Pós-Graduação em Ciência da Computação

Cleyton Vanut Cordeiro de Magalhães

THE ROLE OF JOB SPECIALIZATION IN SOFTWARE ENGINEERING

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Tese de Doutorado apresentada ao Programa de Pós-Graduação em Ciência da Computação da Universidade Federal de Pernambuco, como requisito parcial para a obtenção do título de Doutor em Ciência da Computação.

Área de Concentração: Engenharia de Software

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I dedicate this work to my mom and my dad, who always supported me in my studies, to my brother and sister, Ronnie and Vanessa and to Tércio.

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ABSTRACT

The way work is structured affects several aspects of the organization, resulting in practical implications in individual, societal and organizational levels. In this context, some research on Work Design area proposed some work characteristics. However, some of them has not been deeply investigated in Software Engineering. Job Specialization is a work characteristic that have been associated to some issues related to workers' productivity in management area in the past, however, as organizational scenario has changed and also considering that software engineers may have a different perception of work characteristics, we believe that further investigation about Job Specialization is needed. The main goal of this research is to understand the role and the particularities of job specialization in Software Engineering practice. In particular, we investigated the aspects related to this factor and how it affects software engineers at work, in order to guide practitioners in managerial processes. We will use a mix method approach composed of the following phases: 1) The phase 1 of this PhD work was the development of support studies towards the identification of the research problem addressed in this research. 2) The second phase defined a research approach for collecting, analyzing and integrating quantitative and qualitative data about Job Specialization in Software Engineering. 3) In this phase we applied techniques from meta-ethnography in order to synthesize the findings of the previous thee phases. 4) Finally, Phase 4 is characterized as the conclusion of this work with the development of a specialist verification about the results of this PhD work. Our analysis in quantitative data demonstrated a set of relevant correlations among job specialization and several work-related factors, such as autonomy and variety and also with some outcomes, such as burnout and satisfaction. We also investigated the relation between specialization and variety, and different from literature in other fields, findings show that specialized work can vary in terms of tasks and skills in Software Engineering.

Keywords: Software Engineering. Work Design. Work Characteristics. Job Specialization.

RESUMO

A maneira como o trabalho é estruturado afeta vários aspectos de uma organização, resultando em implicações práticas nos níveis individual, social e organizacional. Nesse contexto, algumas pesquisas na área de Design do Trabalho propuseram algumas características do trabalho. No entanto, alguns deles não foram profundamente investigados em Engenharia de Software. A Especialização no Trabalho é uma característica do trabalho que já foi associada a alguns problemas relacionados à produtividade dos trabalhadores na área de Gestão, no entanto, como o cenário organizacional tem mudado e também considerando que os engenheiros de software podem ter uma percepção diferente das características do trabalho, acredita-se que uma investigação mais profunda sobre a Especialização no Trabalho é necessária. O principal objetivo desta pesquisa é entender o papel e as particularidades da especialização do trabalho em tarefas na prática de engenharia de software. Em particular, foram investigados os aspectos relacionados a esse fator e como ele afeta os engenheiros de software no trabalho, a fim de orientar os profissionais em processos gerenciais. Foi usada uma abordagem de método misto composta pelas seguintes fases: 1) A fase 1 deste trabalho de doutorado foi o desenvolvimento de estudos de apoio à identificação do problema de pesquisa abordado nesta pesquisa, como Replicação de estudos empíricos e Design do trabalho. 2) A segunda fase definiu uma abordagem de pesquisa para coletar, analisar e integrar dados quantitativos e qualitativos sobre a Especialização no Trabalho em Engenharia de Software. 3) Na fase 3, foram usadas técnicas da meta-etnografia para sintetizar os achados das três fases anteriores. 4) Finalmente, a Fase 4 é caracterizada como a conclusão deste trabalho com o desenvolvimento de uma verificação especializada sobre os resultados deste trabalho de doutorado. A análise em dados quantitativos demonstrou um conjunto de correlações relevantes entre a especialização no trabalho e vários fatores relacionados ao trabalho, como autonomia e variedade e também com alguns resultados, como desgaste (burnout) e satisfação. Também investigamos a relação entre especialização e variedade e, diferentemente da literatura em

outros campos, os resultados mostram que o trabalho especializado pode variar em termos de tarefas e habilidades em engenharia de software.

Palavras-chave: Engenharia de software. Design do Trabalho. Características do Trabalho. Especialização.

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1 INTRODUCTION

Work Design defines how the work can be planned, allocated across organizational levels, and structured into tasks to be performed by individuals or teams (TORRACO, 2005). In this sense, it is possible to state that the way a given work is structured affects several aspects of a company, resulting in practical implications on individual, team and organizational levels. In general, an organization seeks to obtain certain outcomes from individuals' work, such as efficiency, motivation and satisfaction. To achieve these results, the way in which the work is designed might have a direct influence on how professionals experience their jobs (GRANT et al., 2011).

Several theories concerning work design have been proposed since early 20th century. Taylor (1911) conducted studies in order to systematize how managers should perform the division of labor in an efficient way, while Gilbreth (1911) contributed with studies based on simplification and specialization of work as an attempt to maximize worker's productivity. As the organizational scenario and the nature of work has changed since these theories were proposed, the research on human resource management are frequently investigated practices to resolve issues related to employee productivity and work performance.

In the 1950's, the use of methods such as job rotation and job enlargement were some of the strategies used to increase task variety and minimize fatigue and boredom resultant from job simplification and specialization (VITELES, 1950). In addition, in the last decades, a review on the theories of work design raised important issues about this topic, such as whether the theories proposed so far were capable of explaining the design of work in the current work environments and the dynamics of different companies. In summary, these reviews aimed to investigate if studies about work design were kept up with the reality of practice (TORRACO, 2005). The theories analyzed in this process included the Sociotechnical Systems Theory (TRIST, 1969), Job Characteristics Model (HACKMAN & OLDHAM, 1976), Process Improvement (DAVENPORT, 1993),

Technostructural Change Models, Activity Theory (LEONT'EV, 1978) and Adaptive Structuration Theory (DESANCTIS & POOLE, 1994).

The analysis of these previous theories (TORRACO, 2005) concluded that all of them provide some understanding regarding the work design topic. However, they seem to be insufficient to comprehend the evolution of work environments. In other words, each theory represents a specific organizational context and the moment (period of time) in which they were proposed. Based on that, Morgenson and Humphrey (2006) concluded that the existing measures regarding work design might be incomplete. Therefore, these authors reviewed the work design literature of several research fields, in order to identify and integrate work characteristics from those previous theories and based on a new review, they developed a more consistent and comprehensive measure composed by work characteristics related to motivational, social, contextual, and knowledge factors at work.

Nowadays, but analyzing the work of Morgenson and Humphrey (2006) it is possible to observe that several work characteristics discussed in their work have been separately studied in different organizational contexts over the years. This means that, regarding the industrial context and the nature of the work, these work characteristics can produce different outcomes. Following this, over the last decade, research in Software Engineering has highlighted the importance of studying work characteristics and their particularities in software industry, based on the belief that software engineers might have a different perspective of work in comparison with other professionals (FRANÇA, 2014; MONTEIRO et al., 2016; SANTOS et. al., 2017). This statement reinforces the need for further investigation on work characteristics in Software Engineering.

In order to explore the gaps related to work design and the nature of work in Software Engineering, recently we analyzed the literature and identified two studies that investigated general aspects related to work characteristics in different types of industries (MORGENSON, HUMPRHEY, 2006; HSIEH, CHAO, 2004). These studies presented a series of conclusions about several work

factors, practices and outcomes, and how they might affect professionals at work. However, some of these conclusions were conflicting among them and among previous studies published in the literature. Therefore, in order to improve the understanding about work characteristics in Software Engineering, we performed a replication of these two studies (MORGENSON, HUMPRHEY, 2006; HSIEH, CHAO, 2004) with a sample of 80 software engineers working in 35 different software organizations in Brazil. Our replication measured 21 work design factors together with four work outcomes (SILVA et al, 2016).

Following this replication, the preliminary analysis demonstrated, among other results, that job specialization is a work factor that presents strong correlations with several other work-related factors, from the list of 21 factors investigated. In addition, it also revealed relevant correlations among job specialization and some outcomes, such as job burnout and job satisfaction. In fact, job specialization is a relevant research topic that has raised concern in other fields over the years (HSIEH; CHAO, 2004), presenting different results depending on the specific context where this topic is under investigation. However, the theme has not been widely discussed in Software Engineering, although over the years software engineers have demonstrated both positive and negative attitudes towards job specialization and its impact on software development (SANTOS et. al., 2017).

Thus, considering that specialization is no longer a simple and standardized job characteristic as it was in the past, and that software engineers may have a different perception of how this work factor can affect their work and the software development afterwards, there is a current need for a deep understanding regarding the impacts of job specialization in software companies, as an attempt to improve software development management and practice. Therefore, the main goal of this research is to understand the role and the particularities of job specialization in software industry. In particular, we are interested in investigating the effects of job specialization in traditional and agile projects, and how this factor affects software engineers at work, in order to

produce relevant results that could guide practitioners in managerial processes. In this sense, we aim to answer the following research questions:

RQ1: What is the role of job specialization in Software Engineering?

RQ1.1: How is job specialization defined by Software Engineers?

RQ1.2: How is job specialization characterized in Software Engineering?

RQ2. What is the relation between Specialization and Variety in Software Engineering?

RQ3. What is the relation between Job Specialization and work-related factors?

Following this introduction, this work is structured as follows. Chapter 2 presents the theoretical background related to this research, presenting details about the definitions and concepts related to work design in Software Engineering and the work characteristics investigated in this study, especially job specialization. Chapter 3 presents the research design and details the methodological approaches followed in this research in order to answer the research questions and accomplish the main research goal. Chapter 4 presents the results obtained in this research and discuss these findings in comparison to the literature in other fields. Finally, Chapter 5 presents the implications and conclusions of this work.

2 THEORETICAL BACKGROUND

Industrial revolution caused several changes in the way that work was designed and how organizations could get more efficiency from their employees. In this context, when mass-production was performed in most industries, Taylor (1911) proposed rationalization of work and division of labor to reach higher levels of productivity at work. Years later, problems with worker's morale, working conditions, and safety and its relation to repetitive and simplified tasks started to be observed.

Since then, several studies have been published proposing strategies to improve both quality of work and employees experience at work. In this context, Work Design has been established as one of the main concepts regarding how the work is conceived, assigned across organizational levels, and structured into tasks performed by individuals or teams (TORRACO, 2005; GRANT, FIRED and JUILLERAT, 2011). Therefore, over the last decades many authors focused their research effort in order to investigate different work environments to propose theories and complementary discussions about work design and its particularities regarding different industries.

2.1 WORK DESIGN THEORIES AND MEASUREMENT INSTRUMENTS

The Job Characteristics Model (JCM) from Hackman and Oldham (1976) is one of the most well-known theory of work design. This model describes job design characteristics and explains their relationship with work motivation. In this theory, five core work characteristics are used to understand job- and work-related tasks: skill variety, task identity, task significance, autonomy, and feedback. According to this theory, jobs that include these five dimensions influence psychological states of workers and results in favorable work outcomes. Based on JCM theory, Hackman and Oldham (1980) developed the Job Diagnostic Survey (JDS), which is a measure to evaluate the motivational potential of jobs. This measure became popular over the years and started to be applied in different contexts.

More recently, Morgenson and Humphrey (2006) argued that subsequent studies that applied this measure found very low levels of internal consistency, as well as problems with its structure. In other words, the authors reported that this measure has been successfully applied in several fields, however, it has been considered incomplete. As an attempt to address the issues found in previous measures, Morgenson and Humphrey (2006) developed the Work Design Questionnaire (WDQ), which can be defined as an instrument constructed based on years of work design literature that follows the previously identified and integrated work characteristics. Since then, the WDQ became one of the most applied measures of work design in many studies published over the years.

According to Morgenson and Humphrey (2006), several studies investigating work design were performed of the years; however, their measures were not complete in terms of work characteristics. As an effort to address this issue, they performed an integrative study to build a more comprehensive work design instrument, which they named the Work Design Questionnaire. The authors identified work characteristics elements discussed and measured in the literature, and grouped them in a classification model with 21 factors. These factors are organized in four categories of work characteristics, as presented in Table 1.

Table 1 – Characteristics and factors from The Work Design Questionnaire

Characteristic Type	Factor	
Task Characteristics	Autonomy	Work scheduling autonomy (WSA)
		Decision-making autonomy (DMA)
		Work methods autonomy (WMA)
	Task Variety (TV)	
	Task Significance (TS)	
	Task identity (TI)	
	Feedback from job (FFJ)	
Knowledge Characteristics	Job Complexity (JC)	
	Information processing (IP)	
	Problem solving (PS)	
	Skill variety (SV)	
	Specialization (SPE)	
Social Characteristics	Social support (SS)	
	Interdependence	Initiated (II)
		Received (RI)
	Interaction outside the organization (IOO)	
	Feedback from others (FFO)	
Contextual Characteristics	Ergonomics (ER)	
	Physical demands (PD)	
	Work conditions (WC)	
	Equipment use (EU)	

Source: Adapted from Morgenson and Humphrey (2006).

Task characteristics are concerned with how the work itself is accomplished and the range and nature of tasks associated with a particular job. This includes work scheduling autonomy, decision-making autonomy, work methods autonomy, task variety, task significance, task identity and feedback from job. Knowledge characteristics reflect the kinds of knowledge, skill, and ability demands that are placed on an individual as a function of what is done on the job. The characteristics included in this category are job complexity, information processing, problem solving, skill variety and specialization. Social characteristics concern interpersonal and social aspects of work such as social support, interdependence (initiated and received), interaction outside the

organization, and feedback from others. Finally, Contextual characteristics refer to the physical and environmental context, such as ergonomics, physical demands, work conditions, and equipment use.

Morgenson and Humphrey (2006) validated the WDQ with a sample of 540 professionals holding 243 distinct jobs and presented higher levels of reliability as well as convergent and discriminant validity than the previous measures. The WDQ instrument covers a wider set of work characteristics that should be more flexible in supporting managerial techniques to be applied in practice. The instrument has official translations in several languages, including Portuguese, and some recent research has validated the Spanish (BAYONA et al. 2015) and French (BIGOT et al., 2014) versions of questionnaire to apply it in different contexts. Da Silva et al. (2016) performed a replication of Work Design intending to confirm psychometric properties of the questionnaire as there was no official validation of the questionnaire in Portuguese.

Despite of its completeness in terms of work-related factors encompassed and even though the WDQ has being successfully used by many researchers over the years, it is important to highlight that other studies have demonstrated the need to investigate correlation among work-related factors as well as work outcomes not considered in the WDQ or previous theories, and that might be useful to improve work environments. For instance, Hsieh and Chao (2004) performed a study in the work design context, in which they investigated the relation among job specialization, job rotation and job burnout in high-tech industry, as well as the relations among role ambiguity, role conflict, task variety, task autonomy and task feedback.

In this research, Hsieh and Chao (2004) applied existing scales to measure these constructs in a survey with 304 employees from Taiwan's high-technology companies and concluded that this type of organizations might have different dynamics than those from a more traditional industrial settings. Their results revealed a significantly positive relation among job specialization and task variety, autonomy, identity and feedback. In addition, they pointed out that that

the adoption of job specialization in high-tech industry raises professional efficacy and reduces employees' feeling of job burnout. These results are opposed to the findings obtained in years of research regarding conventional jobs in different fields.

The study of the work design background and the observable evolution of instruments proposed over the years to assess and measure work-design characteristics and work outcomes, in order to understand the dynamics of work in different contexts, might indicate that the studies' results are depended from the particularities of each research field under investigation. Therefore, to improve industrial practice these instruments needed to be tested and applied in different companies and the obtained results will require interpretations based on the characteristics of the different types of work. In this sense, considering previous discussions regarding the differences between the work in software companies and in other types of jobs (FRANÇA, 2014; MONTEIRO et al, 2016; SANTOS et. al., 2017), da Silva et. al (2016) performed a replication of previous studies regarding work-design, performed in different fields, in order to understand the nature of work in Software Engineering.

NATURE of Work and Work Design in Software Engineering

Da Silva et al. (2016) developed a replication of previous studies regarding Work Design intending to confirm psychometric properties of the questionnaire and, in addition, to test a preliminary set of hypotheses in order to reveal opportunities for future research. Replications of empirical studies play an important role in the construction of knowledge. Schmidt argues that a replication "is the proof that the experiment reflects the knowledge that can be separated from the specific circumstances (such as time, place, or persons) under which it was gained" (SCHMIDT, 2009, p. 1).

In Software Engineering, it is observable that although there are several studies published over the years discussing the replications and also performing replications, there is no consistent definitions or guidelines that support the execution of a replication of empirical studies in this area. In this sense, to support

the replication of da Silva et al. (2016), we developed a mapping study that analysed and discussed the content of the papers about replications of empirical studies in Software Engineering (MAGALHÃES et al., 2015).

This mapping study (MAGALHÃES et al., 2015) provided a deeper understanding of the concepts, classifications, guidelines, and theoretical issues that are relevant during the execution of a replication in Software Engineering. The mapping study also contributed to the understanding of replications in the sense that it identified a set of types and classifications of replications used in Software Engineering, supporting the comprehension on how replications are classified and how they can be performed in Software Engineering.

Following, supported by the results from the mapping study (MAGALHÃES et al., 2015), da Silva et al. (2016) replicated the surveys performed by Morgenson and Humphrey (2006) and Hsieh and Chao (2004) seeking to generalize the application of the previous instruments to a different population (Software Engineering professionals). These two studies were selected to the replication because together the cover an extensive group of work-related factors and outcomes. In addition, they provide different point of views about the correlations among work design characteristics.

Following the hypothesis presented in the two previous studies, da Silva et al. (2016) investigated the relationship between job specialization, job rotation and job burnout (HSIEH; CHAO, 2004) and explored the relations of work design characteristics from WDQ (MORGENSON & HUMPHREY, 2006). The hypotheses were tested using statistical analysis of data by calculating the correlations among all study variables using Spearman's ρ. For the replication, the sample was composed by 77 professionals from 35 different organizations, and included the four major roles of software development: program developer, software tester, system analyst, and project manager.

