Gamification for agile: a systematic literature review

Rita Marques* and Miguel Mira da Silva

Instituto Superior Técnico, Universidade de Lisboa,
Av. Rovisco Pais 1,
1049-001, Lisboa, Portugal

and

INOV Inesc Inovação,
Rua Alves Redol nº9,
1000-029, Lisboa, Portugal
ORCID: 0000-0002-0672-9260
ORCID: 0000-0002-0489-4465
Email: rita.marques@tecnico.ulisboa.pt
Email: mms@tecnico.ulisboa.pt
*Corresponding author

Daniel Gonçalves

Instituto Superior Técnico,
Universidade de Lisboa,
Av. Rovisco Pais 1,
1049-001, Lisboa, Portugal

and

INESC-ID,
Rua Alves Redol nº9,
1000-029, Lisboa, Portugal
ORCID: 0000-0002-5121-6296
Email: daniel.goncalves@inesc-id.pt

Abstract: Gamification has been used in software engineering to motivate practitioners to adopt agile. This study assesses the state of the art regarding the use of gamification in agile projects. A systematic literature review was followed by searching for peer-reviewed papers and dissertations on the topic and assessing their quality. Overall, 225 studies were found, but only 12 selected. Most studies focused on the Scrum framework, and the completion of stories/tasks was the practice subject to gamification more times. While the impact of gamification initiatives was positive, these studies lacked a proper empirical validation of the proposed gamification solutions. Despite the novelty of this field, there seems to be potential in the use of gamification to improve agile projects, but future studies should address the gaps identified in this analysis and provide more detail when reporting their results, namely regarding the discussion of the impact, benefits, and challenges of gamification.

Keywords: gamification; agile; agile management; agile projects; agile practices; scrum; SLR; systematic literature review; software engineering; software engineers; motivation.

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Biographical notes: Rita Marques is an Agile Consultant with a PhD in Information Systems and Computer Engineering from Instituto Superior Técnico, University of Lisbon, Portugal. She developed her thesis while working at INOV INESC Inovação, where she applied gamification to improve improve workers adherence to software development processes and methods, such as Scrum. She holds a MSc in Computer Science from the same University. Her Master thesis was about the application of gamification to reduce hospital-acquired infections, and was based on her work as a researcher on Instituto de Higiene e Medicina Tropical.

Miguel Mira da Silva is currently an Associate Professor of Information Systems at Instituto Superior Técnico, leader of the research group "Digital Transformation" at INOV, and coordinator of the MISE online MSc. Miguel has a PhD in Computing Science from the University of Glasgow and an MSc in Management from the London Business School. Miguel created five companies, published four books and 200 research papers, managed dozens of research and consulting projects, graduated 9 PhDs and 150 MSc students, and created a MOOC about digital transformation. His current interests include digital transformation, IT governance, and online learning.

Daniel Gonçalves is a Researcher at the Visualisation and Multimodal Interfaces Group of INESC-ID and Professor of Computer Science at Instituto Superior Técnico (IST/UL). His research encompasses information visualisation, personal information management and gamification, having published over 160 peer-reviewed papers. He managed and participated in several national and European projects and has served as Program Chair of several conferences. Since 2015 he is part of the Editorial Board of the UAIS journal. He is a Senior Member of ACM and Member or the Board of Directors of the Portuguese Computer Graphics Group (the national Eurographics chapter).

1 Introduction

Software development organisations have been adopting an agile mindset (Beck et al., 2001) to improve the overall success of software projects (Riemenschneider et al., 2002), which are often challenged or fail (Standish Group, 2018).

There is evidence that agile projects are twice more likely to succeed and one-third less likely to fail when compared against a traditional methodology (Standish Group, 2018). Additionally, agile software development is associated with greater satisfaction than more traditional approaches (Kropp et al., 2018).

Many companies are already implementing agile with success in varied areas. As an example, Faustino et al. studied how organisations are applying agile principles on the Incident Management process, to quickly restore business interruptions and minimise its negative impact on the business (Faustino et al., 2020).

Nevertheless, this topic remains important as some companies are still maturing their adoption (Hoda et al., 2018) and facing some challenges. While some researchers have been trying to understand how to address technical challenges (such as those linked to effort estimation (Kaushik et al., 2020) and requirements volatileness (Shameem et al., 2019)) or high-level strategic challenges (which can be somehow addressed with a continuous strategy approach (Hossain and Prybutok, 2016)), there are also challenges related to human factors (Conboy et al., 2010; Hajjdiab et al., 2012).

As a result, researchers are not only trying to understand how to address challenges affecting a proper agile adoption, but also trying to integrate agile with game design since the early 2010s – the same period when gamification started emerging (Hoda et al., 2018).

In fact, gamification – the use of game elements and game design in non-game processes (Deterding et al., 2011) – has been widely used in field such as education (Barata et al., 2017) and health (Marques et al., 2017) to engage and motivate people to adopt new behaviours (Werbach and Hunter, 2012; Alsawaier, 2018), and has recently started to be used in the field of software engineering to increase engagement and motivation of software engineers (Pedreira et al., 2015).

Despite the novelty of the field, some authors have been exploring the potential of gamification to improve agile software development. However, and as we describe later in this document, while there are some systematic studies on the matter, no systematic literature review (SLR) was conducted on the topic.

Thus, the objective of this paper is to understand how gamification has been used to improve agile practices in industry; how did such initiatives impacted the agile projects; and which were the main challenges faced.

For that, we conduct a SLR based on the guidelines proposed by Webster and Watson (2002) and Kitchenham and Charters (2007). The search protocol was built based on the analysis of previous studies presented in this document, but also on our experience with research work (both theoretical and empirical) on this topic.

This paper is organised as follows. In Section 2 the related work (including systematic works in related subjects) is discussed. The systematic literature protocol is described in Section 3. The results obtained in this SLR are described in Section 3.5 and discussed in Section 5, where the defined research questions are answered. We close the paper by discussing this research work's threats to validity in Section 6 and presenting some conclusions and future work in Section 7.

2 Related work

Some systematic studies have been conducted regarding the application of gamification in software engineering. Pedreira et al. (2015) performed a systematic mapping study (SMS) on this topic, selecting 29 papers from the 1079 found, published between June 2011 and June 2014. Most studies focused on the area of software implementation, while

only 23% of the studies addressed the project management area. These studies focused on the application of simpler game elements, such as points, levels, and badges, and proposed new tools specifically developed for gamification. The authors identify the latter result as a challenge and argue that the success of a gamification initiative improves if the solution is integrated with the organisation's existent procedures and tools. Additionally, the fact that these papers are mostly published in conference proceedings and lack a proper empirical evaluation or validation shows that results reported are still preliminary.

On the same topic, a SLR selected 17 papers out of 136 found, published from 2008 to 2016 (Platonova and Bērziša, 2017). The authors found that most papers focused on the software development phase, and only 4% addressed project management. These studies propose tools specifically designed for gamification, forcing practitioners to change their work processes and adapt to these tools, which are frequently based on points, feedback, and achievements. While results show that gamification can help motivating practitioners and improve their performance, they are preliminary since little research is available. This could be since implementing gamification can be a very time-consuming task that requires much effort from both designers and participants.

Another SLR focused on using gamification for improving software project management processes (Machuca-Villegas and Gasca-Hurtado, 2018). During the periods of August to December 2017 and February to June 2018, 1930 papers were found and 49 were selected. The authors identified a growing interest in this subject, whose works are mostly solution proposals or present preliminary results published in conference proceedings. Moreover, most studies are conducted in an academic environment and use game elements such as points, rewards, badges, leaderboards, levels, and progress bars. Overall, gamification seems to have a positive impact not only in the improvement of the targeted processes, but also in participants' motivation, engagement, communication, and participation.

Despite the valuable insights provided by these reviews, none particularly examined the use of gamification to improve agile practices. Nevertheless, and to the best of our knowledge, there are two systematic mappings studies directly addressing this topic.

The SMS on using gamification in agile software development selected six out of the 129 papers found and published between 2011 and December 2017 (Alhammad and Moreno, 2018). The authors found that the impact of gamification in agile software development seems to be overall positive, but not all papers provide adequate empirical evidence to support the results. These reduced and preliminary results mirror the novelty of the field. Additionally, the authors found that Scrum and user stories were the mostly gamified agile framework and practice, respectively, and points and badges the most frequently adopted gamification elements.

Tana et al. conducted a systematic literature mapping on the use of gamification on the use of Scrum in industry (Tana et al., 2019). Based on the five papers selected, the authors concluded that studies in this field are in an initial state and need more empirical validation. The authors further highlight these papers' lack of detail when discussing the benefits of and challenges affecting these gamification initiatives. In the selected studies, the Daily Scrum events, the sprints, and the issues are the agile aspects mostly covered by gamification. The proposed tools are not disclosed, and the game elements most frequently used are points; badges; feedback; levels; and characters.

