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THE USE OF MATURITY MODELS IN AGILE SOFTWARE DEVELOPMENT TEAMS: FOCUS ON HUMAN FACTORS

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ABSTRACT

The use of software products is growing, leading to an increase in quality demand. With that, standards were created to implement maturity models inside organizations, including CMMI and MPS-BR. **Objective:** To investigate the use of maturity models for the development of human aspects in agile teams. **Method:** A survey was carried out, and the results were analyzed based on the frequency of responses and qualitative analysis. **Results:** The maturity models focused on people management (P-CMM and MPS-RH) are still little known. **Conclusion:** Although low, it is noticed the simultaneous use of maturity models and agile methods in software development. But to be used together, some factors must be considered.

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INTRODUCTION

Software development projects can be considered different from traditional ones since they undergo many changes during their life cycle; a different approach is essential (MARTINS, 2011). More and more software companies started to adopt agile and incremental methods instead of the traditional methods of software development (PETERSEN; WOHLIN, 2010). The expansion of software products' use led to an increase in the demand for quality products. This fact obliged the developers to follow some models different from the traditional methodologies for project management, as these no longer fully met the organizational needs (ROVAI, 2013). As a result, several standards have emerged for the implementation of project management maturity models, including the Capability Maturity Model Integration (CMMI) (SEI, 2010) and MPS-BR (Brazilian Software Process Improvement) (SOFTEX, 2009). Despite several models, this work chose to approach the CMMI as it is considered an international standard in the software industry; and MPS. BR, for being the model proposed in Brazil. When software development is mentioned, there is no way to forget the human aspects since software development is an intellectual activity that depends on people, who usually form teams and work together. Thus, it is impossible to exclude human factors during software development because it is developed by and for people (MIRANDA, 2011). Due to the importance of people to organizations, two other maturity models stand out, which are derivations of the CMMI and MPS-BR models, and aim to improve the capacity of organizations to develop their human resources. They are the People-CMM (People Capability Maturity Model), or P-CMM (CURTIS *et al.* 2001) and the MPS Reference Model for People Management (MPS-RH) (SOFTEX., 2014). But the complexity of the traditional models most used today opens an opportunity for the implementation processes to be adapted to the specific needs of each organization. Along these lines, there are works in the literature that compare and suggest the adoption of the CMMI methodology and agile methods (POTTER; SAKRY, 2009); (LINA; DAN, 2012) and even its integration (SILVA; SANTOS; SHIBAO, 2017a), in an attempt to improve product quality (through a maturity model) in agile software development environments. But a gap is found in the scenario of using a maturity model to develop human aspects in agile teams. Given the above, the present work intends to investigate the use of maturity models in agile software development environments, more specifically, focused on developing human aspects.

To this end, a survey was carried out to understand issues related to development methodologies and maturity models in agile software development teams.

The article is organized as follows: in section 2, the theoretical framework of this research will be presented; in section 3, the methodology used will be covered; in section 4, the results obtained will be presented, and, finally, the conclusions will be presented in section 5.

Conceptual Bases

In this section, the aspects that support this study will be presented.

Agile Software development methodologies: The agile manifesto (HIGHSMITH *et al*., 2001) states that agile development should focus on four central values: a) individuals and their interactions over procedures and tools; b) the operation of the software above comprehensive documentation; c) collaboration with the client above negotiation and contract; d) the ability to respond to changes above a pre-established plan. Agile methods were originally designed for use in small projects (BOEHM; TURNER, 2005). However, its benefits have also become attractive outside this context, mainly for projects and in larger companies, despite the difficulty raised by Dyba and Dingsoyr (2009), addressing organizational inertia. Compared to small projects, ideal for agile development, the larger ones are characterized by the need for additional coordination. This creates unique challenges when introducing agile at scale, and there may be a need to interact with other organizational units (DIKERT *et al*., 2016). The use of agile methodologies in the software development process has been growing in recent years (VERSIONONE, 2018). According to Hamed and Abushama (2013), two of the most popular agile methods are Extreme Programming (XP) and Scrum. The study by Melo *et al.* (2013) indicates that Brazilian companies are also adopting agile practices, such as XP, Scrum, and Lean, as they become more mature. Within the context of the use of agile methods, the search for adherence to maturity levels through agile processes that demand low levels of effort has been placed as an alternative for software development organizations (FURTADO; MEIRA, 2013). This subject will be covered in the following section.