Da Silva et al. (2016) concluded that the measures applied are suitable to be used in the context of Software Engineering, allowing aggregation to the data items at the construct level. Regarding work-design, the study demonstrated

that task and knowledge characteristics of the work must be addressed in the (re)design of work in software companies. In fact, the study indicated several correlations among job specialization (knowledge characteristic) and many other work-related factors that may affect professionals at work. This demonstrated the need for a further understanding about the effects of work (re)design techniques, such as job specialization, on work outcomes, such as burnout, satisfaction, motivation and software engineers' work in general

2.3 JOB SPECIALIZATION IN SOFTWARE ENGINEERING

Job Specialization is one of the factors included in the Work Design Questionnaire (MORGENSON & HUMPHREY 2006) and it was investigated in different types of fields over the time. It is defined as "the extent to which a job involves performing specialized tasks or possessing specialized knowledge and skill" (MORGENSON & HUMPHREY 2006). As the dynamics of organizations are constantly changing, it is expected that the use of techniques such as job specialization may affect the work itself in a different way. Robbins and Judge (2013) argued that in management area, managers know that job specialization may provide benefits in certain jobs as well as some issues when it is used in excess. Figure 1 shows that as the specialization increases, the productivity increases as well. However, when the levels of specialization are too high, productivity starts to decrease.

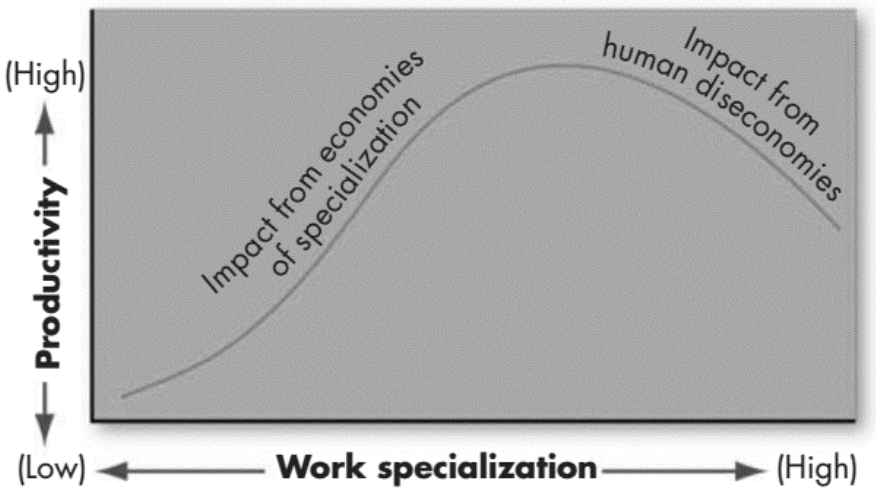

Figure 1 – Economies and Diseconomies of Work Specialization

Source: ROBBINS; JUDGE (2013).

The authors discuss the uses of job specialization in different types of organizations. For example, high levels of work specialization help fast-food restaurants to make and sell their dishes efficiently. On the other hand, in software development areas, for example, some projects have extremely small pieces of programming, data processing and evaluation tasks that are delegated to a global network of individuals by a program manager who then assembles the results. These emerging approaches may suggest that there may be advantages in the use of specialization, especially in software development organizations (ROBBINS & JUDGE, 2013).

Narayanan et al. (2009) has discussed the relation of job specialization and other work characteristics, such as task variety, defined as “the degree to which a job requires employees to perform a wide range of tasks” by Morgenson and Humphrey (2006). Narayanan et al. (2009) believe that task variety may enhance productivity and learning in workplace and they consider that productivity is maximized when there is a good balance between specialization and also exposure to variety, which means that neither high levels of

specialization nor a high level of diverse experiences is most favourable to productivity.

A non-Systematic Literature Review in the Software Engineering literature demonstrates that there are no published studies focused on job specialization in software companies. In addition, there are only few evidences published in studies mentioning the effects of job specialization in Software Engineering practice. Recently, da Silva et al. (2016) pointed out job specialization as one of the work-related factors addressed in the (re)design of work in software companies. However, they pointed out the need for a deep understanding about its effects. In addition, Santos et al. (2017) discussed that the attitude towards job specialization is not uniform among software engineers. Therefore, it is possible that these professionals are differently affected by job specialization at work, which might require managerial attention. In the past, Kautz and Nielsen (2004) mention that job specialization is an important element in the innovation process, although they do not provide deeper information about the topic.

In summary, the lack of discussions about job specialization in Software Engineering and its effects on the work of software engineers justify the development of a research focused on produce deep understanding about this factor and its use in software industry practice.

3 RESEARCH DESIGN AND METHODS

This chapter describes the research strategy followed to answer the research questions. In summary, due to the lack of studies about the topic under study, a mix-method research strategy combining different empirical studies was applied. A mix-method research is considered a research strategy that supports the researcher to accurately answer the study's questions that cannot be completely answered through a single method (DENZIN & LINCOLN, 2000). In addition, mixed research design benefits the exploration process and lead to a better interpretation of the topic under study, as well as its applications and implications. Therefore, in order to collect as much evidence as possible, a systematic mapping study, two qualitative studies based on interviews, and a quantitative survey were performed resulting, to the best of our knowledge, in the most extensive amount of information about job specialization in Software Engineering produced so far. The research phases and their main results are summarized in Figure 2, and described below. In addition, the following sections describe with details each phase.

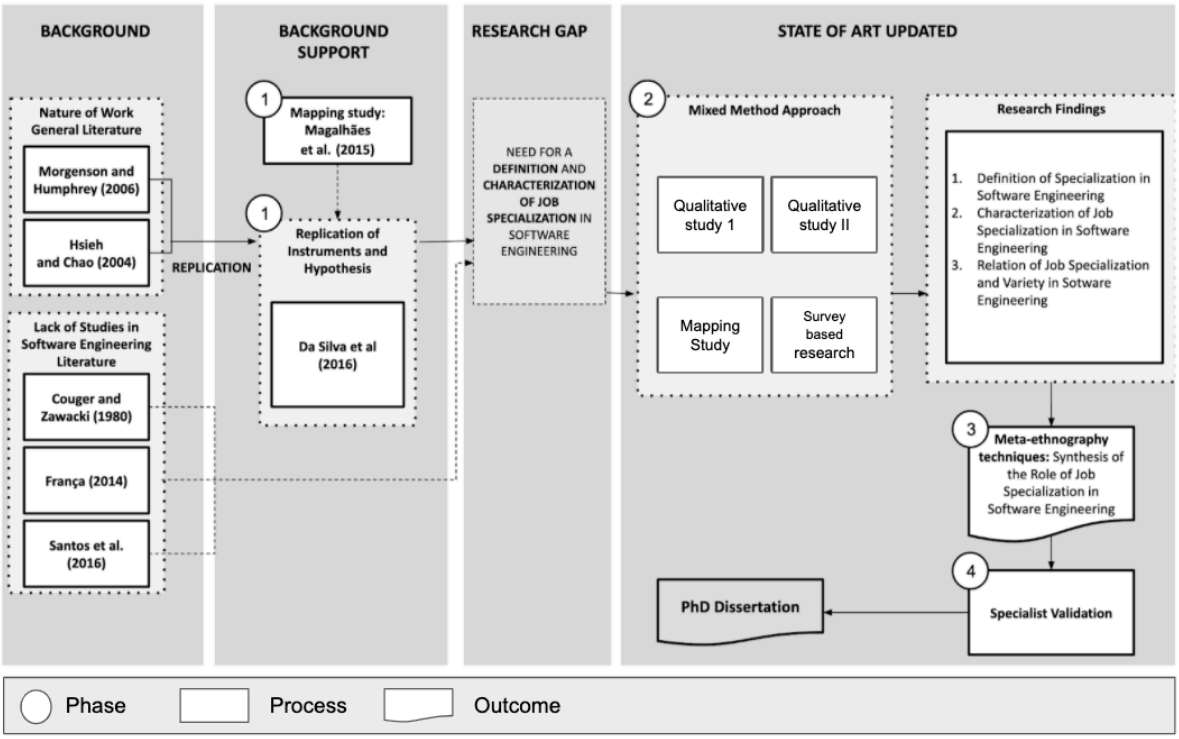

Figure 2 – Research Phases

Phase 1 – Background Support: The phase 1 of this PhD work was the development of support studies towards the identification of the research problem addressed in this research. As discussed in Section 2.3 the need for investigating the role of job specialization in Software Engineering is result of the replication of previous work-design studies and instruments (da Silva, et al., 2016). This replication was supported by a mapping study about replication of empirical studies in Software Engineering developed previously from the main results of this PhD Dissertation. The main contribution in this phase is the summarization of information from different sources that supported the replication performed by da Silva, et al. (2016) and posteriorly supported our own replication in the second phase of this work. The mapping study is published in Magalhães et al. (2015). Posteriorly to the development of these studies and to the analysis about work design presented in Chapter 2, the Phase 2 of this research encompassed the group of studies developed in order to fill the gap observed in the Software Engineering literature.

Phase 2 – **Mixed Method Research**: The second phase of this PhD work has defined a research approach for collecting, analyzing and integrating quantitative and qualitative data obtained from multiple sources. This approach was applied due to the nature of the research problem under investigation and due to the lack of information regarding the topic under study, in order to provide better understanding about the subject. In this process we performed the following steps:

- **Qualitative study 1**: Initially, a qualitative study based on interviews was performed in order to collect evidence about the experience of software engineers with job specialization at work. In this process, we selected a mobile development company and interviewed 12 software engineers collecting information about the topic directly from industrial practice. The interviews happened in the organization's facilities and each interview took between 30 and 45 minutes.
- **Qualitative Study – Enlargement**: In order to obtain more information about the topic, we collect experiences from 21 software engineers working in different types of projects (agile and traditional) and with different technologies, by using a strategy to replicate de Qualitative study 1 and produce more qualitative data for the qualitative study 2 (Enlargement). The same interview guide was used in this study.
- **Survey**: In step three, we followed the same process of da Silva et al. (2016) by applying a quantitative approach to investigate the correlations between job specialization and several work characteristics in software companies. In this sense, we performed a replication of two original studies: Hsieh and Chao (2004) and Morgenson and Humphrey (2006), seeking to obtain the set of correlation among job specialization and several work-related factors and outcomes.
- **Mapping Study**: Finally, since the literature in Software Engineering presented no paper focused on the investigation of job specialization in software companies, we performed a mapping study to

select from the literature those studies that mentioned the factor in some level, in order to enlarge our data set.

Phase 3 – In this phase we applied techniques from meta-ethnography (DA SILVA et al., 2013; NOBLIT & HARE, 1988) in order to synthesize the findings of the previous four phases. This stage is characterized as an extensive analysis of the literature of Software Engineering, Work Design and Organizational Psychology to refine our findings and construct a definition about the role of job specialization in Software Engineering and the effects of this work-related factors in the work of software engineers. In this process, we developed a reference material do guide practitioners regarding the uses and the need for management of job specialization in software companies. So far, this is the most extensive body of knowledge regarding this topic in the Software Engineering context and these results can be used to inform industrial practice in the improvement managerial processes.

Phase 4 – Finally, Phase 4 is characterized as the conclusion of this work with the development of a specialist verification about the results of this PhD work. In summary, a senior software manager and a technical leader who works at an international software company analyzed the consistency of our results and pointed out the relevance of the results.

In summary, the mixed method approach was successfully applied to achieve the main goal of this research. The following sections present the details of each method applied.

3.1 QUALITATIVE STUDY I

According to Merriam (2009), “Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences.” The primary characteristics of qualitative research include: 1) the focus on understanding peoples’ experiences with intent to convey experiences into meaning, 2) the researcher is the key instrument for data collection and analysis, 3) the research

process is inductive and not deductive, and 4) the product of qualitative research is richly descriptive. In summary, a qualitative research seeks to understand certain phenomenon and its dynamics in a particular context. In this qualitative research we investigated the role of job specialization in Software Engineering, its characteristics, and the relationship with work-related factors such as task and skill variety. To do so, performed interviews with software engineers seeking to understand their points of view regarding the topic in discussion.

Regarding the selection participants in a qualitative study, Merriam (2009) presents two basic types of sampling which are probabilistic sampling (allows the results to be generalizable to the population from which that sample was chosen) and non-probabilistic sampling (based on purposive selection of participants). Since generalization is not the aim of a qualitative study, we used a non-probabilistic sampling in this qualitative research.

Merriam (2009) also point out data collection methods to be used in a qualitative research and states that interviewing is a common method to collect data from participant. In this qualitative study, we followed some good practices on conducting interviews presented by Merriam (2009), such as:

a) performing pilot interviews to improve the quality of questions.

b) another researcher participating of the interview to take notes.

c) recording the interview.

3.1.1 Research Planning

The lack of a consistent literature of job specialization in Software Engineering lead us do design a qualitative study to understand this construct in details. This study aimed to precisely define the role job specialization in software companies, as well as to identify the effects of this factor in software engineers' work together with the specific characteristics of this factor in agile and traditional software projects. In summary, in this study we aimed to explore the concept of job specialization in the Software Engineering field.

3.1.2 Preparation for Data Collection

For this qualitative study, we needed to selected professionals working in a software project under development for at least one year, with a software team composed of diverse types of professionals, such as, developers, testers, analysts and managers, and with different levels of experience (years). We believe that different points of view may support us in the construction of consistent definition and characterization of the role of specialization in Software Engineering. In summary, we selected a project with the following characteristics:

- A group of professionals in the project is specialized in a specific domain or technology.

- A group of professionals in the project has experience in working in a wide variety of domains and/or technology.

- The project can provide full access to data or individuals necessary to our investigation.

With these requirements, we selected 12 participants from a software organization located in Recife, Brazil, that performs research and development of technologic solutions for mobile and PC. The company has around 70 professionals. The criteria for sampling participants was defined accordingly to the availability of professional to participate of this research; however, we made an effort to achieve maximum variation in terms of education, roles and experience (years). The roles of participant are defined in Table 2.

Table 2 – Qualitative study 1 participant's roles.

Role	Amount of participants
QA Lead	1
QA	4
Project manager	1
Tech Leader (Software engineer)	1
Software Engineer	5

Source: The author (2020)

3.1.3 Collecting Evidence

Merriam (2009) argues that interviews are an effective way for gathering information about things we cannot observe, such as, participants' understandings about a research topic. As this is an exploratory qualitative study, in which the main goal is to understand the specific characteristics of job specialization in Software Engineering, we applied semi-structured interviews to collect data about how the participants understand this factor.

We performed two pilot interviews with two software engineers that did not participate of the main study in order to verify that questions were clear to the participants and make any improvements necessary in the questionnaiore. To facilitate data collection and the access to the participants, the interviwes were conducted in the compnay's facilities. In addition, all interviews were recorded in order to perform the transcripstions used in data analysis.

As we did not find any relevant literature of job specialization in Software Engineering, in depth interviews were appropriate for this investigation, since in this type of interviews it is possible to ask key respondents about facts of a matter as well as their opinions about events and their insights into occurences. Thus, we developed the interview script based on few gaps identified in the Software Engineering literature in addition to the discussions of conflicting results observed in the literature of other fields. To validate the the questions in the script we preformed pilot interviews with a group of 5 researchers with experience conducting qualitative studies in Software Engineering. The complete interview script is available in Appendix C. Finaly, during the interviews the interviewer was supported by a second researcher, responsible for taking notes to be used in the process of data analysis.

3.1.4 Analysis of Collected Data

In a qualitative study, the data collected are usually descriptions, comments and reports of experience regarding a given topic or phenomenon. In fact, Mason (2002) stimulates the collection of qualitative data since the

information obtained is capable to connect the context and the explanation of a phenomenon. It means that qualitative research is adequate to produce well-founded cross-contextual generalities rather than aspiring to more fragile de-contextual versions. Merriam (2009) discusses that one of the interests of a qualitative research is to explore the understanding that people have built along their experiences about the phenomenon under study.

Specifically in Software Engineering context, Seaman (2013) argues that due to the variety of human and social aspects observed in this area, researchers frequently address questions and problems involving human elements that are complex to interpret. Therefore, qualitative analysis can be helpful in handling this complexity in this research and support our understanding about how software professionals understand job specialization and its relation with other work characteristics.

Regarding data analysis, in this study the main objective of this phase is to consolidate, reduce, and interpret data obtained from various sources, and make sense of them (MERRIAM, 2009). In this process, we had to perform labeling and coding in all data aiming to identify similarities and differences to describe the phenomenon under study. Therefore, we applied coding techniques to code, categorize, and synthesize our data, in order to understand the particularities of job specialization in Software Engineering.

Processing qualitative data often begins during the early stages of data collection. According to Merriam (2009), it is recommended performing data collection, data analysis, and reporting simultaneously, because ongoing findings can affect the data being collected. Often, the data analysis is conducted by applying coding techniques, as recommended by Strauss and Corbin (2008), in three phases:

Open Coding: It is the process in which “the data are broken down into discrete parts, closely examined, compared for similarities and differences, and questions are asked about the phenomenon reflected in the data”. In this step, the transcripts are completely analyzed in order to identify the concepts and their

properties. Usually, this process is focused on label chunks of quotations provided by the interviewee (Figure 3) and posteriorly group them into representative categories (Figure 4).

ID	Interview quotation	Key point
P001	*"...Something that demands a **certain experience in a set of technologies**, programming languages, tools."*	***certain experience in a set of technologies***
P002	*"...people should have **a specific knowledge"***	***specific knowledge***
P004	*"a work that demands a **level of specific knowledge** in a certain area"*	***level of specific knowledge***

Figure 3 – Open Coding: Building Codes that lead to a definition of job specialization.