Overall, the solutions proposed in these studies are mostly based on simple game elements, such as points and badges, and implemented as standalone technologies that are not integrated with participants' work processes. Moreover, these tools are rarely disclosed, thus cannot be evaluated in different settings by other authors. All these systematic works concluded that selected papers are mostly solution proposals lacking an adequate empirical validation, thus results are very preliminary and cannot support important conclusions.

A summary of the main characteristics of these systematic studies is shown in Table 1. This information includes an ID and the reference for identifying the study; whether the type of the paper is a SMS or a SLR; the topic covered regarding the application of gamification; the timespan that was searched for; and the number of primary studies.

Table 1 Systematic studies regarding the application of gamification in software engineering

ID	*References*	*Paper type*	*Topic*	*Time span*	*# Primary studies*
S1	Pedreira et al. (2015)	SMS	Software Engineering	June 2011–June 2014	29
S2	Platonova and Bērziša (2017)	SLR	Software Engineering	2008–2016	17
S3	Machuca-Villegas and Gasca-Hurtado (2018)	SLR	Software Project Management processes' improvement	August 2017–December 2017 + February 2018–June 2018	49
S4	Alhammad and Moreno (2018)	SMS	Agile Software Development	2011-December 2017	6
S5	Tana et al. (2019)	SMS	Scrum in industry	Not specified	5

Three of these reviews were focused on a broader software engineering area, while only two were focused on agile methodologies. The systematic reviews on the first topic analyse a high number of papers, but only a small part is focused on software project management. Compliant with this, a very small number of papers were selected in the systematic works studying the use of gamification in agile frameworks.

There are two systematic studies on the use of gamification for agile. The S4 paper is a SMS, a research method mainly aiming to discover research trends at a higher level, rather than a narrow focus (Petersen et al., 2015). Additionally, this study covers papers published until 2017, whereas more works might have been published in the last years. While S5 is a SLR, it is only focused on Scrum (and not on all agile frameworks and practices) and it is not written in English.

The research questions studied, and the search strings applied in these systematic studies are listed in Table 2. All studies were focused on identifying the areas, processes, or practices where gamification was applied, as well as the main game elements used. Both studies on the agile topic (S4 and S5) were also focused on identifying the impact, benefits, and challenges of using gamification in the context of Agile.

Table 2 Research questions and search strings defined in the systematic studies regarding the application of gamification in software engineering

ID	*Research questions*		*Search string*
S1	1	What software engineering processes have been the object of gamification?	(gamification OR gamifying OR gamify OR funware) AND ((software engineering) OR (software process) OR (software requirements) OR (software testing) OR (project planning) OR (project assessment) OR (software risk) OR (software configuration) OR (software design) OR (software construction) OR (software implementation) OR (software integration) OR (software maintenance) OR (software verification) OR (software validation) OR (software metrics))
	2	What gamification elements have been used in existing work on software engineering gamification?	
	3	What research methods have been used in research into software gamification quality evaluation?	
	4	What types of publications or forums have dealt with the issue of software engineering gamification?	
S2	1	At which software development phases is the gamification used?	(“gamification” OR “gamifying” OR “game elements” OR “game methodology”) AND (“software development” OR “software engineering” OR “project management” OR “testing” OR “requirement management” OR “software integration” OR “software management” OR “scrum agile” OR “waterfall”)
	2	What kind of gaming techniques are used in software development projects?	
	3	What are the benefits of using gamification in software development projects?	
	4	What problems are encountered when gamification is implemented?	
	5	What applications/software tools are used for the implementation of gamification principles	
S3	1	Which software project management areas are currently being explored using gamification as a strategy for improvement?	(gamification or gamifying) AND (software project or software project management OR project management OR agile project management).
	2	Which gamification elements have been used in existing gamification works for software project management?	
	3	Which research methods are being applied in this context?	
	4	Which types of industries are using gamification in software project management?	
S4	1	How has gamification been implemented in the agile software process?	((agile OR ‘extreme programming” OR scrum OR XP) AND (gamification OR gamify OR gamified OR gamifying OR gameful))
	2	What is the evidential impact of gamification on the agile software process?	

Table 2 Research questions and search strings defined in the systematic studies regarding the application of gamification in software engineering (continued)

ID	*Research questions*		*Search string*
S5	1	Which game elements have been used by gamification proposals in the context of the Scrum agile methodology?	scrum AND (gamification OR gamefication)
	2	Which Scrum practices have been more adopted in the context of gamification?	
	3	Which are the main benefits and challenges identified in the studies regarding the use of gamification in the context of Scrum agile methodology?	

To define the search string, all papers used the same strategy: they considered their two main topics (in this case, gamification plus the topic mentioned in Table 1) and synonyms or related keywords; merged the synonyms with an OR Boolean, and the two sub-strings with an AND Boolean.

Following this analysis, we conclude that, despite the existence of two systematic studies on the use of gamification for agile, there is still a need for a more thorough and focused SLR on the subject. Therefore, we conducted a SLR of peer-reviewed papers and dissertations that discuss how to use gamification to improve the adoption of agile practices. We aim to address the previously discussed limitations by:

- Conducting a SLR on the topic, thus conducting a focused and in-depth work on the use of gamification for agile.
- Explore interesting insights that have been covered in the broader software engineering systematic studies but not specifically in the agile ones, such as the research methods used to conduct the studies and the software tools used to support the implementation of gamification.
- Analyse studies that have been published between 2018 and 2020 that are not included in the analysed papers.
- Compare the results described in these studies against those of our research work, to understand if some conclusions remain.

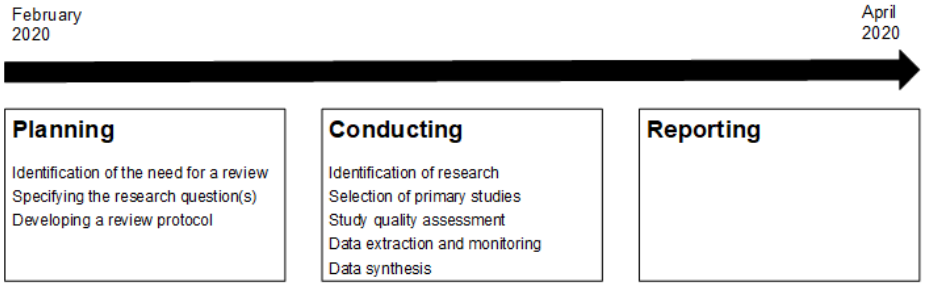
In the next section, we describe the method implemented.

3 Methods

This research work has been implemented as a SLR by following the original guidelines proposed by Webster and Watson (2002) and Kitchenham and Charters (2007). The latter defines that an SLR method comprises three consecutive stages: planning, conducting, and reporting.

These phases and activities comprised are illustrated in Figure 1 and described in the next subsections. The protocol was developed by one author, and further reviewed and refined by remaining authors to ensure its quality (for example, to guarantee that data extracted allows to answer the research questions).

Figure 1 Research method phases and activities described by and Kitchenham and Charters (2007)



It is important to mention that all authors are experienced in conducting research in this field, and have several papers published on the subject. This might have influenced not only the establishment of the search protocol, but its implementation and results' analysis as well.

This SLR was managed and documented using Parsifal,[1] an open-source web application based on the steps suggested by Kitchenham and Charters (2007) for performing SLRs in software engineering.

The first step of the planning phase, which consists of identifying the need for a review, was already described in Sections 1 and 2. This section focuses on the remaining planning phase, which involves the definition of the research questions and the development of the review protocol, which describes the procedures for the conducting phase, including the search process; the establishment of inclusion and exclusion criteria; the quality assessment instrument; and the data extraction and synthesis strategy. The conducting and reporting phases are described in Sections 3.5 and 4, respectively.

3.1 Research questions

Based on the studies discussed in Section 2 (including the RQs used, and the main conclusions presented) and our experience with research work (both theoretical and empirical) on this topic, we defined the following research questions to be answered by this research work:

RQ1: How is gamification being applied to agile projects?

RQ2: What are the evidences for the impact of gamification in agile projects?

RQ3: Which challenges are affecting gamification initiatives in agile?

To address RQ1, we explore the different characteristics of the gamification studies conducted in agile projects. Also based on the related work and our experience, we defined the following as the main aspects of the studies that we will consider answering RQ1:

- The **agile frameworks** studied; the **agile practices** that are subject to gamification; and the **agile metrics** used, which allow to understand which agile topics are in the focus of these studies;

- The **game elements** that are being explored, to understand which ones are currently mostly used to motivate people in adopting agile frameworks and practices;
- The **applications and software tools** that are being used for implementing gamification initiatives, which allow to understand how gamification is being integrated within agile teams' routine;
- The **research methods** that are being used to evaluate the impact of gamification on agile, which will also allow us to understand whether research in this area is being **validated through empirical studies**.

