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Escuela de Posgrado

SYSTEMATIC MAPPING OF SOFTWARE ENGINEERING MANAGEMENT WITH AN AGILE APPROACH

Trabajo de Investigación para obtener el grado académico de Maestro en Informática que presenta:

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Informe de Similitud

Yo, **Hernán NINA HANCO**, docente de la Escuela de Posgrado de la Pontificia Universidad Católica del Perú, asesor del trabajo de investigación titulada **"**SYSTEMATIC MAPPING OF SOFTWARE ENGINEERING MANAGEMENT WITH AN AGILE APPROACH**"**, del autor **David Brando MAUTINO RUBIO**, dejo constancia de lo siguiente:

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DEDICATORIA

Dedico este trabajo principalmente todas las personas que ya no se encuentran con nosotros, como Eder Mautino y Lombardo Mautino, muchos han dejado una huella irremplazable en nuestras vidas. A mi madre, por darme su apoyo incondicional. A mi padre, que a pesar de los fuertes problemas suscitados en los últimos años no se ha dado por vencido y continúa luchando.

David Brando Mautino Rubio

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Agradezco a Dios por darme fuerzas para superar obstáculos y dificultades a lo largo de toda mi vida.

A mis asesores Dr. Hernan Nina y Dr. Jose Pow Sang, por su enorme apoyo y valiosa guía en todo este arduo camino.

David Brando Mautino Rubio

RESUMEN

El enfoque ágil ha generado una amplia variedad de estrategias para administrar con éxito diversos proyectos de software en todo el mundo. Además, podemos asegurar que los proyectos de software se han beneficiado de los métodos ágiles ya conocidos. En este sentido, este artículo busca demostrar cómo se aplica el enfoque ágil en las áreas de la gestión en la ingeniería del Software. Para ello, este estudio realiza un mapeo sistemático para identificar las principales tendencias en la gestión de la ingeniería de software con un enfoque ágil. Se han identificado un total de 1137 artículos, de los cuales 165 son relevantes para los fines de este estudio, estos indican que la entrega temprana de valor, un principio clave de la agilidad, sigue siendo la principal tendencia para el uso de métodos ágiles. Sin embargo, también existen fuertes tendencias enfocadas en puntos clave de la gestión en ingeniería de software, como optimizar la gestión de calidad, optimizar la especificación de requisitos, optimizar la gestión de riesgos y mejorar la comunicación y coordinación del equipo, estos resultados permitirán generar nuevas líneas de investigación para cada punto clave de la gestión en la ingeniería del software impactado por el enfoque ágil.

ABSTRACT

The agile approach has generated a wide variety of strategies to successfully manage various software projects worldwide. In addition, we can ensure that software projects have benefited from the already known agile methods. In this sense, this article seeks to demonstrate how the agile approach is applied in Software engineering management areas. To do this, this study performs a systematic mapping to identify the main trends in software engineering management with an agile approach. A total of 1137 articles have identified, of which 165 are relevant for the purposes of this study, these indicate that early value delivery, a key principle of agility, continues to be the main trend for the use of agile methods. However, there are also strong trends focused on key points of management in software engineering, such as optimize quality management, optimize requirements specification, optimize risk management, and improve team communication and coordination, these results will allow generating new lines of research for each key point of management in software engineering impacted by the agile approach.

Keywords. - Agile Methods, Software Engineering Management, systematic mapping review, Software Development Life Cycle, Software project management

INDEX

FIGURES INDEX

TABLES INDEX

1. INTRODUCTION

In recent years, the agile approach is considered essential for the Software projects early delivery, for its adaptation to complex goals, evolution over time and responsiveness to scant information that the scope definition could has. These have been used in several small, medium, and large projects [1] showing a high percentage of adoption from 27 percent in 2020 to 86 percent in 2021 [2]-[3], the using of an agile approach in decision making, implementation of frameworks in the team and support of agile tools allows adaptation to business rapid changes [4]. Its impact and success are such that companies seek to adapt to change and make the most of it, it is only necessary to observe the Chaos Report [5] to understand the agile impact on software projects. However, given the various variants of agile methodologies and techniques, there is a growing interest in identifying the most appropriate according to the project or organization. To do this, it is correct to start by observing trends in projects and organizations.

On the other hand, Software project management, defined by the SWEBOK as "the application of management activities (planning, coordination, measurement, monitoring, control, and reporting) to ensure that software products and software engineering services are delivered efficiently, effectively and for the benefit of stakeholders" [6, p.7-1], has been defined empirically, based on the various projects successfully executed throughout history. For this reason and due to the complexity involved in the management of Software projects, there are specialized guides that provides the guidelines allow us to achieve or approach the objective scope of a project. [6]-[7].

The area of Software engineering management is "the application of management activities to plan, coordinate, measure, monitor, control and report" [6]-[7], this definition abstracts from the concept of project management and centralizes it in the branch of software engineering. It is structured in the key subareas defined by the SWEBOK as "Definition of initiation and scope, Planning of Software Projects, Enactment - Review and Evaluation of Software Projects, Closing, Measurement of Software Engineering and Software Engineering Tools" [6, p.7-2]. In the mentioned subareas, it is indicated that the first step is to select an adequate SDLC model and adapt it to the scope, requirements and a risk assessment of the project [6]. SDLCs include waterfall, incremental, and spiral models plus various forms of agile software development [8], such as Scrum, Rapid Application Development (RAD), Extreme Programming (XP), and Feature-Driven Development (FDD) [6]. However, in recent years it has been shown that the agile approach is not focused only in the SDLC. Rather, they can be used for scope definition, risk management, quality management, time estimation, monitoring and control, etc.

On another front associated not only with software projects, the PMBOK® GUIDE - 7 Edition [7], which provides the guidelines to follow for project management in general, has undergone quite a big change compared to its previous editions, it removes its predictive nature and focus on processes, and is now based on principles that allow for more adaptive/agile management,

with a focus on delivering ongoing value to the organization or project.

