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Analysis of Agile Practices Adoption on CMMI Organizations through a Systematic Literature Review

Análisis de la adopción de prácticas ágiles en organizaciones CMMI a través de una Revisión Sistemática de Literatura

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Abstract: In the recent years, the adoption of agile frameworks and methodologies in Software Development Organizations (SDO) has grown up considerably. Unfortunately, the level required of formal documentation in bigger or longer software development projects is not full covered by agile practices alone; likewise, this kind of situations happen frequently in a context of CMMI organizations. The aim of this study is identify, review and analyze the most used agile practices that are being used in combination with CMMI within SDO. To accomplish this, a systematic literature review has been performed according to relevant guidelines. This study has identified multiple practices such as Daily Meeting and Product Backlog management that are being used constantly in combination with CMMI. In addition, we could identify that there are specific benefits of implementing practices from both approaches.

Keywords: Agile Practice, Agile Software Development, CMMI

Resumen: En los años recientes, la adopción de marcos de trabajo y metodologías ágiles en las Organizaciones de Desarrollo de Software (ODS) ha crecido considerablemente, Desafortunadamente, el nivel requerido de documentación formal en proyectos de software más grandes y extensos no es totalmente cubierto por las prácticas ágiles únicamente; de igual manera, este tipo de situaciones ocurren frecuentemente en contextos de organizaciones CMMI. El objetivo de este estudio es identificar, revisar y analizar las prácticas ágiles más usadas que están siendo usadas en combinación con CMMI dentro de una ODS. Para cumplir con el objetivo, una revisión sistemática de literatura ha sido ejecutada de acuerdo a las directivas relevantes. Este estudio ha identificado múltiples prácticas ágiles como Daily Meeting y gestión de Product Backlog que son usadas constantemente en combinación con CMMI. Adicionalmente, se identificaron beneficios específicos al implementar prácticas de ambos enfoques en conjunto.

Palabras Clave: Práctica Ágil, Desarrollo Ágil de Software, CMMI

1. Introduction

The methodologies or process models that have being used on the Software Development Organizations (SDO) have evolved over time; as a consequence of this evolution, in the last years these organizations have considered (with more interest) the adoption of agile practices in software development (Dahlem, Diebold, & Marc, 2014), (Dingsøyr, 2012). This agile approach promotes an easy and fast way of software development where short iterations are scheduled for satisfying customers with product's partial deliveries (Dahlem et al., 2014), (Cockburn, 2002) and (Boehm & Turner, 2003).

On the other side, CMMI (Capability Maturity Model Integration), which is a model that groups best practices in development and maintenance activities (Salinas, Escalona, & Mejías, 2012), (Team, 2010); is a process model that has been adopted by many SDO (Marcal, de Freitas, Furtado Soares, & Belchior, 2007), (Łukasiewicz & Miler, 2012). According to (Omran, 2008), the practices and process adoption from a certain level is relatively a challenge in small companies, that is why the importance of identifying agile practices which in concordance with CMMI could help in software development improvement's process.

The analysis concluded that this study was performed in order to identify agile practices commonly used in contexts of organizations which have already adopted CMMI. In fact, identifying most used agile practices in these kinds of organizations will allow recognizing activities and processes that could get higher benefits when implementing agile and CMMI together. To sum up, the aim of this research is to identify the practices from frameworks and agile methodologies commonly used in CMMI organizations.

To accomplish the goal of this research, a Systematic Literature Review (SLR) (Kitchenham & Charters, 2007) was performed in the relevant digital databases. This study also pretends to identify mappings between agile practices and CMMI processes, primary studies about application of agile practices in CMMI contexts and, finally, researches about adoption of recent agile practices and CMMI.

The remainder of this paper is structured as follows: section 2 presents the background and related work; section 3, the methodology of the SLR; section 4, the identified agile practices and results; and finally, in section 5, it is presented the final discussion and future work.

2. Background and Related Work

On the other hand, there are several studies related with agile practices and CMMI and how these different approaches work together First of all, there are researches of how agile practices could contribute to get CMMI maturity levels (Salinas et al., 2012), (Kähkönen & Abrahamsson, P, 2004). Second of all, there are case studies (Omran, 2008), (Dybå & Dingsøyr, 2008) that describe the consequences of implementing agile practices within an organization with CMMI culture.