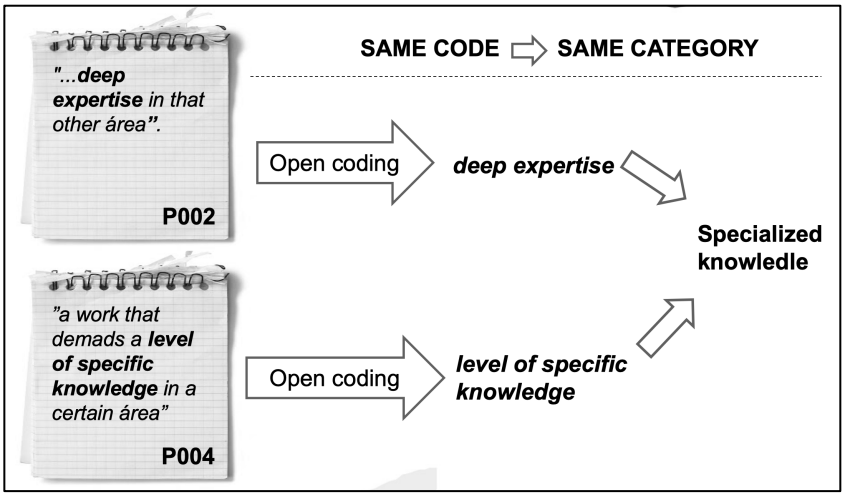

Figure 4 – Open Coding: Building Categories.

Axial Coding: This phase consists in a linking process, based on intense analysis observing the categories and how there are connected along the interviewees opinions about the phenomenon. In this study, we applied axial coding as an inductive and deductive process, searching for causal relationships amongst data (Figure 5).

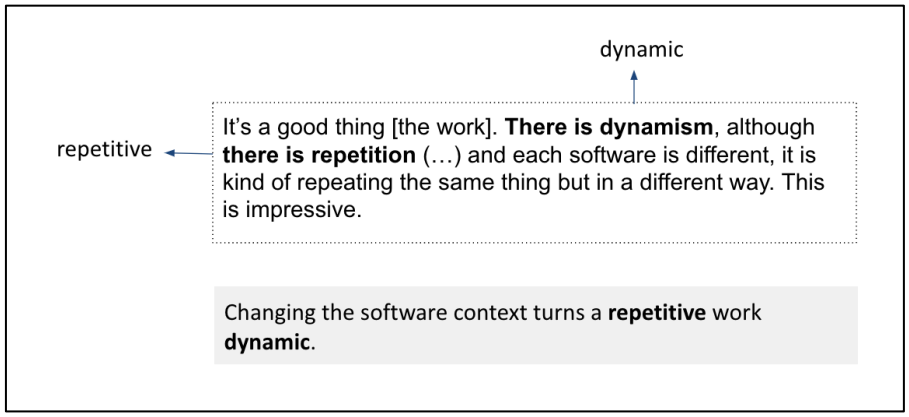

Figure 5 – Example of axial coding.

Selective Coding: The final phase of data analysis consists in the development of the main story highlighted in the investigation. It frequently involves the identification of a core category that gathers all the data. In this study, the selective coding was applied in order to integrate categories and developed the explanations required to answer our research questions.

According to Eisenhardt (1989), the data analysis process is followed by a literature analysis in order to sharpen construct definitions, generalizability, and raise theoretical level, by contrasting the results of a qualitative study with the findings in the literature review. Since the Software Engineering literature presented wispy evidence about the topic under study, we compared our results with the results from other fields, and posteriorly with the results obtained from the complementary studies developed in this research.

Finally, the member checking is a quality control for qualitative research used to improve accuracy and validity of what was interpreted form the data collected in the interviews (HARPER & COLE, 2012). In this qualitative study, the member checking was performed in the process of specialist validation (Section 3.5) after the results of other studies were consolidated.

3.1.5 Reporting

The report of this qualitative study included all the relevant information obtained from the data analysis to support the conclusions, such as, citations and narratives. In addition, due to ethical purposes we used anonymous quotations

of participants when presenting the data. Finally, research instruments and details of the procedure undertaken to conduct the qualitative research are available allowing researchers to perform replications and further investigations about the topic under study.

3.2 QUALITATIVE STUDY II – ENLARGEMENT

This stage consisted in the process of extending the data collected in the first qualitative study (study 1) to gather evidence from a larger group of software engineers with different levels of experience in software development. The logic of replication of qualitative studies described by Yin (2003) was applied in this stage, in which each subsequent qualitative study can either predict comparable results or predicts different results. In this research, we are targeting both scenarios, either comparable of different results, within a multiple qualitative studies to increase the confidence and the variability of the results.

In this process, a group of graduate students officially enrolled in a qualitative methods course was invited to participate in the data collection process. Each pair of students from a class about 40 individuals received the interview script and instructions about how to collect data from participants. As part of their training of collecting qualitative data from software industry, they were required to identify a professional software engineer and conduct the interview, recording data e taking notes. At the end of this process, the results of all interviews were analyzed regarding quality and clarity of the data collected, and 21 of them were selected to be used in this research, enlarging the information collected during qualitative study 1. At the end, the same process of data analysis followed in the qualitative study 1 was applied.

3.3 SURVEY

The survey-based approach was the methodology applied in this research to collect quantitative data from professional software engineers in order to obtain their perceptions on the work-related characteristics and how these characteristics are correlated to job specialization. In summary, the main

objective in this research phase was to investigate the correlations among work characteristics, work outcomes, and job specialization.

To perform this survey, we followed the guidelines of Pfleeger and Kitchenham (2001) that defines the steps to design and conduct cross-sectional surveys in Software Engineering. In this type of survey, a questionnaire can be applied to collect information about a specific topic in one fixed point in time and the information collected is used to provide a snapshot of the context under study allowing understanding and discussions about a particular fact.

A quantitative approach is relevant to this research because it can reveal correlations not identified before in the previous qualitative studies, and at the same time, it allows comparisons with the findings obtained in the previous stages of this research. In this sense, following the above-cited guidelines, we defined the main objective of the survey, which is centered in the investigation of the correlations among work design factors and the practice of job specialization in software companies.

We developed the questionnaire using well-known tested measures and existing instruments to facilitate comparisons with previous related work and to increase reliability, as suggested in the guidelines (PFLEEGER & KITCHENHAN, 2001). In summary, the items in the final questionnaire are the same used in the replication performed by da Silva et al. (2016) with few modifications suggested in the previous study. Therefore, this new application can be considered as a replication of da Silva et al. (2016) with a new increased sample. The final instrument was composed as follows:

- About 17 different work-related factors, including job specialization were measured using the items of the Work Design Questionnaire (WDQ) developed by Morgeson and Humphrey (2006).

- Satisfaction as an outcome was measured by applying existing measures for satisfaction using the Michigan Organizational Assessment Package.

- Job Burnout as an outcome was assessed using the Maslach Burnout Inventory - General Survey (MASLACH, JACKSON & LEITER, 1996), which is composed of 16 items and measures three dimensions of job burnout: exhaustion (5 items), cynicism (5 items), and professional efficacy (6 items).

- Role conflict and role ambiguity as outcomes were measured by accessing two correlation variables used by Hsieh and Chao (2004) and obtained from the Role Stress Assessment of Rizzo et al. (1970).

- Job rotation in software companies were measure using the instruments of Santos et al. (2016) and Van de Ven and Ferry (1980), applied in order to confirm or refuse previous findings in the literature of several fields, which claim for a negative correlation, meaning that the practice of job rotation leads for lack of specialization at work.

We applied the Portuguese version of each instrument cited above, which were validated in previous studies performed in different research fields. Although the study of da Silva et al. (2016) has validated the instruments previously, as recommended in the guidelines, we performed a pilot study for this research aiming to validate our complete instrument. This pilot was performed with 16 participants, among Software Engineering professionals and researchers, and we used the results of the pilot test to improve the questionnaire, regarding the wording of some sentences in the context of software development.

Following, we used the pilot study to test the reliability and construct validity of all factors presented in the questionnaire, which also considered the validation obtained by da Silva et al. (2016). Table 3 presents the validation of measures obtained from the sample of this study. The complete questionnaire is presented in Appendix D. Further, all individual and original instruments are available in each of the cited studies (MORGESON & HUMPHREY, 2006; MASLACH, JACKSON & LEITER, 1996; HSIEH & CHAO, 2004; RIZZO et al., 1970; SANTOS et al., 2016; VAN DE VEN & FERRY, 1980).

Table 3 – Means, Standard Deviations, and Reliability

Construct	*M*	*SD*	*α*
Task Characteristics			
Work scheduling autonomy	3,69	0,79	0.70
Decision-making autonomy	3,61	0,8	0.77
Work methods autonomy	3,66	0,78	0.76
Task variety	3,96	0,74	0.82
Significance	3,96	0,82	0.80
Task identity	3,82	0,75	0.72
Feedback from job	3,39	0,92	0.83
Knowledge characteristics			
Job complexity	3,61	0,74	0.62
Information Processing	4,18	0,59	0.66
Problem solving	3,85	0,66	0.55
Skill variety	4,11	0,71	0.84
Specialization	3,93	0,65	0.67
Social characteristics			
Social support	3,89	0,71	0.78
Initiated interdependence	3,51	0,85	0.71
Received interdependence	3,43	0,81	0.66
Interaction outside organization	3,11	1,14	0.86
Feedback from others	3,17	0,97	0.81
Rotation Intensity	2,67	0.77	0.52
Job Interchangeability	2.87	0.76	0.52
Outcomes and Correlates			
Job Burnout	2,05	0.59	0.85
Role Conflict	2,47	0.76	0.78
Role Ambiguity	2,06	0.70	0.88
Satisfaction	4,19	0.79	0.78

Source: Adapted from Morgenson and Humphrey (2006)

Regarding data collection, we obtained answers for a sample of 126 different software professionals. To achieve this amount of participants we used two strategies to increase variation and diversity of respondents, as follows:

- During the step one, a group of students in the postgraduate level attending a course on empirical Software Engineering were invited to participate in the data collection as part of their training in data collection techniques. Each student (in a class of 20 people) identified five unique professionals working with software development to answers the questionnaire. No restriction was imposed on the type of company, type of software or professional role, but they were required to identify professionals working directly with software development tasks who has a

minimum experience of five years. This is the same strategy used by Morgenson and Humphrey (2006) while developing the WDQ.

- In addition to the postdoctoral student's data collection, in the step two, we sent the questionnaire to software engineers working in a software company located in Recife, Brazil. The company had over 120 employees, of which 75 individuals were working directly in software development activities, such as, software programming, software quality assurance, and software design, among others. In this stage, we sent a link with the questionnaire to software project managers and directors and asked them to forward this link to all individuals working in software development activities. The email contained a brief description about the research as well as details about the questionnaire.

At the end of data collection, the diversity in the professional and academic background of the group of students helped to reach 39 distinct commercial software companies and total amount of 89 valid questionnaires completely answered. In addition, during the step two, we obtained answers from 36 individuals (from the total of 75 individuals) working on the software company directly invited to participate in the survey. After data collection we proceeded with data analysis by applying a similar process to the one applied by Morgeson and Humphrey (2006) and da Silva et al. (2016), that is, using Spearman's ρ correlation. In this case, we considered all scales to be interval, supported by the argument of Carifio and Perla (2007) about Likert scales and Likert response items.

As a result, using the correlations obtained using Spearman's ρ we concentrated the work in a process of understanding these correlations and their meaning, as for how job specialization affects work design factors in software development and how these correlations might affect software engineers while performing their tasks. In addition, we tested the first hypothesis proposed by da Silva et al. (2016) and the second hypothesis presented in Hsieh and Chao (2004).

Hypothesis 1: Job specialization and job burnout are negatively related.

Hypothesis 2: Job specialization and job rotation are negatively related, implying that job rotation will lower employees' job specialization

By the end of the survey (in addition to the qualitative studies), we had collected information to answer all the research questions that guided this research. However, the lack of studies in the Software Engineering literature required the development of a strategy to gather any evidence regarding this subject published by researchers while investigating other aspects of software development. Therefore, a mapping study was conducting in order to allow comparisons with the literature.

3.4 MAPPING STUDY

The scientific literature differentiates at least two types of systematic reviews: conventional systematic reviews and mapping studies (PETTICREW; ROBERTS, 2008). The former aims to aggregate results about the effectiveness of a treatment, intervention, or technology, and therefore seeks answers to causal or relational research questions (e.g. Is intervention I on population P more effective for obtaining outcome O in context C than comparison treatment C?). The latter, aims to identify all research related to a specific topic and to answer broader and exploratory questions related to trends in research (e.g., What do we know about topic T?).

Petersen et al. (2015) differentiates mapping studies and systematic reviews of literature (SLR) as follows: "they are different in terms of goals and thus approaches to data analysis. While systematic reviews aim at synthesizing evidence, also considering the strength of evidence, systematic maps are primarily concerned with structuring a research area". Research questions are another aspect that differentiates mapping studies and SLRs, while mapping studies present general questions that aim to discover research trends, research questions in SLRs aim to aggregate evidence about a very specific theme (DA SILVA et. al., 2010).

The use of mapping studies in Software Engineering allows researchers to collect and analyze data regarding the different and sometimes conflicting aspects of software development, with the purpose of integrating these results (KITCHENHAM, DYBÅ and JØRGENSEN, 2004). In this stage, the conceptual work on systematic literature review (PETTICREW and ROBERTS, 2006) and the guidelines for performing a systematic review in Software Engineering (KITCHENHAM and CHARTERS, 2007) were applied, following steps below.

3.4.1 Data Sources and Search Process

An automatic search was performed in four search engines and indexing systems (Table 4) using a search string constructed with terms presented in the general research question, as presented Table 4.

Table 4 – Automatic Sources

Search Engine	Link
ACM Digital Library	http://dl.acm.org/
IEEEXplore	http://www.ieeexplore.ieee.org/Xplore
Science Direct	http://www.sciencedirect.com/
Springer Link	https://link.springer.com/

Source: The author (2020)

The automated search process performed in early 2019 retrieved almost 40 papers. We decreased the sensitivity of the search, decreasing coverage, in order to increase precision, since the use of synonymous or variations to the terms were retrieving an amount of non-relevant studies, such as, studies reporting software systems, discussing topics related to generalization and specialization in the software code. In addition, it would not make sense to use synonyms of specialization to build the string because it is a consolidated term in other areas. The definition of specialization is presented in Morgenson and Humphrey (2006).

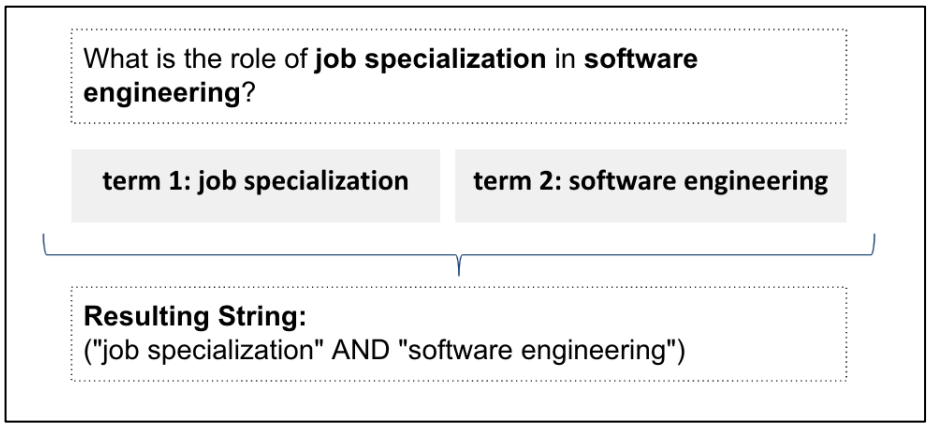

Figure 6 – Search String

3.4.2 Inclusion and Exclusion Criteria

From the initial set of 39 papers, the inclusion criteria was based on the selection of studies presenting concepts, discussions, comments, lessons learned or experience reports mentioning job specialization in software companies. In addition, we excluded studies following eight exclusion criteria:

(1) Papers written in any language but English;

(2) Papers not accessible on the search engines;

(3) Keynote speeches or workshop reports;

(4) Incomplete documents, drafts and presentation slides;

(5) Papers addressing other contexts besides Software Engineering;

(6) Studies only citing papers about job specialization;

(7) Studies addressing topics of computer science that were not related to the theme (e.g. database systems, human–computer interaction, computer networks, artificial intelligence, etc.);

(8) Papers that do not present any type of consideration or discussions about job specialization in the context of Software Engineering.

3.4.3 Data Selection

The pre-selection of papers was based on the analysis of the full text of all papers identified in the automated search using exclusion criteria 1 to 6. Then, the selection was concluded by observing the exclusion criteria 7 and 8. Two researchers were working independently in the process of excluding papers that met any of the exclusion criteria. This selection process excluded mainly studies addressing topics not related to the theme, such as, software coding strategies. Duplicates were also excluded in this phase. When a study had been published in more than one journal or conference, all versions were reviewed for the purpose of data extraction. However, the first publication was used regarding demographics analysis. Data selection finished with 21 unique studies.

Disagreements between the two researchers during data selection were solved in a consensus meeting. Figure 7 summarizes the process of search and selection of papers.

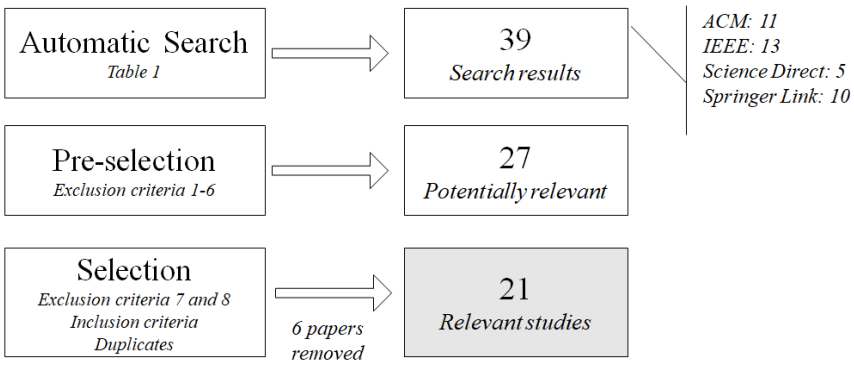

Figure 7 – Search and Selection Processes

3.1.4 Data Extraction

Similar to data selection, the data extraction process was carried by two researchers, working independently, by analyzing each paper in order to collect information as described on Table 5. The data extraction performed by two

researchers is relevant since it can improve the accuracy of the evidence obtained and the reliability of the results.