With RQ2, we aim to understand whether gamification initiatives have an impact on the implementation of agile projects, and if that impact is positive or negative.

Regarding RQ3, we aim to explore the challenges and problems identified not only in the proposed gamification solutions, but also the ones that might be limiting the execution of gamification initiatives in agile projects, thus justifying the reduced number of studies conducted in this area.

3.2 Search process

Aiming at capturing all relevant papers studying the use of gamification in agile practices, several sources should be selected, since no single source can find all relevant studies. Therefore, we performed the SLR using seven digital libraries that are relevant for software engineering and information systems:

- ACM Digital Library (http://portal.acm.org)
- AIS Electronic Library (https://aisel.aisnet.org/)
- EBSCO Host (http://eds.b.ebscohost.com/)
- IEEE Xplore (http://ieeexplore.ieee.org)
- ISI Web of Science (http://www.isiknowledge.com)
- Science@Direct (http://www.sciencedirect.com)
- Scopus (http://www.scopus.com).

The ACM Digital Library, IEEE Xplore, Science@Direct and Scopus sources were suggested by Brereton et al. (Brereton et al., 2007) and mentioned in the Kitchenham and Charters guidelines followed in this research.

Additionally, we performed the search in three other sources. The EBSCO Host and ISI Web of Science libraries were searched because they are relevant for the Engineering area and are included in the agreement of our institution's online library. The AIS Electronic Library repository was considered because it includes papers published in venues that are relevant to the information systems academic community.

The papers returned were obtained by applying the search string to the title and abstract in each digital library. For this reason, Springer Link was not used because, despite being a relevant digital library, it does not allow search by title and abstract. Nevertheless, many papers published by Springer were retrieved from other digital libraries (e.g., Scopus and EBSCO Host).

Moreover, all primary papers selected from the digital libraries were analysed using a snowballing strategy, as recommended by Webster and Watson (Webster and Watson, 2002) and based on Wohlin's guidelines (Wohlin, 2014). Both snowballing strategies were applied: we performed backward snowballing by analysing the reference list of each primary paper and performed forward snowballing by analysing the citations to each primary paper, which were searched using Google Scholar.

Given the low volume of research in this field, we decided to use a less restrictive search string and apply the inclusion and exclusion criteria to filter only the relevant papers. This way, relevant papers would not be excluded in the first place. The search string was built using a similar strategy from the studies discussed in Section 2. First, we considered the two main topics of this research (gamification and agile). Then, we built each part by including synonyms and keywords related to those topics.

The alternative keywords for gamification were selected based on the previous works' search string. For the agile keywords, we considered a subset with the most used agile frameworks, according to the widely known State of Agile Report (Version One, 2019). All frameworks that were reported by at least 5% of the respondents (Scrum, Scrumban, and Kanban), including the ones used in hybrid approaches (eXtreme Programming). We also added "XP" as a synonym of "eXtreme Programming".

The generic search string used is shown in Table 3. The Boolean "OR" was used to join the terms in each sub-string, while the Boolean "AND" was used to join the two sub-strings.

Table 3 Search string

Scope	*String*
Gamification	("Gamification" OR 'Gamifying" OR 'Gamify" OR 'Gamified" OR "Gameful")
Agile	("Agile" OR 'Scrum" OR 'Kanban" OR 'eXtreme Programming" OR 'XP" OR "Scrumban")

The search was conducted on 11 March 2020 in the selected digital libraries, using the search string defined in Table 3. Some configuration needs to be performed depending on source, such as the modification of the search string. The advanced search applied to each digital library is presented in Table 4.

After retrieved, papers were screened considering the inclusion and exclusion criteria presented in Section 3.3. After discarding papers based on more practical issues, the remaining were screened first on title and abstract, and then on full text.

Afterwards, the snowballing strategy was applied. First, papers that have been previously examined and excluded in the process were discarded. Then, the inclusion and exclusion criteria were applied in three steps: first to the citation (including title, year, and venue), then to the paper's abstract, and finally to the full paper.

3.3 Inclusion and exclusion criteria

A set of inclusion and exclusion criteria was defined to filter the papers collected and identify the ones that were relevant for this work.

Table 4 Advanced search configuration for each digital library

Digital library	*Configuration*

ACM Digital Library	• Select items from: The ACM Full-Text Collection
	• Search Within: Name (add generic search string)
	• Search Within: Abstract (add generic search string)
	• Publication Date:
	  • From: Jan + 2010
	  • To: Mar + 2020
	• View Query Syntax: change the Boolean connecting the Title and the Abstract from "AND" to "OR"

AIS Electronic Library	• Select "Title" and add the generic search string • Click "+", select "OR" and "Abstract", and add the generic search string • **Date range:** 01/01/2010-11/03/2020 • **Limit search to:** AIS Electronic Library (AISel)

EBSCO Host	• Advanced Search
	• Query: generic search string
	• Select a Field (optional): TI Title
	• Select "OR"
	• Query: generic search string
	• Select a Field (optional): AB Abstract
	• Search Modes and Expanders
	  • Search modes < Boolean/Phrase
	  • Also search within the full text of the papers: uncheck
	  • Apply equivalent subjects: uncheck
	• Limit your results
	  • Date Published: January 2010 – March 2020
	• Refine Results:
	  • Source Types: Academic Journals + Conference Materials + Dissertations/Theses

IEEE Xplore	• Query: ((("Abstract":"Gamification" OR "Gamifying" OR "Gamify" OR "Gamified" OR "Gameful") AND("Abstract":"Agile" OR "Scrum" OR "Kanban" OR "eXtreme Programming" OR "XP" OR "Scrumban"))) OR ((("Document Title":"Gamification" OR "Gamifying" OR "Gamify" OR "Gamified" OR "Gameful") AND("Document Title":"Agile" OR "Scrum" OR "Kanban" OR "eXtreme Programming" OR "XP" OR "Scrumban"))) • Year: 2010-2019

Table 4 Advanced search configuration for each digital library (continued)

Digital library	*Configuration*
ISI Web of Science	• Enter generic query • Select "Topic" • Timespan < Custom year range: 2010 to 2020
Science@Direct	• Advanced Search • Add generic search string in "Title, abstract, or author-specified keywords" • Year: 2010–2020
Scopus	• Documents • Search: generic search string + "Paper title" • Click "+" and select "OR" • Search: generic search string + "Abstract" • Limit: • Date range (inclusive): Published 2010 to Present

This review focused on research work reporting original research on using gamification for improving the adoption of agile methods and techniques by practitioners. From this focus, we developed the following inclusion criteria:

1 focuses on the use of gamification to improve agile adoption in industry settings

2 evaluates gamified solutions with real agile teams

3 empirical study included (qualitative and quantitative)

4 clearly describes the impact of outcomes related to gamification for agile.

Criteria 1 was included to ensure the paper reported on the specific context of this SLR. Criteria 2 was selected to focus on the use of gamification solutions with real agile teams (and not in other contexts, such as teaching). Criteria 3 and 4 were chosen to assess the real impact of gamification when used in agile projects.

Moreover, we excluded papers with the following features:

1 duplicated document (including the same paper published in different databases and multiple publications refereeing to the same study and data)

2 not written in English or Portuguese language

3 published before 2010. The first gamification studies started emerging during this year (Marczewski, 2015).

4 non-peer reviewed publication (except theses and dissertations)

5 secondary and tertiary study

6 full-text not accessible

7 explores gamification in a domain other than agile software development.

8 focus on using gamification to teach agile practices.

9 covers complete games (serious games) not gamification

10 gamification is mentioned but not evaluated

11 out of scope.

Criteria 1–6 focus on more practical issues. Criterion 1 covers both the same paper published in different databases and multiple publications of the same study. In the first scenario, only one copy was considered. In the latter, the most complete version of the study was considered. Criterion 4 limited the search to journal papers and conference papers, excluding book chapters that might contain a higher theoretical load. However, thesis and dissertations were included. All secondary and tertiary studies were removed, as they were out of the scope of this literature review.

Criterion 7 excludes all papers that are not addressing the use of gamification in agile software development, and criterion 8 excludes research that focus on using gamification to teach (and not to motivate the use) of agile practices.

Criteria 9–10 exclude studies that mislabel serious games as gamification or do not provide enough detail to understand whether it constituted gamification. Finally, criterion 11 exclude studies that are completely out of scope (for example, that are not even focused on gamification).

