Impact of Agile Practices Adoption on Organizational Learning: a Survey in Brazil

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***Abstract*—Agile software development is a particularly intense knowledge activity in which the success depends greatly on the experience of the professionals involved in the process. Knowledge Management Strategies play an important role in assisting knowledge acquisition and sharing among Agile teams. In this scenario, this paper answer the following research question: What is the impact caused by the use of Agile practices in the process of organizational knowledge acquisition at software development companies? The objective is to analyze strategies for Knowledge Management among teams and evaluate the impact caused by the adoption of Agile practices on the Organizational Learning process. For this, we proposed a model which it was possible evaluate this impact. Thus, a survey was conducted with 455 respondents in order to validate the proposed model. The data collected in this research was processed and analyzed using Structural Equation Modeling. The results corroborates the impact of software development practices on Knowledge Management Strategies and Organizational Learning. Additionally, this study provides mechanisms for software engineering professionals to implement strategies that contribute to the knowledge acquisition and sharing in their teams.**

***Index Terms*—Agile, organizational learning, SEM, agile tailoring**

I. Introduction

Software development teams adopt different approaches for Knowledge Management with the objective of broadening the understanding of individuals, maximizing the productivity of teams and promoting improvements of quality indexes of the projects [1], [2]. In addition, it generates competitive advantage for the company from the application of the available knowledge [3].

Over the last two decades, Agile methods have gained focus in the software engineering research area [4], [5]. Different organizations have changed their processes of software development and adopted Agile practices. However, Agile methods depend on communication and interaction among individuals so that knowledge sharing takes place [6]–[8] and the strategy used is based on customization [9]. In the other words, in practice, Agile methodologies can be combined with traditional approaches, which organizations adopt and customizes the approaches according to their need, using a hybrid software development approach [10]. In spite of providing a simpler and less bureaucratic process, the Agile methods face difficulties such as the sharing and management of the knowledge the teams had [1], which impact the process of Organizational Learning (OL) at software companies.

So, the present study was guided by the following research question: What is the impact caused by the use of Agile practices in the process of organizational knowledge acquisition at software development companies? The aims of this study are: (1) to investigate which Agile practices are more frequently used by software development teams; (2) to investigate which Knowledge Management Strategies are the most diffused among software development teams that adopt Agile practices; and (3) to propose an empirical model capable of measuring the impact caused by the adoption of Agile practices in the Organizational Learning.

To achieve these goals, this research conducted a survey with 455 professionals from software development companies that utilize Agile methods and practices. The data was collected by using a questionnaire and analyzing it applied to structural equations modeling (SEM). The results demonstrate the possibility of identifying that Agile practices have meaningful influence over the strategies used by the teams in order to share knowledge and affect significantly the Organizational Learning in IT companies. As contribution of this study, we emphasize the importance of Agile practice in the learning process of individuals and organizations. Furthermore, the proposed model represents a breakthrough in literature that lacks empirical studies for Agile methods adoption [11]. We also highlight that the research instrument as well as the parameters used in our research may be reproduced in order to enlarge the comprehension of how Knowledge Management and software engineering correlate, especially when using Agile methods.

The rest of the paper was organized as follows: Section II shows the proposed model. Section III discusses the research method adopted. Section IV presents the results of the study and the Section V presents the threats to validity. The conclusions and future work are presented in Section VI.

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II. Proposed Model

The proposed model in this paper suggests that the adoption of Agile methods affects both Knowledge Management Strategies and the Organizational Learning process. This relationship is justified by the fact that Agile methods are based on learning processes [12]. The use of these methods requires a constant learning stream from teams [13] and Knowledge Management practices are embedded in Agile practices [1], [14]. In this respect, in literature we found the following constructs that compose the model: (a) Agile Adoption, (b) Knowledge Management Strategies and (c) Organizational Learning (OL).