Table 5 – Data Extraction Form

Data	Description
Title	Title of the paper
Year	Year of publication of the paper
Publisher	Type of publication: journal or conference
Job Specialization	Excerpt of the study referring to job specialization
Type of Citation	Focus of the job specialization citation, such as, mention, effect or definition.

Source: The author (2020)

3.4.5 Data Analysis

Considering that the evidence collected from the papers identified in the mapping study has a qualitative nature, we applied the same data analysis process conducted in the qualitative studies. Thus, each excerpt of text from the papers were processed as a quotation from an individual participating in an interview, and the coding techniques were applied to make sense of this data.

In summary, this review identified evidence from 21 empirical studies mentioning or commenting the use of job specialization in software companies. Despite of this wispy set of evidence, this research step was relevant in terms of comparison with the previous findings obtained both in the qualitative studies and in the survey.

3.5 SYNTHESIZING EVIDENCE FROM MULTIPLE SOURCES

The fifth phase of this research can be defined as a meta-ethnographic synthesis (DA SILVA et al., 2013; NOBLIT & HARE, 1988) performed to consolidate the results produced in the qualitative studies, the survey, and the mapping study. The steps followed in this strategy are presented below.

1) **Deciding what is relevant for the synthesis**: The first step is the process of selecting studies to perform the meta-ethnographic synthesis. In this research, the four studies are selected (qualitative studies, survey and

mapping study) since each of them gather complementary information about the problem under investigation.

2) **Reading the Studies**: The second stage is focused in carefully analyze the individual findings searching for key concepts addressed in the studies, in this circumstance, the definitions and characterization regarding job specialization in Software Engineering and its effects on other work-related factors.

3) **Determining how the studies are related**: In this phase, the relationships between the different studies were explored and their findings were constantly compared.

4) **Translating the studies into one another and raising theoretical level**: This final step is centered in the conclusive definitions of concepts considering similarities and differences obtained in the studies, such as, findings in one study are identical to findings in the other studies or different. Following the authors, an acceptable translation preserves the denotations of concepts in each study, while compares the meanings of concepts among the group of studies in three different ways: 1) concepts are directly comparable as common; 2) concepts are contradicted or stand in opposition as refutational translations; 3) concepts represent a line-of-argument in a complementary way. In this synthesis, we identified both concepts that are comparable as common, representing reciprocal translations, and also concepts represent a line-of-argument in a complementary way.

5)
6)
7)

8) Table 6 presents an example of how the translation of the concepts were built in this meta-ethnographic synthesis.

Table 6 – Meta-Synthesis Process

Qualitative study 1	Qualitative study 1 - Enlargement	Survey/WDQ Definition	Mapping Study	Synthesis of the Concept
Specialization in Software Engineering work that demands a high level of specific knowledge, as well as the ability to deal with particular technologies or develop specific tasks in software development process.	Specialization in Software Engineering demands specific depth of knowledge and specific skills to work with specific technologies.	Specialization reflects the extent to which a job involves performing specialized tasks or possessing specialized knowledge and skill	Specialization Definition N/A	Specialization in Software Engineering refers to a work that demands a high depth of specific knowledge and skills to perform tasks that involves the use of specific technologies.

Source: The author (2020)

In

Table 6, columns 1-4 shows the definitions extracted from each study used in the synthesis and the fifth column presents the concept definition built from the translation of the studies, which means the comparison of all definitions and how these definitions produced the same meaning

After the process of translation, the definitions for each factor synthesized from the four studies were compared to the definitions from the literature from different research fields. Finally, the interaction among job specialization and the final list factors were analyzed to build a complete list of relationships determining

its effects on the work of software engineers. These findings might be useful to enable managerial processes towards the use of job specialization in software industry, in order to maximize its positive effects. These results were validated in a qualitative process determined as a specialist verification, conducted to check the relevance of this research.

3.6 SPECIALIST VERIFICATION

In this final stage, as job rotation and job specialization are related topics, we contacted an international software development company that uses job rotation techniques to improve the performance of interns and verified if they would be interested in participate of a research that investigates job specialization and its characterization in Software Engineering. The company was interested in participate of the study. This company is a single software developer, what might make the professionals more likely to be specialists in that certain product and then, a good company to contribute with this study.

We selected an experienced software engineer (10 years of experience) considered as a specialist in terms of knowledge about a certain component of the product, who also performs managerial and technical leadership activities in the software company. The role of a tech-leader is between the software manager role (due to the leadership needed to perform that work) and the developers roles (due to the support that a tech-leader should provide to the rest of the team in terms of technical knowledge). Therefore, we believe that a tech-leader would be able to understand both points of view to validate the data collected in previous phases.

This professional has more than 10 years of experience in software development, which includes working in several different software projects over the years. In addition, by working in managerial and leadership activities, the participant had been in contact with different types of software engineers, with different levels of specialties, which provided him the opportunity of observe several levels of interactions among professionals and teams.

In summary, this Specialist Verification was conducted following methodological steps to conduct member checking in qualitative studies performed in the Software Engineering. For this, the work of Santos, da Silva and Magalhães (2017) guided this process that consisted in one hour interview where the results and the statements of this research were presented and debated. In this process, initially, the general results of this research were presented to the participant. Then, an interview was conducted to evaluate the specialist's level of agreement regarding the statements obtained from the meta-ethnographic synthesis. As a methodological attempt to avoid biases in the verification process, the participant was not involved in any of the previous phases of this research.

Therefore, the specialist verification consisted in an experienced software engineer commenting the definition and the characterization of job specialization in Software Engineering, obtained in this research. This participant also discussed the findings obtained about the effects of job specialization in the software engineers' work. Finally, he was asked about the importance of such research and the applicability of our findings to practitioners. The complete interview was recorded and the coding process to analyze qualitative data was applied. The results of this specialist verification, including descriptive quotations, are presented in Chapter 4.5.

3.7 THREATS TO VALIDITY

Regarding the qualitative approaches, according to Merriam (1995), internal validity verifies whether the findings are consistent with reality. In this context, we assume that reality is multidimensional and ever changing, and not a single and immutable reality is waiting to be observed. Therefore, there may be several interpretations of the reality, which means that a researcher offers his/her own interpretation of a phenomenon. Thus, in order to ensure that findings are valid, we applied the specialist verification as a strategy similar to the member checking process performed in case studies (SANTOS; MAGALHÃES; DA SILVA, 2017).

Regarding the quantitative approach, we addressed construct validity by applying well-known instruments that had been already tested in other research and in a recent replication. However, these instruments were not developed specifically to assess Software Engineering work, which could induce wrong interpretation of the questions and, thus, impact construct validity. Our data showed good internal consistency and inter-rater agreement, indicating that threats to construct validity have been minimized.

One important threat to external validity, in both qualitative studies and the survey, is that our samples are composed from professionals working in Brazilian companies. Therefore, cultural issues such as the legal framework that regulates job relationships might influence the results. In order to minimize this issue, we collected data from companies that apply international procedures, which also include software projects to international clients. In addition, the results from the mapping study produced a certain level of variation in this data, since the studies analyzed were developed in different countries.

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4 RESULTS AND DISCUSSIONS

This chapter presents the findings of each individual study, followed by the consolidation of results obtained from the meta-ethnographic synthesis and the observations obtained during the specialist validation. In conclusion, each study provided relevant results to answer the individual research questions and the consolidation of these results are the most extensive body of knowledge constructed about the role job specialization in Software Engineering and its effects in the work of software engineers.

4.1 QUALITATIVE STUDY I

Building a definition of job specialization in Software Engineering was the goal of this qualitative study. As demonstrated in the literature review presented in section 2.3, no relevant research focused on job specialization in Software Engineering was found. Therefore, the main goal of this qualitative study was to collect as much information as possible regarding definitions about this concept as well as its characterization and its effects in the work of software engineers. In this sense, the first question asked in the interviews aimed to establish a definition of job specialization considering the specific aspects and the dynamics of work in software companies. In this study, we used the code **S0nP0m** in quotations mentioned both in qualitative study 1 and in qualitative study 2 (enlargement). S represents the study (01 and 02) and P represents the participant.

The participants commented that in Software Engineering a specialized work is often related with the development of tasks that require a **specific knowledge** to be completed as demonstrated in the quotations below.

“You have a general knowledge [about software development] and in one specific part of the work you have more knowledge” (S01P03).

"When you domain a certain programming language or technology [knowledge] that you are working on, for example, I’d say that mobile

development is a specialization [specialization in comparison with general software development]" (S01P07) .

In addition, participants also mentioned that another important aspect of the specialized work in Software Engineering is the **level of knowledge** that one has, for example, consider two software engineers who have knowledge about practices of a certain development methodology, such as Scrum. One of them knows how to apply all the practices related to this methodology while the other partially knows it, in this case, the first software engineer mentioned has a higher level of knowledge. This concept is illustrated in the quotations below.

"Ok... it's... a job that requires a certain level of specific knowledge in a given domain" S01P04.

"So, I understand that [a specialized work] is when you concentrate and focus your efforts, studies, I mean, activities in a given technology" S01P06.

Following, interviewees commented that a specialized work demands **specific skills** to be accomplished. In this study, the concept of skill is associated to the expertise that one possesses to correctly perform a specific work. The quotations below exemplify this scenario.

"It's like when someone doesn't have the ability to work as back-end developer for example, or a tester, or any work other than the one that he or she is specialized" S01P04.

"A developer, for example, can find a bug but the tester usually has the ability to report that bug" S01P03.

Analyzing and synthesizing the aspects that participants used to describe a specialized job in Software Engineering, we can determine that job specialization in Software Engineering refers to **a work that demands a high level of specific knowledge, as well as the ability to deal with particular technologies or develop specific tasks in software development process**. On the other hand, we obtained information about what would not be defined as

a specialized work in this context. In this sense, participants discussed that a work that involves interdisciplinary activities, generalist background or general knowledge is not specialized. Quotations below illustrates a non-specialized work in Software Engineering.

“When you don’t need a specific work” S01P05.

“It's a job that anyone could do, that is, do not require any specific in-depth study on that domain” S01P06.

Once the definition of job specialization in Software Engineering was determined, the data collected in the interview was used to characterize this work-related factor. In summary, these characteristics are important to sharpen the construct built so far. Following the narratives of participants, the most cited characteristic of a specialized work in Software Engineering is **technical skill,** which can be explained as the ability of a professional to work with a specific technology in software development. A participant declared that, for example, "if you are a developer, you have to know the development techniques very well", which confirms that technical skills are needed in a specialized work. Another participant mentioned that job specialization “demands a lot of technical knowledge” to be executed, which also refers to the need of technical skills to accomplish activities in a specialized work.

Following, participants pointed out that job specialization is characterized as a work that demands **accumulated experience** from software engineers in a particular subject. In this context, one of the interviewees was categorical, stating that the software engineer “needs previous experience in a particular field”. Other participants reinforced that “in addition to the technical skill, it is interesting that he [the software engineer] also has experience, because it is no use just having studied about that subject or read about it”. Thus, that professional needs to have experienced some practical cases in that domain. Both affirmations highlight the importance of the accumulated experience before handling a specialized work.

In addition, **focused** is another characteristic that represents job specialization according to participants of this qualitative study. Interviewees stated that “only someone who has spent time studying, evaluating all possible examples and situations, could have the maturity to give an answer or a solution”. It means that a specialized work demands focus in a specific topic or field. Another affirmation that arose from the interviews is that a specialized work could be characterized as “…a work focused in a specific field, dedicated in a specific field or even an exclusive work”, strengthening the notion that a specialized work is focused in a specific field.

Finally, characteristics such as **depth of knowledge** and **challenging** were related to a specialized work in Software Engineering. However, there is a lack of details regarding these two characteristics obtained in the interview transcripts.

The subsequent aspects investigated in this qualitative study are resulting from definitions presented in the work of Morgenson and Humphrey (2006) and discussed in Section 2. In their work, two characteristics were defined to measure the construct variety. Task variety “refers to the degree to which a job requires employees to perform a wide range of tasks on the job” while skill variety “reflects the extent to which a job requires an individual to use a variety of different skills to complete the work”. Also, the general literature usually proposes that specialization “reflects the extent to which a job involves performing specialized tasks or possessing specialized knowledge and skill” (MORGENSON; HUMPHREY, 2006), which is commonly known to be conflicting to variety at work. However, considering that job specialization might present particularities in the context of Software Engineering, we hypothesized that even a specialized job in software companies might vary in terms of skills and tasks.

When asked about the possibility of performing a diversity of tasks in an specialized work, participants revealed that opposite to what literature defines, it is possible to relate variation of tasks and specialization. For example, a participant declared that “a wide variety of tasks can be performed [in a

specialized work], in that case, a software engineer may have several types of things [tasks] that he can do, but related to specific domain". Another statement regarding the relation between specialization and variety that emerged in the interviews says that "even though I have variety in all of these activities, I will need to commit to some kind of specialized knowledge to develop that activity". Following, the argument above was reinforced by other participants, one of them said that "even though if a professional has a variety of responsibilities and tasks [in his field], those tasks sometimes require a specialized skill and prior knowledge to be able to perform that activity". We present below (Table 7) a summary of all quotations of participants that were asked if a specialized job may have task variety.

Table 7 – Summary of quotations confirming that specialization may have task variety

Participant	Quotation
P001	"Yes! A wide variety of tasks can be performed [in a specialized work], in that case, a software engineer may have several types of things [tasks] that he can do, but related to specific domain"
P002	"Yes, precisely because of the application [related to the task you have to do] in the context".
P003	"I think that when you're like a technical leader, technical coordinator, you vary the job a lot".
P004	"Even though I have variety in all of these activities, [the software engineer] will need to commit to some kind of specialized knowledge to develop that activity. So I think so".
P005	"So, I think you can. So, I believe you can have different tasks"
P007	"Yes, because the person can do many things, but for a certain activity he needs a specific knowledge, a specific skill"
P008	"the role of the technical leader has a wide variety of tasks".

Source: The author (2020)

The information collected in this qualitative study allowed us to understand that different from the statements and discussions presented in other research fields, in Software Engineering, specialization at work do not necessarily means lack of variety. Contrariwise, the dynamics in software development creates the possibility of perform different tasks even working in a specialized domain. In

addition, our analysis pointed out that the knowledge in software development tend to be specialized, while the tasks tend to be variable.

In the interviews, participants defined the level of specialization of their work, declared how variable are the tasks of that work and also detailed, with examples, the variety of tasks they perform in a daily basis. We analyzed the answers, and created a scale that allowed us to distribute the participants into a quadrant depending on their level of specialization (low to high) and the variety of tasks (low to high) in the work. We created a scale based on 5 point Likert-scale, which is used to ask participants to show their level of agreement with a set of particular questions. The answers vary from strongly disagree (SD) to strongly agree (SA) with a given statement (JOSHI, 2015).

As we are analyzing the level of specialization of a work and the level of variety of tasks in that work, we used the following scale (based on Likert-scale) to support the creation of a quadrant that relates specialization and task variety. The items of the scale were defined based on the answers of the participants as shown in Table 8.

Table 8 – Correspondent values to each level of specialization (5 point Likert-scale).

Level of specialization/Task variety	Correspondent value
Low	1
Moderate-low	2
Moderate	3
Moderate High	4
High	5

Source: The author (2020)

The one show the distribution of participants in a quadrant that relates the level of specialization of a certain participant and the variety of tasks that they perform in their work. In addition, examples of tasks that they perform in each role are also presented in Table A (part of

Figure 8).

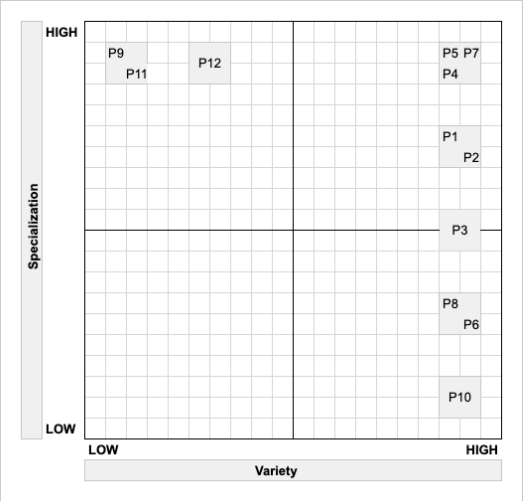

Figure 8. Table A.

ID	Examples of variety of tasks performed by participant in Software Development.
P1	Reports to project manager, Project analysis.
P2	Requirement analysis and review, Requirements understanding, Design Test Scenarios, etc.
P3	To break a system in various features, and each feature has different subtasks/strategies.
P4	Conflict management, Activities management, Members relationship, Give valur to the product.
P5	Different projects understanding.
P6	Code review, Create Technical solution, Build Diagrams, Create proof of concept, etc.
P7	Requirement analysis, Develop (idea) a solution to a problem, coding the solution, Perform tests, etc.
P8	Define requirements, Understand requirements, Build test scenarios, Execute tests, Automate testes.
P9	Test execution, Build test cases, Create Automation.
P10	Define test scenarios, Build test cases.
P11	Develop features and fix bugs.
P12	Develop features, code review.

Figure 8 – The relationship between Specialization and task variety.

The results demonstrated that from the amount of 12 interviewees, two participants (P9 and P11) considered that, on a daily basis, they execute a specialized work in software development, while experiences low levels of task variety. Three participants (P5, P7 and P4) reported that they experience high level of specialization combined with a high variety of tasks. Two participants (P1 and P2) consider the level of specialization of their work as moderate-high, while they experience high levels of task variety. One of the participant (P3) considers that he works in a job with moderate level of specialization, while he experiences high level of variety on the tasks that this work require. Two participants (P8 and P6) considered that their work involves a moderate-low level of specialization, while they perform a variety of tasks. One participant (P10) reported that his job involved a variety of tasks, and this is associated to low levels of specialization.