3.4 Quality assessment

A quality assessment was conducted for each selected paper to evaluate the relevance and quality of their contents. This way, the importance of each paper can be compared and considered during the analysis of the results in the conducting phase. Additionally, we were able to remove papers of low quality from the search.

The quality assessment was based on a set of seven questions defined based on our research questions and a quality checklist from a similar study in gamification (Sardi et al., 2017). The scoring procedure was based on Kitchenham and Charters (2007). Each question could have one of the possible answers: Yes (Y) = 1, Partially (P) = 0.5 or No (N) = 0. The quality assessment questions defined are:

QA1: Does the research propose a specific gamification solution for agile?

QA2: Does the paper present a detailed description of the game elements employed?

QA3: Is the research work evaluated in industry with real practitioners?

QA4: Does the paper explicitly discuss the benefits and limitations of gamification?

QA5: Does the study reflect the impact of gamification on the motivation to adopt agile?

QA6: Are the contribution's limitations precisely identified?

QA7: Has the study been published in a relevant journal or conference proceedings?

Question QA7 was scored based on the computer science conference rankings (CORE)[2] and on the Scimago Journal and Country Rank (SJR).[3] The following criteria was defined:

- Yes: ranked Q1 or Q2 in SJR; ranked A or A* in CORE
- Partially: ranked Q3 or Q4 in SJR; ranked B or C in CORE
- No: not ranked in SJR nor in CORE.

The total quality score for each paper is calculated by adding the scores of all seven questions, with a maximum value of 7. After performing the assessment for all primary studies, we discarded papers with low score, more specifically those with a score lower than 3.0/7.0.

3.5 Data extraction and synthesis

To answer the defined research questions, a data extraction form was designed and created on Parsifal, which was filled in for each of the papers selected by one reviewer. To improve accuracy, the other two authors reviewed the data extracted. The data extracted for each RQ is described in Table 5.

Table 5 Data extraction form

Item description	*Value*	*RQ*
Agile Framework	Set of agile frameworks	RQ1
Agile Practices	Set of agile practices	
Agile Metrics	Set of agile metrics	
Game Elements	Set of names of game elements	
Technology(ies) Used	Name of the technology(ies) used to support gamification	
Research Type	Solution proposal; Evaluation; Validation	
Empirical Study Category	Experiment; Case study; Survey	
Sample Size	Integer	
Sample Type	Description of the sample	
Study Duration	Duration of the study	
Impact Observed	Description of impact observed	RQ2
Challenges Observed	Description of challenges observed	RQ3

When the study of a primary paper comprised different goals and activities, we only considered the ones related to the gamification intervention. First, we collected data related to the agile environment where gamification was applied.

Regarding the agile environment where the gamification initiative was conducted, we collected the agile framework, the agile practices, and the metrics used. When no specific agile framework was considered, we describe it as 'General'.

The game elements used as the main list were the ones proposed in Werbach and Hunter's framework (Werbach and Hunter, 2012). There are other frameworks proposing different sets of game elements, such as Octalysis (Chou, 2019) or HEXAD (Marczewski, 2015), but we chose Werbach and Hunter's since it proposes categories for game elements, namely dynamics, mechanics, and components.

The list of most important game elements in each category, as proposed by the authors, can be consulted in Appendix A. Other game elements could be added, and the ones that did not fit any of these categories were classified as 'Other'.

Additionally, we also collected the technologies that supported the gamification initiative.

The research type was categorised as (Wieringa et al., 2006):

- *Solution proposal*: A solution is proposed to a problem without providing a full validation. This solution can be either new or a significant improvement of an existing technique. Papers stating that a new solution was used in practice but do not report the empirical evaluation are also considered proposals (Petersen et al., 2015)
- *Evaluation*: The subject is investigated with an empirical validation in practice. In this work, this corresponds to studies conducted in real-world industrial contexts.
- *Validation*: The subject is investigated with an empirical validation, but not in a practical setting. For example, gamification proposals that are evaluated with students, instead of practitioners.

Empirical research studies were further categorised as (Wohlin et al., 2012):

- *Experiment*: A highly controlled method where one variable of a studied setting is manipulated.
- *Case study*: A study where projects are investigated in their real-life context, based on multiple sources of evidence.
- *Survey*: A method where data is collected from a sample of the population at study, usually by means of questionnaires and interviews.

Additionally, validation research could also be categorised as a simulation (Wieringa et al., 2006).

Finally, we described the impact of gamification observed in the studies and the challenges occurred and identified during the gamification initiative.

Next, the synthesis method aims to summarise the relevant information of the selected studies to answer the research questions. In this study, data extracted was tabulated and some graphics were created to allow to interpret results.

4 Results

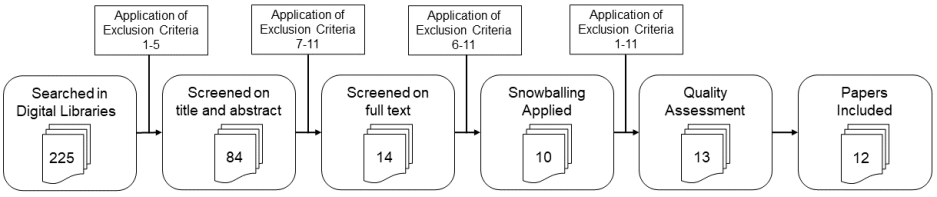
This section describes the results obtained by conducting the SLR.

The steps of the selection process are presented in Figure 2. The search returned a total of 225 papers from the seven digital libraries used: ACM Digital Library ($n = 11$); AIS Electronic Library ($n = 11$); EBSCO Host ($n = 35$); IEEE Digital Library ($n = 20$); ISI Web of Science ($n = 43$); Science@Direct ($n = 1$); and Scopus ($n = 101$).

After applying the exclusion criteria 1–5 (which are based on more practical issues), 141 papers were discarded. In the second step, 84 papers were screened in the second step based on title and abstract. From these, 70 were removed based on exclusion criteria 7-10. Then, the remaining 14 papers were screened based on the full text, where four

papers were removed based on the exclusion criteria 6–10. Three additional papers were identified after applying a snowballing strategy to the 10 selected papers.

Figure 2 Paper selection process



The 13 papers selected are shown in Table 6, including its title, the authors, and the year of publication. Moreover, we added the ID we used in the remaining of this document to refer to that study, and its reference. The quality of these papers was evaluated, and the P13 paper was discarded due to its low score (as further described in Section 4.6), and is thus greyed in Table 4. In the end, 12 papers were included in this SLR. The complete list of included and excluded studies is available online.[4]

Table 6 Included studies

ID	*Ref*	*Title*	*Authors*	*Year*
P1	Marques et al. (2018)	Using Gamification for Adopting Scrum	Marques, Rita; Costa, Gonçalo; Mira da Silva, Miguel; Gonçalves, Daniel; Gonçalves, Pedro	2018
P2	Lombriser et al. (2016)	Gamified Requirements Engineering: Model and Experimentation	Lombriser, Philipp; Dalpiaz, Fabiano; Lucassen, Garm; Brinkkemper, Sjaak	2016
P3	Yilmaz and Connor (2016)	A Scrumban Integrated Gamification Approach to Guide Software Process improvement: A Turkish Case Study	Yilmaz, Murat; O'Connor, Rory V	2016
P4	Pereira et al. (2017)	Gamification Use in Agile Project Management: An Experience Report	Pereira, Igor M.; Amorim, Vicente J. P.; Cota, Marcos A.; Goncalves, Geovana C	2017
P5	Silva et al. (2017)	Gamification at Scraim	Silva, Diogo; Coelho, António; Duarte, Cesar; Henriques, Pedro Castro	2017
P6	McClean (2015)	An Exploration of the Use of Gamification in Agile Software Development	McClean, Alan	2015
P7	Češka (2016)	Gamification in the SCRUM Software Development Framework	Češka, Bc Martin	2016
P8	Modesto (2016)	Using Gamification to Increase Scrum Adoption	Modesto, Sofia	2016

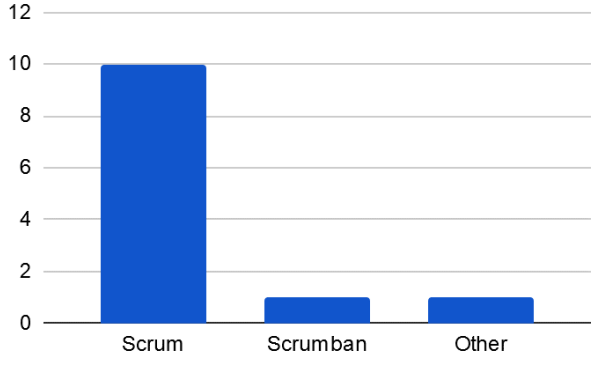
Table 6 Included studies (continued)