Therefore, it is observed that the most representative standards already consider agile methods as a potential solution in software project management. This document identifies the management strategies with the most representative modern agile approach in the various articles, projects, and studies, evaluating their impact on the management of software engineering, for which an analysis of the various publications and relevant studies in the databases is carried out. most representative data such as SCOPUS, IEEE, Web of Science and ACM. For this, the structure of the document will have the following detail: Part I introduction, part II defines the research methodology, part III shows the systematic mapping study results, and part IV shows the conclusions and future work.

2. RESEARCH METHODS

It was discovered during the initial examination of the topic, Software Engineering Management with Agile Approach, that was very broad. For this reason, it was decided a literature review in the form of a systematic mapping study. According to Kitchenham and Charters [9], "it is suitable for obtain an overview of a large topic and can give us more specific research questions".

Some steps of systematic mapping related to software engineering include [11]. Likewise, figure 1 presents the steps carried out for the systematic mapping in this study.

In software engineering management we use definitions from the SWEBOK-Body of Knowledge [6] and Software Engineering [10].

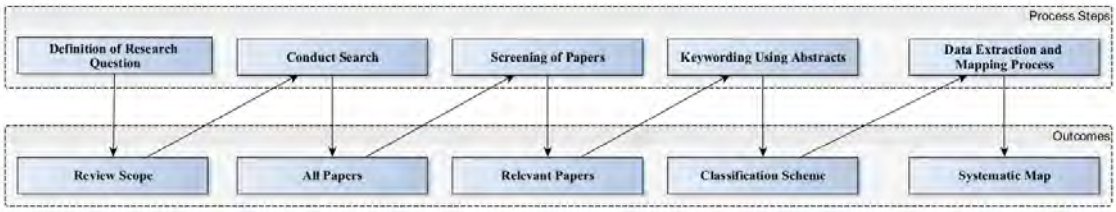

Figure 1. Process steps for systematic mapping studies [11].

2.1 Definition of Research Question

In the next phase, to define the general concepts, the PICo technique was used [12].

After defining the criteria, interest and context the following 7 research questions were formulated (Table 2).

Table 1. PICo process

Concept	Description
Population	Agile software projects
Interest	Software project management
Context	Software industry or academics

Table 2. Research questions.

ID	Research Question
RQ1	What are the main types of articles for software project management with agile approach?
RQ2	What are the main trends in software project management with agile approach according to the country of publication?
RQ3	What are the main trends in software project management with agile approach?
RQ4	What methods are most used in the software project management with agile approach according to its dimension?
RQ5	What techniques prevail in the software project management with agile approach?
RQ6	What agile artifacts are the trend in software project management with agile approach?
RQ7	What tools are trending in software engineering management with an agile approach?

2.2 Conduct Search

In the next phase, the following bibliographic databases were used: SCOPUS, IEEE Xplore, Web of Science and ACM Digital Library.

The search in the databases followed the following pattern of terms grouped according to the study criteria (Table 3).

Considering this, the following query strings were designed (Table 4)

Articles published from the year 2018 onwards are considered. Considering that in the year 2017 was published the Systematic literature reviews in agile software development: A tertiary Study [13]. It concludes that some topics can benefit from more future studies, that include evaluating benefits and challenges of ASD (Agile Software Development) methods, agile hybrids in large-scale setups, sustainability, motivation, teamwork, and project management [13]. Therefore, this study focused on software engineering management, to provide relevant information for future researchers:

Table 3. Terms grouped according to the study criteria.

Concept	Terms
Population	- Agile Method - Agile Methodology - Agile Framework - Extreme Programming - XP - Scrum - Dynamic Systems Development Method - DSDM - Rapid Software Development - RAD - Feature-Driven Development - FDD
Interest	- Management
Context	- Software Project - Software Engineering - Software Development - Software Construction

Table 4. Search String by database

Database Name	Code
SCOPUS	TITLE-ABS-KEY(("Software Project" OR "Software Engineering" OR "Software Development" OR "Software Construction") AND ("Agile Method" OR "Agile Methodology" OR "Agile Framework" OR "Extreme Programming" OR "XP" OR "Scrum" OR "Dynamic Systems Development Method" OR "DSDM" OR "Rapid Software Development" OR "RAD" OR "Feature-Driven Development" OR "FDD") AND ("Management"))
IEEEXplore	(("Document Title":"Software Project" OR "Document Title":"Software Engineering" OR "Document Title":"Software Development" OR "Document Title":"Software Construction") AND ("Document Title":"Agile Method" OR "Document Title":"Agile Methodology" OR "Document Title":"Agile Framework" OR "Document Title":"Extreme Programming" OR "Document Title":"XP" OR "Document Title":"Scrum" OR "Document Title":"Dynamic Systems Development Method" OR "Document Title":"DSDM" OR "Document Title":"Rapid Software Development" OR "Document Title":"RAD" OR "Document Title":"Feature-Driven Development" OR "Document Title":"FDD") AND "Document Title":"Management") OR ("Abstract":"Software Project" OR "Abstract":"Software Engineering" OR "Abstract":"Software Development" OR "Abstract":"Software Construction") AND ("Abstract":"Agile Method" OR "Abstract":"Agile Methodology" OR "Abstract":"Agile Framework" OR "Abstract":"Extreme Programming" OR "Abstract":"XP" OR "Abstract":"Scrum" OR "Abstract":"Dynamic Systems Development Method" OR "Abstract":"DSDM" OR "Abstract":"Rapid Software Development" OR "Abstract":"RAD" OR "Abstract":"Feature-Driven Development" OR "Abstract":"FDD") AND "Abstract":"Management" OR ("Index Terms":"Software Project" OR "Index Terms":"Software Engineering" OR "Index Terms":"Software Development" OR "Index Terms":"Software Construction") AND ("Index Terms":"Agile Method" OR "Index Terms":"Agile Methodology" OR "Index Terms":"Agile Framework" OR "Index Terms":"Extreme Programming" OR "Index Terms":"XP" OR "Index Terms":"Scrum" OR "Index Terms":"Dynamic Systems Development Method" OR "Index Terms":"DSDM" OR "Index Terms":"Rapid Software Development" OR "Index Terms":"RAD" OR "Index Terms":"Feature-Driven Development" OR "Index Terms":"FDD") AND "Index Terms":"Management"
Web of Science	TS= (("Software Project" OR "Software Engineering" OR "Software Development" OR "Software Construction") AND ("Agile Method" OR "Agile Methodology" OR "Agile Framework" OR "Extreme Programming" OR "XP" OR "Scrum" OR "Dynamic Systems Development Method" OR "DSDM" OR "Rapid Software Development" OR "RAD" OR "Feature-Driven Development" OR "FDD") AND "Management")
ACM DL	Title:((("Software Project" OR "Software Engineering" OR "Software Development" OR "Software Construction") AND ("Agile Method" OR "Agile Methodology" OR "Agile Framework" OR "Extreme Programming" OR "XP" OR "Scrum" OR "Dynamic Systems Development Method" OR "DSDM" OR "Rapid Software Development" OR "RAD" OR "Feature-Driven Development" OR "FDD") AND "Management")) OR Abstract:((("Software Project" OR "Software Engineering" OR "Software Development" OR "Software Construction") AND ("Agile Method" OR "Agile Methodology" OR "Agile Framework" OR "Extreme Programming" OR "XP" OR "Scrum" OR "Dynamic Systems Development Method" OR "DSDM" OR "Rapid Software Development" OR "RAD" OR "Feature-Driven Development" OR "FDD") AND "Management")) OR Keyword:((("Software Project" OR "Software Engineering" OR "Software Development" OR "Software Construction") AND ("Agile Method" OR "Agile Methodology" OR "Agile Framework" OR "Extreme Programming" OR "XP" OR "Scrum" OR "Dynamic Systems Development Method" OR "DSDM" OR "Rapid Software Development" OR "RAD" OR "Feature-Driven Development" OR "FDD") AND "Management"))