On the other hand, in the Silva study (Silva et al., 2015) the authors analyzed the combined use of agile and CMMI through a SLR. This previous research (Silva et al., 2015) only considered studies published up to 2011 and the research questions were mainly focused on benefits and limitations of implementing both approaches. We could identify differences between their and our research. The newest in our research are: (i) verify if team's size affects the combined use of agile and CMMI, (ii) analyze studies and researches published up to 2016, which extends the scope of the previous research (iii) analyze if any agile methodology can be used in contexts of CMMI organizations. Due to these differences mentioned, we consider that this work is needed because it will include new primary studies and also, it will consider all recent agile practices incorporated in CMMI contexts.

This study is a complement to a previous research (Palomino, M., Dávila, A., Melendez, K., & Pessoa, 2016) that was focused also on the agile practices adoption in context of CMMI organizations. This recent research includes a deep analysis on the bibliometric results and it considers one additional research question to the analysis. Also, this research adds more conclusions and discussions on the previous four research questions in order to improve the first approach provided in the previous study.

3. Systematic Literature Review

This section presents the SLR fundamentals taken into account and the application of the review according to the defined review.

3.1 Systematic Review Fundamentals

The research method used is a SLR based on the guidelines and lessons learned proposed by Brereton and Kitchenham (P. Brereton, B. A. Kitchenham, D. Budgen, 2007) (Kitchenham & Charters, 2007). In the figure 1, we can show the three phases described on the guidelines.

As part of Phase 1, Plan Review, it was specified the research questions, which were separated into three bibliometric questions and five research questions.

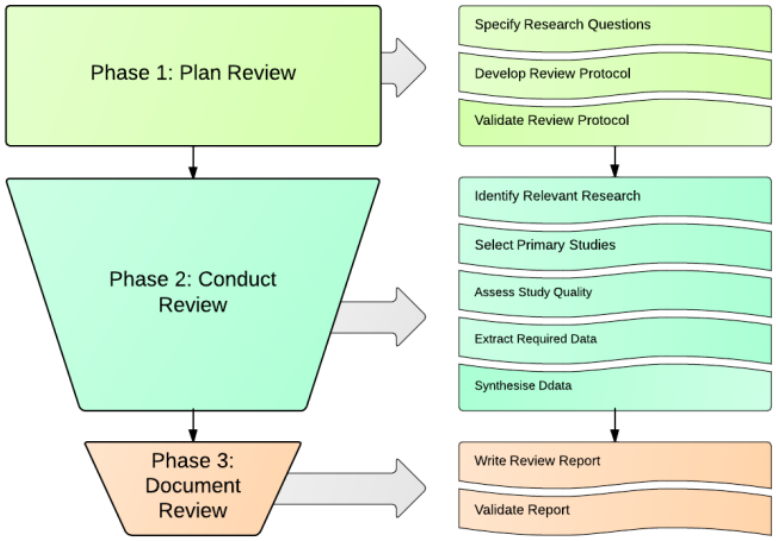

Figure 1. *The SLR Process by Brereton (P. Brereton, B. A. Kitchenham, D. Budgen, 2007)*

The bibliometric questions (BQ) are:

- BQ-1: How was the evolution of number of published articles related with the topic of this research?
- BQ-2: What kinds of researches are presented related with the topic of this research?
- BQ-3: Which are the Conferences, Journals, Digital Libraries with more publications related to the topic of this research?

The research questions (RQ) are:

- RQ-1: Why are agile practices implemented in organizations with CMMI culture?
- RQ-2: Could any agile practice be used in combination with CMMI?
- RQ-3: Is there any influence from the team's size in the agile practices use with CMMI culture?
- RQ-4: Are there primary studies related with the combined use of agile practices and CMMI?
- RQ-5: Are there advantages or disadvantages in the agile practices use with CMMI culture?

In order to frame the research questions and define the search string, it was used the PICOC (Population, Intervention, Comparison, Outcome, Context) criteria

applied to software engineering. The Table 1 shows the main keywords used on PICOC criteria and Table 2 shows the different Search Strings elaborated regarding all Data Sources used.

Population:	Organizations with CMMI and Agile Methodologies
Intervention:	Agile Practice, Activity
Comparison:	None
Outcome:	Analysis, Researches
Context:	Software Engineering

Table 1. *Principal Keywords used based on PICOC Criteria.*

Data Source	Search String
Scopus	("CMMI" or "Capability Maturity Model Integration") AND ABS("Agil*" or "Agile Method" or "Agil* Software" or "Light*" or "Scrum" or XP or "Extreme Programming" or "Scrumban" or "Kanban" or "software development") AND("Practic*" or "Activit*" or "Software Development Practice" or "System Development" or "Application") AND("Research*" or "Mappin*" or "Evaluation*" or "Experience*")
IEEE Xplore	((("Abstract":(agile OR "Agile Methodology" OR scrum OR xp OR light* OR kanban)) AND "Abstract":cmmi OR "capability maturity model") AND "Abstract":software)
Elsevier ScienceDirect	ALL((cmmi or maturity)) and TITLE-ABSTR-KEY(("Agil*" OR "scrum" OR "xp" OR "light" OR "kanban"))[Journals(Computer Science)]
ACM Digital Library	content.ftsec:(cmmi "capability maturity model integration") AND (agile "software development" "Agil* Method*" scrum xp "extreme programming" kanban "light*")