ID	*Ref*	*Title*	*Authors*	*Year*
P9	Sharma, Kaulgud and Duraisamy (2016)	A Gamification Approach for Distributed Agile Delivery	Sharma, Vibhu Saujanya; Kaulgud, Vikrant; Duraisamy, P	2016
P10	Sisomboon, Phakdee and Denwattana (2019)	Engaging and Motivating Developers by Adopting Scrum Utilising Gamification	Sisomboon, Wantana; Phakdee, Nuttaporn; Denwattana, Nuansri	2019
P11	Medeiros and Passos (2015)	Working and Playing with Scrum	Medeiros, Danilo B.; Dos Santos Neto, Pedro De Alcantara; Passos, Erick B.; Araujo, Wandresson De Souza	2015
P12	Souza, Zavan and Flôr (2017)	Scrum Hero: Gamifying the Scrum Framework	Souza, Jamila Peripolli; Zavan, Andre Ricardo; Flor, Daniela Eloise	2017
P13	Hermanto (2018)	Gamified SCRUM Design in Software Development Projects	Hermanto, Sherly; Kaburuan, Emil R; Legowo, Nilo	2018

4.1 Agile frameworks, practices, and metrics

As shown in Figure 3, selected papers mostly focus on exploring the Scrum agile framework ($n = 10$). Only paper P3 focused on Scrumban, while P2 focused on eliciting requirements for agile projects in general.

Figure 3 Agile frameworks studied in the selected papers (see online version for colours)

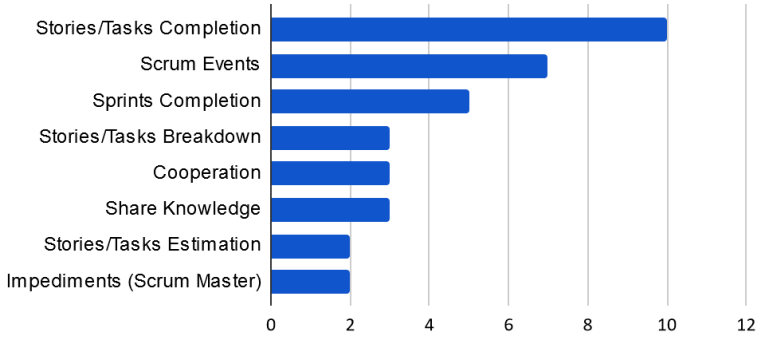


The agile practices that were subject to gamification in each paper are shown in Table 7, and the number of papers where each agile practice was gamified is presented in Figure 4. For ease of reading, only agile practices explored at least in two papers are shown. Some practices that were considered in only one study were more specific, such as distributed agile and requirements engineering.

Table 7 Agile practices where gamification was applied in selected papers

Agile practices	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	*P10*	*P11*	*P12*
Scrum Artefacts												X
Stories/Tasks Completion	X		X	X	X		X	X	X	X	X	X
Stories/Tasks Assignment	X											
Stories/Tasks Estimation	X					X						
Stories/Tasks Breakdown						X		X		X		
Scrum Events	X			X			X	X		X	X	X
Sprints Completion	X						X	X		X	X	
Scrum Roles												X
Impediments (Scrum Master)								X		X		
Cooperation	X		X	X								
Share Knowledge			X					X		X		
Usage of Software Tool					X							
Distributed Agile Projects									X			
Requirements Elicitation		X										

Figure 4 Number of studies where agile practices were gamified (see online version for colours)



Almost all studies applied gamification to the stories or tasks completion ($n = 10$). The second most commonly gamified agile practice is the Scrum Events ($n = 7$), followed by the sprints' completion ($n = 5$). The breakdown of stories and tasks into smaller stories/tasks; the cooperation; and the knowledge sharing amidst teams and participants were covered in three papers each. Finally, the estimation of stories/tasks and the Scrum Masters' responsibility of removing impediments were considered in two papers each, and six agile practices were only gamified in one paper each.

In Table 8 the agile metrics considered in each study are presented, and in Figure 5 the number of studies where each agile metric was used are shown. For ease of reading, only agile metrics used at least in two papers are shown. Three papers did not report the agile metrics considered in the studies.

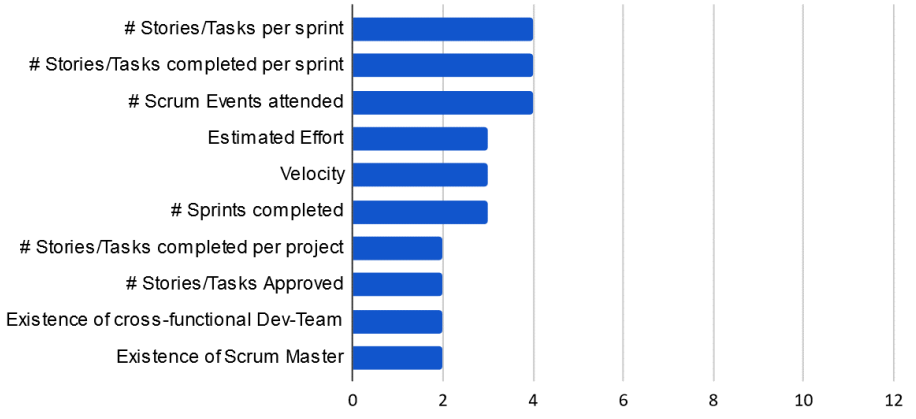
Table 8 Agile metrics considered in selected papers

Agile metrics	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	*P10*	*P11*	*P12*
# Stories/Tasks per sprint	X					X		X		X		X
# Stories/Tasks per project								X				
# Stories/Tasks completed per sprint	X							X		X	X	
# Stories/Tasks completed per project							X	X				
# Stories/Tasks Assigned	X											
# Stories/Tasks Persistent	X											
# Stories/Tasks Reopened	X											
# Stories/Tasks Approved							X				X	
# Assignees that edited a Story/Task								X				
# Days to Deliver Stories/Tasks									X			
Average Story/Task Size						X						
Estimated Effort	X					X			X			
Velocity	X			X			X					
Sprint duration									X			
# Sprints completed	X						X				X	
# Sprints started less than one day after sprint end											X	
Existence of cross-functional Dev-Team								X		X		
Existence of Product Owner										X		
Existence of Scrum Master								X		X		
# Scrum Master Interventions (to help DevTeam)										X		
# Scrum Events attended	X							X		X	X	
#/% Sprints where PO participated in Planning and Review											X	

Table 8 Agile metrics considered in selected papers (continued)

Agile metrics	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	*P10*	*P11*	*P12*
# Acceptance Tests created		X										
# User Stories submitted		X										
Relative Dedication				X								
Relative Productivity				X								

Figure 5 Number of studies where agile metrics were considered (see online version for colours)



The agile metrics mostly considered were the number of stories/tasks per sprint (total and completed) and the number of Scrum Events attended ($n = 4$). Following in the list there are the estimate effort, velocity, and number of sprints completed, each considered in three studies. However, the velocity metric was computed in two different ways: while in papers P1 and P7 this metric corresponds to the sum of the estimations completed in the sprint, in P4 is considered as "the number of points held on the number points that should be performed".

4.2 Game elements and software tools

Table 9 lists the tools applied in the gamification solutions, including game elements and software technology. Regarding the latter, three papers did not use nor proposed any specific technology to support the gamification initiative, and three papers only presented a prototype. In the remaining half of the papers, Jira Software[5] was used twice, and Rally[6] and Wordpress[7] were used once each. In papers P5 and P6, a proprietary tool was used.

Figure 6 shows the game elements used in at least two papers, categorised according Werbach and Hunter's framework. Game elements proposed in this framework were the ones most commonly used, while the 17 elements that did not fit the proposed categories were less common and applied in just one or two papers, except for physical rewards ($n = 5$) and progress bar ($n = 4$).

