Perceptions of knowledge management in Brazilian software development companies

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Abstract. *The software development companies conduct activities that generate a considerable amount of knowledge. Knowledge Management (KM) allows working with the generated knowledge helping in organizational learning. However, professionals in software companies still face several challenges to articulate and leverage knowledge in the organization. We aim at providing evidence about how KM has been adopted in practical environments of software development. We designed a survey instrument that was distributed to Brazilian software development professionals. The survey results improved the current understanding of KM and how it manifests itself in practical software development environments.*

1. Introduction

Software companies develop projects that generate a considerable amount of knowledge that can be valuable for further projects. Knowledge Management (KM) principles can help organizations to store, distribute and use the generated knowledge [Dalkir 2017]. Such principles have received attention in academia and industry since they support the organizational learning process. KM emerges as a means to manage organizational knowledge and, consequently, to ensure quality in software development [Souza et al. 2021].

Software Engineering is a highly complex area that involves people and a large volume of information. According to Rus and Lindvall (2002) [Rus and Lindvall 2002], knowledge in software engineering is diverse and its proportions are immense and growing. In this context, problems are constantly being solved and new problems arise. So, in this environment, knowledge needs to be updated all the time, since technologies in the domain of Software Engineering are constantly evolving [Vasanthapriyan et al. 2015].

Although KM provides several benefits to software companies, these organizations still grapple with some problems such as difficulty in systematizing information generated throughout the software processes, difficulty in reusing knowledge, loss of organization's intellectual capital, and employees ordinarily reluctant to share their knowledge [Souza et al. 2015]. A possible explanation for this might be that the knowledge generated in organizations is not processed, i.e., the knowledge is not articulated [Souza et al. 2015].

Implementing KM practices, in general, is not an easy task [Menolli et al. 2015]. However, some research has emerged in recent years considering proposals on how to implement new KM solutions in the organization [Napoleão et al. 2021, Souza et al. 2021].

Moreover, knowing how organizations apply KM in the software development domain, such as practices, challenges, and tools, makes it easier to understand how to support such organizations improve the adoption of KM approaches [Napoleão et al. 2021].

In order to provide evidence about how KM has been adopted in practical environments of software development, we designed a survey distributed to professionals working with software development in Brazilian companies. This study provides perceptions of software engineering professionals about tools, KM practices, communication channels, knowledge reuse, and KM hindrance. We investigated these perceptions considering three KM activities: creation, sharing, and application of knowledge. The survey received 80 replies from professionals involved in software companies from different sizes and segments, and demographically distributed throughout Brazil.

The main contribution of this study is to provide a basis with empirical observations on the practice of KM in software development companies from a practitioner's perspective. Furthermore, survey results could help direct future research and support professionals when deciding on the best strategies to apply KM.

The remainder of this study is structured as follows. Section 2 reviews the literature. Section 3 introduces the procedures used to conduct the research. Section 4 presents the results. Section 5 highlights some points of our research. Related works are presented in Section 6. Lastly, conclusions and future directions are described in Section 7.

2. Background

KM formally manages the increase of knowledge in organizations in order to facilitate its access and reuse [Herrera and Martin-B 2015]. Nonaka and Takeuchi (1995) [Nonaka and Takeuchi 1995] define the knowledge generated in an organization as tacit-explicit. Tacit knowledge, as known as personal know-how, is based on people's experience. In turn, explicit knowledge represents the knowledge that can be recorded and, consequently, it becomes easy to disseminate. Generating value from knowledge conversion (tacit to explicit) is to promote conditions for the creation of organizational knowledge [Nonaka and Takeuchi 1995].

KM involves a set of organizational activities that are systematically performed. Effective KM requires executing activities such as identifying, generating, acquiring, diffusing, and capturing knowledge. KM cycles (or models) are responsible for presenting how the different KM activities are organized and promoting their execution within the organization [Dalkir 2017]. KM cycles aim at identifying and disseminating knowledge and knowledge sources within the organization [Dalkir 2017]. Based on different basic KM cycles, Dalkir (2017) proposes an integrated KM cycle represented by the interaction between three activities, described following three activities:

- **Knowledge capture and/or creation:** Knowledge capture refers to the identification of existing knowledge from the environment. In this activity, tacit knowledge is captured or elicited, and explicit knowledge is organized or coded.
- **Knowledge sharing and dissemination:** Once knowledge has been captured, it needs to be shared throughout the organization. Some practices used to share knowledge within the organization are team meetings, written instructions, ad-hoc information, verbally disseminated information, intranet posts.