Based on the participant's answers, it is possible to define some personas that can explain the distribution of interviewees profiles into the quadrants. For instance, participants reported that a software tester could have a high level of specialization, considering the domain of the software under development, while performs a great variety of tasks, such as, planning and designing test cases, executing tests and reporting results, or creating test automation. On the other hand, a software developer (programmer) could

possess high levels of specialization in a given technology, while his tasks will vary according to part of the system under development. In summary, it is likely that a specialized work in software development would commonly present high levels of variety due to the dynamic of the software engineering process.

In order to verify our hypothesis that specialization is composed of two dimensions (skill and task), such as observed in variety as presented in WDQ (MORGENSON; HUMPHREY, 2006), we continued our investigation by asking to participants about their point of view about skill variety in a specialized work. The data analysis in this qualitative study revealed that software engineers believe that a specialized work can vary in terms of the skills needed to perform that work. In this context, respondents stated that the higher the level of knowledge that a software engineer has, the greater the variety in that work and the quotation below exemplifies it.

“An example for this is the level of depth that [the software engineer] wants to reach. The more the level of depth of knowledge that [a software engineer] has the more [he] increases the variability (S01P03)”.

Several participants associated the notion of variety to the role of a project manager in software development, for example, the citation that follows demonstrates that several skills are necessary to perform the management of a software project. The participant believed that he “thinks the job of a project manager is a job that requires leadership skills, communication, and management skills, etc. It is the job that would also need to have specialized knowledge in the various areas that he is managing” (S01P06).

Figure 9 shows the distribution of participants in a quadrant that relates Job Specialization and Skill variety. It also present examples of the variation of skills that software engineers that participated in this study believe they have. We used the same approach used in the verification of the relationship between job specialization and task variety (

Figure 8) using a Likert-scale based scale to distribute the data into the quadrant. The level of Specialization and skill variety followed the same definition presented in Table 8 that define the level of specialization and skill variety as low, moderate-low, moderate, moderate-high, and high.

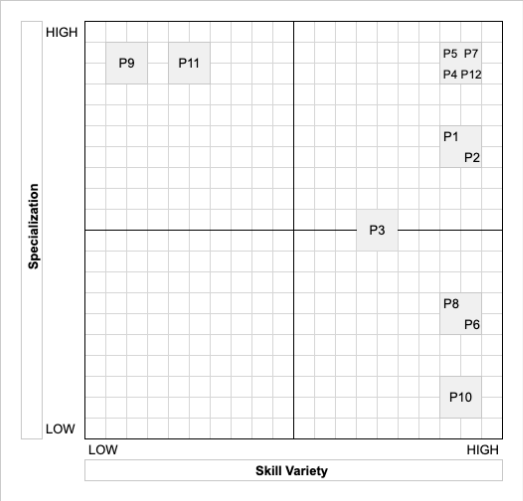

Figure 9. Table A.

ID	Examples od variety of tasks performed by participant in Software Development
P1	Deal with people, Communication, Programming Skiills, Business Understanding.
P2	Leadership.
P3	Creativity to create test scenarios.
P4	Different projects, techniques, methods and problems everyday.
P5	Develop people, Planning, Design products.
P6	Mentoring, communication, skills of leadership.
P7	Skill of thinking in a solution, coding that solution, etc.
P8	Review requirements and Automate a test are examples of tasks that need different skills from a QA.
P9	Attention.
P10	Focus, Curiousity, Skills to deal with the tools related to the process (Jira).
P11	Basically, programming skills
P12	Algorithm understanding, Skill to think of different solutions.

Figure 9 – The relationship between Specialization and skill variety.

Regarding skill variety, it is possible to observe that almost all participants believe they have a high level of skill variety in their work. Only two participants (P9 and P11) believe that they have a low level of skill variety in their work. In summary, all participants, except P9, believes that a high variety of skills are needed in Software engineering and 60% of these participants experience moderate to high levels of skill variety in specialized works, opposite to what is defined in other areas that specialization is related to monotony and boredom. Participants mentioned a variety of skill needed in Software Engineering related works such as skills to deal with people, communication, programming skills, business understanding, leadership and creativity to create test scenarios (Figure 9).

The data analysis revealed that software engineers believe that a specialized work can vary in terms of the skills needed to perform such work. In this context, respondents stated that high levels of specialization will demand more accumulated knowledge, and therefore, the levels of skills applied to cope

with it. Several participants associated the notion of skill variety to the role of a software project manager, for example, participants believe that the job of a project manage is specialized in terms of knowledge required, while is variable in requiring different skills, such as, leadership abilities, interpersonal relations, management capacities, among others.

In summary, the results of the qualitative study successfully answered the three research questions designed for this study revealing particularities of job specialization in the context of software engineering. In particular, these findings demonstrate that in software companies, specialization are usually related to the knowledge required to work on a specific domain/technology. However, this specialization can be associated to high levels of work variety, meaning that software engineers in specialized jobs might experience high levels of task and skill variety. Thus, confirming previous propositions that work design in software engineering tend to be different from other areas.

4.2 QUALITATIVE STUDY II - ENLARGEMENT

A new qualitative study was performed in an attempt to complement the findings from the first qualitative study and to find new constructs. As in qualitative study 1, participants from different roles in software development field were selected. In this study we had 21 participants distributed in the same roles of study 1 except for software analysts that is an exclusive role for this study (Table 9).

Table 9 – Participants of qualitative study 2 (enlargement) by role.

Role	Amount of participants
QA	1
Project manager	2
Tech Leader (Software engineer)	1
Software Engineer	11
Software Analyst	6
Total	**21**

Source: The author (2020)

In this study, we continued investigating how participants define job specialization in Software Engineering. As found in study 1, participants mentioned that a specialized work demands **specific depth of knowledge** and **specific skills** to be performed, confirming the findings in our first investigation. **Specific technology** is another term related to specialization mentioned in this investigation. A participant mentioned that a specialized work used a "technology that is not normally used in most software, something specific." In this quotation, we can confirm that in Software Engineering, a specialized work is related to a specific knowledge and skills in a specific technology. Then, findings from qualitative study 2 reveal that **specialization in Software Engineering demands specific depth of knowledge and specific skills to work with specific technologies.**

In sequence, we kept investigating aspects that characterize a specialized work and in addition to characteristics we found in study 1, participants mentioned that a specialized work can be described as **complex** for this reason the professional selected to develop the work needs to be carefully chosen. One of the interviewees revealed that specialization is "something more complex, not trivial and critical to the project" (S02P02). Participants also raised the aspect **"structured"** in the interviews, meaning that a specialized work can be described with the following quotation: "when a software engineer use a methodology correctly it tends to have fewer gaps".

Regarding the relation between specialization and task variety, in this case respondents declared that a specialized work can vary in terms of tasks, confirming results from study 1. One of the interviewees declared that even though his work is considerably specialized, he experienced a variety of tasks. Another participant used the project manager role to exemplify a varied specialized work, demonstrating that the work played by these professionals can

vary regarding the different contexts of the projects in an organization. Quotations below present the perception of these participants.

"I believe that my work moderately or highly specialized due to the technologies I have to know and I still have a wide variety of tasks" S02P02.

"Yes, they can also be highly specialized, like a Project manager. He has to have a range of tasks and activities that involves all projects of a unit. He has to do manage different projects and coordinators. So, he has to be very specialized" S02P10.

An aspect that participants often mention is the use of different technologies in a specialized work. They believe that a specialized software developer, for example, may possess knowledge in different programming languages and use them in a same project. The same would happen in a software tester role, as shown in the quotation below.

"I believe so. An example of that would be to perform coding tasks requiring knowledge of different technologies such as Spring, Hibernate, REST and Angular, or in software testing context, to perform test tasks requiring knowledge of TDD, JUnit and Selenium" CP02P08.

Considering these examples, whereas an individual is specialized in multiple technologies, an interesting concept that emerged from the interviews is the notion of multi-specialist. Thus, we believe that it means that a professional in a specialized position can experience variety and for that it is necessary to focus in more than one field of specialization.

"I believe so, but for that the professional must be multi-specialist" S02P06.

In summary, qualitative study 2 did not find any new evidence regarding the variety of tasks in a specialized work. The information obtained in this study reinforces the statements presented in study 1 that task variety is one of the work factors related to specialization.

We then investigated if skill variety is a work-related factor associated with specialization. As found in study 1, participants confirmed that specialized work may need variety of different skills to be performed. The next quotation demonstrates that in a context of project change, when a specialized software engineer has to move to another project, he will work with different scopes, technologies or methodologies and different skill will be needed in that case.

“Sometimes teams change and some teams work with different focuses and even in different projects, with other objectives, which implies different technologies and techniques, it does not make a software engineer less specialized. So I believe a variety of skills are needed” S02P01.

We can observe that qualitative study 2 showed a low level of variation about the theme when compared with study 1. No new relevant information about the definition or characterization of specialization was found in new interviews which demonstrates that results present a good level of reliability. On the other hand, it also demonstrates the need to obtain complimentary evidences from other methods in order to fill the gap found in the literature and fulfill the goals of this research. Therefore, the next step in this research is the development of a survey to identify correlations between job specialization and other work-related factors.

4.3 SURVEY

We conducted a survey as a complementary method seeking to extend the results obtained in previous qualitative studies in order to enhance our perspective and reach a deeper understanding about the topic under study by highlighting the correlations among job specialization and several work-related factors. These correlations were obtained using the statistically significant correlations of Spearmans’s ρ. To achieve such goal, a sample of 126 Software Engineering professionals answered a survey questionnaire designed to capture their experiences at work with several work-related factors and job specialization.

Regarding the groups of participants in the survey we obtained variation in the group of individuals. Regarding the role in the software project, the sample was composed of 50% (63/126) of *Developers*, 29% (35/126) of Systems *Analysts*, 13% (17/126) of Software *Testers*, 5% (6/126) of Project *Managers*, and 4% (5/126) of UX/UI *Designer*. Regarding the years of experience working in software industry, the survey was composed of 26% of professionals (33/126) with less than 5 years of experience, 31% of individuals (39/126) with experience between 5 and 10 years, and 43% of participants (54/126) with more than 10 years of experience in software development. Table 10 summarizes this information.

Table 10 – Summary of Participants

			Age		Job Experience (years)		Gender
Role	**Total**	**% (N=126)**	**M**	**SD**	**M**	**SD**	**%men**
Analyst	35	28%	36,5	9,6	13,1	13,1	21%
Manager	6	5%	45,2	6,7	22,7	22,7	1%
Tester	17	13%	35,9	3,9	8,4	8,4	6%
Developer	63	50%	31,5	5,4	8,9	8,9	47%
Designer	5	4%	37,8	4,9	8,6	8,6	3%
Total	126	100%					79%

Source: The author (2020)

To organize and present the results we are using the same categories used in the Morgeson and Humphrey's WDQ model (2006). In addition, we used the descriptions in the literature and in the instruments to assess the impact of each correlation on the work of software engineers.

For instance, work design theories contend that all work characteristics are advantageous for professionals; in this sense, all 17 work-related factors investigated in this survey are determined as having a positive effect in someone's work. Therefore, when job specialization is negatively correlated to a given factor, it means that it represents a limitation at work, since it might reduce the positive effect of such factor. However, a positive correlation means that job specialization can be applied to increase the positive effect of the work-related factor.

Following, the literature defines outcomes such as Role Conflict, Role Ambiguity and Job Burnout as negative factors associated to someone's work, while Satisfaction as an outcome defined as positive. Finally, we investigated the existing dynamics regarding the existing correlation between job specialization and job rotation, since for many years the literature has presented divergent conclusions about this, and therefore, it is important to understand such correlation in order to support software management activities in practice.

Table 11 presents the summary of results obtained from the survey. In this table, we present positive correlations and/or impacts between job specialization and other work-related factors with a (+) sign, while negative correlations are presented with a (-).

Table 11 – Correlation between Job Specialization and other work-related factors

Factors	Correlation with factor	Impact of factor on the work	Conclusion
Work Characteristics			
Task Characteristics			
Work Scheduling Autonomy	+*	+	Beneficial
Decision Making Autonomy	+**	+	Beneficial
Work Methods Autonomy	+**	+	Beneficial
Task Variety	+**	+	Beneficial
Task Significance	+**	+	Beneficial
Task Identity	+**	+	Beneficial
Feedback from Job	+**	+	Beneficial
Knowledge Characteristics			
Information Processing	+**	+	Beneficial
Problem Solving	+**	+	Beneficial
Skill Variety	+**	+	Beneficial
Social Characteristics			
Social Support	+**	+	Beneficial
Initiated Interdependence	+**	+	Beneficial
Received Interdependence	+*	+	Beneficial
Feedback from Others	+**	+	Beneficial
Outcomes			
Job Burnout	-*	-	Beneficial
Role Ambiguity	-**	-	Beneficial
Satisfaction	+**	+	Beneficial

* $p < 0.05$; ** $p < 0.01$ (two tailed)
Source: The author (2020)

The correlations obtained from this survey demonstrated that usually job specialization is an advantageous factor in software engineer's work due to its positive effect in different work related-factors. Our results demonstrate that from the set of 17 work-related factors, which are all considered as positive to someone's work, job specialization demonstrated positive significant correlations with 14 factors.

Following these results, job specialization demonstrated positive correlation with seven factors related to task characteristics of software development. According to the definitions on the WDQ and the literature, these factors can be defined as follows:

- Three dimensions of Autonomy that reflects the extent to which a job allows freedom, independence, and discretion to schedule work, make decisions, and choose the methods used to perform the tasks.
- Task Variety, which refers to the degree to which a job requires employees to perform a wide range of tasks on the job.
- Task Significance, which reflects the degree to which a job influences the lives or work of others.
- Task Identity refers to the degree to which a job involves a whole piece of work, and the results of each piece can be easily identified.
- Feedback from Job can be defined as the extent of how individuals can acquire useful information about their performance at work based on the results of the activities that they are developing.

In summary, following recent studies, such as FRANÇA et al., 2018, most of these factors that are positively affected by job specialization have also a direct and positive effect in two dimensions of the work motivation when considering the specific context of Software Engineering, namely, Engagement and Focus. This scenario leads to a different conclusion from those presented in the literature in different research fields, which claims that specialization at work can increase the levels of boredom and monotony and decrease worker's motivation. This can reinforce our previous observations

that demonstrated that a specialized work can have variety in terms of tasks being performed.

Regarding knowledge characteristics of work, job specialization demonstrated a positive correlation with three factors. Following the definitions on the WDQ and the literature, these factors can be defined as follows:

- Information Process reflects the amount of information, especially new information, that individuals can acquire and process while performing their work.
- Problem solving reflects the degree to which a job requires unique ideas or solutions and reflects the more active cognitive processing requirements of a job.
- Skill variety reflects the extent to which a job requires an individual to use a variety of different skills to complete the work.

Observing the positive correlation of job specialization with knowledge related factors, two statements can be elaborated. First, similar to task characteristics these factors also have a strict relation to two dimensions of work motivation in software companies (Engagement and Focus) (FRANÇA et al, 2018), which means that job specialization can in fact be an important element in order to build strategies to increase software engineer's motivation at work. Secondly, these correlations reinforce our previous observations, which demonstrated that a specialized work might be variable in terms of skills required from professionals in order to perform their work.

Social characteristics encompasses the factors that usually demonstrated the effect of the interaction of an individual with his/her teammates. The correlations obtained in this survey demonstrated a positive relation of job specialization with four of these factors. Following the definitions on the WDQ and the literature, these factors can be defined as follows:

- **Social Support** reflects the degree to which a job provides opportunities for advice and assistance from others.

- **Initiated Interdependence** refers to the extent to which work flows from one job to other jobs.
- **Received Interdependence** the extent to which a job is affected by work from other Jobs.
- **Feedback from Others** reflects the degree to which others in the organization provide information about performance.

Considering recent studies on motivated behavior of software engineers, we observed that most of the factors related to social characteristics at work had no direct relation to the dimensions of motivation. However, these factors in addition to Feedback from Job, defined previously, might produce a positive impact on job satisfaction and how individuals feel about the outcomes of their work, in other words, how happy the software engineers are while working in a given company.

In fact, the positive effect of job specialization and satisfaction can be hypothesized by the direct correlation that this factor has with this outcome, as presented in

Table 12. Regarding other work outcomes, job specialization demonstrated a negative correlation with role ambiguity and job burnout. These two factors are considered as detrimental to the work of individuals in general. The first is well-known as responsible for many conflicts, while the second one can indicate that the individual are not able to continue performing his/her tasks or handle his/her work. Therefore, this negative correlation might indicate that job specialization can be applied in the process of reduce or avoid these problems in software companies.

As previously pointed out by Narayanan (2009) and observed in the qualitative studies, the correlation between specialization and variety is an important aspect to be observed. In fact, our results showed relevant correlations among job specialization, variety (task and skill) and the outcomes job burnout and satisfaction.

Table 12 demonstrates these correlations organized by the years of experience of a professional.

Table 12 – Benefits and limitations of Job Specialization by years of experience

Factor (Impact on job)	10 or more years or experience			Less than 10 years of experience		
	Correlation with factor	Impact for work	Benefit/ Limitation	Correlation with factor	Impact for work	Benefit/ Limitation
Work Characteristics						
Task Variety	N/A	+	N/A	+**	+	Beneficial
Skill variety	+**	+	Beneficial	+**	+	Beneficial
Correlate Variables						
Role Ambiguity	-**	-	Beneficial	N/A	-	N/A
Outcomes						
Job Burnout	-**	-	Beneficial	N/A	-	N/A
Satisfaction	+**	+	Beneficial	N/A	+	N/A

Source: The author (2020)

These findings confirm that the concept of variety in Software Engineering may have different meanings. For example, if a professional who works as a software developer in a project starts to work on another project in a different application or business area but with the same role, one would expect an increase in skill variety while task variety would not change. Our data demonstrated that job specialization is positively related to skill variety both in more experienced professionals and in less experienced professionals. We contend that in Software Engineering, even in a specialized work, a professional can still experience skill variety.