Table 2. *Search Strings*

On the other hand, the automatic search of primary studies was complemented by a manual search in the main repositories and conferences related with Agile and CMMI. The reason of this additional search was that there are several studies and researches of the combined use of Agile and CMMI that have not been published yet in scientific databases, but most of them add a significant value to this research.

3.2 RSL Protocol

A RSL protocol was defined and adjusted later to reduce the possibility of researcher bias. This protocol was structured by six steps that included a first studies selection regarding the execution of Search String in scientific databases plus the original results obtained from the manual search. Then, the articles were analyzed, considering the article Title and Abstract and then the article Introduction and Conclusion. At the end, the final articles were verified by peer review in order to evaluate their exclusion or inclusion in our research.

The exclusion and inclusion criteria considered were:

- Inclusion criteria: Academic articles with methodological basis (mainly experiment, case study, Systematic Reviews, Systematic Mappings). In addition, only papers from sources mentioned in the research were considered. Also, we saw convenient to consider papers in Spanish and English language due to in recent years the agile approach in software development is widely adopted in Latin American companies. Finally, only papers that show the combined use of agile and CMMI approaches were considered. Even if the paper mentions agile practices, we do not use it unless the adoption of those practices is performed within an organization implementing CMMI.

In order to include articles that add significant value to our research, we also considered the reference list from all primary studies.

- Exclusion criteria: Duplicated papers were excluded and the search scope was limited to the following publication types: Journals, Conferences, Magazines, Technical Reports and Books. In addition, we excluded the papers that only show the results of adopting agile practices without considering CMMI contexts.

3.3 Quality Assessment

Quality Assessment of this SLR followed 11 criteria defined by (Dybå & Dingsøyr, 2008) based on (Shea et al., 2007). The following are the criteria used in the Quality Assessment:

- Is this study based on research?
- Is there a clear statement of the aims of the research?
- Is there an adequate description of the context?
- Was the study design appropriate to address the aims of the research?
- Was the selection strategy appropriate to the aims of the research?
- Was there a control group for comparing treatments?
- Was the data collected in a way that addressed the research aims?
- Was the data analysis rigorous enough?
- Has the relationship between researcher and participants been considered as an adequate degree?
- Is there a clear statement of results?
- Is the study relevant for practice or research?

According to (Shea et al., 2007), these mentioned criteria include three important issues related to quality, which were considered in the Quality Assessment:

- Rigor: a complete and adequate approach was applied to key research methods in the study?
- Credibility: are the results in a meaningful and well-presented way?
- Relevance: how useful are the results to the software industry and the scientific community?

For the assessment, each one of the primary studies obtained after inclusion and exclusion criteria of the RSL protocol was analyzed using the 11 questions defined. The scale used in the assessment had two values ("yes" or "no"). When the answer was affirmative, the criteria had a value of "1"; otherwise, the value was "0". As a result, the minimum result could be "0" and "11" as maximum value.

3.4 Data Extraction and Data Synthesis Strategies

The Petersen Guides (K. Petersen S. Mujtaba, 2008) suggest the exploration of some papers sections in case the abstract is not well-structured or vague. For this study and with the aim of answer all of the research questions, all the primary studies selected after last step of the RSL protocol were fully read.
A spreadsheet editor was used in order to elaborate a template for getting the relevant information of all primary studies. This information was helpful for summarizing the data in order to make the data synthesis easier.

The following data were extracted from the primary studies:

- bibliographic References
- type of study (Presentation, Conference, Journal, Technical Report, Magazine, Book chapter)
- editor
- year
- aim of the study
- research question that makes reference
- point of view regarding the research question

Then, the primary studies were grouped in order to associate it in a high level. The aim of this grouping is to identify the main concepts that will allow the answer of the five research questions. In order to conduct the analysis, a narrative synthesis was defined (Popay J Sowden A, Petticrew M, Arai L, Rodgers M, Britten N, 2006); especially the "Grouping and Clustering" as main method.