2.3 Screening of papers

In this phase, the following process (Figure 2) was applied, using the criteria in (Table 5), to the studies selected in the queries to the databases.

After applying the same process in each study, 165 relevant articles (See Appendix A) were selected (Table 6).

Figure 2. Study Selection

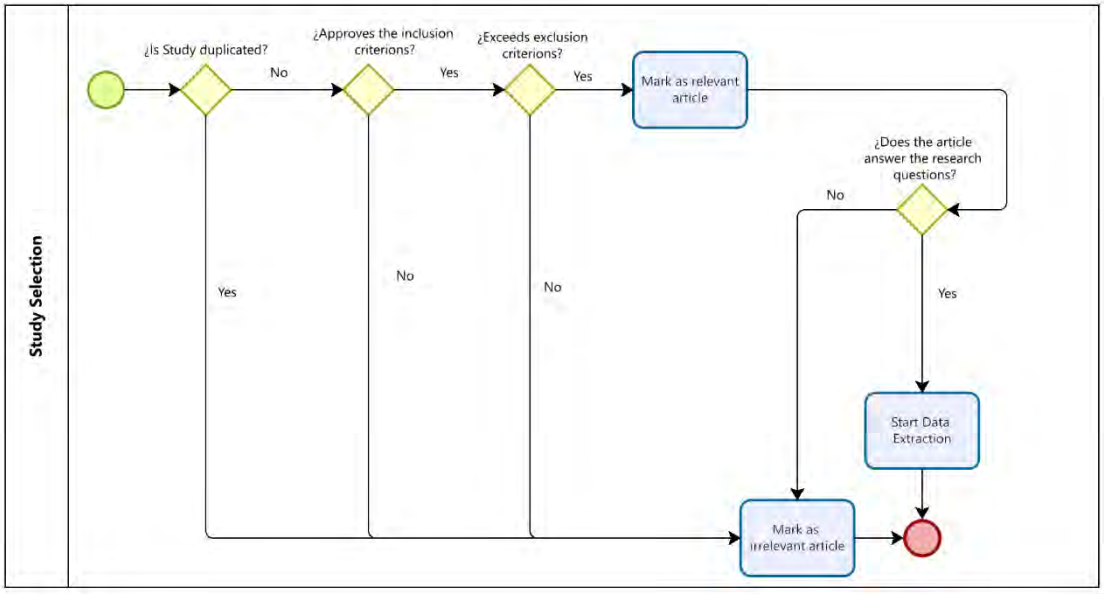

Table 5. Inclusion and Exclusion criteria.

Type	Nro	Criterion
Inclusion	**1**	Articles in which agile methods are used in software projects management.
	2	Articles that are in the field of software engineering
	3	Articles that were peer-reviewed at conferences or journals
	4	Articles that are in the English, Spanish or Portuguese languages.
	5	Articles that have been published between the year 2018 - 2022
Exclusion	**1**	Articles related to software projects with pure traditional approach.
	2	Articles related to software projects that do not indicate the agile method used.
	3	Articles that are Literature Reviews.
	4	Articles related only to hardware projects for software use.

Table 6. Summary of results.

Database Name	Search Results	Duplicated Papers	Relevant Papers
SCOPUS	640	0	120
IEEE Xplore	323	72	39
Web of Science	151	66	6
ACM DL	23	16	0
Total	**1137**	**154**	**165**

2.4 Keywording of Abstracts

For data extraction, information detected in the Abstracts and/or results of the articles, was registered the classification scheme (Figure 3), which is based on the trends observed in the relevant studies and on the following definitions:

Studies

In the case of the studies, it was observed necessary to identify characteristics that can provide greater detail on the types of study, types of validation and the demographic trend by country of the relevant articles, for which recommendations such as the proposal in the article used the existing classification of research approaches [14] and a demographic approach by country.

Software Engineering Management.

The definition described in the Software Engineering Management section of the SWEBOK [6] was used, considering:

- Software engineering management activities happens in the management of these three levels: organizational and infrastructure, project, and of the measurement program.
- Breakdown of topics for Software Engineering Management. (Figure 5)
- Main trends in software engineering management, and their relationship with the previous points Software Engineering Management Levels (Figure 4) and Software Engineering Management Activities or Topics (Figure 5).