The maturity models (CMMI, MPS-BR, P-CMM, AND MPS-RH): The increase in the adoption rate of maturity models can be attributed to these methodologies' success, and several studies have documented this phenomenon (DINGSOYR *et al*., 2012). There are several maturity models currently available that aim to improve the software process, focusing on optimizing the time, cost, and quality of management and engineering practices in software development organizations (AYSOLMAZ and DEMIRORS, 2011). CMMI is a process improvement approach that provides organizations with essential elements of effective processes (SEI, 2010). It can be used to guide process improvement in a project, division, or an entire organization, being focused on organizational capacity, categorizing organizations into five levels of maturity. It is oriented towards traditional software development methodologies. The MPS-BR model aims to help organizations, tiny and medium-sized Brazilian companies (SMEs), to obtain quality software development more smoothly and at a lower cost, defining 7 (seven) levels of maturity (SOFTEX, 2009). Although the initiative's focus is SMEs, the model is also suitable to support process improvement in large organizations. In addition to these, two other models stand out: the People Capability Maturity Model, or P-CMM (Curtis *et al*., 2001); and the MPS Reference Model for People Management (MPS-RH) (SOFTEX, 2014). Both are aligned with people management processes to help organizations manage and develop their intellectual capital. The ultimate goal is to improve the ability of organizations to attract, train, motivate, organize, and retain their human resources. Studies show that P-CMM provides a framework for the empowerment of human capital (GAMAL, 2008). It is a fundamental piece to discover the critical factors that significantly influence product quality and the stabilization of people in software companies (LU *et al*., 2010). MPS-RH, on the other hand, offers necessary guidelines for the gradual implementation of HR management practices to select, develop, and retain the human talents required to meet the strategic objectives of the companies. It is essential to understand that, however, complete a model may be, it is only a set of processes. Therefore, if there is no discipline to comply with these processes, it is necessary to monitor and educate the team to execute them. The next section will address issues related to human factors in software development.

Human factors in Software Development: The intangible nature of the software has made a product difficult to create successfully, and a close examination of the reasons for the significant flaws in the software system shows that numerous issues are related to human problems. However, such problems remain a neglected area of research, and the possible reasons may be the complex relationships between human psychology and software development processes, a lack of awareness of the impact of human factors on software engineering and, possibly, the lack of confidence in empirical studies on human factors (CAPRETZ *et al*., 2017). Despite this panorama, it is essential to highlight the efforts being made to reduce this neglect. The academy, for example, has several national and international forums that seek to analyze human factors and how they can impact software development. They are Workshop on Social, Human and Economic Aspects of Software (WASHES), Brazilian Symposium on Information Systems (SBSI), Brazilian Symposium on Collaborative Systems (SBSC), Brazilian Symposium on Human Factors in Computer Systems (IHC), RevistaBrasileira Information Systems (iSys), International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE), and Computers in Human Behavior Journal.

Silva (2017) carried out systematic mapping of the literature to investigate human and cultural factors in software development projects. One of the results indicated that human aspects are part of the 14 critical success factors in agile projects. Also, the study consolidates the existing concepts about human factors in the development, execution, and success of agile software. In the specific case of agile methods, the literature shows that they represent strategic support for organizations to achieve more excellent performance in developing their software systems. There is an understanding that problems in human resources are capable of negatively interfering in the fulfillment of the company's objectives, presenting difficulties in complying with the rules and procedures that aim to correct flaws, achieve the highest quality standard and lead to organizational success (MOE, DINGSØYR, 2008; PIRZADEH, 2010). Given this reality, companies need to be prepared to develop their employees' skills as an option to make their performance more dynamic. The following section presents the works related to this study.