3.5 Studies Selection

The studies selection process started with the automatic search in November 2015 with the first tests. Then, in January 2016 the last execution was performed. Using a spreadsheet editor, the titles, abstracts and references were selected from all studies obtained after executing the search strings in the digital sources. After this step, a total of 2,265 potential studies were identified. On the other hand, the Manual Search was conducted in December 2015 and January 2016 in order to get relevant studies from journals and conferences specialized in agile approaches. At the end, 110 studies were defined by Manual Search. The initial results are displayed in Table 3.
Then, the duplicated studies were excluded using the list of all 2,375 studies. After that, the titles were revised in order to exclude irrelevant studies. After this step, 299 studies were selected.

Type	Name of Database	Initial Results	Search Date
Automatic Search	IEEE Xplore	736	January, 2016
	ACM Digital Library	236	January, 2016
	Science Direct	215	January, 2016
	Scopus	1,078	January, 2016
Manual Search	Agile Journal, Agile Conferences and SEI Digital Library	110	January, 2016

Table 3. *Data Sources of the Systematic Review*

Then, the abstracts of all 299 potential studies were reviewed in order to exclude the studies that do not consider agile practices and CMMI approaches. After abstract's review, a total of 75 studies were defined. Finally, the introduction and conclusion of all 75 studies were analyzed in order to get all the studies that considers agile and CMMI approaches. At this moment, 47 studies were identified. Finally, the references of the 47 studies were analyzed in order to get additional studies. At the end, 5 more studies were added and a total of 52 studies were identified. The Table 4 shows the 52 studies along with the identifier we used on the research.

ID	Ref
D1	(Clark, 2011)
D2	(Abdel-Hamid & Hamouda, A. E. D, 2015)
D3	(Weller, 2013)
D4	(Potter & Sakry, M., 2009)
D5	(McMahon, 2012)
D6	(Alegria & Bastarrica, M. C, 2006)
D7	(Jakobsen & Sutherland, J, 2009)
D8	(Maller Ochoa, C., & Silva, J, 2005)
D9	(Paulk, 2001)
D10	(Baker, 2006)
D11	(Kovacheva, 2011)
D12	(Sutherland Jakobsen, C. R., & Johnson, K, 2007)
D13	(Aggarwal Deep, V., & Singh, R, 2014)
D14	(Anderson, 2005)
D15	(Bos & Vriens, C, 2004)
D16	(Garzás & Paulk, M. C, 2013)
D17	(de Souza Carvalho, 2011)
D18	(Selleri Silva Santana Furtado Soares, F., 2014)
D19	(Omran, 2008)
D20	(Torrecilla-Salinas Sedeño, J., Escalona, M. J., & Mejías, M., 2016)
D21	(Cohan & Glazer, 2009)
D22	(Santana Furtado Soares & Romero de Lemos Meira, 2015)
D23	(Pikkarainen & Mantyniemi, A, 2006)
D24	(Trujillo Oktaba, H., Pino, F. J., & Orozco, M. J., 2011)
D25	(Miller & Haddad, H. M., 2012)
D26	(Gandomani, 2013)
D27	(Łukasiewicz & Miler, 2012)
D28	(Diaz Garbajosa, J., & Calvo-Manzano, J. A., 2009)
D29	(Marcal et al., 2007)

ID	Ref
D30	(Jakobsen & Johnson, 2008)
D31	(López-Lira Hinojo, 2014)
D32	(Lina & Dan, 2012)
D33	(Morris, 2012)
D34	(Bougroun Zeaaraoui, A., & Bouchentouf, T., 2014)
D35	(Pikkarainen, 2009)
D36	(El Deen Hamouda, 2014)
D37	(Kähkönen & Abrahamsson, P, 2004)
D38	(Gazzan Shaikh, A., 2014)
D39	(Torrecilla-Salinas Sedeño, J., Escalona, M. J., & Mejías, M, 2014)
D40	(Tuan & Thang, H. Q., 2013)
D41	(Marcal de Freitas, B. C. C., Soares, F. S. F., Furtado, M. E. S., Maciel, T. M., & Belchior, A. D., 2008)
D42	(Leithiser & Hamilton, D., 2008)
D43	(Salinas et al., 2012)
D44	(Konrad & McGraw, 2008)
D45	(Boehm Turner's, R., & Network, P. I., 2010)
D46	(Irrazabal Vásquez, F., Díaz, R., & Garzás, J., 2011)
D47	(Turgeon., 2011)
D48	(Glazer Dalton, J., Anderson, D., Konrad, M. D., & Shrum, S., 2008)
D49	(Turner & Jain, A., 2002)
D50	(Santana Gusmão, C., Soares, L., Pinheiro, C., Maciel, T., Vasconcelos, A., & Rouiller, A., 2009)
D51	(Vriens, 2003)
D52	(Mahnic & Zabkar, N., 2007)

Table 4. *Identified Studies*

4. Results

In addition to Research Questions, it was also performed a review of the 52 studies selected in order to analyze the publication years, publication channels and research types of all studies identified at the end of selection process. The following section will display the answer of the Bibliometric and Research Questions defined in previous section.

