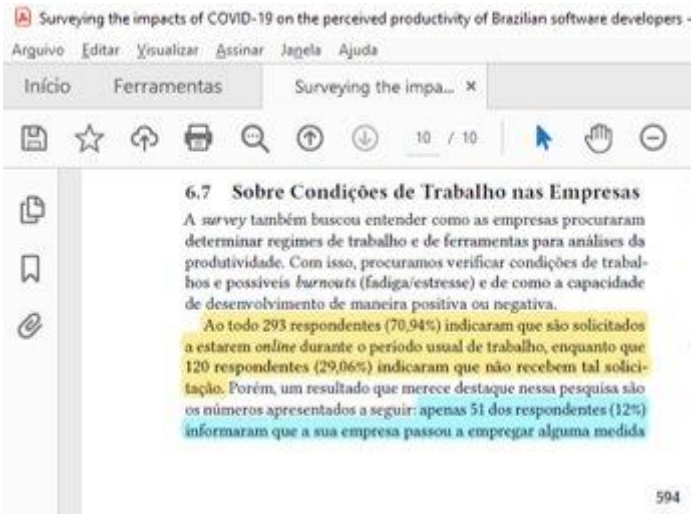

Figure 3 Text snippet highlighted in Adobe PDF

Figure 4 Text snippet translated into code shows the same text in the data analysis software. Note that now that it has been assigned to a label. The same figure shows that the text snippet is related to the “case” (study) and that the respective code is part of the theme hierarchy.

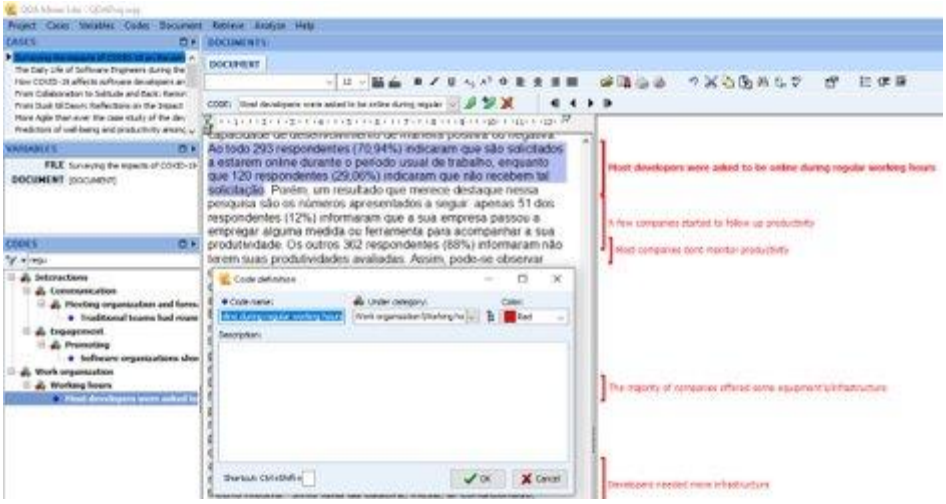

Figure 4 Text snippet translated into code

Chapter 4: Results

The findings of this study are presented in this chapter. They are organized in the following manner: section 4.1 presents metadata about the primary studies assessed in this paper section 4.2 presents the mind map resulting from the data analysis; sections 4.3, 4.4 and 4.5 unravels each of the 3 high-order themes emerging from the Thematic Synthesis: Interactions, Work Organization, and Human and Social, respectively.

4.1 Demographic Data

Demographic information about the included studies is reported in this section: the publication venues and types, the citation status, and the chronological view. All included studies are listed in Appendix B.

4.1.1 Publication venues and types

Researchers seeking to conduct relevant research on a specific topic/theme may find it useful to identify the types and venues of publications for that topic/theme. For this reason, one of the reporting elements of a SLR is the demographic information included in it.

Table 4: Publication Venues and respective quantity of articles found shows how the 12 primary studies are distributed over 7 different publication venues including journals and conferences.

Publication Venue	**#**	**%**
Anais do XXXIV Simpósio Brasileiro de Engenharia de Software (SBES) 2020	3	25%
International Conference on Lean and Agile Software Development (LASD) 2021	3	25%
Empirical Software Engineering Journal (EMSE)	2	16.7%
27th Annual Americas Conference on Information Systems (AMCIS) 2021	1	8.3%
43rd International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP) 2021	1	8.3%
IEEE 34th International Symposium on Computer-Based Medical Systems (CBMS) 2021	1	8.3%
International Conference on Agile Software Development (XP) 2021	1	8.3%

Table 4: Publication Venues and respective quantity of articles found

As shown in Table 4, SBES, LASD and EMSE are the leading publication venues for studies. A note on EMSE Journal is that they have published the first study in their Volume 25 - November 2020, issue 6; and the second one in Volume 26 - July 2021, issue 4. In total, 66,67% (8 studies) of the selected studies were published in these 3 previously cited venues. The following other 4 venues have published only one study up to the search stage that was realized in September 2021: AMCIS, ICSE-SEIP, CBMS, and XP.

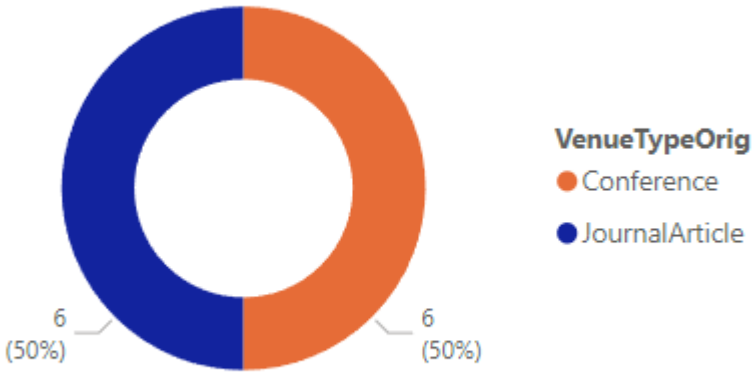

Figure 5: Total Articles per Venue type

As Figure 5 shows, half of the studies (6 out of 12, 50%) were published in journals. The second half represents articles published at relevant conferences (6 out of 12, 50%). These studies included in this review have appeared in both general Software Engineering venues as well as specific venues related to agile software development and computer-based medical systems.

4.1.2 Citation Status and chronological view

The citation status of a paper is an indicator of relevance of the reported work. Table 5 provides an overview of the citation status including citation counts as well as the

month and year of publication of the included studies. These numbers have been extracted from Google Scholar on the 1st of July 2022.

As shown in Table 5: Overview of studies and their respective citation count, four studies (25%) have been cited by more than 20 sources, while other 4 (25%) have been cited by less than 10 sources. Considering that all of these 12 papers have been published in the last 2 years a low citation count was expected. Two studies (12,5%) got 0 citations so far, but they were among the most recently published among the review period. The top 4 studies that received the highest citation count in range 21 – 68 are [S4, S11, S10, S8] in crescent order or citations. Two of them were published in Journals [S8, S11] and two of them were published in Conferences [S4, S10].

Study Id	Year	Month	Citation Count
S1	2021	January	19
S2	2021	June	10
S3	2020	October	8
S4	2020	October	21
S5	2021	January	14
S6	2021	July	0
S7	2020	November	4
S8	2021	July	68
S9	2020	October	12
S10	2021	May	27
S11	2021	January	22
S12	2021	August	0

Table 5: Overview of studies and their respective citation count

Figure 6: Publication venues type and total quantity of articles found per month shows the evolution of publication over the timespan of this study. The first three of the source articles were published simultaneously at the XXXIV Simpósio Brasileiro de Engenharia de Software - SBES (34th Brazilian Symposium on Software Engineering).

Only one of them was published in the Brazilian Portuguese language, the other two were published in English.

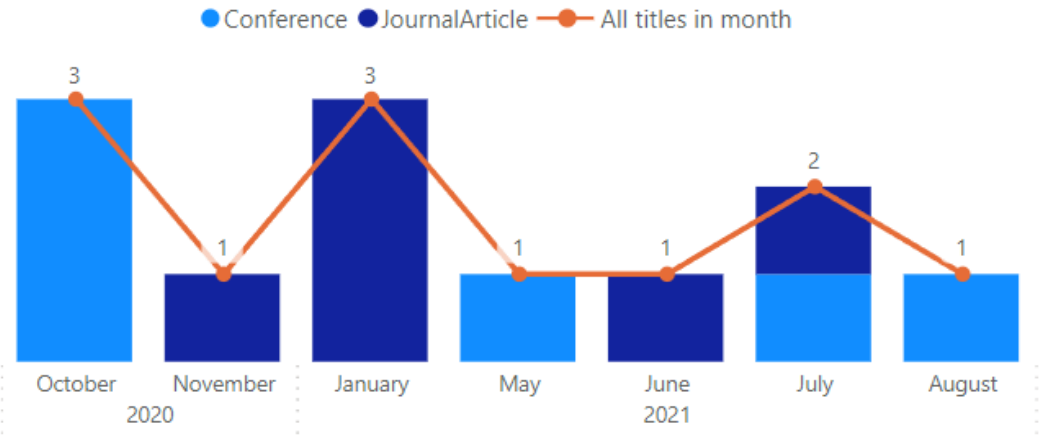

Figure 6: Publication venues type and total quantity of articles found per month

4.2 Findings overview

The process of revision and grouping of the 179 identified codes was made iteratively and based on their affinity and similarity. The code/theme revision step resulted in a set of 24 categories. Then each of these categories were grouped around 9 intermediary themes. Finally, the themes aggregate around the 3 high-order themes.