- **Knowledge acquisition and application:** The knowledge that has been captured and shared is put to use. KM can succeed if the knowledge is used. Consequently, it is crucial to understand which knowledge is used to which set of people and how best to make it available. The use of KM systems, for instance, can be designed to optimize knowledge application in an organization.

The transition between the three KM activities is illustrated in Figure 1. In the integrated KM cycle, the transition from knowledge capture to knowledge sharing, knowledge content is assessed. Knowledge is then contextualized in order to be understood and used. This process then feeds back into the first activity in order to update the knowledge content became an iterative and incremental cycle [Dalkir 2017].

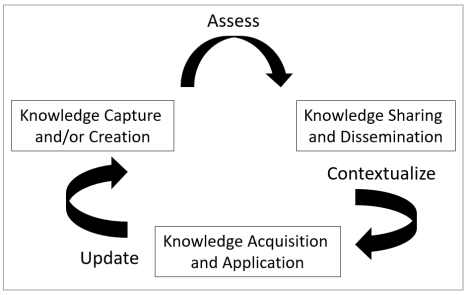

Figure 1. An integrated KM Cycle. Adapted from [Dalkir 2017]

In this study, the integrated KM cycle was used to create the survey questions. We created specific questions to understand how knowledge creation, sharing, and application activities occur in practice in software development companies.

2.1. KM and Software Engineering

Vasanthapriyan et al. (2015) describe that effective management of information in software development processes became a need for organizations to survive in the competitive scenario. In order to get strengths in the development process business, organizations need to execute the software development efficiently and for that, they can introduce KM principles. Introducing KM in software engineering concepts helps the organization to improve the decision-making process, innovation, and organizational performance.

Integrating KM practices with software engineering has brought much discussion about how to manage knowledge in the organization. In a software development environment, for instance, professional company experiences (know-how) can be collected and stored in a knowledge base to be easily reused, and, therefore, accessed by several organization members. In addition, recent research showed that the challenge faced by software organizations is concentrated on how to capture and share this knowledge [Napoleão et al. 2021]. On the other hand, a KM diagnostic[1] conducted in software companies to evaluate KM activities showed that, in practice, the use/application of knowledge is the main point of attention for the investigated software organizations.

3. Survey methodology

We surveyed to collect opinions from professionals working with software development in Brazilian companies. We followed the six phases proposed by [Kitchenham and Pfleeger 2008] to conduct our survey (Figure 2).

– Phase 1: Setting the objectives – Our objective is to provide an empirical basis on the state of KM practice in software development organizations. The base created will

[1] A KM diagnostic analyzes an organization's current state on KM [Bukowitz and Williams 2000].

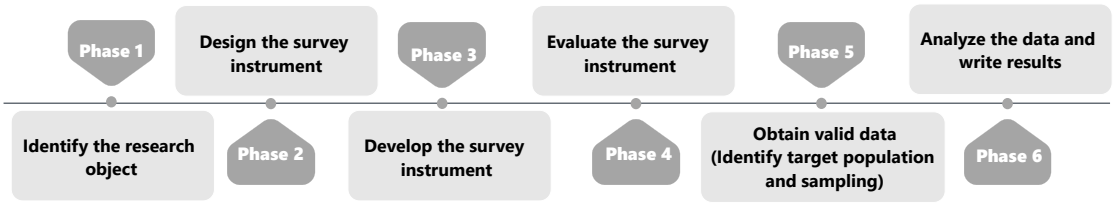

Figure 2. Research phases of this study

present the main KM problems faced by software development organizations and KM practices most used by professionals to create, share, and apply knowledge.

– Phase 2: Designing the survey – Our survey is a cross-sectional study [Kitchenham and Pfleeger 2008]. Software development professionals were asked about KM challenges and practices used to create, share and apply knowledge in their companies.

– Phase 3: Developing the survey instrument – The survey comprises a questionnaire with five sections: 1) Professional Profile; 2) Company Profile; 3) Knowledge creation; 4) Knowledge sharing, and 5) Knowledge application. An online version of the survey is available on *https://doi.org/10.5281/zenodo.6578796*.

The questions of sections 3, 4, and 5 were based on systematic literature reviews and surveys about KM in software engineering, such as [Dingsøyr and Conradi 2002], [Bjørnson and Dingsøyr 2008], [Menolli et al. 2015], [Vasanthapriyan et al. 2015], [Pinto et al. 2018], as well as in classic KM references, such as [Dalkir 2017].

For some questions, participants could choose more than one option as an answer. Therefore the number of answers to the question is greater than the number of respondents. For other questions, some answers' possible choices vary in a scale based on the Likert Scale, which is a metric used in questionnaires such as attitude surveys. At the end of the sections referring to KM activities, an open question was created for participants to provide any comments about challenges on the KM activity. Moreover, in some questions, elements mentioned only once were grouped into the "Others" category.