4.1 BQ-1. How was the evolution of number of published articles related with the topic of this research?

In Figure 2 are the studies that were identified grouped by the publish year. As we can see, the studies were obtained in a 2001-2016 period. It is important to mention that the first three years (2001-2003) were the years with the less number of studies, while 2014 is the year with more studies. In addition, at the end of the 90's, the first versions of XP and Scrum appeared and it is necessary to highlight the importance of these agile methodologies due to the years where the first versions appeared, also appeared studies of the integration of CMMI and agile approaches.

Also, from 2008 to 2014 is the period with most papers. In fact, during this time around 69% of the total studies were obtained. This pattern is caused by the recent interest in agile approaches for the software industry and also the scientific community. It is important to point that the year 2010 has only one study. This result does not represent a trend in the scientific community due to the previous and next years there are numerous articles.

After reviewing all the studies obtained from the first step in the selection process, we could see that several studies were excluded due to the aim of the research. These studies did not display combinations of CMMI and agile approaches and, as a result, were discarded from this research.
Finally, regarding the last two years, from 2015 to 2016 there was not obtained many studies related to the combined use of agile and CMMI approaches. In case of 2016, it is necessary to point that the automatic and manual searches were performed only up to January. Regarding to 2015, it should be noted that in the early stages of selection, numerous articles were obtained, but most of these were not explicitly focused on the combined use of agile and CMMI practices; as a result, those studies were discarded in the following stages of the selection procedure.

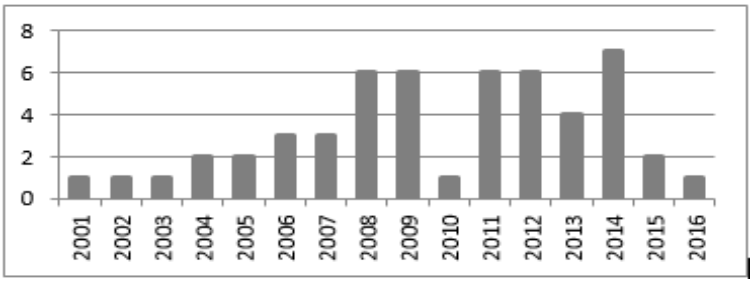

Figure 2. *Number of publications by year*

4.2 BQ-2. What kinds of researches are presented related with the topic of this research?

In Table 5, there is a list with the number of studies grouped by the Research Type. As we can see, the highest number of occurrences is found in Conferences and Journals with a 73% of the total approximately. This high number of occurrences is caused by the execution of search string in recognized scientific databases due to these data sources collect academic researches which are published mainly in specialized conferences or journals.
It is important also to point the studies obtained from book chapters because all of them represents a 15% approximately. This percentage makes this research type an important source to consider in future researches related with CMMI and agile approaches. Finally, the research types with less presence are Magazines and Technical Reports with only 1 study each one.

4.3 BQ-3. Which are the Conferences, Journals, Digital Libraries with more publications related to the topic of this research?

There are various conferences and journals specialized in CMMI and agile approaches (e.g. Agile Conference and Agile Journals). These sources represent 22% of the total of primary studies with 11 elements. Moreover, the rest of the primary studies were published uniformly in the other publication channels.

Research Type	# Occurrences
Conference Paper	26
Journal Paper	12
Book Chapter	8
Presentation	4
Technical Report	1
Magazine	1

Table 5. *Number of studies regarding research type*

The majority of the publication channels had only one primary study. In fact, there are 21 distributed in Conferences, Journals and Workshops; each of these with

only one primary study. This variety between these 21 publication channels proves a real interest in the scientific community regarding the adoption of agile approaches and CMMI.

Finally, in Table 6, there is a list of all publication channels where the 52 primary studies were collected.