After researching the literature, the construct related to Agile methods adoption was subdivided into two constructs that classify Agile practices into "Project Management Practices" (PMP) and "Software Development Practices" (SDP). We choose this subdivision because agile methods tailoring is a reality in companies that adopt agile methods [15] and the utilization of agile methods as constructs maybe not be suitable for our objectives. This subdivision is based on the justification that methods such as Scrum are more focused on management practices while XP provides more development practices [16], [17]. Moreover, this division provides a method to verify how each proposed Agile practice group impacts the Organizational Learning.

Concerning the "Knowledge Management Strategies" (KM Strategies) construct, the variables used are the strategies that show how organizations promote knowledge sharing [18], [19] and therefore influence the Organizational Learning process [20], [21].

The last construct of this model is the "Organizational Learning" and it has variables of the constructs considering the levels that learning occurs in the organizational environment. [22]. The Figure 1 shows the variables that compose the constructs proposed in this model.

A. Research hypotheses

From the proposed model to conduct this study, 5 hypotheses were drawn up in order to respond to the proposed research question. The proposed hypothetical model:

- H1: The adoption of Agile practices for project management has direct influence over the Knowledge Management Strategies used by the teams.
- H2: The adoption of Agile practices for project management has direct influence over the process of Organizational Learning.
- H3: The adoption of Agile practices for software development has direct influence over the Knowledge Management Strategies used by the teams.
- H4: The adoption of Agile practices for software development has direct influence over the process of Organizational Learning.
- H5: The adoption of Knowledge Management Strategies influence directly the Organizational Learning process.

The proposed hypothesis H1 and H3 claim that Agile practices adoption by software development teams significantly affect the KM strategies they use. Even though the organizations to where these teams perform have no set Knowledge Management processes, the Agile methods are based on learning processes [12] and the use of these practices contributes to the production and knowledge sharing among team members, since the practices of Knowledge Management are incorporated into Agile practices [1], [14]. In addition to that, software development activities require constant learning and sharing of information as well as cooperation among individuals is crucial for the success of software projects [2].

As for H2 and H4, the model proposed in this study presents a direct influence on Organizational Learning processes when using Agile practices. OL is considered a change that occurs in organizations due to acquired knowledge and experience [22]. This change is identified from the moment individuals in the organization gain new knowledge, new products and services are proposed and also work routines are improved, meaning an alteration in the behaviour of the company [3], [22]. The OL process starts by the production and sharing of knowledge which are activities related to the individual [23]. Once shared, this knowledge produces a common understanding that spreads among the work group [21] and this allows the production and modification of products, services and company routines [3], [22].

In this respect, the adoption of Agile practices encourages the knowledge sharing among individuals [24], [25], meaning experience and knowledge being acquired and shared. Moreover, the adoption of Agile practices and methods require a culture prone to cooperation and knowledge sharing from the organization [4], [24], [25], since a culture led by knowledge sharing is an essential prerequisite for OL to happen [1].

At last, the H5 hypothesis claims that Knowledge Management Strategies directly impact the Organizational Learning process. KM is a process in which the objective is to protect the knowledge resources of an organization [23] and enhance the productivity by means of strategies to knowledge acquisition and sharing [20]. In addition, effective strategies for Knowledge Management provide mechanisms for the production of new knowledge, so that the existing knowledge may be shared among individuals of the organization and the available knowledge turns into a competitive advantage [1], [3]. As a result, knowledge is created by means of Organizational Learning processes managed by Knowledge Management Strategies [21]–[23].

III. Method

In order to evaluate the proposed model, a survey questionnaire was performed. A survey questionnaire is suitable for a standardized data collection and allows the researcher to gather relevant information in order to get answers for the research hypotheses [26].