– Phase 4: Evaluating the survey instrument – We conducted a pre-testing by applying the survey to a smaller sample (6 participants) to identify any problems with the questionnaire. The questionnaire was also evaluated by one experienced researcher in KM and software engineering. The goal of this validation was to mitigate potential threats to validity and correct eventual mistakes.

– Phase 5: Obtaining valid data – Definition of population: In order to identify our population (software development professionals in Brazilian companies), we invited potential respondents to answer the survey in the following ways: (i) a direct request by e-mail was sent to professionals known by the authors. These professionals participated only in the survey pre-testing, and (ii) a request was sent to LinkedIn[2] groups. *Linkedin* is a social network focused on professional relationships. The survey was available for answers during March and June 2021. In the end, 80 participants answered our survey.

– Phase 6: Analyzing the data – The answers were stored directly after the partic-

[2]https://www.linkedin.com

ipants had submitted them. We check the responses in terms of consistency and completeness. After, we define how to analyze each type of response (numerical data, textual data, or ordinal scale). For the open questions, we grouped the answers into categories. The coding technique was used to label the qualitative data and identify different categories.

4. Study Results

Profile Professional. In section 1, we requested that only professionals involved with software development activities respond to the survey. Out of 80 survey participants, 29 (36.25%) work as system analysts, 12 (15%) are information technology (IT) managers, 8 (10%) support analysts, 7 (8.75%) are software engineers, and 24 (30%) are other professions related to IT. Participants have an average of 8.33 years of experience in their positions, with a standard deviation of 13.4.

Regarding KM knowledge level, 28 (35%) participants mentioned to have a basic level of knowledge, 30 (37.5%) answered to possess an intermediate knowledge, 11 (13.75%) mentioned to possess a piece of advanced knowledge in KM, and 11 (13.75%) of the participants reported not know KM.

Profile Companies. Based on the company's names mentioned by the participants who answered the survey, at least 54 companies were identified. Concerning the number of employees in companies, 31 companies have more than 100 employees (38.75%), nine companies between 51 and 100 employees (12.5%), ten companies between 10 and 12 employees (12.5%), and four companies have less than ten employees (5%). Regarding the demographic distribution of companies, 51.25% are in the state of São Paulo, 33.75% in Paraná, 6.25% in Minas Gerais, 3.75% in Bahia, 2.5% in Rio de Janeiro, 1.25% in Distrito Federal, and 1.25% in the Rio Grande do Sul.

The main products developed by the companies are software on demand (23.75%), commercial automation (12.5%), enterprise resource planning (8.75%), software components (7.5%), among others. The principal software development methodologies used by companies are Scrum (45.3%), Incremental Model (14%), Cascade Model (10%), Extreme Programming (XP) (9.3%) and Spiral Model (5.3%).

KM Activities Outcomes. The last survey sections are related to the three main KM activities: i) knowledge creation, ii) knowledge sharing, and iii) knowledge application. In the following, we describe the primary outcomes for these activities:

i) Knowledge Creation

The knowledge creation survey section made it possible to identify how actions related to knowledge creation occur in practice. First, recognize which were the main techniques used to capture tacit knowledge within the companies. Figure 3 presents the main techniques mentioned by the participants.

The technique most cited by participants was short and informal meeting (67 answers – 83.75%). 45.3% of companies use Scrum practices in their development (Section 4). In [Napoleão et al. 2021], synthesis research on KM and Agile Software Development (ASD) was conducted. According to Napoleão et al. (2021), Scrum activities that occur to capture and/or create knowledge are Sprint Planning, Daily Scrum, Development Work,

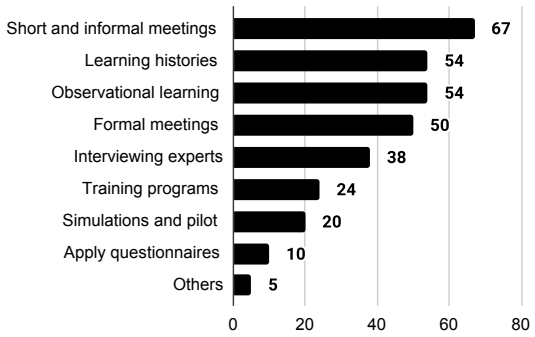

Figure 3. Capture tacit knowledge

Product Backlog, Sprint Backlog, and Increment. Almost all Scrum activities allow to capture or create knowledge. Short and informal meetings support these activities. This behavior aligns with the survey responses.