Management Tools

The definition used of management tools described in the SWEBOK [6] for Software Engineering Management Tools and in Agile for Project Managers [15] for Agile Tools.

Agile Approach

The definition used of agile methods described in Managing and leading software projects [8] and in Agile Development at Scale: The Next Frontier [1].

Regarding agile artifacts, which are the development artifacts so far considered in agile development, the definition was used is [16], that indicates should be organized into three artifact categories:

- Requirements Specification: This documents contain all the information that is useful for a optimal understanding of what should be implemented.
- User Story: These are requirements documents that are not necessarily formal.
- Project Artifacts: There are three types:
    - Architectural Design: According to the ISO Standard 42010, this is about the “fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution” [17].
    - Test Specification: A group of conditions that confirm if the software is working as specified.
    - Source Code: Executable that must initialize the system detailed in the requirements specification, the user

stories, and the architectural design.

Finally, for the classification of agile techniques used in projects with an agile approach, the concepts used in Managing and Leading Software Projects [18] to generate the classification.

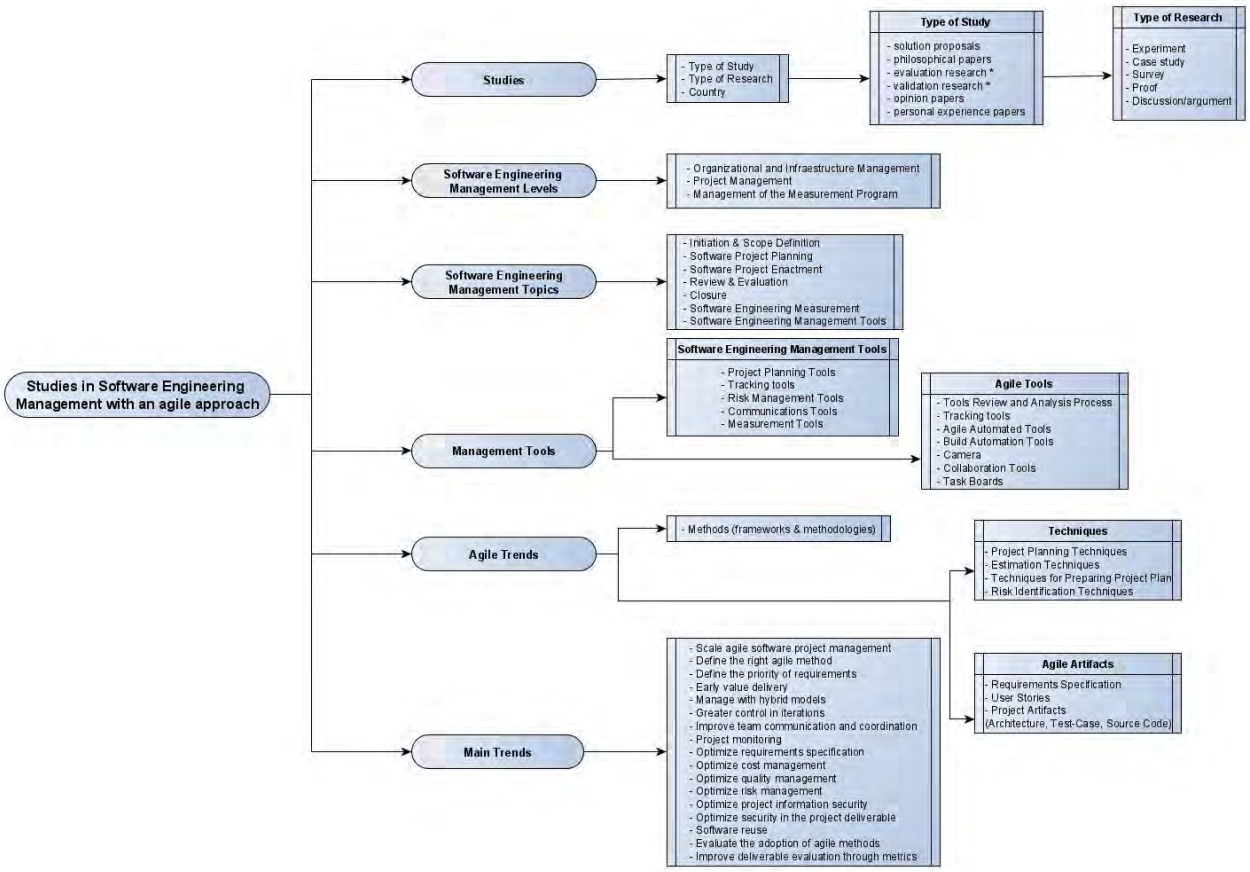

Figure 3. Classification scheme for data extraction

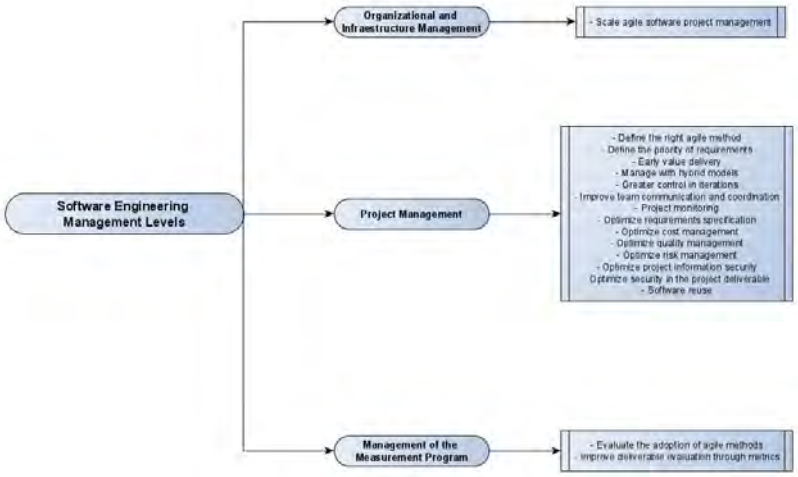

Figure 4. Main trends vs top topics for Software Engineering Management Level

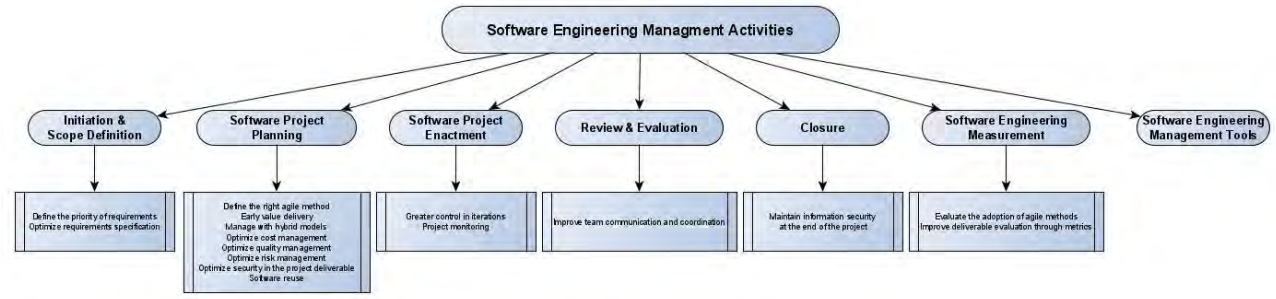

Figure 5. Main trends vs top topics for Software Engineering Management Activities

2.5 Data Extraction and Mapping Process

In this step, a procedure very similar to [19] was used.

An Excel was used as a repository of the relevant articles, for each article it was included: title, abstract, key words, author(s), document type, type of study, publication year and country in which it takes place.

In the process of completing the classification of the articles, new categories or subcategories were added, or were also removed if not have been useful [19].