The proposed questionnaire was composed of 38 items subdivided in 4 parts: (1) respondent characterization, (2) use of Knowledge Management Strategies, (3)

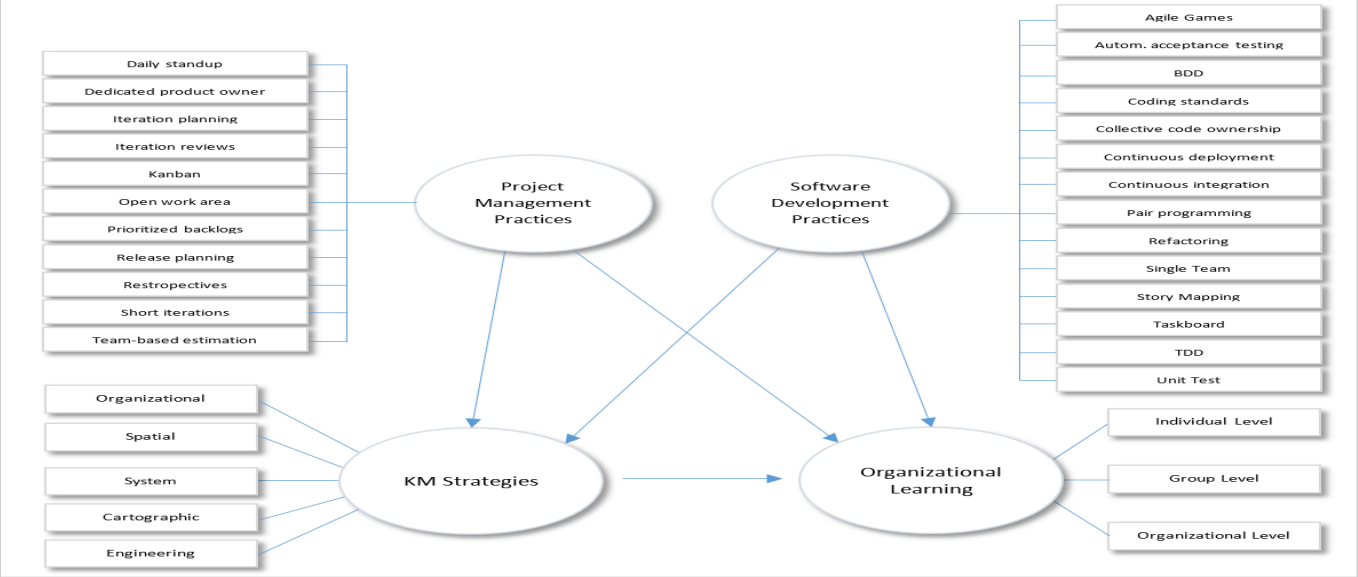

Fig. 1. Research model with constructs and variables.

Organizational Learning and (4) use of Agile practices. Hence, five queries were used to characterize the sample, which include the following item: the individual's job position at the company, schooling, experience with agile methods, level of agile methods knowledge and company stature. The questionnaire was composed by items related to Knowledge Management Strategies, Organizational Learning Agile Practices and it can be seen by link: https://www.dropbox.com/s/htr6z8ibx1a5pux/sbsi-2019.pdf?dl=0

IV. Results

This section presents the analyzed results obtained from the data collected utilized for this research.

A. Descriptive analysis of the sample

The survey questionnaire was answered by 455 valid respondents. Among them 52.75% act on the development team as programmers, testers, designers. 30.99% are professionals in management and leadership position such as Scrum Masters and project managers. As for the education, 40.88% of respondents hold graduate degree and 44.62% postgraduate degree or an MBA. 5.05% of individuals mentioned are students in the process of graduating. 11.2% have knowledge on Agile methods, adopt practices on their daily routine but never effectively used these methods in projects. However, most participants are currently embracing Agile methods on projects for their companies, meaning that 20.2% have worked with Agile methods for less than a year and 30.33% have around 1 to 3 years of experience in Agile methods and practices. Emphasizing that 44.62% of respondents consider themselves professionals that have intermediate knowledge on the subject and 26.59% claim to have advanced knowledge on Agile methods. Another highlight is on the fact that 59.12% of individuals work for big companies.

B. Structural Model

To verify the quality of adjustments, the R^2 was used to represent in a scale from 0% to 100% how much the independent constructs explain the dependent ones. Therefore, the values below 25% represent a weak explanatory capacity, the ones between 25% and 50% indicate a moderate explanatory capacity and the values above 50% highlight a substantial explanatory capacity [27].