The techniques "Learning histories" and "Observation learning" were also frequently mentioned, with 54 answers (67.5%). Learning histories are a beneficial means of capturing tacit knowledge. This technique represents a retrospective history of significant events that occurred in the organization's recent past and described by the people who took part in them. Likewise, the observational learning technique is the process of learning by watching the behaviors of others, for example, in the presentations of a sample problem, scenario, or case study [Dalkir 2017].

In knowledge creation, it is crucial to codify this knowledge to the organization. When codifying knowledge into a tangible and explicit form, companies allow that knowledge can be communicated much more widely, with less cost and, build an organizational memory [Dalkir 2017]. As reported by the survey participants, techniques most used to codify knowledge are Unified Modeling Language (UML) (45 answers – 56.25%), Source code and comments (44 answers – 55%), Flowchart (40 answers – 50%) and Manuals (38 answers – 47.5%). Figure 4 presents the techniques mentioned by the participants to codify knowledge.

Finally, in the last survey part, an open question was asked to collect participants' opinions about the companies' main challenges related to knowledge capture. We grouped the main challenges mentioned into categories as shown in Figure 5.

As stated by participants, the main challenges of companies concerning knowledge capture are organizational culture (23 answers – 28.75%) and communication (21 answers – 26.25%). Organizational culture is directly related to the way the company thinks and acts, influencing the behavior of employees [Dalkir 2017], and the communication directly benefits software projects, since skills and experiences cannot be fully mastered in isolation. When there are problems with organizational culture or communication, low productivity is generated [Ouriques et al. 2019].

ii) Knowledge Sharing

In the integrated KM cycle (Figure 1), after knowledge is captured, it must be shared. In this survey section, we ask participants the most used resources to share knowledge in the company. The most resource used is short and informal meetings (55 answers

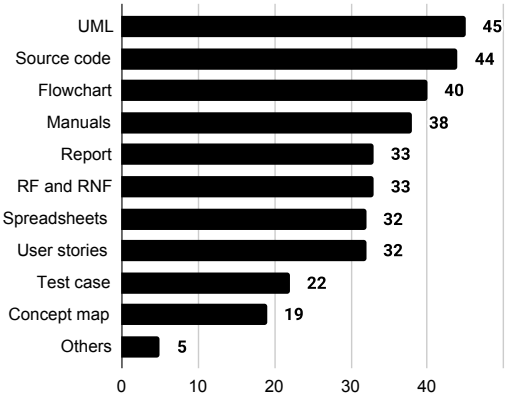

Figure 4. Coding explicit knowledge

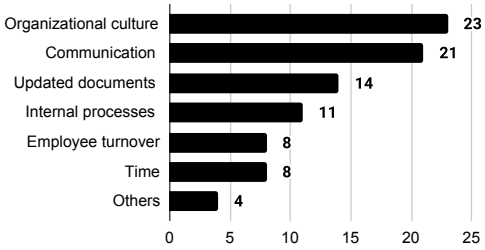

Figure 5. Main knowledge capture challenges

– 68.75%). In addition, internal training programs (46 answers – 57.5%) and formal meetings (42 answers - 52.2%) also was mentioned by participants as resources to share knowledge. Figure 6 presents the resources cited by the participants.

In Napoleão et al. (2021), the most common KM activity adopted in the context of software development organizations is knowledge sharing, mainly when the organization uses ASD. It makes sense since ASD prioritizes the exchange of information and communication among teams. Agile values promote a focus on the people involved in a project and how they interact and communicate. As previously shown, 45.3% of companies use Scrum practices. One of the characteristics of Scrum is the short meetings that take place during the Sprint. This behavior is in agreement with our findings.

When knowledge sharing occurs through the resources mentioned above, we asked participants what knowledge types the company usually shares, as detailed in Figure 7. “Best practices” (68 answers - 85%) was the knowledge most mentioned by professionals. Best practices are those practices that have been shown to produce superior results and judged as exemplary, good, or successfully demonstrated [North and Kumta 2018].