The aforementioned category and theme hierarchy is represented in Figure 7. This image presents a mind map that helps visualize their relationships. Because of the high quantity and deep granularity of the codes they had to be omitted from the map, so it only shows the categories, themes, and high-order themes are represented. A table containing all the detailed codes and their respective categories and themes is available within the Appendix C at the end of this study.

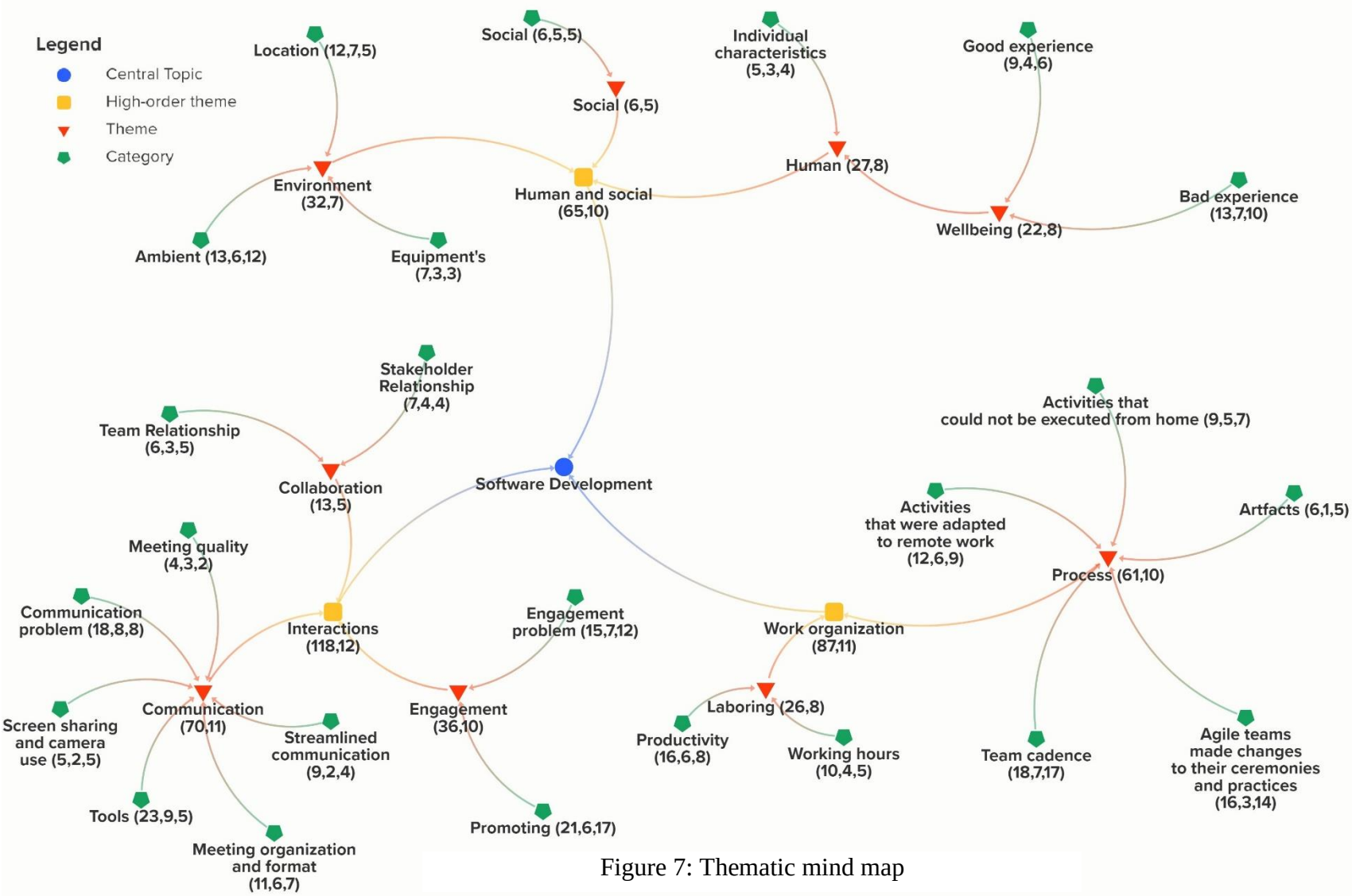

Figure 7: Thematic mind map

Each green pentagon represents a category of codes. Besides the category name, it is also displayed the total quantity of code occurrences, then the quantity of articles in which the same category appeared, and the quantity of codes that grouped to form the category: '<category name> (<code occurrence quantity>, <article quantity>, <code quantity>)'.

The red triangles represent the themes, and the yellow squares are the high-order themes. Their nomenclature is similarly formed: the name is concatenated with the total quantity of occurrences and the quantity of articles in which it has appeared: '<(high-order) theme name> (<occurrence quantity>, <article quantity>)'.

Finally, the blue balloon is the central topic of the discussion. Also, the arrows show the relationships among categories, themes, and high-order themes. The three high-order themes that have been identified in this analysis reveal the main concerns discussed in the literature during this pandemic context: Interactions; Work Organization; 'Human and Social'.

4.3 High-Order Theme 1: Interactions

On the following paragraphs there is a detailed discussion of the findings concerned with the Interactions theme. From now on, **bold font weight** is used when the text is a code. Also, the symbol ¬ at the end of the code implies that the specific code was extracted in vivo from the raw data. Some codes were adjusted to better fit the text fluency. The raw relation of codes, categories, theme hierarchy, and source text is presented in Appendix C.

Intra-team and stakeholder collaboration were affected by the lack of in-person contact caused by the obligatory social isolation and consequent migration to WFH. Suddenly everyone had to adapt to different and new forms of remote communication, which made it more difficult to contact colleagues and stakeholders. Some knowledge management and visual tools were applied to a better team communication. Then the flood of reunions that filled calendars led to a necessity of better organization of online meetings. Finally, after some isolation time several factors caused a lack of focus and concentration that spoiled developer's engagement. So, some measures were taken to reestablish the team's commitment.

Team interaction with external stakeholders seems to have been deteriorated. **The social isolation difficulted interactions with stakeholders**. Because of this isolation,

physical meetings between developers and customers/stakeholders were not possible. Other activities like **on site user testing, usability testing and focus groups also were not possible** as well.

Stakeholders had to assume more responsibilities and the **lack of contact with them made it difficult to find accurate information.** This could be a problem because **the lack of cooperation might compromise the quality of the product**. Therefore, **some features had to be postponed** and some **rework had to be done because of stakeholder's unavailability.** Nevertheless, **team's commitment compensated for lack of communications and problems with stakeholders** and then proactively **reviewing the priorities and assuming part of the stakeholder's duties kept the project on time**¬. On the other hand, a couple of studies cited that most of their survey's respondents declared to **consider that their relationship with stakeholders was normal**¬.

Team relationship was another concern. Although **remote collaboration is not natural as in office**¬, company **employees were encouraged to keep good practices and to experiment new forms of collaboration**¬. The result is that **team communication was easy**, and **most developers find their teams collaborative**. An interesting side effect was that **fully remote work improved communication in teams that had both distributed and on-site members before by moving all communication to online tools** because now everyone has access to every discussion. The fact that **new communication tools were used to coordinate activities** was the single most cited code with 18 appearances in 7 different papers shows the importance of the category. DE MENDONCA et al. (2020) cites that in their experience the "communication between the design and development team has been making great progress, made possible using platforms such as Figma (for the prototyping of screens) and Discord (for meetings). The use of e-mail and WhatsApp for timely and fast communications also collaborates a lot with efficiency." But this increasing number of tools in use comes with the downside that **developers had to familiarize themselves with new technologies to work from home** and that **the use of different tools lead to fragmentation of information across the various platforms**¬. To address this issue **a communication plan was used to choose the appropriate communication channel for each type of needs.** Also, **developers formed groups**

or teams for different topics, and some **knowledge management tools were integrated with communication tools for information centralization** besides providing **easy access to product backlog.** Those are examples of **how collaborative tools can simplify work processes and enable interactive workflows**¬.