4.4 RQ-1. Why are agile practices implemented in organizations with CMMI culture?

First of all, we want to define if both approaches are compatible or not. From the analysis of the 52 primary studies, we could identify that both agile and CMMI approaches are not opposed to each other. In fact, both cultures share similar criteria and practices. From the previous premise, we can affirm that there is a compatibility level between agile and CMMI approaches which is corroborated in the studies [D1], [D3], [D4], [D5], [D6], [D7], [D9], [D12], [D14], [D16], [D17], [D20], [D23], [D28], [D30], [D32], [D34], [D35], [D37], [D44], [D45], [D48], [D49] and [D52] where we could identify that practices from different cultures, such as agile or CMMI, can be complemented each other in order to improve the current processes. Additionally, it proposes that the compatibility level is defined by the organizations. In conclusion, we can affirm that both approaches can coexist but there are some inconveniences mentioned in [D3], [D7], [D24], [D25], [D45] and [D27] that should be considered:

- Keep the agile principles while the agile practices and processes are extended.
- Identify the organization needs for a successful implantation of both approaches.
- Keep the premise that both approaches are complemented each other and there are no practices substituted by others.
- Make sure to combine successfully the maturity approach in the organization and agile approach in the practices.

Due to both agile and CMMI approaches can coexist in a same organization, there is a recent interest from the organizations that even with the CMMI culture decide to get familiar with agile approaches in order to continue improving their processes.

On the other hand, we can see that the adoption of agile practices in organizations with the CMMI approach is not influenced by the CMMI maturity level of the companies. In fact, the studies [D4], [D6], [D28], [D29], [D30], [D37], [D41] and [D43] shows scenarios where the organizations have or try to get levels 2 and 3 from CMMI; whereas in studies [D7], [D12], [D14], [D21] and [D24] there are references to higher maturity levels such as 4 and 5. This indicates that there is

an interest in agile practices regardless the maturity level of the organizations. Also, it is important to point that the organizations with CMMI culture looks to continue to improve not only by using one single agile methodology; in fact, the adoption of agile practices can be done by using a mix of agile approaches in order to get the best of these practices. The studies [D14], [D24], [D34], [D20], [D39], [D43] and [D51] show the multiple agile practices that were used in contexts of CMMI organizations.

Additionally, there are scenarios where the use of agile practices in combination with CMMI is appropriate; for instance, in the studies [D13], [D27] and [D29] there are situations where is recommendable getting certain level of flexibility and agility, which is achieved with agile practices adoption. In fact, in software projects where changes are constant and rapid responses are required as noted in studies [D36], [D28] and [D47], it is recommendable the requirement management proposed by Scrum; furthermore, in web development projects, where the "time to market" is one of the main features, it is necessary to have partial deliveries, which are proposed by agile approaches as we could find from [D20], [D39] and [D43] studies.

Publication Channel	Total
Agile Conference	8
Lecture Notes in Computer Science	4
Agile Journal	3
Crosstalk	3
IEEE	3
Agile Development Conference	2
Communications in Computer and Information Science	2
CLEI Electronic Journal	2
Lecture Notes in Business Information Processing	2
SEI	2
ACM SIGSOFT	1
CISTI	1
Fourth Symposium on Information and Communication Technology	1
ICACCI	1
ICCSEE	1
ICTTA	1
Indian Journal of Science and Technology	1
Information and Software Technology Journal	1
Information Science and Technology	1
Innovations in Systems and Software Engineering Journal	1
Institution of Engineering and Technology	1
International Journal of Mathematics and Computers In Simulation	1
ISD	1
ITNG	1
Journal of Software: Evolution and Process	1
Proceedings of the 46th Annual Southeast Regional Conference on XX	1
QUATIC	1
SCCC	1
Software Engineering Workshop	1
SPICE	1
14th International Conference on Information Integration and Web-based Applications & Services	1

Table 6. *Studies by publication channel*

Finally, we can conclude from the analysis of all 52 primary studies that agile practices are implemented in CMMI contexts because that combination allows the organizations to:

- Reduce the "waste time" inside the team
- Reduce the delivery time of the products
- Increase the team productivity
- Improve the competitiveness of organizations and product's quality
- Include flexibility and agility in the processes of CMMI organizations
- Improve communication with stakeholders using agile practices

4.5 RQ-2. Could any agile practice be used in combination with CMMI?

From the analysis of 52 primary studies we could identify that agile methodologies and practices are characterized mainly because they obey entirely to the agile principles and as long as this principles are respected, as we can see in the studies [D2], [D22] and [D33], any kind of agile practice could be adapted to any context, even those where the organization culture is more traditional.

In the previous Research Question (RQ-1) it was defined that both agile and CMMI approaches can coexist. Using this statement, we could see in the primary studies that there are various agile practices from different methodologies that were implemented in CMMI contexts; in fact, there is also mentioned in [D37], [D39], [D6], [D21] and [D25] that it is possible to get a CMMI certification using agile practices as a starting point.