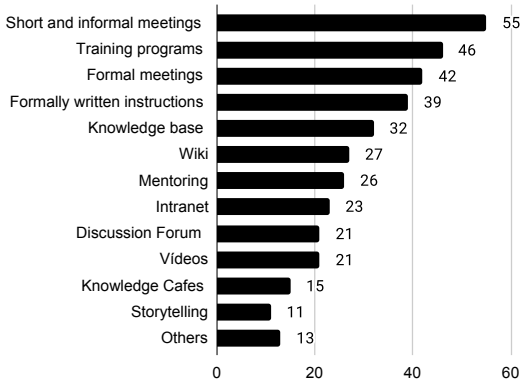

Figure 6. Resources most used to share knowledge

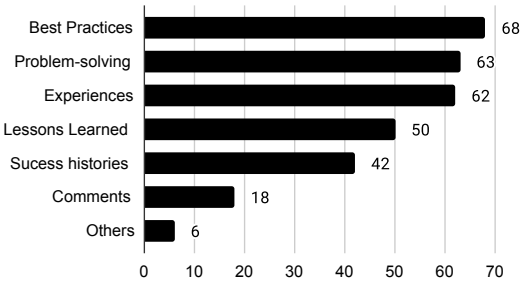

Figure 7. Knowledge types shared

Considering the most valuable communication channel for sharing knowledge, 55

participants (68.75%) responded that virtual meetings are helpful. Contrarily, 25 participants (32.5%) prefer person communication. Most of those who prefer to communicate through a virtual channel mentioned that virtual meetings (e.g., email, forum, wiki, social networks) could keep a history easier to be stored and because of its practicality. On the other hand, those who prefer personal meetings justified that interaction is the main reason for preferring this communication channel.

Figure 8 displayed the results linked to the perception of participants on the frequency that knowledge is shared in the company. We asked about the frequency that they receive motivation to share knowledge, how often they usually share their knowledge, how well they consider that people know each other's knowledge and skills, and how much it is possible to trust in the knowledge shared. The responses are based on the Likert Scale method, which ranges between 1 and 5, where 1 means "Never" and 5 "Always".

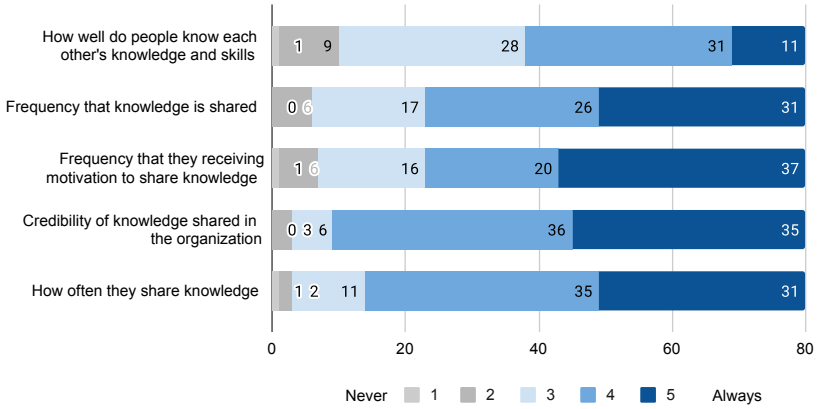

Figure 8. Respondents' perception about the knowledge sharing in the company

In summary, most of the questions presented in this survey section had positive responses (4 and 5 scales). Reflecting on the questions: "How well do people know each other's knowledge and skills" and "Frequency that knowledge is shared" (the first two questions in Figure 8), the concentration of answers is on scales 3 and 4, which means a positive, but with a trend closer to a neutral opinion about them. The question with more positive answers is "Credibility of knowledge shared in the organization" with 36 answers (45%) scale of 4 (very often) and 35 answers (43.75%) scale 5 (always), out 80, totaling 71 (88.75%) answers. This result on the credibility of shared knowledge becomes a good indicator for companies since one of the main hindrances to knowledge sharing is the credibility of the content, and the source [Dalkir 2017].

Several challenges can hinder knowledge sharing within organizations. For this reason, we created a question in the last survey part for participants to express their opinion about the main challenges to sharing knowledge in the company. Figure 9 presents the main challenges mentioned by them.

In participants' opinion, increased workload (86.25%) is the main challenge to work with knowledge sharing in the company. According to [Souza et al. 2015], shortage of time is a potential risk to incorporate the principles of KM and knowledge sharing can imply increasing the employee workload. In the category "Others" (8%), some challenges mentioned were lack of confidence, initiative, awareness, and a clearly-defined process.

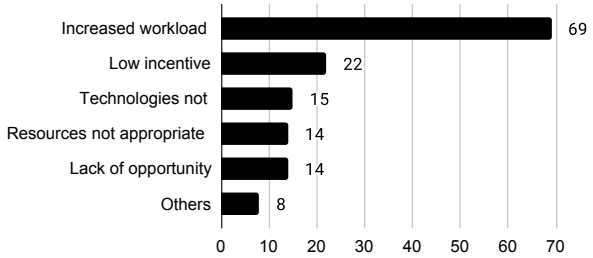

Figure 9. Challenges to sharing knowledge in companies

iii) Knowledge Application

Knowledge application refers to the actual use of knowledge that has been captured or created [Dalkir 2017]. This activity closes the integrated cycle of KM, as proposed by [Dalkir 2017]. The application of knowledge is directly related to the reuse of knowledge. In this survey part, our goal was to understand how participants seek knowledge to solve problems, how knowledge is reused, and the main challenges for applying knowledge in the participants' practical view.