Even those teams who do the planning upfront using waterfall methodologies were impacted by communication difficulties. That is why **traditional teams felt need to communicate more**, so this kind of team **had reunions more regularly**. Several developers, while working agile or not, cited that the **threshold to approach the colleagues has increased** and that **less time was spent networking**.

Virtual communication has unique requirements that need to be understood for a smooth workflow. TANNER; NAIDOO (2021) adds that "a lack of non-verbal subtexts was experienced when teams hosted audio-only meetings. The lack of body language, eye contact and facial expressions made it more difficult for hosts and attendees to participate". This when summed with the fact that **team coordination reduced** and that the **lack of rapport added difficulties to asynchronous communication**¬ resulted in a perception of **poor quality of communication** and more **difficulties to remote problem solving and collaborative design**¬. This kind of behavior exemplifies the previous code of unnatural remote collaboration.

To address these deficiencies a **visual approach was used to enhance communication**. Various measures were taken in this direction, TANNER; NAIDOO (2021) comment about them: "the most common mechanism to improve virtual meetings was to enable video, as it offered additional non-verbal subtext which was lost with audio-only calls. […] Through visuality, users can also present themselves or an artifact. Therefore, visuality was also perceived and exploited through the gallery view and screen sharing features offered by some tools (e.g., MS Teams and Zoom)".

Teams explored their tool's functionalities to support communication and collaboration. New **visual collaborative tools** allowed features like **gallery view, screen sharing, remote control and draw on screen.** In addition, **programmers even used special tools to mimic collocated Pair Programming (PP)** resulting in the possibility that **online PP and live coding could be made while sharing screen**. But some of these measures had a short lifespan because **after some time, team**

members no longer wanted to turn on their cameras. Another weak spot cited was that **audio/video and network issues compromised the communication's quality**.

Even though **developers seem to be more focused** when WFH**,** they suffered from engagement issues. They cited a **lack of concentration and loss of focus.** Also, **developers feel disconnected from their team members** as **working from home hindered collaborative practices**. They also **find it difficult to keep discipline** and that **work from home has more distractions.** Despite that, these **distractions do not influence the amount of time spent on work activities**.

Measures used to promote the engagement were that **developers were encouraged to act autonomously and creatively** and that **shared ownership and open collaboration was stimulated**. Besides of increasing teamwork, remote **Pair Programming enhances working at home experience for the sake of socialization** and **dojo sessions led to an improvement in internal communication and allowed solving problems effectively**. At the same time, visual indications like **presence signaling were used to improve responsiveness** and **non-verbal feedback was used to address lack of rapport**.

Even though **explicit written communication was used** to avoid misinterpretations some **synchronous communications had to be used for clarification**. As a result, **virtual daily meetings were employed** and **alignment meeting between diverse teams** were more frequent, which **enhanced communication quality**. The results of **remote meetings with experts made work easier and less stressful** and that they **avoided problems and conflicts that could have arisen later**. About the last code, DE MENDONCA et al. (2020) exemplifies: "some developers reported difficulties in implementing some screens due to either some details in the layout or the lack of experience. After recognizing the problems, the meetings were held with the UX designer, who noticed that some of these details might actually not improve the user experience, and that they could easily be replaced by a simpler alternative".

Developers felt a **necessity to informal conversations** too. RUSSO et al. (2021) recommended that **software organizations should regularly organize both formal and informal online meetings**. Other measures like **new virtual coffee room for socialization and help exchange** as well as **encouraging employees to build strong, meaningful relationships within work environment** were applied.

Online meetings experience **a faster engagement decrease when compared to when in person** but due to the pandemic context **teams tried to substitute face-to-face meetings with online meetings** anyway. On top of that **the elevated number of meetings caused a lack of focus**. To counter that kind of issue, **meetings were reduced but more efficient/organized** and the **frequent meetings were facilitated by online tools**¬ culminating in **less time dedicated to them**¬. Yet another result perceived was that **scheduling meetings was helpful when working from home**¬ as well.

4.4 High-Order Theme 2: Work Organization

This theme concerns with many aspects of work organization: (i) productivity perception; (ii) the activities that could or not be adapted do WFH conditions; (iii) the developer's complaints about the increasing number of working hours even though team cadence (or velocity) stayed the same; (iv) and the adaptation of practices and artifacts to the new conditions.

There is an inability of companies to track productivity: **most companies do not monitor productivity**, only a **few started following it up** and **the few that already followed it did not add new metrics**. When questioned about productivity, most developers could only respond their own perception and self-evaluation. This kind of response generated a set of contradictory groups of codes: while OLIVEIRA et al. (2020) and BEZERRA et al. (2020) cited in the result of their surveys that developers **perceived more productivity than before**, RALPH et al. (2020) and BUTT et al. (2021) commented that **professionals are perceiving less productivity** on their surveys. Also, DE MENDONCA et al. (2020) said that in his project's experience **working from home has no impact on productivity** after some time, but OLIVEIRA et al. (2020) affirmed that **the perception of productivity has changed for the majority of the developers**.

Considering that companies have difficulties monitoring productivity and that they are still having communication difficulties another impact reported is that **WFH might have a negative impact in terms of feedback agility**¬.

Regarding the activities that had to be eliminated, one developer team had planned **focus groups, usability, and on-site user tests** for their project, but those kind of interview and tests had to be cancelled. The same project also tried to substitute

physical meetings between developers and customers/stakeholders with online meetings in the same frequency, but those scheduled interactions were also often cancelled.

All those activities involved physically close human interaction. We have found that **particular situations were allowed to use the office.** SMITE et al. (2021) cited that only "Employees with a particular reason for being at the office (such as the need to run tests on a particular network or particularly problematic situation at home), are allowed to use the office". So, infrastructure activities also figure in the list of office-only activities.

On the other hand, most work activities could be adapted to remote work. Because **most developers had little to no experience in remote working,** some adaptations were needed in work processes and activities. **Software design patterns gained importance** in addition to **checkpoints and documents that were created to follow up activities**.

The requirement analysis was a challenge. Because of that challenge **project coordinators had to be more proactive when proposing requirements**. Product owners engaged more efficiently by better refining activity requests and determining team workload, so **the process of refining and addressing work to the team was simplified**. In contrast, other teams reported that **tasks were more detailed,** and had their **prioritization more rigorous**. The activities **backlog was made more granular**, which means that the future sprints for each team were more clearly defined.

Pair programming "by the book" is not possible when everyone works from home because it depends on the developers to be physically side-by-side so **PP frequency reduced** at first. Even though **remote collaboration is not as natural as in office**¬its use has **increased as developers became more experienced with remote work**. About the previous code, SMITE et al. (2021) explains that "as people realized that remote work was not a temporary situation, the need for more collaborative practices increased and new ways of remote pairing were sought in order to address complex problems, like developing something new, or improving a design". Adaptations like when **some teams that started scheduling Remote PP sessions**¬ and some teams where **PP evolved to switch between synchronous and parallel work**: developers would work together for one period, then they divided tasks and worked separately for

another period, and then returning to syncing. Those changes resulted in **programmers starting to practice PP more**. As a downside **remote PP tools where difficult to use and had technical issues** and **newly onboarded developers had more difficulties to start PP**.

A similar technique to Pair Programming is Pair Testing, in which two team members collaborate to test a software application. One project cited that programmers had to modify their **on-site pair testing** activities but did not detail further.

Agile teams also made changes to other ceremonies. GRIFFIN (2021) cited that "small changes remove a lot of waste and free up precious calendar time for the teams by defaulting some of the updates to an asynchronous manner" then suggested that "Lean principles can be applied to Scrum with minor adjustments and minimal friction". **Daily meetings were recorded, better detailed, documented, planned and efficient**. This kind of recording enabled some of the **scrum ceremonies to be made asynchronously** and allowed **meetings to be replayed** for later clarifications. The daily scrum meeting can be delivered by text, but they can still use calls to align daily goals. They pre-recorded Sprint Review demos so the team could consume it in their own time. Another aspect of the better planned and efficient meetings is that a **strict timeboxing alleviates the burn out of frequent meetings.**

MAREK; WISKA; DBROWSKI (2021) mentioned about project's artifacts that "the disturbance […] was surprisingly low. Almost half of the teams did not change either their Product Backlog or their Product Vision". **The definition of done in most cases remained unchanged**, but when **Product's Vision and Backlog was changed** these **teams had to modify their workflow to address those changes**. **The definition of done became more inflexible in teams that did not work fully remotely before** on the other hand in some teams **the definition of done became more open to respond to either Product Vision or Backlog changes.**

More time was dedicated to specification and documentation. Also, BUTT et al. (2021) found that **developers took more time to complete simple tasks**, while, on the other hand, for both BEZERRA et al. (2020) and RUSSO et al. (2021) **the time spent in activities from home was comparable to when working from office**. This can be explained considering that **after a period of adaptation there is no difference in task accomplishment working from home versus onsite,** which enabled teams **to**

conduct activities as planned before the pandemic. An exception is when **developers sick with COVID-19 affected project deliveries**.