With the information obtained, we proceeded to group the information to calculate the frequencies and design the graphs to answer the questions research.

3. RESULTS AND ANALYSIS

This part shows the results for each research question and provides more information of the software engineering management with agile approach trend. To determine the relevant aspects of the topic, the defined in Keywording of Abstracts section was used.

3.1 RQ1. What are the main types of articles for software project management with agile approach?

The classification used to determine the types of articles was based on the article used the existing classification of research approaches [14]. Based on this, Figure 6 shows the segmentation of article types based on percentages, resulting in the following detail for the 165 relevant articles: solution proposals (39 Articles-24%), philosophical papers (0 Articles-0%), evaluation research (88 Articles-53%), validation research (25 Articles-15%), opinion papers (0 Articles-0%) and personal experience papers (13 Articles-8%).

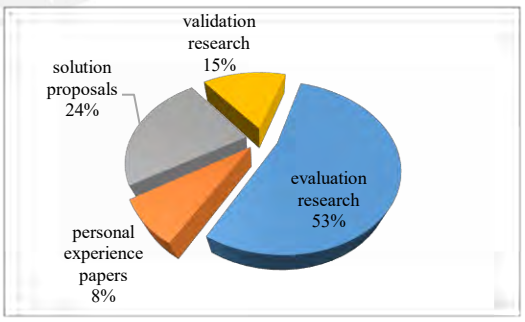

Figure 6. Classification by type study

In the types of articles evaluation research or validation research types, there is a subclassification. Figure 7 shows the segmentation mentioned for

the 114 articles that comply with the research type, showing the following result Experiment (24 Articles-21%), Case study (53 Articles-47%), Survey (31 Articles-27%), Proof (6 Articles-5%) and Discussion/argument (0 Articles-0%).

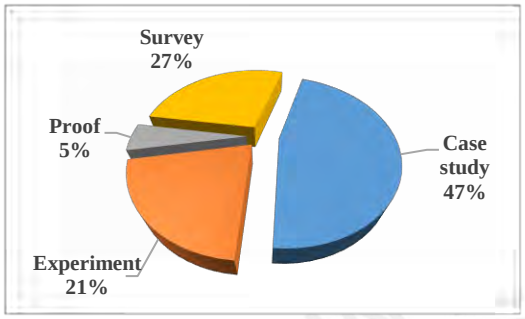

Figure 7. Classification by type of research

3.2 RQ2. What are the main trends in software project management with agile approach according to the country of publication?

Regarding the following geographical research question, used a classification by continents. The result obtained from the 165 articles is in Figure 8 and Figure 9 is a summary by continent.

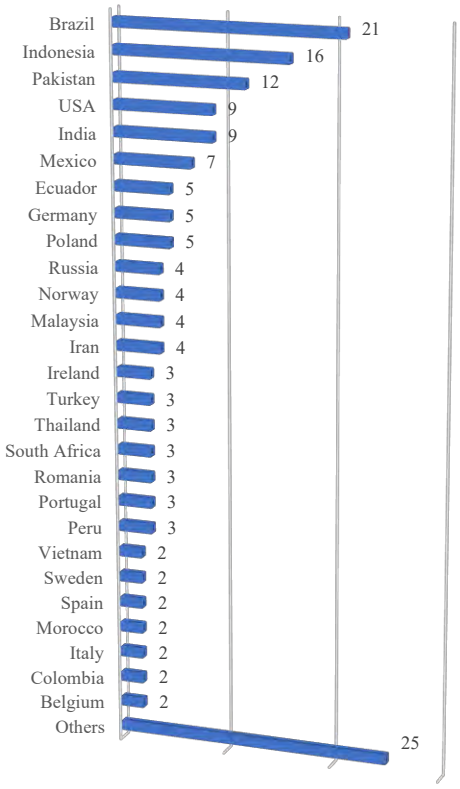

Figure 8. Classification according to the country of publication.

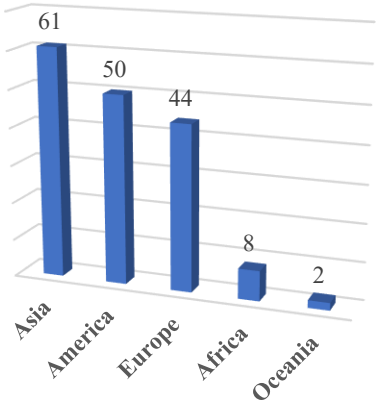

Figure 9. Classification according to the continent of publication.