Regarding agile practices using in CMMI contexts, we identify that in the studies [D3], [D4], [D5], [D6], [D7], [D8], [D9], [D10], [D12], [D16], [D17], [D19], [D20], [D22], [D23], [D24], [D25], [D26], [D27], [D28], [D29], [D30], [D32], [D33], [D34], [D35], [D36], [D37], [D39], [D41], [D43], [D44], [D45], [D47], [D48], [D50], [D51] and [D52], there are some agile practices mentioned. In addition, we could found that in the majority of the studies, Scrum and XP are mentioned. In fact, regarding [D8], [D20], [D39], [D43] and [D52] studies, both methodologies can be complemented each other; whereas Scrum focus in the organization and management, XP focus in the technical area proposing agile development practices. This features makes easier the adoption of agile practices in organizations with CMMI due to in case an improvement at organization or management level is required, using Scrum practices is the best option; whereas if it is required an improvement in development practices, using XP approach would be recommendable.

Due to agile methodologies do not consider formal classifications or levels, the adoption of any agile practice is possible, but it is necessary in some cases, adapting the practice to the organization context.

In addition, there are also scenarios where the use of agile practices are not recommended; for instance, those scenarios where the kind of project requires an in-depth documentation and those where it is necessary to record all changes periodically. In addition, there are similar cases where contractual conditions prevent communication and intense customer involvement. This point was evident in [D17], [D28] and [D52], which using agile practices that demand approach to customers is only possible according to the facilities that customers can give.

It is worth mentioning that the aim of a combined adoption of agile and CMMI approaches is to get adequate synergy for getting the benefits of both. This aim is mentioned in the studies [D28], [D30], [D31], [D32], [D44] and [D48] which states that the success of a combined application will depend on the convergence degree between both approaches.

Finally, from the analysis of 52 studies, we could find that the agile practices applicability is defined by the organization's needs, when the needs are defined correctly and agile principles are considered, there are no restrictions on the use and adaptation of certain agile practices unless the application of some of them are conditioned by the project or organization context. Next, in Table 7, there are all agile practices which are mentioned or referred in the primary studies.

4.6 RQ-3. Is there any influence from the team's size in the agile practices use with CMMI culture?

The agile approach is distinguished due to, among others, it proposes intensely the interaction of team members; in fact, the success of the applicability of these practices is based on trust and compromise reached within teams [D47]. This feature negatively influences in the correct functioning of agile practices in scenarios where teams are larger, since as the team grows, it requires more robust and stable channels to allow free flow of communication. That's why in [D17], [D36], [D29] and [D32] are mentioned, for example, that small teams are ideal for implementing agile practices.

Agile practice	Primary Studies
Daily Meeting	[D1], [D4], [D5], [D7], [D8] [D33], [D34], [D52]
Burndown Charts	[D2], [D4], [D13], [D14], [D24] [D28], [D52]
Story Points	[D13], [D21], [D28], [D36]
Sprint Meetings	[D4], [D17], [D24], [D28] [D30] [D43], [D45], [D52]
Retrospectives	[D13], [D21], [D24], [D35] [D43], [D45]
Backlog Management	[D7], [D8], [D12], [D13], [D17] [D21], [D24], [D28], [D34] [D43], [D45]
Continue Integration	[D8], [D34], [D39], [D50]

Table 7. *Agile practices mentioned in primary studies*

Usually, small and medium-sized organizations face more challenges in adopting complex models such as CMMI, so in [D19], [D37], [D41] referred to the benefits that small organizations obtain by implementing agile practices based on the practices defined in CMMI. The processes definition and practices based on CMMI, but adapted to the context of a small organization, enables organizations to consider a CMMI certification in the future.

Additionally, [D48] and [D44] studies mention an important factor besides the team size, this factor is the location of the team members, and it is recommended that teams that implement agile practices should be in the same location because it requires intense communication and interaction among members. In contrast, CMMI provides an organizational infrastructure that allows successful projects with distributed teams, these types of teams can negatively influence in the adoption of agile practices in CMMI contexts.

4.7 RQ-4. Are there primary studies related with the combined use of agile practices and CMMI?

With this RQ we pretend to analyze the interest of the scientific community on the combined use of agile and CMMI practices. To answer this question the results obtained in the selection step were analyzed. As shown in Appendix A, they were 52 primary studies obtained after the selection process. This is a great sign that there is a widespread interest from industry, since it is a large number of studies to analyze in a SRL. Additionally, if we refer to the BQ-1, BQ-2 and BQ-3, we can see that the interest is not only recent; in fact, there is a constant interest over the last 10 years.