No significant changes were made to work distribution so **the release frequency in most cases remained unchanged**¬. Under those circumstances **most projects continued to deliver at the same rate and with same quality**.

Delegating work in task batches makes it easier for individuals to work in a self-oriented manner, resulting in a more empowered stakeholders and developers' team. GRIFFIN (2021) cited "we analyzed the time distribution to perform tasks by asking participants to rate this factor using the following scale (unsatisfactory, regular, good, excellent). 58.6% from 58 participants said that the distribution is good, 24.1% that it is regular, 12.1% that it is excellent and the remaining 5.2% said it is unsatisfactory". This means that most developers in his study were satisfied with their task and time distribution.

Most developers were asked to be online during regular working hours, but a shift in working hours was also cited as **work from home changed the working hours of development teams** and that **teams perform better working on unusual working hours**.

Even though there was **more work demand** and **consequently more working hours** that resulted in a **difficulty to manage working hours**, most **developers maintained the same work routine**.

4.5 High-Order Theme 3: Human and Social

In this section the main subject is the individual and his WFH environment. How individual characteristics affected people in diverse ways. Which factors decreased developer's well-being and what practices made their experience better. The developer's relation with the new workplace environment as an ambient that had to be set up at home, sometimes in a shared room; and the hardware/software infrastructure that most companies offered.

Some developers cited **less interruptions from colleagues**¬when working from home because, as already cited, the **threshold to approach colleagues increased**, but this aspect was balanced out **by more interruptions from family**¬. As a countermeasure **designating specific work areas and times help minimize distractions while working from home**. **Developers had to set up a working place at home** by

modifying their rooms to **adapt their homes to do remote work**. Even though **the majority of developers have a reserved work environment** some had to **share the same home office** with a family member and doing that **without planning is difficult**. Having **better comfort at home¬** was cited as an advantage and some developers commented that **remote PP was not disturbing others unlike in the office¬**.

The majority of companies offered some equipment's and infrastructure. Some developers mentioned having **better resources at work on site**, but others disagreed saying that they have **better resources at home**. Because **work at home infrastructure depends on the length of social isolation period** and the original papers where early in the pandemic timeline some **developers needed more infrastructure** at that time.

Companies sent employees home and prohibited access to office. A commonly cited consequence was that **less time was spent in commuting**. Regarding this aspect BEZERRA et al. (2020) mentions that "traffic was often pointed out as a problem, either because it is stressful or because it is wasted time". Some companies had a starting advantage: the ones that were already **geographically distributed had facilitating conditions**, but in the end **mixed and fully on-site developers where able to shift to full remote work**. Nevertheless, in general, as time passed **developers became more used to working from home.**

As of individual characteristics, **the pandemic may disproportionately affect women, parents, and people with disabilities**. An example is that **female developers report higher levels of stress-induced self-distraction** and that this same group **have higher anxiety levels.** As a conclusion, it seems that **different people need different kinds of support¬**. When considering soft skills, **developers with self-management skills can adapt better** to the social isolation period, **software engineers' psychological and social factors affect 'how' not 'what' they do** in terms of work activities and **introverted software professionals seem to be more negatively affected by the lockdown¬**.

Professionals are experiencing diminished emotional well-being¬ during the pandemic. **Stress, isolation, and other restrictions creates different conditions from normal working from home** so **even developers with experience in remote work may be having negative health effects causes by the pandemic¬**.

Other aspects affecting developer's well-being were cited as they were having **less time spent in breaks**, that **workday intensity has increased**, even **remote pair programming is more intense and tiring than pairing in the office**¬, the fact that **personal and professional spaces may collide**¬, and the **fear of losing contracts**¬.

Organizing the day in a structured way at home appears to be beneficial for software professionals' well-being¬. Developers found that **designating time for hobbies or with family and friends was helpful while working from home**¬so to improve the work experience and professional well-being even more some measures to separate work and personal time were taken. **Most developers practice hobbies and self-care rituals** - like sunbaths, healthy eating meditations, reading, painting, therapies, and dance classes -, **mindfulness practices, and exercises to reduce stress**.

In the end, even though some developers reported having **less work satisfaction,** the majority of **developers feel motivated** as most **of them had a good experience while working from home**¬ resulting in a condition where **most of them wish to keep working from home at least a portion of time**.

The **absence of body language makes it more difficult to detect the team's psychological safety**¬, GRIFFIN (2021) remembers that "in a remote world, where web-cameras may not be available for everyone, it is impossible to gain that sense of how safe the team are. This can have a major impact on the quality of the contributions and hampers the retrospective longer term."

SMITE et al. (2021) argues that **the success of remote collaboration depends on the existing social connections**¬ then raises an interesting hypothesis: "If the future will be a hybrid of remote and office work, and companies will more willingly hire experts from remote locations, we will no longer be able to rely or assume that people will know each other well."

Chapter 5: Discussion

In this chapter we answer the research questions and discuss the themes that were found.

5.1 RQ1 How was the transition process from on-site to remote teams?

Most companies offered some infrastructure as was needed: computers, laptops, monitors, peripherals, VPN access and new remote collaboration software licenses. Monetary supports as reimbursements and financial assistance were also cited as kinds of support given.

Nevertheless, some developers complained about not having office chairs, tables, air conditioning as when they were in office because their companies were among those who did not even offer them any equipment or financial support. Another complaint was that companies offered little to no counselling and mental support to counter developer's emotional well-being decrease.

Those companies that had a mixed environment where some workers already were in a WFH situation before the pandemic had a head start with the transition process. They previously had VPN infrastructure, home office set-ups, a work from home culture. Some of the employees and their leaders were already used to a similar remote work relation long before the pandemic has started.

New tools were used to meet emerging communication necessities as well as to mitigate some of the effects of social distancing. Synchronous communications like reunions were conducted online using webcams (audio and video) or only microphones (exclusively audio) alongside with communication apps like Zoom, Microsoft Teams, and Discord. This simultaneous communication mode was used for regular online meetings, immediate clarifications, and important announcements. Other simultaneous visual resources were also adopted, such as gallery view, screen sharing, remote-control and draw-on-screen were often used for problem solving and Pair Programming.

Being synchronous does not mean that a meeting could not or should not be recalled. On the contrary, some teams started recording reunions and daily contacts. This kind of register not only made it possible to posteriorly retrieve those encounters but allowed them to be participated in an asynchronous form as well. But these kinds of

non-parallel communications and discussions would be carried mainly by text using chat messaging, e-mails, and/or agile story cards.

Developers had to familiarize themselves with new and different communication tools in the very first months of the pandemic work from home.

Name	**Text chat**	**Audio video**	**Task management**	**Code repository**	**Knowledge management**	**File sharing**	**Project white board**
Discord	X	X				X	
Google Meet	X	X				X	
Microsoft Teams	X	X				X	
Skype	X	X				X	
Slack	X					X	
Telegram	X	X				X	
WhatsApp	X	X				X	
Zoom	X	X				X	
Azure DevOps			X	X			
GitHub			X	X			
GitLab			X	X			
Jira			X				
Confluence					X		
Trello						X	
Concept board							X
Miro							X
Mural							X

Table 6: Communication tools and platforms, and their functionalities

Table 6 shows that a handful of communications tools and platforms were used, sometimes with an overlap between them. Notice how the task management apps group (E.G Azure DevOps, GitHub, GitLab, and Jira) and code repository group (E.G Azure DevOps, GitHub, and GitLab) are almost completely intersecting, exception for Jira. On the other hand, Jira is the only one that can be integrated with the only knowledge management system (Confluence) that was cited.

This communication tool overlap caused a fragmentation of information across different platforms, for example a story card could stipulate a requirement, but a specific detail would be asked about (and responded) by e-mail or chat messaging. So, teams had to be careful not to lose those pieces of information scattered around different applications. Because of this dispersion a communication plan is needed to support their work.

The majority of companies provided software, hardware, and monetary assistance. Several new tools were used to fulfill different communication needs.

5.2 RQ2 Which activities could not be migrated to remote work?

Those activities that required close personal contact were not possible to migrated to WFH. A study cited a project that had planned focus groups, usability and user tests, but those kind of interviews and tests had to be cancelled. The same team also cited that they tried to replace face-to-face meetings with online meetings in the same frequency, but those scheduled interactions were often cancelled. Furthermore, another study cited a team in which programmers had to modify their pair testing activities but did not give further details. Some infrastructure activities also had to be executed on-site, so these activities also figure in the list of office-only activities.