The Gof value [28] was also used to obtain a geometric average of AVE in all constructs and R^2 from the model. Such measure also ranges from 0% to 100%. It is worth emphasizing that when the PLS approach is used, Gof has no capacity to differentiate the valid models from the invalid ones and must not be applied on models with formative constructs [29]. In this case, Gof allows only a roundup of AVEs and R^2 of the model in one statistics, which could be useful for future adherence comparisons of different samples of the model.

Table I presents the endogenous, which are constructs influenced by other constructs and also introduces the exogenous which are constructs capable of influencing the endogenous ones. Table I shows the values found for the structural model, meaning β value, the standard error for β (S.E.(β)), the Confidence Interval (CI), p-value and R^2. Highlighting that the proposed model has a Gof of 37.85%. In addition to that, the Confidence Interval was aligned with the results found by p-value, which points out the validity of these results.

TABLE I
Structural Model Evaluation

Endogenous	Exogenous	β	S.E.(β)	C.I. - 95%	p-value	R^2
Knowledge Management Strategies	Project Management Practices	0.11	0.06	[0.00 ; 0.24]	0.058	26.5%
	Software Development Practices	0.43	0.06	[0.32 ; 0.55]	0.000	
Organizational Learning	Project Management Practices	0.01	0.06	[-0.11 ; 0.13]	0.859	31.3%
	Software Development Practices	0.16	0.06	[0.04 ; 0.28]	0.007	
	Knowledge Management Strategies	0.45	0.05	[0.35 ; 0.55]	0.000	

Through the analysis of the construct "Knowledge Man-

agement Strategies", the results indicated a soft (p-value = 0.058) and positive (β=0.11; [0.00; 0.24]) influence of the construct "Project Management Practices" (PMP) over the construct "Knowledge Management Strategies". In this case, it means that the higher the usage of Agile practices for project management, the higher the usage of strategies for Knowledge Management will be. Moreover, there was a meaningful (p-value = 0.000) and positive (β=0.43; [0.32; 0.55]) influence of the construct "Software Development Practices" (SDP) over the construct "Knowledge Management Strategies". This influence is directly proportional, which means the higher Agile practices to software engineering or software development ones are, the higher the Knowledge Management Strategies will be. Thus, the constructs "Project Management Practices" and "Software Development Practices" were capable of explaining 26.50% of the variability of the construct "Knowledge Management Strategies", which means that there is a moderate explanatory capacity. These data are presented on Figure 2 describing the structural model of this analysis.

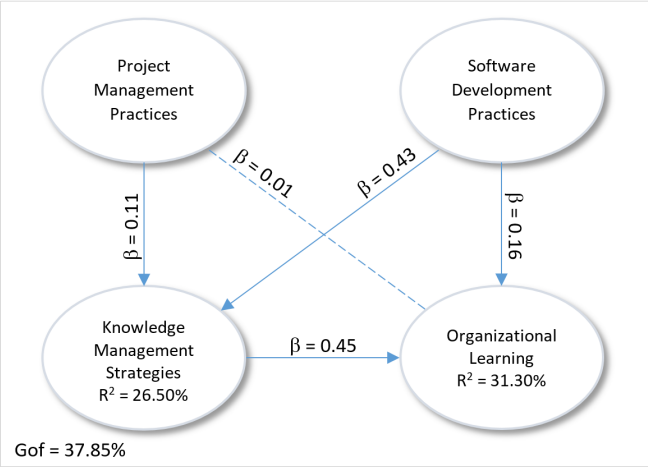

Fig. 2. Structural Model Presentation.

Regarding the construct "Organizational Learning", there was no meaningful influence of the "Project Management Practices" (β=0.01; [-0.11; 0.13]). On the contrary, the results demonstrated meaningful and positive influence (p-value = 0.007) of the construct "Software Development Practices" (β=0.16; [0.04; 0.28]) over the "Organizational Learning". Hence, having high SDP affects directly the Organizational Learning which tends to be high as well. A meaningful and positive influence (p-value = 0.000) of construct "Knowledge Management Strategies" (β=0.45 [0.35; 0.55]) was also identified over the construct "Organizational Learning". Consequently, the growth of "Knowledge Management Strategies" imply the growth of "Organizational Learning". The PMP, SDP and KM Strategies were able to explain 31.30% of the variability in "Organizational Learning", which indicates a moderate explanatory capacity. These data are presented in Figure 2.