Related Works: The study by Henriques and Tanner (2017) highlights the simultaneous use of agile methods and CMMI and also the mapping between a given level of CMMI and agile practices. Examples of the coexistence of agile and CMMI are also found in Fritzsche and Keil (2007), Glazer *et al*. (2008), and Łukasiewicz and Miler (2012). The authors conclude that agile and CMMI can successfully coexist when agile is introduced in already highly mature environments or when the main objective is focused only on delivery. They indicate that, if the aim is to higher CMMI maturity levels, agile cannot be used without being supplemented with other non-agile practices. With simultaneous use, the articles analyzed are concerned with how agile methods can coexist with CMMI in practice without worrying about the level of maturity. First, some authors (BASS *et al*., 2013; COHAN and GLAZER, 2009) consider the two complementary approaches focused on different software delivery aspects. This is confirmed when observing articles in which agile is introduced into an organization and improves the quality of software delivery, without taking into account the reach of any CMMI maturity level (JAKOBSEN and SUTHERLAND, 2009; KOUTSOUMPOS and MARINELARENA, 2013). Much of this research has been carried out by introducing agile practices in an already mature environment (CMMI) or where the primary objective was not necessarily maturity but successful software delivery. Given the above, it is believed that the need for evolution in the proposed areas of the present study was straightforward, aiming at a more detailed investigation about the use of maturity models in agile environments, focused on the development of human aspects. In the next section, the methodology for the present study will be presented.

METHODS

In this section, aspects related to the study method will be presented.

Research Question: According to Gil (1999), all research begins with some kind of problem or inquiry, and it must be formulated as a question. To understand the phenomenon studied, the following research question was developed, which this study aims to answer:

QP: How do you use the maturity models in agile software development teams, more specifically related to the development of human aspects?

The answer to this research question is presented in Section 4.

LITERATURE REVIEW

To give more rigor to this exploratory review, some criteria were used that are used in a systematic review of the literature, such as a) the use of databases for research and b) the requirements for inclusion and exclusion of articles. For manual search, Google Scholar and Periodical Capes were chosen. The keywords used in the manual search were tested in the search engines and adjusted, which resulted in a search string. With the string, automatic searches were conducted on the ACM, IEEE, and Compendex databases. For both manual and automatic search, the range of publications between 2001 and 2019 was considered, assuming that the People Capability Maturity Model (P-CMM) had its initial milestone in 2001 (CURTIS *et al*., 2001). After applying the inclusion and exclusion criteria, removal of duplicates, and exclusion by reading resulted in 41 articles. For the management of the files, the free software Mendeley was used.

Survey: The survey sought to understand issues related to development methodologies and maturity models in agile software development teams. The questionnaire used in this step is available at https://bit.ly/2QTQgsw.

Research and Data Collection Instrument: A structured questionnaire was used, composed of 23 questions, where the profile of the respondent was sought, the shape of the company where the respondent operates as well as the experience/knowledge of the respondent in software development, agile methods, and maturity models. Of the 23 questions, 22 were closed (multiple-choice, open fields to justify the answers) and onefree question. Before making the collection instrument available to respondents, it underwent a trial period, being available on Google tools for three days. This became important because, although the mechanism was based on an existing one (Silva, Santos, and Shibao, 2017), new questions were elaborated and inserted. After this period, the questionnaire was made available on the Survio platform and was known for the reply on the web between 07/12/19 and 07/22/19.

Population and Sample: The population of this initial study consisted of professionals in the area of information technology involved in software development projects. For this work, non-probabilistic sampling was adopted, whose main characteristic is not to use random forms of selection, making it impossible to apply statistical conditions for calculation. It is used when the universe's size is unknown, and individuals are selected through the researcher's subjective criteria (GIL, 1999; MARCONI and LAKATOS, 2010). The sample was used for accessibility and convenience, often used to generate ideas in exploratory research. The initial sample of this study was 53 respondents, with 51 valid responses. The responses will be analyzed in section 4.