An interesting side effect was observed in Pair Programming. It originally required that the two developers be physically sitting side-by-side while sharing the same monitor, keyboards and mouses. So, in the beginning of the pandemic it was among those activities whose frequency was dramatically reduced. But as developers got used to WFH, they started to practice an evolved form called Remote Pair Programming that makes use of special screen sharing programs to mimic collocated Pair Programming. This practice was also performed in a form that included switches between synchronous and asynchronous PP sessions.

Overall, most work activities could or had to be adapted in some way. This means that meetings were made online. Debugging, code assessments, and implementing new functionalities could also be done remotely together. This cooperation could be done when a developer would share the screen and control actions like a driver, and the other would act like a navigator.

Most activities could be migrated or adapted to remote work. There were projects that had presential meetings, focus groups, and some types of tests cancelled. Infrastructure activities still had to be executed on-site.

5.3 RQ3 What work related aspects were affected?

The forced shift to work from home has impacted the traditional 9 to 5 business hours regimen. Even considering that in some cases IT professionals did not really adhere to this traditional timetable scheme before the pandemic, mostly because of work demand necessities, there has been a change in quantity and time organization.

Developers adapted their time schedules to be working at the moments that they felt more productive or willing to do so, either by starting earlier for those who are more productive in the morning or to start later for those that perform better later in the day or after the sun sets.

This timetable flexibility has the advantage of allowing developers to perform at their individual best hours. Another advantage is that this flexibility allowed people from different time zones to work together. For instance, there have been several developers living in Brazil and working for companies in Portugal, or vice versa.

As a downside, this versatility made it more difficult to make teams work schedules to coincide. Most developers were asked to be online at ‘core hours’ to counter this time discrepancy. Even though there was a timetable flexibility, some developers reported that they had to work more hours than before and that they had difficulties organizing their schedules.

The benefits of not having to commute regularly were experienced by almost every developer. They reported savings in fuel expenditures or transportation fare costs, but more importantly, everyone had more free time before and after working to do what they enjoyed doing, be it studying, exercising, shopping, with their family, or even working those hours that were previously lost in traffic.

The perception of productivity demonstrated conflicting results. Even though developers had more flexibility to choose when and where to work, that they were working more hours than before. Some specific groups reported an increase in their own productivity, especially for those between 30 and 45 years old, or those who had 10 years or more of work experience, or those who worked at companies with more than 100 employees. On the other hand, those who are not in the previously cited groups reported a decrease in their productivity perception.

Virtual meetings were created to fill the formal communication necessities since developers could not physically meet anymore. These virtual meetings had to be very well organized to preserve efficiency: strict scheduling was needed not impact other activities planned on the agenda, speaking order was required to optimize the time and to avoid deviations from the meeting agendas, and recording/better documentation to allow the meetings to be recalled. On the other hand, informal meetings like virtual happy hours and coffee pauses created a sense of team culture among co-workers.

Meetings had to be very well organized because calendars were suddenly filled with online appointments that tried to substitute presential conversations and reunions. This organization involved strict timeboxing and scheduling to reduce frequency and duration while at the same time, increase efficiency and organization. Consequently, less time was spent in online reunions after some adjustment period.

Workweek schedules were adapted to include the hours that developers feel they perform better. More overtime hours were demanded. No commuting necessity created more free time and transportation savings. A specific group of more experienced developers perceived an increased productivity.

5.4 RQ3.1 Which changes were implemented in organizational activities and processes?

Some teams tried to increase developer's engagement and creativity by experimenting with new practices. Design patterns gained more prominence when used to speed up the development process, coding dojo sessions were a ludic manner to improve the overall team skills while sharing experiences, and even Pair Programming evolved to enable a remote interactivity.

Agile teams organized their ceremonies. Daily meetings were recorded as previously detailed, retrospective meetings were enforced to improve future releases based on the learnings of the concluding delivery, and a few Scrum teams adjusted their sprint length.

Most projects reported not changing their Product Backlog and Product Vision. But, when at least one of those artifacts had to be modified teams responded by adapting their workflow to a new product plan, one of those adaptations was a more flexible Definition of Done criteria.

Product owners had to review priorities to keep projects on time, some features were postponed or even cancelled. Rework had to be done due to a need for requirement revision, combined with the inability to contact stakeholders.

There was one team that applied Lean software development principles generating a Scrum variation with remote teams in mind. These changes resulted in less time-waste, better priority decisions, and a more empowered stakeholders and developers' team.

Another organizational measure was suggested - to present work in batches instead of individual tasks; this resulted in more autonomy and flexibility for the developers.

A team reported having implemented strategies to stimulate an environment of shared ownership and open collaboration. Members had autonomy and expanded creativity to make decisions. Daily meetings were applied to keep team members aligned, and WhatsApp groups were created for faster communication.

New practices were implemented or encouraged to maintain developers engaged. Agile teams modified their ceremonies. Product vision and/or backlog changes were accompanied by workflow adaptations. Some teams implemented Lean principles to Scrum, other teams stimulated shared ownership and collaboration.

5.5 RQ3.2 Which social aspects were affected?

During business hours, the social restriction meant not meeting in person with colleagues and bosses, which has impacted teamwork. Besides no informal presential reunions, no face-to-face coffee breaks nor in-person Year's End gatherings. Those who were already working remotely, before the pandemic, had the opportunity to occasionally meet their teams. During the strictest moments of the pandemic this possibility was not available.

Developers reported a need for this kind of informal interaction, which could be provided by the virtual meetings that were implemented. They also reported that remote collaboration does not feel natural, in fact even with audio and video calls there is a loss of rapport in virtual communications.

The lack of proximity made it difficult for colleagues to approach each other. Coding dojo sessions and remote pair programming were among the activities used to improve the socialization while allowing the teams to work together.

Professional well-being was impacted by the stress, social isolation and restrictions, and conflicts between personal and professional spaces. They spent less time in breaks despite these more severe work conditions. To counter the negative effects of this scenario, developers were dedicating specific timespans for hobbies, friends, families, and self-care activities.

As the pandemic may have affected specific demographic groups in different manners, companies should support them in an equitable and fair way. Affirmative actions should take care of each individual considering their unique needs by applying the necessary resources to help every player achieve their respective, expected results. – For instance, women developers reported higher anxiety levels and self-distractions, some families had no schools or kindergartens for their small children, people with disabilities also experienced specific accessibility handicaps. As such, these and other specific groups should be addressed through different support alternatives to mitigate the existing inequalities.

Teamwork was impacted as team members experienced a lack of proximity. The threshold to approach the colleagues increased. Professional well-being has deteriorated. Specific demographic groups have been disproportionally affected and needed special support.

5.6 Categories and Research Questions

After answering the Research Questions, it is convenient to show how they relate to the themes and categories presented in the results section. As the we tried, to the best extent, to extract the themes emerging from the data, the link between the themes and categories with the Research Questions is implicit to the data analysis process. Due to

this characteristic of the data analysis process, Table 7 show the explicit the relations between them according to our interpretations.

High-order theme/Theme/Category	**RQ1**	**RQ2**	**RQ3.1**	**RQ3.2**
Human and Social	X	X		X
Environment	X			X
Ambient	X			X
Equipment's	X			
Location	X	X		
Human				X
Individual characteristics				X
Well-being				X
Bad experience				X
Good experience				X
Social				X
Social				X
Interactions	X		X	X
Collaboration			X	X
Stakeholder relationship			X	X
Team relationship				X
Communication	X		X	X
Communication Problem	X		X	X
Meeting organization and format			X	
Meeting quality			X	
Screen sharing and camera use			X	X
Streamlined Communication			X	
Tools	X		X	
Engagement			X	X
Engagement Problem			X	X
Promoting			X	X
Work organization	X	X	X	

Laboring			X	
Productivity			X	
Working hours			X	
Process	X	X	X	
Activities that could not be executed from home	X	X		
Activities that were adapted to remote work	X	X	X	
Agile teams made changes to their ceremonies and practices	X		X	
Artifacts			X	
Team cadence			X	

Table 7: Categories and Research Questions

Chapter 6: Conclusion

The present study provides an overview of the state of remote software development during the pandemic based on recent literature.

6.1 Final considerations

The goal of this study was to understand how remote software development occurred during the COVID-19 pandemic. In general, it appears that the transition to work from home has happened with some difficulties, but as time passed and developers became more familiar with the new work environment most of those difficulties were overcome.

Nevertheless, new relevant aspects emerged from this research. The interactions among developers were one of the main concerns found as it appeared in all the source studies. Teams suffered from communication and engagement problems, but they were sorted out with the use of new tools, meeting organizations and some measures to promote developer engagement. To manage the transition to WFH context, the work organization went through several process changes. Human and social aspects were also considered, while developers enjoyed not having to commute, some demographic groups found working from home during the pandemic to be a burden.