C. Analysis of hypothesis

In this section, the proposed hypothesis is discussed and the results are confronted with the literature presented in the introduction of this work.

As presented on Section IV-B, the hypotheses H1 and H3 referring to the influence of the Agile practices adoption over Knowledge Management Strategies, were confirmed. The marginally significant and positive influence between constructs "Project Management Practices" and "KM Strategies" confirm the hypothesis 1. Furthermore, the meaningful and positive result found between constructs "Software Development Practices" and "KM Strategies" confirm hypothesis 3.

Thus, it is possible to state that Knowledge Management Strategies used by teams that adopt agile methods have direct influence due to the set of Agile practices employed by these teams. It is worth mentioning that the results of the study showed that Agile practices such as "practices for software development" [16], [30] present a higher influence over Knowledge Management Strategies. The practices in this group also present further alignment with social aspects concerning KM and provide mechanisms aimed at individual learning [5], [16].

By assessing the results from the H1 and H3 hypotheses, it is possible to relate them with the results obtained in others researches [14], [31]. The hypotheses H2 and H4 refer to the influence of Agile practices in the Organizational Learning process. The results obtained through the questionnaire confirmed only the H4 hypothesis, which points to a meaningful influence of the construct "SDP" over the construct "Organizational Learning". In this respect, the use of Agile practices for software development has direct influence over the process of Organizational Learning although such influence was not confirmed for Agile practices for project management (H2). The confirmation of the H4 hypothesis may be for the reason that the Software Development Pratice (SDP) encourage the knowledge sharing among individuals [24], [25] and provide a set of practices aligned with the social aspects of learning [5]. Additionally, Agile practices and methods require a change in the culture of the organization, that is, it must be guided by learning and constant update [16].

The non-confirmation of the H2 hypothesis diverges from the results reported by authors that consider practices for project management, such as daily meetings and retrospectives, as efficient mechanisms for the process of Organizational Learning [32]. Schwaber and Beedle [31] state that knowledge sharing takes place by four Agile practices of project management (sprint planning, daily meeting, sprint reviews and retrospectives). However, Hoda, Babb and Nørbjerg [13] emphasize that in an environment under pressure for results and deliveries compromise learning due to the lack of ceremonies and Agile practices related to learning.

The confirmation of these hypotheses (H1, H3 and H4) converges with the discussion regarding the nature of Agile methods and practices, which means that agile methods are based on learning processes [12] and Knowledge Management

practices are incorporated into agile practices [1]. Furthermore, software development activities demand that teams constantly produce new knowledge [13] and share it so that success is achieved in software projects [2], contributing for product construction and improvement of the processes kept by organizations.

Finally, the last hypothesis proposed by the hypothetical model (H5) establishes that the use of strategies for Knowledge Management influence directly the process of Organizational Learning. The results from this study lead to a meaningful influence of construct "KM Strategies" over the construct "Organizational Learning", which confirms the hypothesis 5. The application of appropriated Knowledge Management Strategies provide mechanisms for Organizational Learning to take place, meaning that new knowledge is produced and shared among individuals [1], [3]. This process produces a suitable environment for the development of new products and services, and besides that provides means for the improvement of the routines of the organization [21], [22].

D. Discussion

From the results, it was possible to identify the goals of this research. First, (1) to investigate which Agile practices are more frequently used by software development teams, it was verified the frequency in which professionals use practices described as "Agile practices for project management". As for practices described as "agile practices for software development", the results indicated that they are not often used. Only the practices "Unit Testing", "Taskboard", "Single Team", "Continuous Integration", "Collective Code Ownership" and "Coding Standards" were described as usual practices in the daily work of teams. Even though this result demonstrates that most Agile practices of software development are rarely used by the teams, the results from the present study converge with other researches done by companies from the IT area [30]. This outcome helps us reach the first goal of this paper, which consists of identifying the frequency on which Agile practices are used by teams.