A greater number of articles are in the Asian continent (61), followed by America (50) and Europe (44). In smaller quantity articles are in Africa (8) and Oceania (2).

3.3 RQ3. What are the main trends in software project management with agile approach?

First, the keywords in the articles related to Software Engineering Management defined in the SWEBOK [6] were identified, based on this, 17 main trends were generated.

Next, the main trends detected in relevant articles are in (Table 7).

The main trends in the software engineering management with agile approach are classified on the following categories: 1) Optimize quality management, 2) Early value delivery, 3) Optimize risk management, 4) Scale agile software project management, 5) Improve team communication and coordination, 6) Manage with hybrid models, 7) Optimize requirements specification, 8) Improve deliverable evaluation through metrics, 9) Define the priority of requirements, 10) Define the right agile method, 11) Project monitoring, 12) Greater control in iterations, 13) Optimize cost management, 14) Software reuse, 15) Maintain information security at the end of the project, 16) Evaluate the adoption of agile methods, 17) Optimize security in the project deliverable. Table 7 shows the number of main trends mention in the articles.

Table 7. Number of Main trends in article

N°	Main Trend	Frequenty of Mention	Percentage vs Total Studies
1	Early value delivery	35	21,2%
2	Optimize quality management	29	17,6%
3	Optimize requirements specification	26	15,8%
4	Optimize risk management	25	15,2%
5	Improve team communication and coordination	25	15,2%
6	Scale agile software project management	21	12,7%
7	Manage with hybrid models	19	11,5%
8	Optimize cost management	7	4,2%
9	Improve deliverable evaluation through metrics	6	3,6%
10	Define the priority of requirements	4	2,4%
11	Define the right agile method	4	2,4%
12	Project monitoring	3	1,8%
13	Evaluate the adoption of agile methods	3	1,8%
14	Greater control in iterations	3	1,8%
15	Software reuse	2	1,2%
16	Maintain information security at the end of the project	1	0,6%
17	Optimize security in the project deliverable	1	0,6%
	Totals	**214**	**165 - 100%**

Then, we associate the Software Engineering Management Levels with their respective relationship (Figure 10), such as Organizational and Infrastructure Management, Project Management and Management of the Measurement Program, the total universe of 165 relevant articles included in the classification.

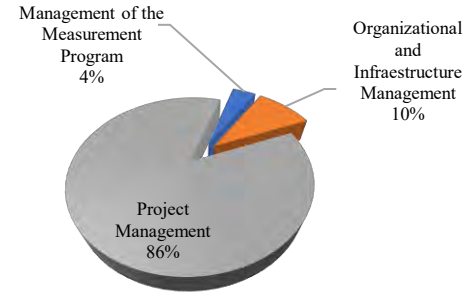

Figure 10. Classification by Software Engineering Management Levels

In the graph, you can see a greater focus on the Project Management level (86%), followed by the Organizational and Infrastructure Management (10%) and Management of the Measurement Program (4%).

Then, the results obtained in the trends classified with their respective relationship to the Software Engineering Management Activities, which in summary covers the levels already mentioned Project Management and Management of the Measurement Program, such as Initiation & Scope Definition, Software Project Planning, Software Project Enactment, Review & Evaluation, Closure, Software Engineering Measurement and Software Engineering Management Tools, a total of 152 of the 165 relevant articles were included in the classification, the 13 remaining articles are only classified and focused on Organizational and Infrastructure Management.

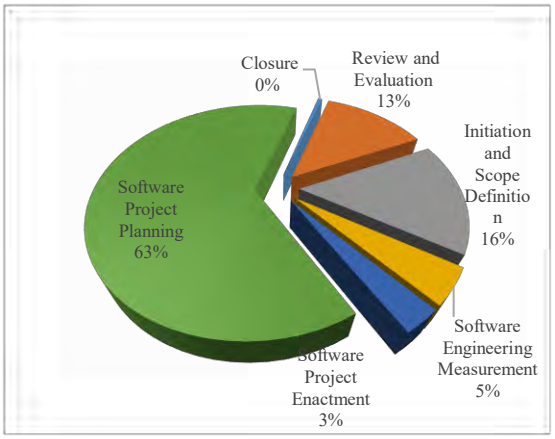

Figure 11. Classification by Software Engineering Management Activities

The main trends in Software Engineering Management Activities for software projects with an agile approach are focused on the Software Project Planning stage (63.2%), this shows the priority that relevant items have in the planning stages. It continues with Initiation & Scope Definition (15.5%) and Review & Evaluation (13%). Finally, the stages of Software Engineering Measurement (4.7%), Software Project Enactment (3.1%) and Closure (0.5%) relegated with lower priority.

3.4 RQ4. What methods are most used in the software project management with agile approach according to its dimension?

First step was identified all agile methods methodologies and frameworks indicated in [8][1]. Then, the various methods and the size of the project identified in the articles, a total of 165 relevant articles included in the classification, highlighting the fact that several articles could use more than one single method in the software project with an agile approach.

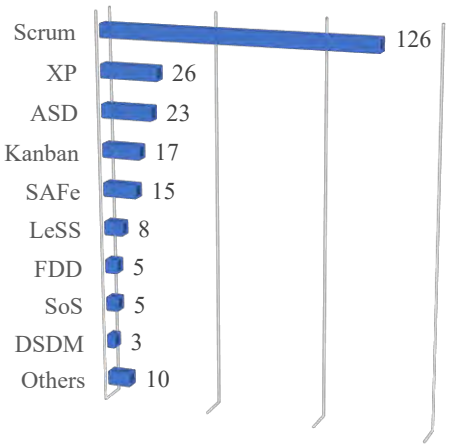

Figure 12. Classification by method used in articles.