Regarding task variety, we observed a relevant correlation with job specialization only in professionals with less than 10 years of experience. We believe that the experience may moderate the way that software engineers understand task variety, i.e., more experienced professionals may need higher levels of variety to perceive the effects of this factor.

Finally, regarding the hypothesis replicated from previous studies and tested in this survey, we were able to support the first hypothesis. However, the

second hypothesis is inconclusive in our results. The first hypothesis establishes that *job specialization and job burnout are negatively related*, as observed by Hsieh and Chao (2004) and supported by da Silva et al. (2016), the correlations demonstrated that the more specialized the job, the lower the individual might experience the feelings of exhaustion and cynicism at work. As for the second hypothesis, which claims that *job specialization and job rotation are negatively related,* our results do not present significant correlations between the practice of job rotation and job specialization.

Contrary to what has being confirmed in other research fields, considering the specific context of Software Engineering, job rotation and job specialization are not conflicting work-factors in software industry. In addition, we can extend the discussion about job specialization and job rotation by stating that a negative (non-significant) correlation was found between job specialization and rotation intensity, the dimension of job rotation that defines how often a software engineer is switching software projects or teams. In addition, we identified a positive (non-significant) correlation between job specialization and job interchangeability, the dimension of job rotation that defines how ease would be to switch an individual to perform the tasks of another.

In addition, these non-significant correlations might support the discussions of Santos et al. (2017) arguing that the effect of job rotation on job specialization depends on the attitude of each software engineer towards job specialization. In fact, our results demonstrated that not only the individual attitudes can generate conflicting results between the two factors, but also, the frequency in which the rotations occur might affect job specialization somehow. Therefore, we can argue that in very specific cases, when an individual is rotated in short intervals of time, job rotation might negatively impact job specialization, and therefore, indirectly affect many work-related factors, such as, those identified in this survey. However, since we did not obtain significant correlations among job specialization and job rotation, the interaction between these two factors might be an interesting research topic to be investigated in the future.

In summary, all the correlations identified in the survey were described and compared with the results obtained from the qualitative studies resulting in a consistent set of findings about the effects of job specialization in software development practice

4.4 MAPPING STUDY

The mapping study analyzed 20 research papers published between 1990 and 2018 with the aim to find additional information about job specialization in Software Engineering.

Table 13 presents a summary of these studies sorted by year of publication. The complete list of studies is presented in Appendix B. As discussed in Chapter 3, there is currently no published research focused on job specialization in Software Engineering, therefore, the 20 papers identified in this research phase were mentioning or discussing this theme in some level, while researching several aspects of software development. Thus, as presented in

Table 13:

- About 37% of papers (7/19) commented about the effects of job specialization in the context of Software Engineering.

- Over 26% of papers (5/19) pointed out evidence that could characterize the specialized work in software companies.
- Almost 16% of papers (3/19) referred to job specialization as an outcome of the dynamics of work in software development.
- 21% of papers (4/19) simply mentioned job specialization while investigating Software Engineering topics, however, not providing further details.

Table 13 – Summary of Selected Papers

Year	Study Ref.	Source	Type of Reference
1990	SPE001	IEEE Transactions on Software Engineering	Effect
1990	SPE002	Communications of the ACM	Characterization
1990	SPE003	Computers and Society	Effect
1994	SPE004	Computer Personnel Research Conference	Effect
2003	SPE005	International Symposium on Foundations of Software Engineering	Effect
2003	SPE006	Managing Software Engineering Knowledge	Effect

2007	SPE007	Symposium on Computer Human Interaction for the Management of Information Technology	Characterization
2009	SPE008	International Conference on Computer and Information Technology	Simple Mention
2009	SPE009	Conference on Software Engineering Education and Training	Simple Mention
2009	SPE010	Managing and Leading Software Projects	Characterization
2011	SPE011	ACM SIGSOFT Software Engineering Notes	Simple Mention
2012	SPE012	IEEE Software	Characterization
2014	SPE013	ACM SIGSOFT Software Engineering Notes	Simple Mention
2015	SPE014	Information and Software Technology	Outcome
2016	SPE015	International Conference on Software Engineering	Outcome
2016	SPE016	International Symposium on Empirical Software Engineering and Measurement	Effect
2016	SPE017	International Conference on Evaluation and Assessment in Software Engineering	Effect
2017	SPE018	Information and Software Technology	Outcome
2018	SPE019	Nordic Conference on Human-Computer Interaction	Characterization

Source: The author (2020)

Regarding the characterization of job specialization in Software Engineering, the evidence identified in the papers refers to specialization as **distinctive work skills** necessary to develop several different activities in software development. In this sense, job specialization would be related to the

division of labor, considering that each activity in the software development life-cycle requires **particular skills** to be accomplished, and therefore, different levels of specialization, which can be directly related to the technologies used in a software project or to the nature of the tasks being performed by individuals. This evidence reinforces the results obtained in the qualitative study 1 and confirmed in qualitative study 2. Further, the evidence collected demonstrated that the development of specialized skills in software development are beneficial for software engineers since such skills will allow them to work with a range of complex issues in software projects, while still maintaining the general skills necessary to provide them the flexibility required to work across different projects in the same company. This evidence reinforces our previous statement that job specialization is not negatively related to task or skill variety.

As for the effects of job specialization in software companies, evidence pointed out that a specialized work "should simplify the communication network [among individuals] but would require **greater capabilities** of the person fulfilling that role". This finding lead us to the hypothesis that job specialization is correlated to high level of **concentration at work**, since software engineers are required to manage all capabilities and skills related to the specialized task that they are performing. In addition, studies reported that job specialization can produce a negative impact on how software engineers experience the interaction between different areas in the software project, meaning that high specialized professionals will be more **focused** in a particular piece of software or software development task and much less involved in the whole project. Following this evidence, this situation could lead individuals to job dissatisfaction. However, the mapping study itself and the results from our survey (Chapter 4.3) demonstrated that job specialization and job rotation are not negatively correlated, thus, it is possible that techniques of job rotation can be applied to overcome this likely problem.

Job specialization was also reported to be a result obtained of managerial practices performed in software teams. As previously stated, differently from what was observed in many contexts and industries over the years, in Software

Engineering, **job specialization and job rotation** are not negatively correlated, which means that software companies might be able to obtain the benefits of specialization highlights in combination to the advantages from the practice of job rotation. However, it is still necessary to investigate how these two work elements can be combined, since both of them present strong correlations, both positive and negative, with several work-related factors.

Finally, a small percentage of papers identified in this mapping study simply mentioned or referred the concept of job specialization, without providing further explanations. We observed that most of these references were related to discussions at the **organizational level**, such as, in the development and standardization of companies' processes, such as, economics, business or human resources. This evidence demonstrated that job specialization might be a work factor that flows from the individual, to the team level and could extrapolate to the organization level, which could affect not only professionals directly related to software development, but also, professionals with different roles. However, this is a hypothesis, based on the evidence collected in a small number of papers identified in the mapping study. Therefore, this finding needs to be checked in future research, since this is not part of the scope of this PhD research.

In summary, the evidence collected in this mapping study consolidates the results obtained in the previous stages of this research, both in the qualitative studies and in the survey. The evidence collected can be only used in a complementary way, since there are no contradictory results among the studies.

4.5 META ETHNOGRAPHIC SYNTHESIS

This section presents the synthesis of the individual studies developed in this PhD research. For this synthesis, meta-ethnographic techniques were applied, as explained in Section 3.5. As the main result of this synthesis process, an updated definition for job specialization considering the particularities of Software Engineering was constructed. In addition, the characterization of a specialized work in software development is presented and explained. Finally, the list of work-related factors that are likely to be affected by job specialization,

representing its benefits and limitations, is presented. Following, we answer the research question presented below.

RQ1: What is the role of job specialization in Software Engineering?

RQ1.1: How is job specialization defined by Software Engineers?

Based on the meta-ethnographic synthesis, an updated definition of the concept of job specialization can be presented, considering the findings of each individual study. This definition considered concepts constructed along the qualitative studies and the survey, since the mapping study did not present definitions to the term. In addition, the obtained definitions were compared, synthesized and contrasted to the definitions in the literature presented in Chapter 2. After this process, the definition of job specialization in Software Engineering can be stated as follows:

Job specialization in Software Engineering refers to a work that demands a high depth of specific knowledge and skills to perform tasks that involves the use of specific technologies.

RQ1.2: How is job specialization characterized in Software Engineering?

Following, using the same meta-ethnographic process it was possible to characterize a specialized work in software development, based on the evidence collected in all individual studies. In summary, a specialized work in software development can be characterized as:

Complex: In Software Engineering, as this research revealed, a specialized work can vary in terms of tasks and skills needed to perform the work, and needs a depth of knowledge in each task performed by a professional and this contribute to the work to be considered complex, which is a term that can relate to a work that is hard to perform.

Structured: A structured work is related to an organized and balanced work. Although a specialized work is considered as complex in Software Engineering, i.e. a work that can be hard to perform by a software engineer.

Challenging: In Software Engineering, as opposed to other fields in which specialization is related to aspects such as boredom and fatigue, the work is considered as challenging. It means that a specialized work tests the abilities of a software engineer.

Focused: Considering that specialization in Software Engineering is considered complex and challenging, a specialized work needs focus to understand and execute all specifics parts of the work.

Accumulated experience: The depth of knowledge in a specific area is not sufficient in a specialized work. Practical experience in Software Engineering area is also demanded in this kind of work.

RQ2. What is the relation between Specialization and Task and Skill Variety in Software Engineering?

Still, considering the characterization of job specialization in Software Engineering, there are important discussions to be presented taking into consideration task and skill variety. Over the years, studies performed in different research fields have demonstrated that individuals working in specialized jobs experience low levels of variety, which can drive them to undergo with problems such as monotony at work, demotivation and dissatisfaction. This research demonstrated the potential for an opposite scenario. In Software Engineering, specialized work can provide variety of tasks and it demands variety of skills from the professional.

Several tasks can be associated to the same specific knowledge acquired with experience in a specific field. For example, a software tester can be specialized in test automation and have a high level of knowledge in different techniques in this area and use them in a variety of tasks in his job. The same can happen with a software project manager, who also can hold deep knowledge

in managerial techniques and apply them in different projects, using then, a variety of tasks. In this context, a variety of tasks, may need a variety of different skills to be performed. For example, a software analyst, may have good skills to communicate with clients and at the same time he has to have skills to transform that information in requirements to be discussed with the development team.

In the definition presented in RQ1.1, it is possible to observe that different skills are needed to perform several tasks in Software Engineering. Thus, below, we present our definition again, highlighting that software engineers believe that their work demands a variety of skills to performs a variety of tasks.

Job specialization in Software Engineering refers to a work that demands a high **depth of specific knowledge and skills to perform tasks** that involves the use of specific technologies.

RQ3. What is the relation between Job Specialization and work-related factors?

Finally, by applying the meta-ethnographic synthesis based on the results obtained in the survey, and observing relations among the findings in the qualitative study, mapping study and the evidence collected from the literature in different fields (presented in Chapter 2), it is possible to explain the correlation between job specialization and several work-related factors presented in Table 11. Our research only identified positive and beneficial effects of job specialization in software engineers' work. Thus, it is possible to discuss that:

- Job Specialization is positively related to three dimensions of Autonomy, which may indicate that software engineers' working in specialized tasks might be able to experience openness to make decisions about how to perform the tasks.
- Job Specialization is positively correlated on Task Variety and Skill Variety, which demonstrates that software engineers may be able to perform a wide range of tasks in their work and use a wide range of skills to perform

these tasks. This was reinforced by software engineers that participated in qualitative study I e II.

- Job Specialization has a positive correlation with Task Significance, which indicates that specialized work in Software Engineering may be likely to be perceived as a work that influences the lives or work of others.
- Job Specialization has a positive correlation on Task Identity, meaning that specialized work in Software Engineering has results that are easily to identify.
- Job Specialization has a positive correlation on Feedback from Job and Feedback from others. It means that specialized work in Software Engineering has commonly clear information about the effectiveness of a task performed.
- Job Specialization has a positive correlation with Information Processing and Problem Solving, which indicates that a specialized work usually provide to software engineers with useful information to be processed while performing their duties which are commonly related to tasks that require the use of unique ideas or solutions.
- Job Specialization has a positive correlation with Social Support, meaning that tasks in general provide opportunities for software engineers to receive advice and assistance from others.
- Job Specialization has a positive correlation on Initiated Interdependence and Received Interdependence, which indicates that specialties and specialized tasks in software development might create ease work flows from one job to another.
- Job Specialization has negative correlation to Job Burnout, indicating that different from literature in other fields, Specialization in Software Engineering does not cause boredom and fatigue at work.
- Job Specialization has negative correlation with Role Ambiguity, which means that specialized works might reduce confusion about what is expected from the professional at work.

- Job Specialization has a positive correlation with Job Satisfaction, demonstrating that the execution of a specialized work makes software engineers experience satisfaction at work. This is also an interesting result, once literature from other fields showed opposite results.

In summary, the results from this research demonstrated that job specialization is an important component of the dynamic process of developing software, since its characteristics and effects are closely related to the managerial process of building software teams and determining how the work in software companies are determined and performed. Further, job specialization is an important element on how individuals interact at work and how several work-related factors can be correlated and experienced while a software is under development. Therefore, to comprehend job specialization is an important aspect in software practice, especially when considering software management activities.

4.6 SPECIALIST VERIFICATION

For the specialist verification phase, we identified a software development company that was interested in participate of this study to contribute on the understanding of job specialization. As this enterprise uses job rotation techniques with interns, they were also interested to understand job specialization as well.

We selected a participant that holds a tech-leader role and is considered as a specialist in a specific component of the product developed in the company. Considering that a tech-leader professional is a role that is connected with the project manager role (both need leadership skills, for example) and also connected with the rest of the team (the tech-leader generally needs to support developers and QAs technically), we believe this professional was an adequate professional to validate the information synthesized in previous phases, because as we collected data from different roles a tech-leader would be able to understand points of view collected both from managers and other roles (software engineers and QAs).

We scheduled an interview with a tech-leader that has more than 10 years of experience in software development projects, and was currently available to participate of this study. An interview was scheduled and we used an interview script in which we validate the following data collected in precious phases:

a) definition of job specialization in Software Engineering.

b) characteristics of job specialization in Software Engineering.

b) the relationship between task variety, skill variety and job specialization.

c) the correlation between job specialization and outcomes.

The participant was asked if he agrees with the definition of Job Specialization in Software Engineering proposed in Chapter 3.5 and he was also asked to add any extra information that he thinks could complement our definition. He considered that the definition proposed in this work is valid and added that a Software Engineering job could be specialized in terms of one or more technologies. Table 14 presents the validation of the definition of job specialization in Software Engineering.

Table 14 – Validation of the definition of Job Specialization in Software Engineering

Job Specialization Definition proposed in this research.	**Specialist Validation**
Job Specialization in Software Engineering refers to a work that demands a high depth of specific knowledge and skills to perform tasks that involves the use of specific technologies.	The specialist believes that the definition makes sense, and reinforced the information in the definition that job specialization in Software Engineering is related to a specific technology, as presented in the quotation below: *"I believe that in Software Engineering is related to a technology that a person is going to work. By technology, I mean, programming language or a method".* The participant also commented that a job could be specialized in terms of many technologies. Not only one in particular. *"I also believe that a software engineer has to have knowledge in a programming language, front-end technologies, GitHub, etc. Then I think a software engineer has to be specialized in a series of technologies".*

Source: The author (2020)

The aspects used to characterize job specialization in Software Engineering were also validated in this phase. The specialist agreed with all but one of the characteristics defined in the previous phases of this research, except with structured, which he thinks that it is not a mandatory characteristic in job specialization. Table 15 shows the impressions of the specialist regarding all characteristics.

Table 15 – Specialist validation of Job Specialization characteristics

Characteristic	Specialist Validation
Complex	*"I do agree that a specialized job in Software Engineering is complex. Maybe, as the time passes by, it gets less complex. But in general, as software development is an area to solve problems, it always involves different complexities of work to solve, so when you are specialized you are able to solve more complex problems".*
Structured	*"I don't think that a specialized work demands a structure. It can be structured and it contributes if it is, but it's not mandatory".*
Challenging	*"I think that it is challenging. When you work with a specific technology and then you find the limits of it, it's challenging to go beyond that to improve it".*
Focused	*"It makes sense. I think that for its complex nature, it has to be focused"*
Accumulated Experience	*"For sure! This one is the characteristic that best represents job specialization. The fact that I have experience in this specialized job, certain situations will demand that experience for me to solve a problem. Scenarios that are not in the theory can be solved based in the experience, and then you improve the theory based on that".*

Source: The author (2020)

Regarding the relation of job specialization and task variety and task identity, the specialist mentioned that he believes that job specialization can vary in term of tasks defined for the work and also in terms of skills needed to conduct the work. In the next quotation, he presented some examples of how his work varies in terms of tasks and skills needed.

"In my specialized work, there is a variety of tasks, for example. I answer questions (from colleagues or from clients) in a certain specific subject. I review technical solutions from people from different areas in the company. I help Support Department to obtain technical information about different products. I

also review product's documentations in terms of its technical content. These are macro tasks; I can have a variety of task in these macro tasks too and each task demands different skills"

The specialist was also asked about the job specialization and its outcomes. Regarding **autonomy**, the specialist believes that job specialization helps a professional to make his own decisions. In terms of **task significance**, he believes that job specialization has a positive effect on it. He also mentioned that the more you know about a certain topic, the more you know about its applications and evolutions. When asked about the positive effect of job specialization in **task identity** he believes on its positive effect on it. **Feedback from others** is another characteristic impacted positively by job specialization according to the survey and the specialist reinforced that affirmation.

In this phase it was possible to confirm data found in previous phases of this study. In summary, except for structure, that he believed that was not mandatory in job specialization, the specialist agreed with most of the information raised in both qualitative studies and the correlations found in the survey. This is an indicative of validity of findings in both qualitative studies and in the survey.