The general perception is that most developers had an enjoyable experience while working from home. This positive perception was experienced by most of the professionals wishing to stay remote, at home, at least a portion of time, a hybrid condition that considers working some days on site and the rest of the week from home. This hybrid relationship would cover the needs for communications and interactions while at the same time proportioning the freedom, comfort, and more free time experienced when working from home.

6.2 Limitations

There are some threats to the validity of this study as follows:

- **Study discovery** in a sole source can present a risk, so to suppress this kind of threat four digital databases were included in the SLR.
- **Study selection** can be subject to bias; because of this the inclusion criteria was performed by more than one researcher so the decisions could be compared and conciliated.
- **Result synthesis** presents an inherent subjectivity for being qualitative research. The advisor reviewed all the codes, categories, and themes.
- **The review protocol** was elaborated solely by the author. This protocol did not have an external expert inspection, but it was reviewed by the advisor.

6.3 Suggestions for future research

The strict time period and context of this research resulted in a set of 12 source studies. Considering that the literature mapping was executed in September 2021, to enrich the presented results a future work could include more recent literature, more digital databases, an expanded keyword set, and more embracing inclusion/exclusion criteria.
Few sources detailed and explored activities that could not be migrated to work from home. One hypothesis is that activities in fact could be migrated. It would be interesting a research effort directed to this particular aspect. Suggested questions are: Which activities could not be migrated? Why they could not be migrated? What was done to substitute those activities? How were they executed considering the pandemic context and restrictions?
Productivity tracking presented conflicting results. The first issue is that companies have difficulties monitoring it with quantitative metrics. When productivity was cited, it was from the developer's own perception and point of view. A group of authors claimed that developers perceived more productivity than before, but a second group cited a reduction in productivity. A third group cited that after the adaptation period there was no productivity impact. This means that there is an opportunity to further investigate the productivity impact due to WFH during pandemic (and after, with hybrid remote work). This could lead to insights of which demographic groups performed better or worse when at home compared to when on site.
Some authors mentioned that teams simplified the task distribution and prioritization, at the same time others cited that tasks were more detailed and more rigorously

prioritized. This apparently contradictory points of view should be thoroughly investigated.

We had planned a fourth research question “What aspects of remote work during the pandemic differ from previous remote work?”, but there is very little information on this subject. It would be interesting to compare differences between remote work before the pandemic (done by choice) and during the pandemic (done by obligation).

References

ALLEN, T. D.; GOLDEN, T. D.; SHOCKLEY, K. M. **How Effective Is Telecommuting? Assessing the Status of Our Scientific Findings**. *Psychological Science in the Public Interest*, [s.l.], v. 16, nº 2, p. 40–68, 2015. ISSN: 1529-1006, DOI: 10.1177/1529100615593273.

BASILI, V. R. **Software modeling and measurement: the Goal/Question/Metric paradigm**. Technical Report. USA: University of Maryland at College Park, 1992.

BEZERRA, C. I. M. et al. **How Human and Organizational Factors Influence Software Teams Productivity in COVID-19 Pandemic: A Brazilian Survey**. Em: *Proceedings of the 34th Brazilian Symposium on Software Engineering*. New York, NY, USA: Association for Computing Machinery, 2020. Disponível em: <https://doi.org/10.1145/3422392.3422417>. Acesso em: 17/maio/22. ISBN: 978-1-4503-8753-8, DOI: 10.1145/3422392.3422417.

BUTT, S. A. et al. **Agile Project Development Issues During COVID-19**. *Lecture Notes in Business Information Processing*, [s.l.], v. 408, p. 59–70, 2021. DOI: 10.1007/978-3-030-67084-9_4.

CASEY, V. **Virtual software team project management**. *Journal of the Brazilian Computer Society*, [s.l.], v. 16, nº 2, p. 83–96, 2010. ISSN: 1678-4804, DOI: 10.1007/s13173-010-0013-3.

CRUZES, D. S. et al. **Case studies synthesis: a thematic, cross-case, and narrative synthesis worked example**. *Empirical Software Engineering*, [s.l.], v. 20, nº 6, p. 1634–1665, 2015. ISSN: 1573-7616, DOI: 10.1007/s10664-014-9326-8.

CRUZES, D. S.; DYBA, T. **Recommended Steps for Thematic Synthesis in Software Engineering**. Em: *2011 International Symposium on Empirical Software Engineering and Measurement*. [s.l.]: [s.n.], 2011. ISSN: 1949-3789, DOI: 10.1109/ESEM.2011.36.

DE MENDONCA, W. L. M. et al. **From Dusk till Dawn: Reflections on the Impact of COVID-19 on the Development Practices of a R&D Project**. Em: *ACM International Conference Proceeding Series*. Virtual, Online, Brazil: [s.n.], 2020. Disponível em: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099369574&doi=10.1145%2f3422392.3422446&partnerID=40&md5=62896c0e5e5e9d66bf7719c02bd7406c>. DOI: 10.1145/3422392.3422446.

E. BOYATZIS, R. **Transforming Qualitative Information | SAGE Publications Inc**. [s.l.]: [s.n.], 1998.

ESPINOSA, A. et al. **Shared Mental Models, Familiarity, and Coordination: A Multi-Method Study of Distributed Software Teams**. [s.l.], p. 11, 2002.

GRIFFIN, L. **Implementing Lean Principles in Scrum to Adapt to Remote Work in a Covid-19 Impacted Software Team**. *Lecture Notes in Business Information Processing*, Virtual, Online, v. 408, p. 177–184, 2021. ISSN: 18651348, DOI: 10.1007/978-3-030-67084-9_11.

JOHRI, A. **Sociomaterial bricolage: The creation of location-spanning work practices by global software developers**. *Information and Software Technology*, [s.l.], v. 53, nº 9, p. 955–968, 2011. ISSN: 0950-5849, DOI: 10.1016/j.infsof.2011.01.014.

LAMERSDORF, W. **Paradigms of Distributed Software Systems: Services, Processes and Self-organization | SpringerLink**. 2011. Disponível em: <https://link.springer.com/chapter/10.1007/978-3-642-35755-8_3?noAccess=true>. Acesso em: 13/jun./22.

LANUBILE, F. **Collaboration in Distributed Software Development**. Em: DE LUCIA, A.; FERRUCCI, F. (Orgs.). *Software Engineering: International Summer Schools, ISSSE 2006-2008, Salerno, Italy, Revised Tutorial Lectures*. Berlin, Heidelberg: Springer, 2009. p. 174–193. ISBN: 978-3-540-95888-8, DOI: 10.1007/978-3-540-95888-8_7.

MAREK, K.; WISKA, E.; DBROWSKI, W. **The State of Agile Software Development Teams During the Covid-19 Pandemic**. *Lecture Notes in Business Information Processing*, Virtual, Online, v. 408, p. 24–39, 2021. ISSN: 18651348, DOI: 10.1007/978-3-030-67084-9_2.

NILLES, J. **Telecommunications and Organizational Decentralization**. *IEEE Transactions on Communications*, [s.l.], v. 23, nº 10, p. 1142–1147, 1975. ISSN: 1558-0857, DOI: 10.1109/TCOM.1975.1092687.

OLIVEIRA, E. et al. **Surveying the impacts of COVID-19 on the perceived productivity of Brazilian software developers**. Em: *Proceedings of the 34th Brazilian Symposium on Software Engineering*. New York, NY, USA: Association for Computing Machinery, 2020. ISBN: 978-1-4503-8753-8, DOI: 10.1145/3422392.3422444.

RALPH, P. et al. **Pandemic programming: How COVID-19 affects software developers and how their organizations can help**. *Empirical Software Engineering*, [s.l.], v. 25, nº 6, p. 4927–4961, 2020. ISSN: 13823256, DOI: 10.1007/s10664-020-09875-y.

RUSSO, D. et al. **The Daily Life of Software Engineers During the COVID-19 Pandemic**. Em: *2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP)*. [s.l.]: [s.n.], 2021. DOI: 10.1109/ICSE-SEIP52600.2021.00048.

SMITE, D. et al. **From Collaboration to Solitude and Back: Remote Pair Programming During COVID-19**. *Lecture Notes in Business Information Processing*, Virtual, Online, v. 419 LNBIP, p. 3–18, 2021. ISSN: 18651348, DOI: 10.1007/978-3-030-78098-2_1.

TANNER, M.; NAIDOO, M. **The Use of Tools Affordances to Support Communication and Collaboration During COVID-19 Remote Work Completed Research**. Em: *DIGITAL INNOVATION AND ENTREPRENEURSHIP (AMCIS 2021)*. [s.l.]: [s.n.], 2021.