When trying to solve a work problem at the company, participants answered that they usually seek knowledge on the Internet (63 answers – 78.7%) (Figure 10). Currently, individuals and organizations can take advantage of the remarkable possibilities and easy access to information that the Internet provides. In software development, several sites allow seeking knowledge developers, e.g., discussion forums. According to Silva et al. (2020) [Silva et al. 2020], forums have become essential repositories of knowledge to be reused.

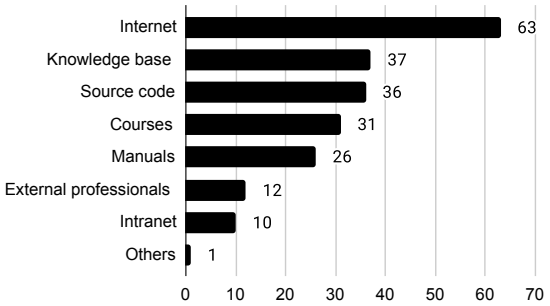

Figure 10. Means to seek knowledge in the company

When knowledge reuse occurs, we ask participants which types of knowledge (tacit and explicit) best contribute to their learning in the company. 42 participants (52.2%) prefer to use tacit knowledge, and 38 (47.5%) mentioned preferring to use the knowledge already explicit. Regarding tacit knowledge, experience from past stories (71 answers – 88.7%) and ideas (77.5%) are the most practiced ways of reusing knowledge in companies. Figure 11 presents the ways to reuse tacit knowledge most mentioned by the participants.

Concerning explicit knowledge, Figure 12 presents the ways most used by participants to reuse knowledge in the company. Functions (methods, classes) (57 answers –

71.2%) is the most reused form of knowledge by participants. In addition, the reuse of system components (subsystems, modules) (43 answers – 53.7%), the entire application system (41 answers – 51.2%), and ready-made libraries (41 answers – 51.2%) were also highlighted. Code reuse, such as functions, components, libraries, test scripts, is a form of knowledge reuse in software development that is essential to minimize costs and reduce development time in new projects [Haefliger et al. 2008].

In knowledge creation, the UML was the most mentioned form for encoding explicit knowledge (Figure 4), and not the most mentioned option for reusing explicit knowledge (Figure 12). Maybe, this happens because professionals who use UML diagrams most often are software architects, followed by software analysts and project managers, corresponding to a very small group in the profile of participants in this study (see Section 4, Profile Professional). In this perception, we can interpret that the UML is not mentioned because it is used more for consultation by the professionals who participated in this research.

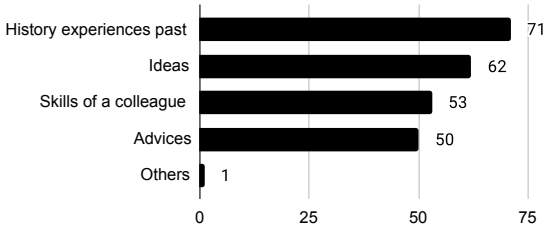

Figure 11. Tacit knowledge reused

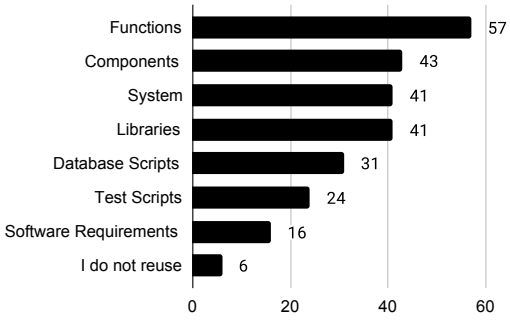

Figure 12. Explicit knowledge reused

It is essential to have tooling support or practices to optimize the process to apply knowledge. In light of this, we seek to know what are the main tools used for KM. Most participants (31 answers – 38.7%) answered that they do not know tools that support KM. Those who mentioned tools affirmed that they do not use specific tools to KM but tools that can support several KM activities, including using/applying knowledge. Some of the most cited tools were: Confluence (12 answers – 15%), Version Control System (VCS) (8 answers – 10%), Microsoft SharePoint (7 answers – 8.7%), and Internal Enterprise System (7 answers – 8.7%). Figure 13 presents the main tools mentioned by participants. Tools mentioned once were added in the "Others" category (33 answers – 41.25%), including Microsoft Teams, ServiceNow, Microsoft Azure, Slack, Degreed, GitHub, Redmine.