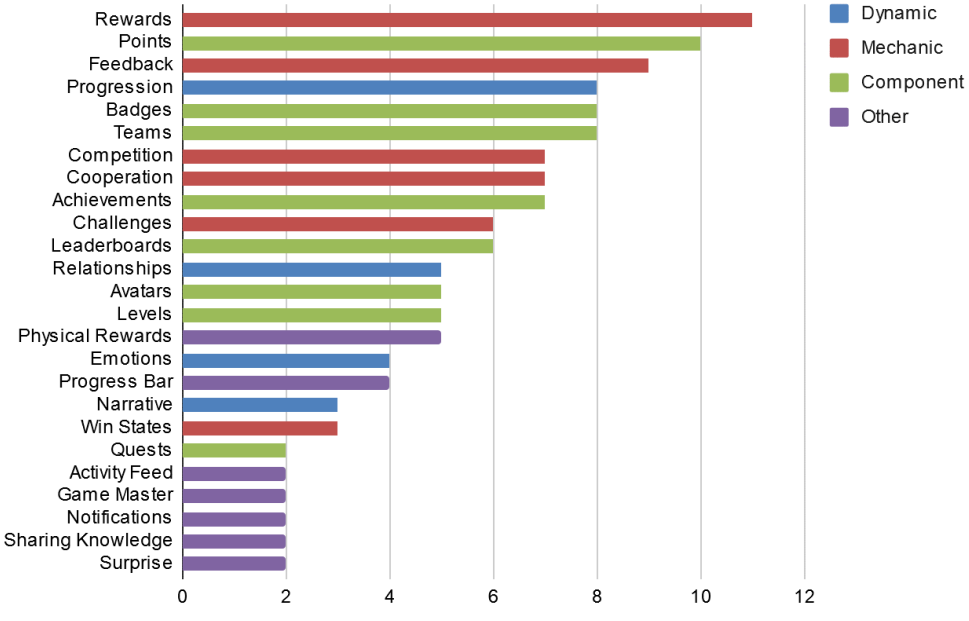
Table 9 Game tools applied in the studies

ID	*Game elements*	*Technology*
P1	**Dynamics**: Emotions, Progression, Relationships **Mechanics**: Challenges, Competition, Cooperation, Feedback, Rewards **Components**: Achievements, Badges, Levels, Points, Teams **Other**: Activity Feed, Gems/Virtual Economy, Notifications, Progress Bar	Jira Software
P2	**Dynamics**: Emotions, Narrative, Progression **Mechanics**: Challenges, Feedback, Rewards, Win States **Components**: Avatars, Badges, Leaderboards, Levels, Points **Other**: Activity Feed, Chat, Game Master, Progress Bar Physical Reward, Timer/Time Pressure	Wordpress + CaptainUp
P3	**Dynamics**: Progression, **Mechanics**: Feedback, Rewards **Components**: Achievements, Avatars, Badges, Levels, Points, Quests **Other**: Social Status, Surprise	
P4	**Dynamics**: Relationships **Mechanics**: Competition, Cooperation, Feedback, Rewards, Win States **Components**: Leaderboards, Points, Teams **Other**: Gifting/Kudos, Physical Reward, Sharing Knowledge	
P5	**Dynamics**: Progression **Mechanics**: Challenges, Competition, Cooperation, Feedback, **Components**: Leaderboards **Other**: Mascot, Notifications, Progress Bar, Sharing Knowledge, Surprise	SCRAIM
P6	**Dynamics**: Emotions **Mechanics**: Chance, Rewards, Win States Components: – **Other**: Lottery, Physical Reward	Rally
P7	**Dynamics**: Progression, Relationships **Mechanics**: Competition, Cooperation, Feedback, Rewards **Components**: Achievements, Avatars, Badges, Leaderboards, Points, Teams **Other**: Progress bar, Physical Reward	Gamified Scrum Development portal
P8	**Dynamics**: Progression, Relationships, **Mechanics**: Competition, Cooperation, Rewards **Components**: Achievements, Badges, Leaderboards, Points, Teams **Other**: Streaks	Jira Software
P9	**Dynamics**: Progression **Mechanics**: Competition, Cooperation, Feedback, Rewards **Components**: Points, Teams **Other**: Dashboard, Game Master	AgileWorkbench

Table 9 Game tools applied in the studies (continued)

ID	*Game elements*	*Technology*
P10	**Dynamics**: Progression, Relationships **Mechanics**: Challenges, Competition, Feedback, Rewards **Components**: Achievements, Badges, Leaderboards, Points, Teams **Other**: Voting	
P11	**Dynamics**: Emotions, Narrative, **Mechanics**: Challenges, Cooperation, Feedback, Rewards **Components**: Achievements, Avatars, Badges, Content Unlocking, Levels, Points, Teams **Other**: –	RUPGY
P12	**Dynamics**: Narrative **Mechanics**: Challenges, Resource Acquisition, Rewards **Components**: Achievements, Badges, Levels, Points, Quests, Teams **Other**: Physical Rewards	Scrum Hero Manager

Figure 6 Number of studies where game elements were used (see online version for colours)



The reward mechanic was the most common game element ($n = 11$), followed by the component points ($n = 10$) and the mechanic feedback ($n = 9$). The most common dynamic was progression ($n = 8$).

4.3 Research methods

The characteristics of the studies are presented in Table 10, including the research type applied, the category of empirical studies (i.e., of type evaluation and validation), the sample's details, and the duration.

Table 10 Studies' characteristics

ID	*Research type*	*Empirical study category*	*Sample size and characteristics*	*Study duration*
P1	Evaluation	Case Study	1 Team (6 people)	3 and a half months (4 sprints)
P2	Evaluation	Experiment	2 Teams (12 people)	2 hours
P3	Evaluation	Case Study	3 Teams (10 People)	6 months
P4	Validation	Experiment	12 Individuals	4 months
P5	Validation	Simulation Survey	6 Individuals	Not reported
P6	Evaluation	Case Study	1 Team (Size not reported)	2 weeks (1 iteration)
P7	Solution Proposal	–	–	–
P8	Validation	Simulation Survey	3 Individuals 11 Individuals	2 weeks [1]month
P9	Solution Proposal	–	–	–
P10	Validation	Experiment	10 Teams (6-9 people each)	1 week
P11	Validation	Simulation	4 Teams (4 people each)	7 months (9-12 sprints)
P12	Evaluation	Case Study	Unreported number of teams (4 people each)	Not reported (4 sprints)

As highlighted in Table 11, five studies performed an evaluation in real settings, other five performed a validation, and two just proposed a solution for gamifying agile. From the five evaluation studies, four were conducted as case studies and one as an experiment. Regarding the validation studies, two were conducted as experiments, one as a simulation, and two combined both a simulation and a survey.

Table 11 Research types and categories applied in empirical studies

	Case Study	*Experiment*	*Simulation*	*Survey + Simulation*	*Total*
Evaluation	4	1	0	0	5
Validation	0	2	1	2	5
Solution proposal	–	–	–	–	2

The evaluation studies were performed with one to three teams, comprising a total of six to ten participants. Paper P6 did not report the size of the participant team, while paper P12 reported that each team was composed by four people but did not state the number of participant teams. On the validation studies, only P10 and P11 worked with teams instead of individuals, although P11 was based on historical data and did not directly work with

the teams. Overall, each study had three to 12 participants, except for P10 with 79 participants.

Papers P5 and P12 did not report the duration of the studies presented. While P11 reported the analysis of seven months' worth of data, the study itself did not last for this period. The duration of the remaining studies varied between a few hours to some months. P2 was the shorter study, lasting for 2 h and P3 was the longest study, where participants used a gamification solution for six months.

4.4 Impact of gamification initiatives

In Table 12 we outline the impact of gamification on the implementation of agile projects, classified as positive, negative, or non-significant. No impact was reported on papers P7 and P9 since they are solution proposals, nor in paper P11 where a validation was conducted with historical data. In the remaining papers, the impact was overall positive or not significant. Additionally to some increases in the metrics considered, some studies report improvements in participants' motivation and engagement, namely P3, P4, and P10. Papers P1 and P6 report the potential of providing quick feedback to improve agile practices.

Table 12 Impact observed in the selected studies

ID	*Impact observed*
P1	Positive (slightly): • Increase in the number of estimated issues • Perceived impact of constant feedback on the team's work Not significant: • Cooperative challenges and rewards did not seem to be motivating • Issues' specification quality did not seem to be influenced by the tips provided
P2	Positive (for treatment group): • Performance is significantly higher and directly impacted by gamification; • Requirements are more numerous, with more quality, and more creative. • Behavioural engagement was higher (more active with requirements creation) Not significant: • Engagement (emotional and cognitive) was high in both groups.
P3	Positive • Improvement in participants understanding of the software development process (Scrumban) • Improvement in performance • Perceived increase in motivation and engagement

Table 12 Impact observed in the selected studies (continued)

ID	*Impact observed*
P4	Positive: • Increase of ~30% in collaborators' performance • Improvement in agile management process tracking • Productivity indirectly influenced by gamification • Promoted cooperation, healthy competition, and commitment within collaborators
P5	Positive: • Decrease in tasks' size • Increase in the percentage of hours logged into the system (to support estimates)
P6	Positive: • Perceived potential of quick feedback to promote good practices • Perceived increase of the software tool's usage due to the surprise factor
P7	–
P8	Positive (treatment group): • More events attended, smaller stories created, and more stories completed.
P9	–
P10	Positive: • Scrum techniques became more fun, motivating, and engaging for participants.
P11	–
P12	Positive: • Increase in the number of sprints completed on time

4.5 Challenges affecting gamification initiatives

The challenges identified in the selected papers regarding both the proposed gamification solutions and the gamification initiatives conducted are listed in Table 13. Four papers did not clearly discuss any challenge. For the remaining, the most common challenge is related with reduced samples, both regarding the number of participants and the duration of the experiments.