Second, (2) to investigate which Knowledge Management Strategies are the most diffused among software development teams that adopt. The data collected in this research demonstrated the Knowledge Management Strategies described as System, Engineering, Organizational and Spatial are present in companies that adopt these methods. Only the use of strategies from Cartographic school [20] got impartial values for the respondents, which demonstrates that the companies do not map the competencies of employees. Even though the participants of this research identified and agreed to most KM strategies, we also identified strategies established by the Behavioral school (Spatial and Organizational) with bigger indexes of concordance than the ones from the Technocratic schools (System and Engineering). These results are justified by the characteristic of the sample obtained through the questionnaire, which was composed by professionals who work in teams that have adopted Agile practices and methods. These results are in conformity with the results of other authors who showed the strategies predicted by Behavioral schools as the most used ones in Agile environments [18], [19], [33], while Technocratic strategies are more present in organizations that use the traditional methods [19].

The last objective, (3) to propose an empirical model capable of measuring the impact caused by the adoption of Agile practices in the Organizational Learning. The fulfillment of this objective allows to answer the proposed research question. From the analysis of the collected data, it was concluded that these practices for project management do not influence significantly the Organizational Learning process. However, the results show that Agile practices for software development have positive and meaningful influence on Organizational Learning. It was also possible to identify that the use of KM strategies have meaningful and positive influence on Organizational Learning. Therefore, agile practices and Knowledge Management Strategies enable to explain the 31.3% of variability in Organizational Learning in software companies. In addition, highlighting that Agile practices (for project management and software development) have meaningful influence on strategies used by Agile teams to Knowledge Management and sharing. The use of Agile practices makes it possible to explain 26.5% of the variability in Knowledge Management Strategies used by the teams.

V. THREATS TO VALIDITY

In this paper, some threats to validity have been identified and some measures have been adopted to mitigate them. The first, the data collection instrument used for this study. There was the possibility that the participants of the research could find difficulties to understand or fill in the questionnaire. In order to prevent this from happening, a previous test was made with the individuals in the same parameters from the original research. From this test, it was possible to measure the average time spent on answering the questions as well as identifying and discussing points for improvement. The items indicated by the individuals taking part in the test were adjusted in the data collection instrument.

The second, the possibility of professionals who were not aware about Agile methods and practices to answer the questionnaire and compromise the data collected. In order to mitigate this, five questions were included in the data collection instrument to characterize the sample. Thus, it was possible to remove from the research database the questionnaires in which participants affirmed having no knowledge concerning Agile methods and practices.

A hypothetical model was proposed seeking to validate it from an empirical research that allows for the generalization of the results obtained. For this reason, the regional character of the data collection was an issue to the research, since the obtained results could express the characteristics of one region of the country instead of the whole software production sector. To prevent this, other than the snowball technique, data collection has been made in three different events in two capitals. Even though data about the work place has not been asked from participants, the events chosen for data collection

have national expression and receive audience from all over the country, especially the Agile Trends event that took place in São Paulo at the occasion of the data collection.

VI. Conclusion

In this study, we proposed a hypothetical model composed by four constructs and conducted a survey with 455 respondents to enable the validation of the the proposed model. The data collected was analyzed from the technique of Structural Equations Modeling (SEM). Thus, with the results of this work it's possible verify that Agile practices have positive and meaningful influence on OL, KM strategies have meaningful and positive influence on Organizational Learning and the Agile practices have meaningful influence on strategies used by Agile teams to Knowledge Management and sharing.

As future work, we suggest the validation of the proposed model, collecting data in companies previously chosen and case studies in these organizations in order to engage in qualitative evaluation when interviewing experienced professionals in Agile methods and practices. Thus, the results obtained in this work may be confronted with the reports of the professionals interviewed. Nevertheless, we can not generate the findings of this study, because the present research was conducted in a specific country, Brazil. Therefore, replication of this survey in others countries is also recommended.

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