Data analysis: For the analysis of the closed questions of the questionnaire, the results were analyzed based on the frequency of the answers and are presented in the form of graphs, available at https://bit.ly/2QW5NrM. As the sample was non-probabilistic, statistical analyzes were not performed. For the open question, qualitative analysis was used. The purpose of this type of research is to consolidate, reduce, and interpret data obtained from various sources and make sense of them (MERRIAM, 2009). Thus, the analysis started with the open coding of responses. Upon reading the first response, the initial codes were defined. With each reading of new reactions, the resulting codes corresponding to each answer were frequently compared to previous responses' codes. From the constant comparisons of the regulations, the categories were formed. As the data analysis process progressed, relationships between types were built. Finally, the main categories were chosen according to their relevance within the studied context. From the definition of the maintypes, the propositions were defined, which enabled the answers' interpretation, presented in section 4. To perform the qualitative analysis, the Excel tool was used.

RESULTS

The general objective of this work is to investigate the use of maturity models in agile software development environments, more specifically, focused on the development of human aspects. The results are presented in this section. The sample profile comprises male professionals between 26 and 35 years old and with higher qualifications. The face of the organizations in which the respondents work are extensive (45.1%), private initiative (64.7%), national (78.4%), located in the Northeast (NE) (96.1%), working in the Consulting / Services area (23.5)% and with a technology team of fewer than 20 people.

Considering the respondent's experience/knowledge in software development, agile methods, and maturity models, some results were obtained:

1. 56.9% of respondents have more than 5 (five) years of experience in software development;
2. 49.1% work in the development area (developing or managing projects);
3. 51% of respondents have more than three years of experience in agile methods;
4. 35.3% of respondents have advanced knowledge in SCRUM;
5. The three main frameworks used in the organizations surveyed are Scrum (78.4%), Kanban (49%), and traditional methodologies based on PMBok (31.4%). CMMI is little used, accounting for 5.9%. The use of agile frameworks in the researched organizations can be highlighted;
6. It is important to note that a relatively high proportion of respondents (35.3%) do not know what a maturity model for software development is. This fact calls attention, considering the profile of the respondents;
7. 49% of respondents say that the organization they work for does not use any maturity model. Only 21.6 responded positively;
8. Considering the maturity models for people management, most respondents (76.5%) do not know what it is. Considering that part of the sample has a managerial position (41.2%), this fact draws attention;
9. 51% of respondents say that the organizations where they work do not use a maturity model for the development of people;
10. The vast majority of respondents (88.2%) are unaware that there is any maturity model aimed at agile software development;
11. 94.1% of respondents do not know a software development maturity model that involves people management;
12. Only 21.6% of respondents say that the organization they work for makes simultaneous use of maturity models and agile methodologies;

From the answers obtained in the open question, it is clear that the respondents are confused between maturity models and software development methodologies. This fact also draws attention since the sample, in its majority, has better technically trained professionals. Another point is about the simultaneous use of maturity models in agile environments that, in the respondents' view, are incompatible since they consider them to be exclusive methodologies. According to the respondents, while the maturity models are aligned with traditional software development methodologies (with well-defined processes and steps), agile methods bring greater flexibility and dynamism to software development. However, for them to be used together, some factors must be considered: a) organization and planning are fundamental for the process to work; b) everything must be very well mapped so that there are no flaws in the implementation; c) the team must be well prepared, with defined responsibilities; d) the role of management is fundamental, and it must conduct the process transparently and with absolute rigor; and finally, e) the organization must have a structure to support the integration of frameworks, maintaining an environment conducive to the use of maturity models, in an agile environment.

CONCLUSIONS

Most organizations use agile software development methods. Regarding maturity models, although known (as is the case with CMMI and MPS-BR), they are not widely used by companies. And the maturity models focused on people management are still little known, as is the case with P-CMM and MPS-RH. Although low, there is a simultaneous use of maturity models and agile methodologies in software development by some companies. To be used together, factors such as organization and planning, management responsibilities, team responsibilities, theright environment, and a good company structure must be considered. This study was limited to collecting data through an accessibility sample. Thus, the result produced reflects the explored environment and, although it is possible to investigate the use of maturity models in agile software development teams, more specifically focused on human development, it is not possible to generalize. As future work, it is possible to carry out further studies that can expand the data used to produce discoveries around the relationships established. Still, qualitative research can be interesting in terms of understanding the reasons why the maturity models for people management (P-CMM and MPS-RH) are not widely used by organizations, since, despite not being alone enough to reach an acceptable level of people management, is a big step towards a significant improvement in the area.

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