Appendix A - Full Research Strings

SCOPUS

TITLE-ABS-KEY ("software development" OR "software engineering" OR "software project" OR "programming team" OR "programming teams" OR "Software company" OR "software team" OR "software teams")

AND TITLE-ABS-KEY ("home office" OR "remote team" OR "remote teams" OR "remote work" OR "telecommuting" OR "work-from-home" OR "work from home" OR "Remote environment")

AND TITLE-ABS-KEY ("pandemic" OR "COVID" OR "corona virus" OR "coronavirus")

Web of science

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AND

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OR AK=("pandemic" OR "COVID" OR "corona virus" OR "coronavirus"))

IEEE Xplore

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AND
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AND
(KY = "pandemic" OR "COVID" OR "corona virus" OR "coronavirus")

Appendix B - Paper list

Id	Release date	Title	Authors
S1	2021/01	Agile Project Development Issues During COVID-19	Butt et al.
S2	2021/07	From Collaboration to Solitude and Back: Remote Pair Programming During COVID-19	Smite et al.
S3	2020/10	From Dusk till Dawn: Reflections on the Impact of COVID-19 on the Development Practices of a R&D Project	De Mendonca et al.
S4	2020/10	How Human and Organizational Factors Influence Software Teams Productivity in COVID-19 Pandemic: A Brazilian Survey	Bezerra et al.
S5	2021/01	Implementing Lean Principles in Scrum to Adapt to Remote Work in a COVID-19 Impacted Software Team	Griffin
S6	2021/07	More Agile than ever: the case study of the development of a dashboard for the management of ICU beds during the coronavirus outbreak	de Morais Barroca Filho et al.
S7	2020/11	Pandemic programming: How COVID-19 affects software developers and how their organizations can help	Ralph et al.
S8	2021/07	Predictors of well-being and productivity among software professionals during the COVID-19 pandemic a longitudinal study	Russo et al.

S9	2020/10	Surveying the impacts of COVID-19 on the perceived productivity of Brazilian software developers	Oliveira et al.
S10	2021/05	The Daily Life of Software Engineers During the COVID-19 Pandemic	Russo et al.
S11	2021/01	The State of Agile Software Development Teams During the COVID-19 Pandemic	Marek et al.
S12	2021/08	The Use of Tools Affordances to Support Communication and Collaboration During COVID-19 Remote Work Completed Research	Tanner and Naidoo

Appendix C - Code, category and theme hierarchy, and source texts

High-order theme	Category	Code	Sources
Human and Social	Ambient	Better comfort at home	S9
Human and Social	Ambient	Better resources at home	S9
Human and Social	Ambient	Better resources at work on-site	S9
Human and Social	Ambient	Designating specific work areas and times help minimize distractions while working from home	S8
Human and Social	Ambient	Developers had to adapt their homes to do remote work	S4
Human and Social	Ambient	Developers had to modify their rooms to make a better working environment	S3
Human and Social	Ambient	Developers had to set up a working place at home	S3
Human and Social	Ambient	Less interruptions from colleagues	S9, S10
Human and Social	Ambient	More interruptions from family	S9
Human and Social	Ambient	Remote Pair Programming does not disturb others unlike in the office	S2
Human and Social	Ambient	Sharing the same home office without planning is difficult	S2
Human and Social	Ambient	The majority of developers have a reserved work environment	S4
Human and Social	Equipment's	Developers needed more infrastructure	S9

Human and Social	Equipment's	The majority of companies offered some equipment's/infrastructure	S2, S4, S9
Human and Social	Equipment's	Work at home infrastructure depends on the length of social isolation period	S9
Human and Social	Individual characteristics	Developers with self-management skills are able to adapt better	S4
Human and Social	Individual characteristics	Different people need different kinds of support	S7
Human and Social	Individual characteristics	Software engineers' psychological and social factors affect 'how' not 'what' they do	S10
Human and Social	Individual characteristics	The pandemic may disproportionately affect women, parents and people with disabilities	S7
Human and Social	Location	Companies sent employees home and prohibited access to office	S2
Human and Social	Location	Developers became more used to working from home	S10
Human and Social	Location	Geographically distributed companies/teams had facilitating conditions	S2, S11
Human and Social	Location	Less time spent in commuting	S3, S4, S8, S9
Human and Social	Location	Mixed and fully on-site developers where able to shift to full remote work	S11
Human and Social	Social	Absence of body language makes it more difficult to detect the team's psychological safety	S5

Human and Social	Social	Developers have less work satisfaction	S1
Human and Social	Social	Most developers feel motivated	S4, S9
Human and Social	Social	The success of remote collaboration depends on the existing social connections	S2
Human and Social	Social	Workday intensity has increased	S5
Human and Social	Well-being - bad experience	Even developers with experience in remote work may be having negative health effects causes by the pandemic	S4
Human and Social	Well-being - bad experience	Fear of losing contracts	S9
Human and Social	Well-being - bad experience	Female developers have higher anxiety	S8
Human and Social	Well-being - bad experience	Female developers report higher levels of stress-induced self-distraction	S8
Human and Social	Well-being - bad experience	Introverted software professionals seem to be more negatively affected by the lockdown	S8
Human and Social	Well-being - bad experience	Less time in breaks	S10
Human and Social	Well-being - bad experience	Personal and professional spaces may collide	S5
Human and Social	Well-being - bad experience	Professionals are experiencing diminished emotional well-being	S7
Human and Social	Well-being - bad experience	Remote Pair Programming is more intense and tiring than pairing in the office	S2

Human and Social	Well-being - bad experience	Stress, isolation and other restrictions creates different conditions from normal working from home	S7
Human and Social	Well-being - good experience	Designating time for hobbies or with family and friends is helpful while working from home	S8
Human and Social	Well-being - good experience	Mindfulness practices, exercises and hobbies to reduce stress	S8
Human and Social	Well-being - good experience	Most developers had a good experience while working from home	S9
Human and Social	Well-being - good experience	Most developers practice hobbies and self-care rituals	S4
Human and Social	Well-being - good experience	Most developers wish to keep working from home at least a portion of time	S3, S9
Human and Social	Well-being - good experience	Organizing the day in a structured way at home appears to be beneficial for software professionals' well-being	S8
Interactions	Communication Problem	Lack of contact with stakeholders made it difficult to find accurate information	S3
Interactions	Communication Problem	Poor quality of communication	S9, S10, S12
Interactions	Communication Problem	Team coordination reduced	S1
Interactions	Communication Problem	Teams experienced difficulties to remote problem solving and collaborative design	S12

Interactions	Communication Problem	The threshold to approach the colleagues increased	S2, S3, S5, S8, S9, S12
Interactions	Communication Problem	The use of different tools lead to fragmentation of information across the various platforms	S12
Interactions	Communication Problem	Traditional teams felt need to communicate more	S9
Interactions	Communication Problem	Virtual communication has unique requirements that need to be understood for a smooth workflow	S8
Interactions	Engagement Problem	Developers feel disconnected from their team members	S12
Interactions	Engagement Problem	Developers find it difficult to keep discipline during the pandemic	S3
Interactions	Engagement Problem	Developers seem to be more focused	S10
Interactions	Engagement Problem	Distractions while working from home do not influence the time spent on work activities	S10
Interactions	Engagement Problem	Lack of rapport added difficulties to asynchronous communication	S12
Interactions	Engagement Problem	Less time networking	S10
Interactions	Engagement Problem	Online meeting engagement decreases faster than when in person	S5
Interactions	Engagement Problem	Professionals suffer from lack of concentration and loss of focus	S4, S5, S9
Interactions	Engagement Problem	The elevated number of meetings causes lack of focus	S4
Interactions	Engagement Problem	The lack of cooperation might compromise the quality of the product	S3

Interactions	Engagement Problem	Working from home has a lot of distractions	S7, S12
Interactions	Engagement Problem	Working from home hindered collaborative practices	S3
Interactions	Meeting organization and format	Frequent meetings are facilitated by online tools	S4
Interactions	Meeting organization and format	Less time dedicated to meetings	S10
Interactions	Meeting organization and format	Meetings were reduced but more efficient/organized	S9, S10, S11
Interactions	Meeting organization and format	More alignment meeting between diverse teams	S9
Interactions	Meeting organization and format	Scheduling meetings is helpful while working from home	S8
Interactions	Meeting organization and format	Teams tried to substitute face-to-face meetings with online meeting	S3
Interactions	Meeting organization and format	Traditional teams had reunions more regularly	S9
Interactions	Meeting quality	Virtual daily meetings were employed	S6, S9
Interactions	Meeting quality	Virtual meetings enhanced communication quality	S6, S12
Interactions	Promoting	Developers were encouraged to act autonomously and creatively	S6