The gamification solutions proposed in P1 and P2 were not considered challenging enough by participants, while in P1 and P6 the notifications were reported as being confusing or excessive, despite being a positive aspect of the solution.

4.6 Quality assessment

The papers included in this literature review were evaluated based on the quality assessment questions defined in Section 3.4. The score for each study is shown in Table 14. Given that P13 had a score lower than 3.0, this paper was discarded from the search, following the criterion defined. Additionally, we can see that only one paper achieved the full score, and eight papers scored more than 3.5 (i.e., half of the total score).

Table 13 Challenges identified in the gamification initiatives and proposed solutions

ID	*Challenges*	
	Initiative	*Solution*
P1	• Small number of participants • Short duration	• Excessive number of notifications launched • Not challenging nor competitive for participants • Biased score system, because not all behaviours are correctly rewarded
P2	• Small number of participants • Short duration • Convenience sampling technique used	• Not challenging for participants • Too focused on extrinsic rewards • Game elements not aligned with players' characteristics
P3	• Small number of participants	–
P4	• Short duration	• Users cannot act in the game • No software used to support gamification
P5	–	• Notifications are confusing • Not considered fun by half the participants
P6	• Small number of participants • Short duration • Participants were reluctant to record time when not corresponding to estimation	• Unclear purpose that participants did not understand • Focused on only one agile aspect
P7	–	–
P8	• Small number of participants • Participants worked individually, and not as a team	• Not integrated with the software management tool used
P9	–	–
P10	• Short duration: Participants were students, and not real practitioners	–
P11	–	–
P12	–	–

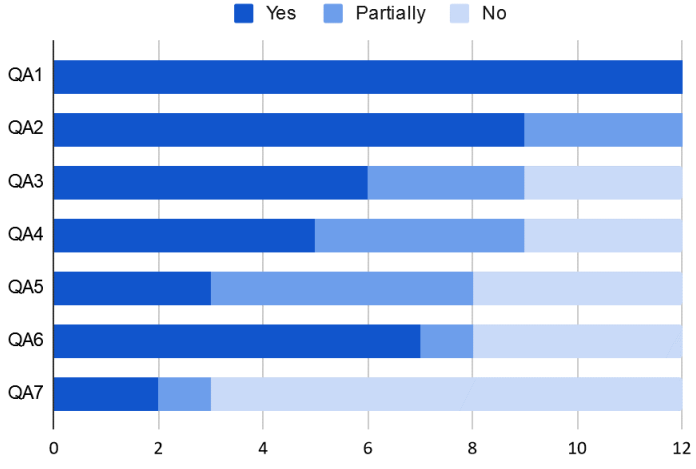
In Figure 7, the quality assessment results are presented according to each question.

These results show that all papers proposed a specific gamification solution for improving agile projects (QA1, $n = 12$), and that most papers present a clearly detailed description of the game elements employed (QA2, $n = 9$).

Table 14 Quality assessment of selected studies

	QA1	*QA2*	*QA3*	*QA4*	*QA5*	*QA6*	*QA7*	*Total score*
P1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.0
P2	1.0	1.0	1.0	1.0	1.0	1.0	0.0	6.0
P3	1.0	1.0	1.0	0.5	0.0	0.5	1.0	5.0
P4	1.0	1.0	0.5	1.0	0.5	1.0	0.0	5.0
P5	1.0	0.5	1.0	1.0	0.5	1.0	0.0	5.0
P6	1.0	0.5	1.0	0.5	0.5	1.0	0.0	4.5
P7	1.0	1.0	0.0	1.0	1.0	0.0	0.0	4.0
P8	1.0	1.0	0.0	0.5	0.5	1.0	0.0	4.0
P9	1.0	1.0	0.5	0.0	0.5	0.0	0.0	3.0
P10	1.0	0.5	0.0	0.5	0.0	1.0	0.0	3.0
P11	1.0	1.0	0.5	0.0	0.0	0.0	0.5	3.0
P12	1.0	1.0	1.0	0.0	0.0	0.0	0.0	3.0
P13	0.5	0.5	0.0	0.0	0.0	0.0	0.0	1.0

Figure 7 Distribution of scores per quality assessment question (see online version for colours)



Half of the studies were evaluated in industry with real practitioners, even if just for validation (QA3, $n = 6$). Three papers were classified as "Partially" in this question for specific reasons. Despite the participants of paper P4 being students, in the context of the study they worked in a more serious environment, and not in an academic context.

In P9, the authors state to have evaluated the proposal in industry with real practitioners, but do not provide further details. Finally, P11 validates the solution with historical data collected from real projects in industry, but these people did not directly used the proposed solution.

Moreover, the benefits and limitations of using gamification are discussed in less than half of the papers (QA4, $n = 5$). Likewise, only three papers reflect on the impact of gamification on motivation to adopt agile (QA5, $n = 3$). This means that while impact

might have been described, authors did not reflect on these results. Additionally, and as already stated, four papers did not explicitly discuss the limitations of their contribution (QA6, $n = 4$).

Finally, most papers were not published in a ranked journal or conference proceedings (QA7, $n = 9$), while only two have been published in top quality venues (P1 and P3, which are case studies published in one conference proceedings and one journal, respectively).

5 Discussion

When compared to the studies discussed in Section 2 regarding the use of gamification in agile, we identified twice more primary studies in this research work. While this could be explained by the longer timespan, only two primary studies were published between 2018 and 2020. Nevertheless, this is still a reduced number of studies for a SLR, which might be explained by the novelty of the field.

Regarding the quality of the evidence provided by the selected studies, not all papers report all the relevant information regarding the studies conducted, thus they were evaluated as medium-quality studies. This might also explain the fact that most papers were not published in high-quality venues.

In the following subsections, we discuss the answers to each of the defined research questions.

5.1 RQ1: how is gamification being applied to agile projects?

Gamification is being mostly applied to a subset of agile practices, instead of trying to promote all agile values and principles. In fact, addressing all agile aspects in a single gamification solution would be very complex and challenging, especially given the novelty of this research field.

While the most commonly gamified practices have been identified in previous studies as being frequent or important for measuring agile implementation (Meyer et al., 2014; Kupiainen et al., 2015; Version One, 2019), other important (yet complex) agile principles that are not as tangible are being overlooked. As an example, the daily work between business people and developers is very important to the success of an agile initiative, but it is difficult to gamify, considering that customer involvement is one of the challenges affecting agile adoption (Lopez-Martinez et al., 2016).

The reported agile practices seem to be measured with the right metrics. For example, the two most common metrics (number of total and completed stories/tasks per sprint) are being used to measure the most common practice (stories/task completion). Still, not all papers reported the use of agile metrics to measure the impact of the gamification initiatives conducted.

Additionally, the meaning of these practices and the way metrics are computer is inconsistent between studies. For example, two studies consider that stories/tasks are completed after being approved by the Product Owner (Medeiros and Passos, 2015; Češka, 2016), while the others only require that they are marked complete. On the other hand, the velocity metric is either computed as the sum of estimates of all completed stories/tasks (Marques et al., 2018) or "the number of points held on the number points that should be performed" (Češka, 2016).

Regarding the proposed gamification solutions, the most common and easy to implement game elements were the most frequent. Overall, most of the game elements were based on extrinsic motivators (i.e., the activity leads to a separable outcome) instead of intrinsic motivators (i.e., the activity leads to a separable outcome) (Ryan and Deci, 2000). However, extrinsic motivators have a limited effect on engagement that usually fades away if not combined with intrinsic motivators (Nicholson, 2015). Thus, these studies should further study how to create conditions to intrinsically motivate practitioners to implement agile practices (Alsawaier, 2018).

Additionally, these gamification solutions are often supported by software tools using diverse technologies, although some papers propose no more than prototypes. These tools are often standalone and not aligned with the existent work processes, which can hamper the adoption of the gamification solutions (Platonova and Bērziša, 2017) and act as a distraction from the participants' work (Kumar and Herger, 2013).

Most of these studies conducted an empirical evaluation or validation of the proposed gamification solutions, almost half of them in industry. Nevertheless, these empirical studies present limitations that hamper the possibility of generalising results, namely the reduced sample size, both regarding the number of participants and the duration of the studies (from a few hours to a few months).