5 CONCLUDING REMARKS AND FUTURE WORKS

The aim of this study was to understand the role of job specialization, its characteristics and particularities in Software Engineering. We applied different research methods and used data from different sources to investigate this work-related aspect. Each individual study gave us valuable results, which were synthesized in the last phase of this study, that used a meta-ethnographic approach, in order to answer the research questions designed for this study. This last phase was conducted to obtain consistency from in the information collected from those different data sources.

While performing background support studies, a preliminary survey (DA SILVA et al., 2016) investigated work-related characteristics in Software Engineering and found correlations between job specialization and other work characteristics that were not found in previous studies in other fields, revealing that job specialization would be differently characterized in Software Engineering. A mix-method approach was used combining three empirical studies and a mapping study to support our investigation about job specialization in Software Engineering.

In order to explore more deeply the findings from in the preliminary survey (DA SILVA et al., 2016) we performed an exploratory qualitative study that aimed to investigate particular aspects in job specialization in Software Engineering. The main contributions of this phase were:

- A specific definition of job specialization in Software Engineering, which is:

  Job Specialization in Software Engineering refers to a work that demands a high depth of specific knowledge and skills to perform tasks that involves the use of specific technologies.

- A set of characteristics that support the understanding of job specialization in Software Engineering. **Complex, Structured, Challenging, Focused, Accumulated Experience** are the aspects that characterize Job Specialization in Software Engineering

- An understanding about the impact of task variety and skill variety in job specialization.

A second qualitative study was performed in order to enlarge the amount of data found in the first study and verify if the first study provided data saturation. In this study we applied the same data collection instruments in a different set of participants that also work in software development context. We did not find new relevant data, but we confirmed the information found in the first qualitative study. Thus, considering that internal validity is the extent to which the observed results are true for the population being studied and, therefore, are not due to methodological errors, the main contribution of the enlargement of the qualitative study was to enhance internal validity of our results.

After the qualitative studies, a survey was conducted and it presented interesting correlations between job specialization and several other work-related factors. Different from literature in other areas (HSIEH, CHAO; 2004), our survey showed that job specialization is not correlated with job burnout, meaning that job specialization is not related to a sense of stress and reduced accomplishment in a Software Engineering work.

Incompatible demands from a job may cause a sense of role conflict in a professional and it's considered a negative outcome from a work. This study revealed that job specialization is not correlated with high levels of role conflict in Software Engineering and, in this case, we can confirm that specialization is beneficial for one's work. The same occurs with role ambiguity, caused by a vague description of the work that may cause confusion during the conduction of the work. In Software Engineering job specialization is not related to role ambiguity and we can, once again, consider job specialization as a beneficial to

work. Another important result obtained from the survey is that job specialization is one of the work characteristics that is correlated with the job satisfaction of software engineers, that is, job specialization is related to a sense of pleasure and a fulfillment of one's expectations in the work.

After collecting qualitative and quantitative data about the nature of job specialization in Software Engineering the next step was to perform a meta-ethnography synthesis. In this phase, we synthesized the findings from both qualitative studies performed in this research, and the survey. Based on data from all these phases, we described the definition of job specialization in Software Engineering, its characteristics and the relationship of job specialization and task/skill variety.

In the specialist verification, all data collected previously was verified by a professional with 10 years of experience in software development. In this phase, it was possible to increase the internal validity of our findings as the specialist agreed with almost all information presented during the meeting.

A mapping study was conducted in order to identify more characteristics of job specialization in Software Engineering. In this context, we did not find any extra aspect different than those that emerged in the qualitative studies. All characteristics found in the mapping studies could be related to those characteristics found in our qualitative studies. For example, **Particular skills** is one of the aspects needed in job specialization according to the findings in the mapping study, which has also been referred in our qualitative studies. **Concentration at work** is a characteristic identified in the mapping study that could be referred to the characteristic **"focused"** that was found in the qualitative study.

Therefore, it is possible to concludes that this work has a contribution for the design of work in Software Engineering by presenting a set of relevant discussions about Job Specialization, which has not been fully investigated in Software Engineering before. The work of Morgenson & Humphrey (2006) presents a definition of job specialization in a general context of Work Design

while the study of Hsieh and Chao (2004) investigates the job specialization and its relation with job burnout and job rotation. In this work we went further and presented a definition of job specialization specifically in Software Engineering, a set of aspects that characterize job specialization in this context. We also investigated the relationships between task and skill variety, and specialized job in Software Engineering. Finally, it was presented a set of correlations between job specialization and work-related outcomes such as satisfaction and job burnout.

As future works, we plan to validate our results with a higher number of specialists, throughout a survey, in order to strongly consolidate the results and identify new relevant data, such as new aspects that could support us to better characterize job specialization in Software Engineering, for example. We also plan to investigate whether there are differences of job specialization in agile or traditional software development projects. This will allow our results to be more applicable in projects with different contexts. Many participants of this research related job specialization to the roles of software development, leading us to believe that different professionals might be more or less specialized depending on their roles. We also plan to deeply understand this aspect.

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APPENDIX A - LIST OF PUBLICATIONS

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APPENDIX C - INTERVIEW SCRIPT (PT_BR)

GUIA DE ENTREVISTA COM ENGENHEIROS DE SOFTWARE SOBRE JOB SPECIALIZATION

APRESENTAÇÃO

- Apresentação do pesquisador e cumprimentos.
- Agredecimento ao participante
- Solicitação de permissão para gravar (caso o participante não autorize a gravação, todos os passos seguintes devem ser registrados por escrito.)

INTRODUÇÃO

O objetivo desta pesquisa é entender o papel e as particulridades da especialização do trabalho (job specialization) na prática da Engenharia de Software. Em particular, pretende-se entender a diferença deste fator em projetos que utilizam abordagem tradicional e agile e como esses fatores afetam engenheiros de software no trabalho.

Todas as informações fornecidas nesta entrevista serão tratadas de forma confidencial. Apenas a equipe de pesquisa terá acesso às informações fornecidas. Em particular, nenhuma pessoa direta ou indiretamente ligada a empresa terá acesso às informações fornecidas nesta entrevista e em nenhuma outra fase da pesquisa. A equipe de pesquisa empregará todos os meios possíveis para evitar que informações individuais possam ser associadas diretamente aos participantes.

Sua participação nesta pesquisa é voluntária e você pode decidir não participar ou se retirar da pesquisa a qualquer momento. Caso você decida não participar, não receberá nenhuma sanção ou penalidade. Você concorda em participar desta pesquisa?

IDENTIFICAÇÃO DO ENTREVISTADO

- As informações a seguir serão utilizadas caso a equipe de pesquisa precise entrar em contato com você no futuro para esclarecimentos sobre a entrevista.
- Por favor, diga seu nome.
- Por favor, diga seu endereço de e-mail.

SOBRE AS RESPOSTAS

Não existem respostas certas ou erradas nesta entrevista. Nosso objetivo é coletar suas impressões, opiniões e sentimentos sobre os vários assuntos abordados. Leve o tempo que for necessário, tudo o que for importante para você me interessa. Reforçando que suas respostas não serão disponibilizadas para a empresa e, portanto, não terão nenhuma influência em avaliações realizadas pela empresa. Por favor, responda da forma mais sincera possível.

AQUECIMENTO

Caracterização do entrevistado

- Idade
- Qual a sua formação profissional?
- Qual e quando foi a última titulação?
- Qual o seu tempo de atuação profissional em desenvolvimento de software?
- Você já trabalhou em outra profissão? [Se sim, qual e por quanto tempo?]
- Qual o seu cargo atual na empresa?
- Quantos anos de experiência você possui no cargo atual?

1. Vamos iniciar com algumas informações gerais sobre sua história nessa organização. Conte-me sua história, da seleção até hoje.

2. Descreva o seu trabalho atual dentro da empresa, suas funções e atividades diárias.

Nas próximas perguntas, vamos conversar sobre características do trabalho em desenvolvimento de software. Por favor, procure relacionar suas respostas com aspectos práticos do seu dia-a-dia, associados a toda a sua experiência profissional. Não existem respostas certas ou erradas. O que me interessa é a sua interpretação pessoal.

[não ler estes cabeçalhos] Definindo Job Specialization (Especialização do trabalho)

3. Considerando sua experiência com desenvolvimento de software, o que você entende por um trabalho especializado?
   Probe: *Você poderia dar alguns exemplos?*
4. De forma complementar, o que você entende por um trabalho não especializado?
   Probe: *Você poderia dar alguns exemplos?*

Características do trabalho especializado e perfil do indivíduo

5. Que características você usaria para descrever um trabalho especializado no desenvolvimento de software?

6. Que habilidades um profissional deve possuir para poder preeencher um cargo em que seja necessário realizar trabalho especializado no desenvolvimento de software?

7. Além dessas habilidades, você acha que um profissional que realiza trabalho especializado deve possuir características pessoais específicas? Quais?
   Probe: *Pensando em colegas de trabalho com quem já conviveu, você poderia dar alguns exemplos destas características?*

8. De forma complementar, você acha que um profissional que realiza trabalho não especializado deve possuir características pessoais específicas? Quais?
   Probe: *Pensando em colegas de trabalho com quem já conviveu, você poderia dar alguns exemplos destas características?*

Relação entre Job Specialization e os papéis (cargos) e metodologias de desenvolvimento no desenvolvimento de software

9. Os cargos (papéis, por exemplo, analista, desenvolvedor ou testador) ocupados pelos membros de equipes de software podem ter tipos diferentes de especialização?
   Probe: *Por favor, ilustre com exemplos.*
10. Como você acha que o tipo de método de desenvolvimento (tradicional ou ágil) afeta a especialização no trabalho?
    Probe: *Por favor, ilustre com exemplos.*

Validação da definição de Morgenson and Humprhey

Considere estas duas afirmações:

(1) um trabalho especializado é aquele que envolve a realização de tarefas especializadas;

(2) um trabalho especializado é aquele que exige a aplicação ou utilização de conhecimento ou habilidades especializadas para ser realizado [mostre essas duas frases em um papel com fonte grande].

Tendo estas afirmações em mente:

11. Você pode dar um exemplo de trabalho especializado que se encaixa na primeira afirmação?
12. E na segunda?
13. Em sua opinião, alguma das duas afirmações descreve ou caracteriza melhor o que é um trabalho especializado no desenvolvimento de software?
    Probe: Se sim, qual e por que? / Se não, por que não?

14. Tomando as duas afirmações como definição de trabalho especializado, o que não seria um trabalho especializado no desenvolvimento de software? [Probe: Exemplos?]

Relação entre características do trabalho e Job Specialization

15. Na sua opnião, qual o nível de especialização do seu trabalho atual?

Probe: *você pode dar exemplos para ilustrar sua resposta?*

(Task Variety)

16. *Você acha que o seu trabalho é variado em relação às tarefas que você realiza*?

Probe: *você pode dar exemplos para ilustrar sua resposta?*

17. *Como você descreveria um trabalho no desenvolvimento de software que tem grande variedade de tarefas?*

Probe: *você pode dar exemplos para ilustrar sua resposta?*

18. *Por outro lado, como você descreveria um trabalho com baixa variedade de tarefas?*

Probe: *você pode dar exemplos para ilustrar sua resposta?*

19. *Pessoalmente, você prefere trabalhar com baixa ou alta variedade de tarefas?*

Probe: *Por que?*

20. *Trabalhos com alta variedade de tarefas podem ser também altamente especializados?*

    Probe: *Por favor, ilustre sua resposta com exemplos do seu dia-a-dia*

(Skill Variety)

21. *Você acha que o seu trabalho é variado em relação às habilidades que você precisa utilizar para realizar suas tarefas*?

Probe: *você pode dar exemplos para ilustrar sua resposta?*

22. *Como você descreveria um trabalho no desenvolvimento de software que exige grande variedade de habilidades?*

Probe: *você pode dar exemplos para ilustrar sua resposta?*

23. *Por outro lado, como você descreveria um trabalho com exigência de pouca variedade de habilidades?*

Probe: *você pode dar exemplos para ilustrar sua resposta?*

24. *Pessoalmente, você prefere um trabalho que exige baixa ou alta variedade de habilidades?*

Probe: *Por que?*

25: Trabalhos com alta variedade de habilidades podem ser também altamente especializados?

Probe: Por favor, ilustre sua resposta com exemplos do seu dia-a-dia

(Relacionando Task and Skill Variety)

25. *Considere dois trabalhos:*

    - Um trabalho com alta variedade de diferentes tarefas, mas exigindo baixa variedade de habilidades diferentes,

    - Outro com menor variedade de tarefas mas com ampla necessidade de habilidades distintas.

    Qual você preferiria?

Probe: *Por que?*

Probe 2: *Por favor, ilustre sua escolha com um exemplo prático da sua vida profissional, se for possível.*

<u>Relacionando com Outcomes [você precisa encontrar os outcomes a partir das respostas. Não fica bom induzir usando diretamente burnout e satisfação]</u>

26. Como você se sente quando tem trabalhos especializados para realizar no seu trabalho?
27. Por outro lado, como você se sente em realizar trabalhos não especializados?

28. **Portanto, é correto eu afirmar que você prefere trabalhos especializados/não especializados** [dependendo da resposta do entrevistado]? [Probe: Por que sim/Por que não?]

De forma semelhante às perguntas anteriores:

29. Como você se sente quando seu trabalho lhe exige realizar uma grande variedade de tarefas?
30. Por outro lado, como você se sente em realizar trabalhos com pouca variedade de tarefas?
31. Como você se sente quando seu trabalho exige a utilização de uma grande variedade de habilidades? Por outro lado, como você se sente em realizar trabalhos sem esta variedade?
32. Considerando tudo o que já conversamos, você se considera um especialista no desenvolvimento de software? [Probe: Por que? O que você faz ou sabe que o leva a dar esta resposta?]
33. Como você acha que a sua trajetória profissional, desde os tempos de estudante, o levou a ser (ou não ser) um especialista?
34. Finalmente, você está satisfeito com os resultados da sua trajetória?

Probe: *Quais são seus planos ou estratégias para manter/alterar estes resultados [fazer a pergunta dependendo da resposta anterior]?*

35. Tem mais alguma coisa que você acha importante comentar e que eu esqueci de perguntar sobre o seu trabalho?

A entrevista foi muito produtiva. Obrigado pelo seu tempo. Quando o trabalho estiver concluído, nós estaremos a disposição para mostrar os resultados caso seja do seu interesse.

APPENDIX D - SURVEY QUESTIONNAIRE (PT_BR)

Introdução

O HASE (Human Aspects in Software Engineering), é um grupo de pesquisa originado no Centro de Informática (CIn) da UFPE que desde 2003 estuda a influência dos fatores humanos e sociais na engenharia de software. Este grupo é coordenado pelo Prof. Fabio Q. B. da Silva, do CIn-UFPE e conta, atualmente, com 3 pesquisadores doutores, 12 alunos de doutorado e 4 pesquisadores colaboradores, além do próprio coordenador.

Objetivo da Pesquisa

Esta pesquisa está sendo conduzida pelo HASE, coordenada pelo Prof. Fabio Silva, que é o responsável geral pelo projeto. O objetivo desta pesquisa é entender aspectos relacionados à dinâmica das atividades executadas pelos profissionais de engenharia de software na prática de seu trabalho.

Condições de Participação

Sua participação nesta pesquisa é voluntária. Caso você decida não participar, não receberá nenhuma sanção ou penalidade.

Caso deseje contribuir com a pesquisa, asseguramos que todas as informações fornecidas por você neste questionário serão tratadas como confidenciais. Em particular, nenhuma pessoa direta ou indiretamente ligada a sua empresa ou local de trabalho terá acesso às informações e dados individuais coletados na pesquisa. Serão empregados todos os meios possíveis para evitar que informações individuais possam ser associadas diretamente aos participantes.

Ao responder ao questionário, forneça respostas relacionadas ao seu trabalho **atual**. Não existem respostas certas ou erradas. Portanto, tente responder as questões da forma mais sincera e objetiva possível, sendo fiel às características do seu trabalho atual e aos seus sentimentos em relação a este trabalho. Tente, também, não deixar nenhuma questão em branco, mesmo que ela seja semelhante a outras que você já tenha respondido.

Os pesquisadores do HASE agradecem sua colaboração.

IDENTIFICAÇÃO DO PARTICIPANTE

Por favor, responda as questões fechadas com um X. Nome e e-mail são informações opcionais, mas muito importantes caso os pesquisadores necessitem entrar em contato para esclarecimento de dúvidas. Por favor, tente responder a todas as questão não opcionais.

1. Nome Completo (opcional)	
2. E-mail (opcional)	
3. Nome da empresa	
4. Sexo	
5. Idade	
6. Formação atual de maior grau (completa)	( ) Médio ( ) Técnico ( ) Superior ( ) Especialização ( ) Mestrado ( ) Doutorado
7. Curso formação de maior grau informada na Pergunta 6	( ) Ciência da Computação ( ) Engenharia de Computação ( ) Sistemas de Informação ( ) Engenharia de Software ( ) Outro. Qual? _____
8. Ano de obtenção formação completa informada na Pergunta 6	Ano: _____
9. Formação em andamento	( ) Não se aplica. Não está fazendo formação em andamento. ( ) Médio ( ) Técnico ( ) Superior ( ) Especialização em andamento ( ) Mestrado em andamento ( ) Doutorado em andamento
10. Ano de início da formação em andamento (se for o caso)	Ano: _____
11. Anos de experiência profissional (desde o início da sua	

vida profissional em qualquer atividade)	
12. Anos de experiência profissional em desenvolvimento de software	
13. Função atual	( ) Analista ( ) Desenvolvedor (codificação; manutenção) ( ) Testador ( ) Gerente ( ) Outra. Qual? _____
14. Anos de experiência na função atual	

CARACTERÍSTICAS DO TRABALHO

Nesta parte do questionário, estamos interessados em informações sobre as características do seu trabalho atual. Por favor, seja objetivo em relação às características reais do trabalho. Em uma escala de 1 a 5, na qual 1 significa "Discordo totalmente" e 5 significa "Concordo totalmente", por favor, marque **apenas um item** para a resposta que melhor representa seu nível de concordância com **cada afirmativa**.