Finally, in the last part of the survey, an open question was comprised for participants to externalize their opinion on the main challenges to applying the knowledge. Participants responded that organizing and making knowledge accessible (21 answers – 26.2%) is the biggest challenge for the company concerning the application and/or use of knowledge. Figure 14 presents the company's main challenges regarding the use of knowledge in the opinion of the survey participants.

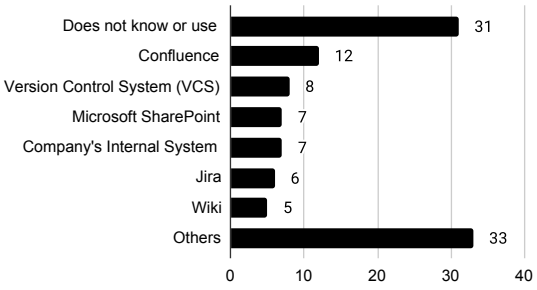

Figure 13. Tools used in the company to support KM

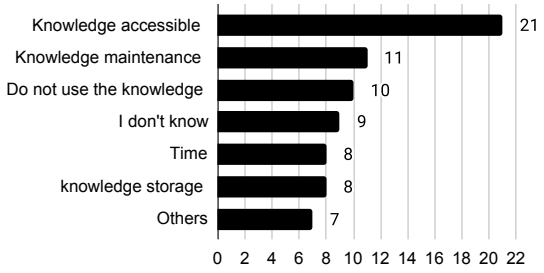

Figure 14. Main challenges in relation to the use of knowledge

5. Discussion

The software has become indispensable in our daily routines and critical and complex application domains, making knowledge increasingly important. KM can provide several benefits for software development companies, but it can also bring several challenges. Our results offer insights into current practices and problems KM as discussed following.

The first KM activity analyzed in our survey was knowledge capture, which refers to the development of new knowledge and know-how innovations that did not have a previous existence within the company [Dalkir 2017]. When analyzing the knowledge capture, the technique most used by participants was short and informal meetings (67 answers – 83.7%). This behavior directly reflects the application of Scrum in the companies in which the participants work. 45.3% adopt Scrum as their development methodology. Scrum activities are based on short and informal meetings, and agile values promote a focus on communication [Ruiz et al. 2018, Napoleão et al. 2021]. Although communication is one of the main principles of agile development, this was identified as one of the main challenges by capturing knowledge in the companies (21 answers – 26.25%). According to Field (2013)[Field 2013], knowledge continuity management is related to communication, i.e., the more critical a job is to the company, the more important is it to be part of a continuity management system. However, the more complex and tacit the professional's knowledge, the more difficult it will be to capture and pass on.

Since the captured knowledge becomes essential to codify before storing it, the techniques most used to codify knowledge are UML and source code. According to Chaudron et al. (2012) [Chaudron et al. 2012], UML modeling contributes to sharing and understanding of the system and more effective communication. As well as the UML, source code can also contribute to the creation and sharing of knowledge. In code review, for example, discussions about coding issues are communicated back and forth between the community or the team members. As a result, developers have the opportunities to reflect, take corrective actions and build concrete experiences.

Regarding knowledge sharing, most participants (55 answers – 68.75%) prefer short and informal meetings which are a trend of the agile development teams. In addition, virtual meetings (55 answers – 68.75%) have also been preferred by most participants, as they believe they are a more practical means. Currently, given the current situation of the COVID-19[3] pandemic and the resulting stay-at-home orders have led to considerable

[3] *https://covid.saude.gov.br/*

changes in the way people work. One of these changes involves increased use of video conferencing as a means of communicating or holding work meetings. While it has been a great challenge for some professionals, it has become the best option, as can be seen from the survey results.

Also, concerning knowledge sharing, most participants demonstrated that they trust in the knowledge shared in the organization (71 answers – 86.25%). However, even though they trust in the knowledge, their biggest challenge is the increased workload to share it (69 answers – 86.25%). The Software Engineering domain is vast, and embedding KM is a real hindrance as it needs commendable efforts from the involved.

The last KM activity analyzed was knowledge application. In order to solve a problem (e.g., implementing a code), most participants (63 answers – 78.7%) are looking for solutions on the Internet, which can make it possible to access and reuse knowledge easily. Knowledge reuse, mainly, is associated with the use of knowledge available in the company. 42 (52.5%) participants believed learning is more accessible when using tacit knowledge to learn within the companies from reuse. The tacit form more commonly reused is the experience from past stories (71 answers – 88.7%). Otherwise, 38 (47.5%) participants prefer to reuse explicit knowledge. In this case, most of them prefer to reuse functions (methods, classes) (57 answers – 71.2%). Source code reuse is crucial for innovation since it can substantially improve the quality of new software products and reduce costs [Haefliger et al. 2008].