The most widely used method is Scrum (126), 76.3% of relevant articles use this method. Continuing with the classification, we observe that XP/Extreme Programming (26), ASD/Adaptative Software Development (23), Kanban (17) and SAFe/Scaled Agile Framework (15) are methods that maintain regular use in the relevant articles of this study. Finally, less use observed in LeSS/Large Scaled Scrum (8), SoS/Scrum of Scrums (5), FDD/Feature Driven Development (5), DSDM/Dynamic Systems Development Method (3) and others (8).

Focusing on the research question, a total of 84 articles were identified that indicated the size of the project (small, medium and large). Obtaining the following result (Figure 13) of the classification according to the dimension.

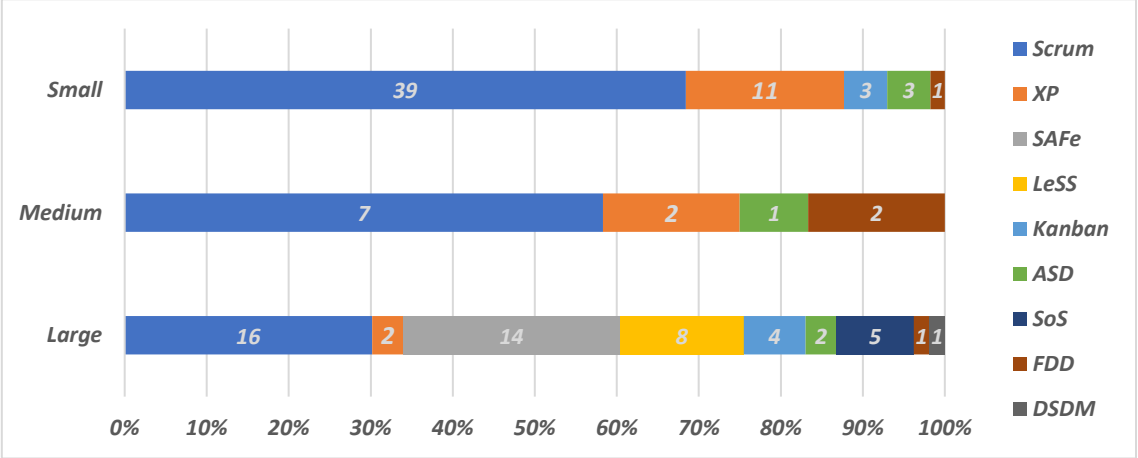

Figure 13. Classification by method used in articles according to the dimension.

A high use of Scrum in Small and Medium projects is visualized for the relevant studies. However, in the large dimension, methods such as the Scaled Agile Framework, Large Scaled Scrum and Scrum of Scrums compete, which according to Agile Development at Scale: The Next Frontier [1] are more focused on minimizing the risk that agile methods presented to development projects. a different dimension to Small and Medium.

3.5 RQ5. What techniques prevail in the software project management with agile approach?

The used classification of techniques was [18]. For this reason, the relevant articles that mentioned one or several techniques used were identified, obtaining the evidence of 64 of the 165 relevant articles, obtaining as a result Figure 14.

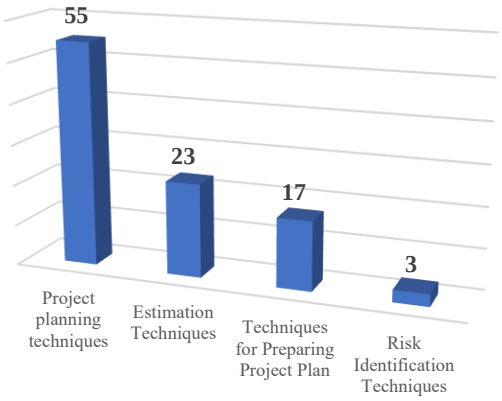

Figure 14. Classification by techniques used in articles.

There is a high focus on project planning techniques (55), continuing with the scale we have Estimation Techniques (23) and Techniques for Preparing Project Plan (17) as regularly techniques, lastly, we have Risk Identification Techniques (3).

3.6 RQ6. What agile artifacts are the trend in software project management with agile approach?

The agile artifact classification used was [16].

Considering this, the relevant articles that mentioned one or several agile devices used were identified, obtaining the evidence of 64 of the 165 relevant articles. One or more techniques used for each article were considered, obtaining as a result (Figure 15).

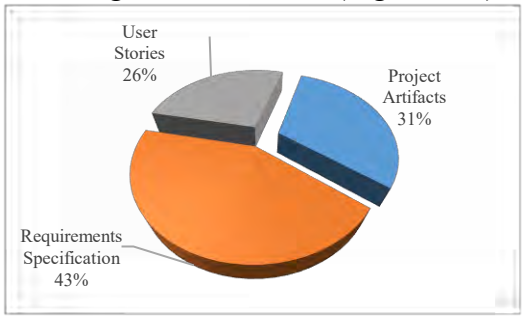

Figure 15. Classification by agile artifacts used in articles.

A high focus observed on Requirements Specification artifacts (91 - 43%), then Project Artifact (65 - 31%) and User Stories (56 - 26%) were detected in regular use for relevant articles.

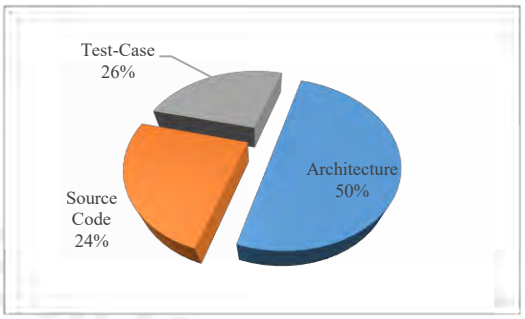

Figure 16. Subclassification by agile Project Artifacts used in articles.

In the case of Project Artifacts, there is the subclassification presented in Figure 16, in which a total of 44 of 165 articles use agile Project Artifact in software projects. The results show a greater focus on the Architecture subclassification. (33 – 50%), followed by regular use of Test-Case (17 – 26%) and Source Code (16 - 26%) artifacts in relevant articles.

3.7 RQ7. What tools are trending in software engineering management with an agile approach?

The agile artifact classification used is from [16]. The Tools used in the 165 relevant articles, were identified, and then classified according to the classification of Software Engineering Management Tools defined by [6] and that of Agile Tools defined by [15].