1	2	3	4	5
▲	▲	▲	▲	▲
Discordo Totalmente	Discordo Parcialmente	Nem discordo nem concordo	Concordo Parcialmente	Concordo Totalmente

Afirmativa	**1**	**2**	**3**	**4**	**5**
Meu trabalho permite-me tomar minhas próprias decisões sobre como programar minhas tarefas.	○	○	○	○	○
Meu trabalho exige a realização de uma grande amplitude de tarefas.	○	○	○	○	○
Meu trabalho envolve a execução de tarefas variadas	○	○	○	○	○
Meu trabalho envolve a realização de tarefas relativamente simples	○	○	○	○	○
Meu trabalho envolve uma grande variedade de tarefas.	○	○	○	○	○

Outras pessoas na organização, tais como gerentes e colegas de trabalho, fornecem informações sobre a efetividade (ex., qualidade e quantidade) do meu desempenho no trabalho.	○	○	○	○	○
No meu trabalho, eu tenho a possibilidade de conhecer outras pessoas.	○	○	○	○	○
Meu trabalho exige o meu envolvimento em uma grande quantidade de atividades que envolvem pensamento	○	○	○	○	○
O meu supervisor está preocupado com o bem-estar das pessoas que trabalham para ele/ela.	○	○	○	○	○
Meu trabalho exige uma variedade de habilidades	○	○	○	○	○
Meu trabalho permite-me planejar como eu faço as minhas tarefas	○	○	○	○	○
O meu trabalho não pode ser feito a menos que os outros façam o seu.	○	○	○	○	○
No meu trabalho, eu me comunico frequentemente com pessoas que não trabalham na minha organização.	○	○	○	○	○
Meu trabalho envolve a realização de tarefas que tem um início e um fim claramente definidos	○	○	○	○	○
Meu trabalho obriga-me a manter o controle de mais de uma coisa ao mesmo tempo	○	○	○	○	○
As pessoas com quem trabalho são amigáveis.	○	○	○	○	○
Meu trabalho requer o uso de um considerável número de habilidades.	○	○	○	○	○
As atividades do meu trabalho são muito afetadas pelo trabalho de outras pessoas.	○	○	○	○	○
Meu trabalho envolve a interação com pessoas que não são membros da minha organização.	○	○	○	○	○
Meu trabalho exige que eu faça somente uma tarefa ou atividade de cada vez.	○	○	○	○	○
As tarefas desenvolvidas no meu trabalho têm um impacto significativo sobre pessoas fora da organização.	○	○	○	○	○
Meu trabalho obriga-me a monitorar uma grande quantidade de informações	○	○	○	○	○
Outros trabalhos dependem diretamente do meu trabalho.	○	○	○	○	○

Eu tenho a oportunidade de me encontrar com outras pessoas no meu trabalho.	○	○	○	○	○
De forma ampla, meu trabalho, em si, é muito significativo e importante	○	○	○	○	○
Meu trabalho ocorre em um ambiente limpo.	○	○	○	○	○
Meu trabalho envolve a resolução de problemas que não têm respostas corretas óbvias	○	○	○	○	○
Meu trabalho consiste em fazer uma série de coisas diferentes.	○	○	○	○	○
Meu trabalho envolve muitas interações com pessoas fora da minha organização	○	○	○	○	○
Meu trabalho exige conhecimento e competências muito especializados.	○	○	○	○	○
Meu trabalho me dá a possibilidade de usar minha iniciativa ou julgamento pessoal na realização das minhas tarefas	○	○	○	○	○
As pessoas com quem trabalho têm um interesse pessoal em mim.	○	○	○	○	○
Meu trabalho é altamente especializado em termos de propósito, tarefas ou atividades	○	○	○	○	○
Meu trabalho permite-me decidir por conta própria sobre como proceder para realizar minhas tarefas.	○	○	○	○	○
Meu trabalho exige profundidade de conhecimento e experiência.	○	○	○	○	○
Meu trabalho envolve um ambiente livre de riscos para a saúde (por exemplo, produtos químicos, gases, etc.)	○	○	○	○	○
O clima no meu local de trabalho é confortável em termos de temperatura e umidade.	○	○	○	○	○
Meu trabalho depende do trabalho de muitas pessoas diferentes para ser completado.	○	○	○	○	○
Meu trabalho obriga-me a utilizar uma variedade de diferentes habilidades a fim de completar as tarefas.	○	○	○	○	○
Foi necessário muito tempo para aprender a usar os equipamentos utilizado no meu trabalho.	○	○	○	○	○
O trabalho, em si, fornece *feedback* sobre o meu desempenho.	○	○	○	○	○
Meu trabalho está organizado de modo a que eu possa fazer uma tarefa completa, desde o início até fim	○	○	○	○	○
Eu tenho a oportunidade de desenvolver amizades no meu trabalho.	○	○	○	○	○

Meu trabalho abrange a realização de tarefas relativamente descomplicadas	○	○	○	○	○
Meu trabalho exige muito esforço físico.	○	○	○	○	○
Meu trabalho exige uma grande resistência muscular	○	○	○	○	○
Meu trabalho me dá considerável oportunidade de independência e liberdade na forma como eu realizo minhas tarefas	○	○	○	○	○
As atividades do trabalho, em si, fornecem informações diretas e claras sobre a efetividade (por exemplo, qualidade e quantidade) do meu desempenho no trabalho	○	○	○	○	○
Meu trabalho exige-me o uso de um número de habilidades complexas ou de alto nível.	○	○	○	○	○
Meu trabalho envolve passar uma grande parte do meu tempo com pessoas fora da minha organização.	○	○	○	○	○
Meu trabalho permite-me tomar muitas decisões por conta própria	○	○	○	○	○
A disposição dos espaços de trabalho é adequada (por exemplo, espaços amplos para sentar, cadeiras confortáveis, apoio postural bom).	○	○	○	○	○
Meu trabalho envolve alcances físicos (ou distâncias) excessivos.	○	○	○	○	○
O trabalho, em si, me dá informações a respeito do meu desempenho.	○	○	○	○	○
Meu trabalho me exige ser criativo	○	○	○	○	○
A menos que o meu trabalho seja feito, outros trabalhos não poderão ser completados.	○	○	○	○	○
Meu trabalho permite-me decidir sobre a ordem em que as tarefas são feitas	○	○	○	○	○
Meu trabalho exige que eu analise muita informação	○	○	○	○	○
Meu trabalho envolve a utilização de tecnologia ou equipamentos complexos.	○	○	○	○	○
Meu trabalho envolve a utilização de uma variedade de equipamentos diferentes.	○	○	○	○	○
O meu local de trabalho é normalmente livre de ruído excessivo.	○	○	○	○	○
As ferramentas, procedimentos, materiais utilizados neste trabalho são altamente especializados	○	○	○	○	○
Meu trabalho exige uma grande quantidade de força muscular.	○	○	○	○	○

Meu trabalho envolve lidar frequentemente com problemas que eu não conhecia anteriormente.	○	○	○	○	○
As tarefas no meu trabalho são simples e descomplicadas	○	○	○	○	○
Meu trabalho exige ideias ou soluções únicas para os problemas	○	○	○	○	○
Meu trabalho tem um baixo risco de acidente	○	○	○	○	○
O local de trabalho acomoda todas as diferenças de tamanho entre as pessoas em termos de alcance, altura dos olhos, espaço para as pernas, etc.	○	○	○	○	○
Meu trabalho me dá autonomia significativa na tomada de decisões	○	○	○	○	○
Meu trabalho permite-me tomar decisões sobre os métodos que eu uso para completar minhas tarefas	○	○	○	○	○
Meu trabalho exige que eu realize minhas tarefas antes que outras pessoas possam completar as suas tarefas.	○	○	○	○	○
Meu trabalho me dá a possibilidade de terminar completamente as tarefas que começo	○	○	○	○	○
Eu recebo uma grande quantidade de informações da minha chefia e dos colegas de trabalho sobre o meu desempenho no trabalho.	○	○	○	○	○
Eu recebo feedback sobre o meu desempenho no trabalho de outras pessoas da minha organização (como a minha chefia ou colegas de trabalho).	○	○	○	○	○
Os resultados do meu trabalho podem afetar significativamente a vida de outras pessoas.	○	○	○	○	○
Meu trabalho me permite completar as tarefas que inicio	○	○	○	○	○
Meu trabalho tem um grande impacto sobre pessoas fora da organização	○	○	○	○	○

SENTIMENTOS SOBRE O TRABALHO

Nesta parte do questionário, estamos interessados nos seus sentimentos em relação ao seu trabalho atual. Em uma escala de 1 a 5, na qual 1 significa “Discordo totalmente” e 5 significa “Concordo totalmente”, por favor, marque **apenas um item** para a resposta que melhor representa seu nível de concordância com **cada afirmativa**.

1	2	3	4	5
▲	▲	▲	▲	▲
Discordo Totalmente	Discordo Parcialmente	Nem discordo nem concordo	Concordo Parcialmente	Concordo Totalmente

Afirmativa	**1**	**2**	**3**	**4**	**5**
Estou perdendo o entusiasmo pelo meu trabalho	○	○	○	○	○
No meu trabalho, eu me sinto confiante de que realizo minhas tarefas com efetividade	○	○	○	○	○
Acho que meu trabalho não contribui para nada	○	○	○	○	○
Considerando tudo, estou satisfeito com meu trabalho	○	○	○	○	○
Trabalhar o dia todo é realmente motivo de tensão para mim	○	○	○	○	○
Quero apenas fazer o meu trabalho sem ser incomodado	○	○	○	○	○
Sinto-me esgotado pelo meu trabalho	○	○	○	○	○
Em minha opinião, eu sou bom no meu trabalho	○	○	○	○	○
Tornei-me menos interessado com o meu trabalho desde que comecei neste emprego	○	○	○	○	○
Em geral, não gosto do meu trabalho	○	○	○	○	○
Sinto-me emocionalmente esgotado com o meu trabalho	○	○	○	○	○
Sinto que estou contribuindo efetivamente com os objetivos da organização onde trabalho	○	○	○	○	○
Sinto-me muito bem quando realizo alguma coisa no trabalho	○	○	○	○	○
No meu trabalho, tenho realizado várias coisas que valem a pena	○	○	○	○	○
Em geral, eu gosto de trabalhar aqui	○	○	○	○	○
Posso resolver efetivamente os problemas que surgem no meu trabalho	○	○	○	○	○
Sinto-me cansado quando me levanto pela manhã e preciso encarar outro dia de trabalho	○	○	○	○	○
Não acho que meu trabalho seja importante	○	○	○	○	○
Sinto-me esgotado no final de um dia de trabalho	○	○	○	○	○

Eu recebo uma tarefa sem os materiais adequados para executá-la	○	○	○	○	○
Eu trabalho com dois ou mais grupos de pessoas que atuam de forma bastante diferente	○	○	○	○	○
Eu tenho que ignorar e até quebrar regras ou políticas da organização, a fim de realizar uma tarefa	○	○	○	○	○
Eu trabalho em coisas desnecessárias	○	○	○	○	○
Eu recebo solicitações incompatíveis de duas ou mais pessoas ao mesmo tempo	○	○	○	○	○
Eu tenho que fazer coisas que deveriam ser feitas de forma diferente sob diferentes condições	○	○	○	○	○
Eu faço coisas que são aceitáveis para uma pessoa e não aceitáveis para outras	○	○	○	○	○
Eu tenho que fazer tarefas sem ter os recursos humanos necessários para completá-las	○	○	○	○	○

No meu trabalho, eu sei quais são as minhas responsabilidades	○	○	○	○	○
No meu trabalho, a explicação sobre o que precisa ser feito é clara	○	○	○	○	○
No meu trabalho, eu sei que eu distribuo o meu tempo de forma adequada para atender diferentes tarefas	○	○	○	○	○
Os objetivos do meu trabalho são claros	○	○	○	○	○
No meu trabalho, eu sei exatamente o que é esperado de mim	○	○	○	○	○
No meu trabalho, eu tenho certeza sobre a quantidade de autoridade que eu tenho	○	○	○	○	○

CARACTERÍSTICAS DO TRABALHO E ROTAÇÃO

Esta parte do questionário é sobre as características do seu trabalho em equipe. Por favor, marque com um X uma única resposta que melhor reflete sua visão sobre o seu trabalho.

1. O local em que você trabalha atualmente realiza movimentações de profissionais de um projeto para o outro ou de uma equipe para a outra, durante o processo de desenvolvimento do software:

( ) Nunca ( ) Raramente ( ) As vezes ( ) Frequentemente ( ) Muito frequente

2. Você é movimentado de uma equipe para outra antes do projeto ser terminado e precisa deixar as suas atividades na equipe anterior para outra pessoa finalizar:

( ) Nunca ( ) Raramente ( ) As vezes ( ) Frequentemente ( ) Muito frequente

3. Você é alocado para realizar uma tarefa ou função, no mesmo projeto, que antes estava sendo realizada por outro membro da sua equipe e precisa deixar as suas atividades para outra pessoa finalizar:

( ) Nunca ( ) Raramente ( ) As vezes ( ) Frequentemente ( ) Muito frequente

4. Durante os últimos 3 meses, quantas pessoas da sua equipe realizaram as mesmas tarefas que você fez, além de você mesmo?

( ) Nenhuma
( ) Apenas uma pessoa
( ) Algumas poucas pessoas
( ) A maioria das pessoas
( ) Todo mundo

5. Quantas pessoas da sua equipe você acredita que são qualificadas ou capazes de realizar as tarefas que você realiza atualmente?

( ) Nenhuma ( ) Apenas uma pessoa ( ) Algumas poucas pessoas ( ) A maioria das pessoas ( ) Todo mundo

6. O quão fácil (viável) seria realizar uma permuta de tarefas entre os membros da sua equipe, ou seja, realizar trocas de tarefas entre os membros da equipe, de modo que cada um continue desenvolvendo com bom desempenho a nova atividade que recebeu e que antes era de outra pessoa?

( ) Muito difícil. A maioria das pessoas iria necessitar de muito treinamento (retreinamento).

( ) Relativamente difícil. Algumas das pessoas iriam necessitar de treinamento (retreinamento).

( ) Um pouco difícil. Poucas pessoas iriam necessitar de treinamento (treinamento).

( ) Relativamente fácil. Algumas pessoas iriam necessitar de pouquíssimo treinamento (retreinamento).

( ) Muito fácil. Ninguém iria precisar de treinamento

APPENDIX E - INTERCORRELATIONS AMONG STUDY VARIABLES

Construct	1	2	3	4	5	6	7	8	9	10
Task Characteristics										
1. Work scheduling autonomy	-									
2. Decision-making autonomy	,668**	-								
3. Work methods autonomy	,662**	,776**	-							
4. Task variety	,337**	,315**	,322**	-						
5. Significance	,290**	,262**	,333**	,376**	-					
6. Task identity	,483**	,477**	,434**	,076	,320**	-				
7. Feedback from job	,400**	,347**	,359**	,199*	,355**	,432**	-			
Knowledge characteristics										
8. Job complexity	-,159	-,136	-,147	,073	-,123	-,286**	-,118	-		
9. Information processing	,234**	,299**	,300**	,553**	,368**	,133	,181*	,226*	-	
10. Problem solving	,268**	,283**	,185*	,363**	,359**	,144	,226*	,091	,377**	-
11. Skill variety	,307**	,385**	,367**	,431**	,343**	,129	,306**	,083	,451**	,401**
12. Specialization	,198*	,326**	,297**	,309**	,254**	,363**	,322**	-,023	,360**	,243**
Social Characteristics										
13. Social support	,474**	,348**	,346**	,205*	,314**	,482**	,294**	-,126	,219*	,266**
14. Initiated interdependence	,073	,158	,053	,239**	,241**	-,012	,101	,012	,286**	,286**
15. Received interdependence	,009	,003	,001	,129	,126	,144	-,061	-,150	,220*	,216*
16. Interaction outside organization	,252**	,307**	,260**	,322**	,177*	,103	,136	,022	,397**	,202*
17. Feedback from others	,457**	,366**	,362**	,278**	,393**	,474**	,741**	-,166	,109	,218*
Outcomes										
22. Job Burnout	-,390**	-,376**	-,433**	-,168	-,308**	-,445**	-,414**	,205*	-,143	-,186*
23. Role Conflict	-,118	-,076	-,054	,260**	-,062	-,354**	-,245**	,103	,097	,164
24. Role Ambiguity	-,431**	-,362**	-,342**	-,123	-,374**	-,558**	-,459**	,224*	-,225*	-,114
Job Rotation										
25. Rotation Intensity	-,109	-,117	-,132	,014	-,136	-,220*	-,267**	,130	,046	,157
26. Job Interchangeability	-,019	-,083	-,084	-,141	-,009	,065	,096	-,007	-,230**	-,005
Outcomes 2										
Satisfaction	,355**	,327**	,349**	,166	,287**	,369**	,415**	-,089	,209*	,261**

	11	12	13	14	15	16	17	22	23	24	25	26
Knowledge characteristics												
11. Skill variety	-											
12. Specialization	,536**	-										
Social Characteristics												
13. Social support	,266**	,319**	-									
14. Initiated interdependence	,292**	,273**	,168	-								
15. Received interdependence	,110	,202*	,144	,313**	-							
16. Interaction outside organization	,138	,168	,243**	,104	,066	-						
17. Feedback from others	,274**	,396**	,451**	,119	,005	,168	-					
Outcomes												
22. Job Burnout	-,273**	-,202*	-,521**	-,002	,093	-,113	-,490**	-				
23. Role Conflict	-,002	-,101	-,334**	,052	,148	,083	-,255**	,524**	-			
24. Role Ambiguity	-,230**	-,269**	-,534**	-,152	-,147	-,098	-,612**	,554**	,426**	-		
Job Rotation												
25. Rotation Intensity	-,084	-,027	,009	,165	,119	,074	-,162	,186*	,137	,115	-	
26. Job Interchangeability	-,081	,060	,151	-,245**	-,107	-,119	,117	-,037	-,190*	,039	,211*	-
Outcomes 2												
Satisfaction	,310**	,260**	,555**	-,006	-,160	,085	,534**	-,706**	-,346**	-,483**	-,207*	,034