Investing in KM is also making use of new technologies or tools. However, according to Menolli et al. (2015), employees have a natural resistance to new technologies, which makes KM implantation more difficult. Our survey results showed that many participants do not know or do not use specific tools for KM (31 answers – 38.7%).

The survey results gave a better understanding of the current state of KM. The results achieved give insights into the current practices and problems of KM in Brazilian software development companies. Concerning professionals, the results of this survey allowed the construction of an empirical base capable of supporting project decisions. From the results, the practitioners can evaluate their own KM situation against companies participating in the research. On the other hand, for research in KM, the results can guide future research, such as solutions to the problems/challenges presented.

5.1. Threats to the Validity

There are some main limitations to our study. Firstly, even not knowing, it is common for professionals to carry out KM activities in their daily lives, mainly those who mentioned using agile practices. Even so, 28 (35%) participants mentioned having a basic level of knowledge regarding KM. Still not possible to state that the responses of these 28 participants can be a bias for this research. Therefore, a pilot study was performed and a survey validated by a KM researcher, so any problem could be identified and corrected before the survey was opened.

Secondly, the data sample was 80. We consider this sample to be representative. We defend that the data collected provided a solid basis for our analysis. However, this study only reflects the situation in Brazil, and we cannot confirm that the findings are valid for companies from other countries.

6. Related Works

Although the first reports of KM in Software Engineering appeared around the year 2000, it is still a relatively new field to be investigated and there are still many challenges about how to apply KM in a software development organization [Bjørnson and Dingsøyr 2008, Souza et al. 2021]. The following are presented some studies that conducted surveys to understand the application of KM in software development companies.

In Maciel et al. (2018) [Maciel et al. 2018], a survey was conducted in software companies in order to identify the perception of professionals in software testing on the use of KM initiatives. The survey was applied to 39 companies. Regarding the main results, testing planning activity and test case reuse have received more attention from companies. According to Maciel et al. (2018), strategic planning and test cases reuse have the potential to reduce software development costs and time significantly.

Ruiz et al. (2018) [Ruiz et al. 2018] surveyed with professionals working with agile tests to understand how knowledge is shared in Brazilian companies that incorporated agile methodology. The survey was answered by 150 professionals. The main results observed were that the knowledge is shared into the team (89.3%), informal communication is most used (52%), tools are used to share knowledge, the future decisions are based on past problems (88%), and the success stories are stored by team (70.9%). Based on the survey results, agile practices support companies to make use of KM principles.

In Menolli et al. (2015), the main tools and technologies to KM used by software-development companies in Brazil are identified. A survey was conducted in Thirteen Brazilian software development companies with high levels of process software maturity. The results show that some of the tools used by the companies do not apply the concepts described in the theories as they do not help promote organizational learning. Furthermore, the tools are not often used, mainly because they are not organized efficiently.

More recently, Mathew and Rodrigues (2019) [Mathew and Rodrigues 2019] presented a study on the KM implementation in Indian software organizations. Critical success factors, process capability, and effectiveness of KM were analyzed by a survey. 423 knowledge workers from 66 large software companies participated in the survey. The results indicated that the overall implementation of KM in Indian software firms was in the right direction with above-average considering the score values of the factors used for analysis in the study.

7. Conclusions

This study sought to understand the three KM activities: creation, sharing, and application of knowledge in Brazilian software development organizations. A survey instrument was distributed and 80 software development professionals participated in this research. This study showed some potential results to be investigated in the future: several no KM specific tools and technologies are used to support the KM activities; ASD practices strongly support KM activities; best practices are the knowledge types the company usually shares; experiences from past stories and source code are fundamental to be reused; and organizational culture, increased workload, and how to make knowledge accessible are the main challenges mentioned by survey participants.

Although our goal in the survey is broader in the sense of knowing the means of

creating, sharing, and applying knowledge, it is still essential to deepen this research in order to understand how certain factors could influence the research responses, for example, the companies and/or project characteristics, knowledge level of KM by participants. A deep investigation with other mechanisms to perception about KM in software companies also is part of future work. Moreover, we intend to conduct the same survey for a longer time to collect more data to improve its representativeness. We also intend to replicate the survey in an international context, and conduct interviews to compare the results. Finally, from the survey results analysis, especially the highlighted problems, we also intend to investigate possible solutions to support software organizations in relation to KM.

Acknowledgement

The author Juliana Oliveira dos Santos acknowledges Institutional Scholarship Program in Scientific Initiation (PIBIC-UTFPR) for the financial support. Dr. Érica Ferreira de Souza is supported by a research grant from the Brazilian funding agency CNPq (432247/2018-1). We also would like to thank the professionals that agreed to answer the survey.

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