In Software Engineering Management Tools, 55 of 165 articles detected that used these types of tools. As shown in Figure 17, a greater use detected in the Tracking tools (26), then a medium use

of Risk Management Tools (12), Communications Tools (12) and Project Planning Tools (10) and less use the Measurement Tools (4).

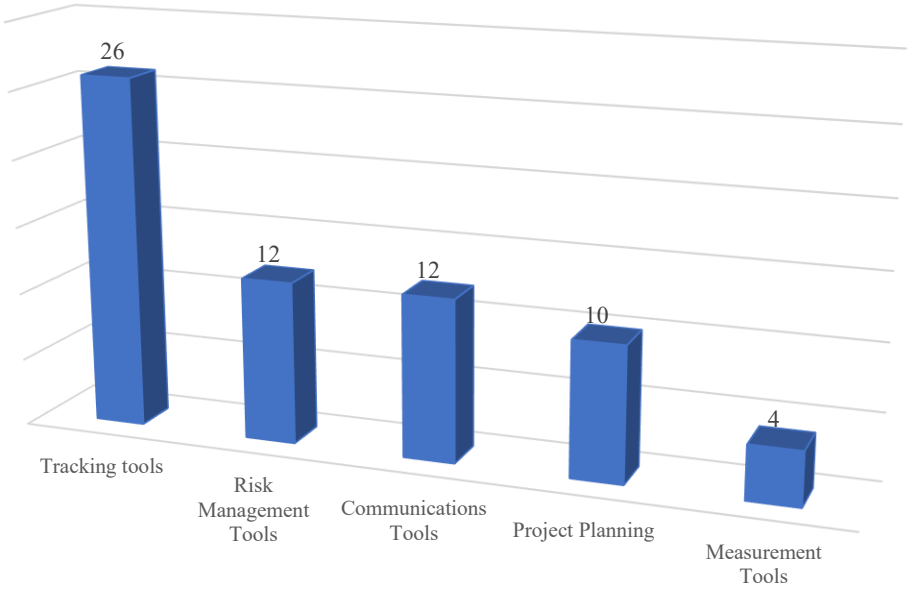

Figure 17. Classification by Software Engineering Management Tools used in articles.

In Agile Tools, 74 of 165 articles used these types of tools. As shown in Figure 18, a higher use detected in the Tracking tools (26) and Tools Review and Analysis Process (26), then a medium use of Collaboration Tools (16), Task Boards (15) and Agile Automated Tools (10) and in less use are the Build Automation Tools (1).

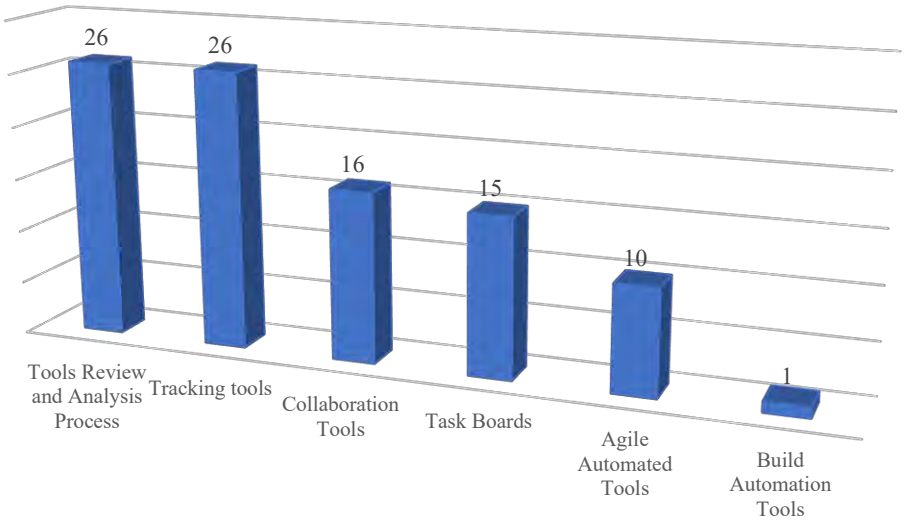

Figure 18. Classification by Agile Tools used in articles.

4. CONCLUSION AND FUTURE WORK

The agile approach has shown high effectiveness when generating added value in various projects in software engineering and there is no doubt that it is also used constantly for management in software engineering.

To demonstrate this, this study shows the main trends and agile methods most used in software engineering management by reviewing 165 articles.

Regarding the main trends, it should note that each author of the relevant articles has used software engineering management with an agile approach to a unique and complex problem, obtaining in this study not only the benefits of agility but also a unique adaptation. for each study. However, it's observed that early value delivery (21.2%), a key principle of agility, continues to be the main trend for the use of agile methods. However, there are also strong trends focused on key management points in software engineering, such as optimize quality Management (17.6%), optimize requirements specification, optimize risk Management (15.8%) and improve team communication and coordination. (15.2%), these results will allow generating new lines of research for each key management point in software engineering impacted by the agile approach. Not only this, but there is also an average trend in Scale agile software project Management (12.7%), evidencing a growing level of adaptability in the agile approach to one of its weakest points, the low success rate in large projects. There is also a medium trend in manage with hybrid models (11.5%), optimize cost Management (4.2%) and improve deliverable evaluation through metrics (3.6%).

Regarding the most used agile methods, Scrum maintains the leadership, followed by Extreme Programming and Adaptive Software Development. However, in the case of agile methods used in large projects, like portfolios, the rule that Scrum remains the main method can be changed by methods

focused on scaling such as the scaled agile framework, Large-scale scrum and Scrum of Scrums, but this can be validated in future analyses.

Considering the depth of software engineering management with an agile approach, required a further analysis through systematic reviews, of the tools, artifacts, and techniques used in software engineering management with an agile approach.

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APPENDIX

A. Papers Identified in the Systematic Mapping of Software Engineering Management with Agile Approach This information is available at:

https://doi.org/10.5281/zenodo.8417647

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