As evidenced in the RQ-1, it is possible to combine both agility and maturity approaches since it is beneficial for an organization either it has traditional schemes such as CMMI or being an organization based on agile methodologies. Both types of organizations, as shown in several studies from 52 obtained, are constantly adapting in order to generate competitiveness; allowing them to be

sustainable over time. Along with the previous reason, the scientific community is in the research and development of empirical studies in order to demonstrate the benefits of using both approaches.
Moreover, the interest of the scientific community can also be seen in the numerous studies that refer to mappings between agile and CMMI practices in different maturity levels. These mappings between some practices are carried out with the aim of facilitating the adoption of them in organizations that require it. In Table 8 there is a list of all studies that we could find mappings between CMMI and agile practices according to CMMI level that is referred.

CMMI Maturity Level	Primary Studies
CMMI Level 2	[D4], [D6], [D9], [D27], [D28], [D29] [D32], [D41], [D47], [D50]
CMMI Level 3	[D8], [D14], [D27], [D29], [D34], [D39] [D47], [D50]
CMMI Level 4	[D21], [D29]
CMMI Level 5	[D21]

Table 8. *Primary studies with agile and CMMI mappings*

4.8 RQ-5. Are there advantages or disadvantages in the agile practices use with CMMI culture?

From the analysis of 52 primary studies, it has been fully identified that both approaches working together significantly contribute to improving productivity of the organizations that implement them. In addition, it is noted that in the way agile practices are adapted using different methodologies in the context of CMMI, the benefit is even greater because recognized engineering practices by CMMI are used with additional flexibility and speed that agile practices provide.

In studies [D28], [D32], [D43], [D47], [D24] and [D22] we found that not having established a flexible structure that allows response immediately to the constant changes is a main drawback in organizations with CMMI. Getting the ability to respond to changes in a fast way increases the competitiveness of SDO.

On the other hand, in studies [D12], [D19] and [D51], there are scenarios where organizations with agile practices require some formality in organizational infrastructure to meet the guidelines that customers may require. This formality, as can be analyzed in the studies, is possible to get by the combined use of agile practices and CMMI. From the previous statement, we can affirm that using both approaches together not only benefits organizations with CMMI, but also organizations whose processes and practices are based entirely in agile methodologies.

Furthermore, from studies [D24], [D25], [D27], [D32], [D33], [D35] and [D39] we can identify the following benefits of using a mix of agile and CMMI approaches:

- Reduce delivery times
- Improve quality of delivered product
- Improve stability of agile teams in organizational processes
- Include flexibility and agility in the processes of CMMI organizations
- Efficient implementations of CMMI when using agile principles
- Improve communication with stakeholders using agile practices
- Reduce defects

Finally, regarding the disadvantages of a combined adoption of agile practices and CMMI, it can be analyzed from the primary studies [D43] and [D48] that by combining both approaches with different principles, there is a risk of affecting the current defined processes. Additionally, it was observed from studies that in some situations the teams modify the agile practices regardless the agile principles; as a consequence, the practices are not well-defined and it ends up generating discomfort on team members due to additional work.

5. Conclusion and Future Work

It can be concluded that there is an interest from industry and scientific community regarding the integration of agile and CMMI approaches. Both were considered by the software industry as guidelines with opposite principles and, in some circumstances, incompatible; however, we have found in recent researches that both share the same goals and that may converge to contribute beneficially to the organizations.

This compatibility between agile and CMMI approaches can take the best of both cultures because it is recognized that agile guidelines provide flexibility that enables organizations to respond to the constant changes, particularly in the management of requirements; on the other hand, organizations with agile guidelines are benefit from CMMI because they incorporate good practices that add formality in organizational infrastructure. On the other hand, we could verify that there are studies that indicate it is possible to get certification in the first CMMI maturity levels through the use of agile practices. In addition, using various practices from different agile methodologies allows organizations to apply for even higher maturity levels of CMMI.

During the SLR, there were validations in the planning and the methodology used. These validations were performed by other members of the project but despite peer review and assurance of the methodological framework, we have considered situations that can influence on the results and conclusions obtained. The main identified threat was the selection bias, because research results are conditioned by the proper selection of primary studies. The omission of any of the studies that

can contribute to research is one of the most important threats to take into consideration.

Finally, in this study, a SLR was conducted in order to analyze studies about combined agile and CMMI approaches. From the research of RSL, we could find that there could be a further work related to the empirical validation of what is stated in the analysis of 52 primary studies. In addition, there could be future works about the verification of advantages and disadvantages in the use of both agile and CMMI approaches; as well as, the review of more successful cases of organization that mixes both guidelines.

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