Interactions	Promoting	Dojo sessions led to an improvement in internal communication and allowed solving problems effectively	S3
Interactions	Promoting	Employers should create new virtual coffee room for socialization and help exchange	S8, S9
Interactions	Promoting	Employers should encourage employees to build strong, meaningful relationships within work environment	S8
Interactions	Promoting	Explicit written communication was used	S9, S12
Interactions	Promoting	Necessity to informal conversations	S9
Interactions	Promoting	Non-verbal feedback was used to address lack of rapport	S12
Interactions	Promoting	Pair programming enhances working at home experience for the sake of socialization	S2
Interactions	Promoting	Presence signaling was used to improve responsiveness	S12
Interactions	Promoting	Remote meetings with experts avoided problems and conflicts that could have arisen later on	S3
Interactions	Promoting	Remote meetings with experts made work easier and less stressful	S3
Interactions	Promoting	Shared ownership and open collaboration was stimulated	S6
Interactions	Promoting	Software organizations should regularly organize both formal and informal online meetings	S8
Interactions	Promoting	Stakeholders had to assume more responsibilities	S3

Interactions	Promoting	Synchronous communications was used to clarifications	S12
Interactions	Promoting	Team's commitment compensated for lack of communications and problems with stakeholders	S3, S6
Interactions	Promoting	Teams explored their tool's functionalities to support communication and collaboration	S12
Interactions	Screen sharing and camera use	After some time, team members no longer wanted to turn on their cameras	S12
Interactions	Screen sharing and camera use	Online Pair programming and live coding was made while sharing screen	S9
Interactions	Screen sharing and camera use	Visual collaborative tools allowed visuality	S12
Interactions	Screen sharing and camera use	Visuality enhanced communication	S12
Interactions	Screen sharing and camera use	Visuality was perceived through gallery view, screen sharing, remote control and draw on screen features	S12
Interactions	Stakeholder relationship	Most developers consider that the relationship with stakeholders is normal	S4, S11
Interactions	Stakeholder relationship	Rework had to be done because of stakeholder's unavailability	S3
Interactions	Stakeholder relationship	Social isolation difficulted interaction with stakeholders	S3
Interactions	Stakeholder relationship	The availability of stakeholders decreased	S3, S6

Interactions	Streamlined Communication	A communication plan was used to choose the appropriate communication channel for each type of needs	S12
Interactions	Streamlined Communication	Developers formed groups or teams for different topics	S12
Interactions	Streamlined Communication	Easy access to product backlog	S11
Interactions	Streamlined Communication	Knowledge management tools were integrated with communication tools for information centralization	S11, S12
Interactions	Team relationship	Employees were encouraged to keep their practices and experiment with new forms of collaboration	S2
Interactions	Team relationship	Fully remote work improved communication in teams that had both distributed and on-site members before by moving all communication to online tools	S11
Interactions	Team relationship	Most developers find their teams collaborative	S4
Interactions	Team relationship	Remote collaboration is not as natural as in office	S2
Interactions	Team relationship	Team communication was easy	S4
Interactions	Tools	Audio/visual and network issues compromises the quality of communication	S5, S9
Interactions	Tools	Collaborative tools can simplify work processes and enable interactive workflows	S8

Interactions	Tools	Developers had to familiarize themselves with new technologies to work from home	S3
Interactions	Tools	New communication tools were used to coordinate activities	S3, S4, S5, S6, S9, S11, S12
Interactions	Tools	Programmers used special tools to mimic collocated PP	S2
Work Organization	Activities that could not be executed from home	Focus group was not possible	S3
Work Organization	Activities that could not be executed from home	On-site pair testing is not possible	S9
Work Organization	Activities that could not be executed from home	On-site user test is not possible	S3
Work Organization	Activities that could not be executed from home	Pair Programming "by the book" is not possible when everyone works from home	S2
Work Organization	Activities that could not be executed from home	Particular situations are allowed to use the office	S2
Work Organization	Activities that could not be executed from home	Physical meetings between developers and customers/stakeholders were not possible	S1, S3, S6

Work Organization	Activities that could not be executed from home	Usability testing was not possible	S3
Work Organization	Activities that were adapted to remote work	Backlog was made more granular	S5
Work Organization	Activities that were adapted to remote work	Checkpoints and documents were created to follow up activities	S9
Work Organization	Activities that were adapted to remote work	Less time dedicated to bug fixing	S10
Work Organization	Activities that were adapted to remote work	More time spent in learning	S10
Work Organization	Activities that were adapted to remote work	Most developers had little to no experience in remote working	S4
Work Organization	Activities that were adapted to remote work	Project coordinators had to be more proactive when proposing requirements	S3
Work Organization	Activities that were adapted to remote work	Software design patterns gained importance	S9
Work Organization	Activities that were adapted to remote work	The process of refining and addressing work to the team was simplified	S5

Work Organization	Activities that were adapted to remote work	The Requirement Analysis was a challenge	S6
Work Organization	Agile teams made changes to their ceremonies and practices	Daily meetings were recorded and better detailed/documented/planned/efficient	S9
Work Organization	Agile teams made changes to their ceremonies and practices	Newly onboarded developers had more difficulties to start Pair Programming	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Pair programming frequency reduced	S2, S9
Work Organization	Agile teams made changes to their ceremonies and practices	Pair Programming has evolved to switch between synchronous and parallel work	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Recorded meetings can be recalled	S9
Work Organization	Agile teams made changes to their ceremonies and practices	Remote Pair programming is not as natural as in office PP	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Remote Pair Programming tools where difficult to use and had technical issues	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Scrum ceremonies can be made asynchronously	S5, S9

Work Organization	Agile teams made changes to their ceremonies and practices	Some programmers started to practice more Pair Programming	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Some teams started scheduling Remote Pair Programming sessions	S2
Work Organization	Agile teams made changes to their ceremonies and practices	Strict timeboxing alleviates the burn out of frequent meetings	S5
Work Organization	Agile teams made changes to their ceremonies and practices	Tasks were more detailed	S9
Work Organization	Agile teams made changes to their ceremonies and practices	The definition of Done was automated	S5
Work Organization	Agile teams made changes to their ceremonies and practices	The use of Remote Pair Programming increased as developers became more experienced with remote work	S2
Work Organization	Artifacts	Product's Vision and Backlog was changed	S11
Work Organization	Artifacts	The Definition of Done became more inflexible in teams that didn't work fully remotely before	S11
Work Organization	Artifacts	The Definition of Done became more liberal to respond to either Product Vision or Backlog changes	S11
Work Organization	Artifacts	The Definition of Done in most cases remained unchanged	S11

Work Organization	Artifacts	The few teams that changed their workflow did so to address changes to the Product Backlog and Vision	S11
Work Organization	Productivity	A few companies started to follow up productivity	S9
Work Organization	Productivity	Developers take more time to complete simple tasks	S1
Work Organization	Productivity	More perceived productivity than before	S4, S9
Work Organization	Productivity	Most companies don't monitor productivity	S9
Work Organization	Productivity	Most projects didn't add new monitoring metrics	S11
Work Organization	Productivity	Professionals are perceiving less productivity	S1, S7
Work Organization	Productivity	The perception of productivity has changed for the majority of the developers	S9
Work Organization	Productivity	Time spent in activities from home was comparable to when working from office	S10
Work Organization	Productivity	Working from home has no impact on productivity	S3
Work Organization	Productivity	Working from home might have a negative impact in terms of feedback agility	S3
Work Organization	Team cadence	After a period of adaptation there is no difference in task accomplishment working from home versus onsite	S3, S8
Work Organization	Team cadence	Companies can rethink the estimation strategies for delivering tasks	S4
Work Organization	Team cadence	Cost and time of projects increased	S1

Work Organization	Team cadence	Delegating work in task batches makes it easier for individuals to work in a self-oriented manner	S8
Work Organization	Team cadence	Developers sick with COVID affected project deliveries	S4
Work Organization	Team cadence	More time dedicated to specification and documentation	S10
Work Organization	Team cadence	More work demand	S9
Work Organization	Team cadence	Most developers maintain the same work routine	S4
Work Organization	Team cadence	Most projects continued to deliver at the same rate and with same quality	S11
Work Organization	Team cadence	No significant changes to work distribution	S10
Work Organization	Team cadence	Reviewing the priorities and assuming part of the stakeholder's duties kept the project on time	S3
Work Organization	Team cadence	Some features had to be postponed because of stakeholder's unavailability	S3
Work Organization	Team cadence	Task prioritization was more rigorous	S9
Work Organization	Team cadence	Teams were able to conduct activities as planned before the pandemic	S3
Work Organization	Team cadence	The release frequency in most cases remained unchanged	S11
Work Organization	Working hours	Difficulty to manage working hours	S3
Work Organization	Working hours	More working hours than before	S4, S9

Work Organization	Working hours	Most developers were asked to be online during regular working hours	S9
Work Organization	Working hours	Teams perform better working on unusual working hours	S3, S4
Work Organization	Working hours	Work from home changed the working hours of development teams	S3, S4, S5, S9