By conducting longitudinal studies during larger periods of time, insights on the long-term effects of gamification could be gathered, particularly on the individual impact of each game element on participants' motivation (Platonova and Bērziša, 2017; Alsawaier, 2018). Moreover, studying different real-world agile teams would allow researchers and practitioners to better understand which settings can leverage the effects of gamification on Scrum teams (Pedreira et al., 2015).

Finally, it is important to mention that some of these results support those of the previous systematic studies discussed in Section 2. Namely, these gamification studies propose gamification solutions mostly based on simple game elements and implemented as standalone tools, which lack an adequate empirical validation.

5.2 RQ2: what is the evidence for the impact of gamification in agile projects?

The primary studies report mostly a positive, sometimes not significant, impact of gamification on the implementation of agile practices, which is in line with the previous systematic mapping on the subject (study S4 in Section 2).

However, this result is not exclusive to gamification of agile. Hamari et al. found that gamification can motivate users to adopt a behaviour in many domains, despite the lack of empirical data (Hamari, Koivisto and Sarsa, 2014). We further found that gamification often boosts other factors beyond performance and motivation, such as communication and engagement (Reeves and Read, 2009).

Nevertheless, these results might be subject to publication bias, meaning that papers reporting positive results are more likely to be published rather than negative results. Additionally, we found that these studies rarely discuss the benefits related to the use of gamification, as concluded in a previous systematic study discussed in Section 2 (study S5).

5.3 RQ3: which challenges are affecting gamification initiatives in agile?

The challenge that mostly affects gamification initiatives is the existence of reduced samples. Even though this issue was not reported in all papers, all empirical studies had a short duration and did not study the effect of gamification on the long term (e.g., for at least a year). The implications posed by this challenge were already discussed in Section 5.1 when analysing the research types and sample characteristics.

While some challenges were reported regarding the gamification solution, no one stood out from the others. However, we argue that some suggest a misalignment between the developed solution and the participants' needs.

Finally, we must consider that the challenges affecting the gamification studies are rarely discussed in-depth by authors, similarly to what has been discussed when answering RQ2 regarding the impact of gamification. Additionally, most studies did not evaluate the gamification solution with real practitioners in industry, which is in itself a challenge affecting the research in this field, since motivation can only be assessed in real settings with real users.

6 Threats to validity

This paper is subject to some limitations that may threat the validity of the presented results. Below we discuss these threats, categorised according to Wohlin et al. (2012) and based on the threats to validity that Zhou et al. identified as being common in SLRs on software engineering (Zhou et al., 2016).

Construct validity. To avoid mistakes in the search and selection process, a detailed search protocol was validated by all authors prior to conducting the search. Moreover, all the decisions and results were thoroughly documented. Despite considered important, the Springer Link repository was not searched, since it did not allow for advanced searches, thus widening ineffectively the number of search results. Nevertheless, we believe this threat was mitigated by using multiple repositories combined with a snowballing strategy. The specificities of each repository were considered and reported in this document.

Internal validity. Seeking to avoid study selection bias and issues while assessing studies' quality, the inclusion and exclusion criteria were discussed and validated by all authors to ensure misinterpretations. Decisions for inclusion and exclusion were documented and discussed by the authors to ensure that only relevant studies were included. Moreover, the fact that all authors are experts on the research field might have reduced bias in the interpretations and conclusions reported. As already discussed, the results might suffer from publication bias, since mostly positive results were reported in the analysed studies. To address this limitation (which is out of our control), we followed Kitchenham and Charters' suggestion to include papers published in conference proceedings in the search (Kitchenham and Charters, 2007).

External validity. The search includes papers published between January 2010 and middle March 2020. Thus, this study might miss relevant works published outside this timespan. However, we believe that no relevant study published prior to 2010 was left out of the analysis, since the first gamification results only started appearing in this year. Moreover, the full text of a relevant paper was not accessible. The authors were contacted

to obtain this full text, but we obtained no answer, and thus the paper was discarded from the search.

Some of the primary papers did not present all the research information needed to answer the research and quality questions defined, which might have hampered the conclusions drawn and the quality assessment of the studies (Kitchenham and Charters, 2007). Nevertheless, we have considered all information reported in these studies, and in some cases (such as the impact of gamification and the challenges associated to these studies) the absence of data was a result by itself.

Construct validity. We tried to reduce bias in data extraction by having all authors revising both the data extraction protocol and the data extracted.

7 Conclusion

In this paper, we studied how gamification has been used to improve agile practices in industry; the impact this approach had on agile projects; and the challenges faced. To achieve this goal, we conducted a SLR of research works addressing the use of gamification for improving agile projects.

This study differs from related systematic studies on the use of gamification in agile since it aims at providing an in-depth analysis, and not just discover trends, while exploring interesting insights that have been covered in broader software engineering systematic studies. Moreover, it covers two more years when compared to the previous studies (i.e., papers published between 2018 and 2020).

In total, 12 primary studies were selected, twice more when compared to previous studies. However, this is still a reduced number, which exposes the novelty of this field. Moreover, as a result of a quality assessment we found that these papers are of medium quality, which might explain why most papers were not published in high-quality venues.

As reported in previous related studies, gamification seems to have the potential to improve the adoption of agile practices, although such studies present relevant limitations. The primary studies are mostly proposals of gamification solutions, often based on simple game elements that are based on extrinsic motivators, which have a limited effect on engagement. Additionally, the benefits and challenges of implementing gamification in agile projects are rarely discussed in-depth by the authors.

On the other hand, by studying aspects that have been addressed in systematic studies related to the use of gamification in software engineering in general, we have found that some patterns still apply specifically in agile-related studies. These solutions are often implemented as standalone technologies that are not integrated with existing work processes. Also, these solutions are either not evaluated empirically, or evaluated based on small samples, which makes it difficult to generalise results and draw relevant conclusions.

Additionally, we found out that most gamifications solutions cover only a subset of relevant agile practices. Yet, important and less tangible agile aspects are not being explored in gamification studies, such as the relation with the customer. Furthermore, the meaning of some agile practices and metrics seems to be inconsistent between studies.

7.1 Future work

Following these conclusions, we identify some potential directions for researchers and practitioners to address the research gaps identified throughout this study. More specifically, these opportunities for future work consider not only the development of gamification proposals, but also the management and communication of such initiatives.

Regarding the gamification solutions proposed, in the future researchers and practitioners should try to develop solutions focused on agile practices and game elements other than those being currently covered. There are agile practices that are not being considered yet are important for the success of an agile initiative, and game elements based on intrinsic motivators could help boosting motivation more effectively and for longer periods.

Moreover, there should also exist an increased consistency in the way agile practices are described and metrics are computed. An alternative is to select practices aligned with relevant sources, such as the official Scrum Guide (Schwaber and Sutherland, 2016).

Regarding the studies' characteristics, more longitudinal studies with stronger empirical validations should be conducted to better understand the impact of gamification on practitioners' adoption of agile practices.

Additionally, authors should focus on providing more detail when reporting their studies, specifically regarding the discussion of the impact, benefits, and challenges of gamification. By reporting and debating these aspects, the results of gamification initiatives could be better understood and used to improve future studies on the subject.

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Appendix A: Game Elements framework

Category	*Name*	*Description*
Dynamic	Constraints	Limitations or forced trade-offs
	Emotions	Curiosity, competitiveness, frustration, happiness
	Narrative	Consistent, ongoing storyline
	Progression	The player's growth and development
	Relationships	Social interactions generating feelings of camaraderie, status, altruism
Mechanics	Challenges	Puzzles or other tasks that require effort to solve
	Chance	Elements of randomness
	Competition	One player or group wins, and the other loses
	Cooperation	Players must work together to achieve a shared goal
	Feedback	Information about how the player is doing
	Resource acquisition	Obtaining useful or collectible items
	Rewards	Benefits for some action or achievement
	Transactions	Trading between players, directly or through intermediaries)
	Turns	Sequential participation by alternating players
	Win States	Objectives that makes one player or group the winner– draw and loss states are related concepts
Components	Achievements	Defined objectives
	Avatars	Visual representations of a player's character
	Badges	Visual representations of achievements
	Boss Fights	Especially hard challenges at the culmination of a level
	Collections	Sets of items or badges to accumulate
	Combat	A defined battle, typically short-lived
	Content Unlocking	Aspects available only when players reach objectives
	Gifting	Opportunities to share resources with others
	Leaderboards	Visual displays of player progression and achievement
	Levels	Defined steps in player progression
	Points	Numerical representations of game progression
	Quests	Predefined challenges with objectives and rewards
	Social Graphs	Representation of players' social network within the game
	Teams	Defined groups of players working together for a common goal
	Virtual Goods	Game assets with perceived or real-money value