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The Application of Game Mechanics and Technological Trend in Game-Based Learning: A Review of the Research

[1]Mhd. Adhitiya Okta Riyandi, [2]Harry Budi Santoso, [3]Panca Oktavia Hadi Putra
[1,2,3]Faculty of Computer Science, Universitas Indonesia
[1]mhd_adhitiya@ui.ac.id, [2]harrybs@cs.ui.ac.id, [3]hadiputra@cs.ui.ac.id

Abstract

The rapid development of information technology affects numerous aspects of human life, including education. An example of IT application in education is game-based learning. Game-based learning has been implemented in various fields or subjects on various platforms. This is due to the potential of game-based learning to enhance the student engagement in the learning process. Nevertheless, the effectiveness of this method is still needs to be studied further. This systematic literature review aimed to explore about game mechanics that applied on current game-based learning researches, accompanied by the trend of technological utilization in research paper published in this domain. This study covered 30 journal and conference proceeding papers published from 2012-2022. The review was conducted using the Kitchenham method. Selected papers were then analyzed to determine the engagement model used in each paper (Feedback Model, Incentive and Achievement Model and Progression Model). Findings included the trend of research in this field (technology applied to each research, online feature, study majors/subject) are displayed based on the time paper were published. The result of the study indicated that all previous research used at least one of the engagement models, with 12 papers using all three models. In terms of technology, it was found that the adoption of web-based technology has been increasing in recent years, including online features which have also increased, along with the study subjects that implemented game-based learning. In summary, game-based learning can be applied in a wide range of subjects and platforms with the support of its feature, making learning more flexible.

Keywords: game-based learning; systematic literature review; engagement model; technology; study subjects

1. Introduction

In recent decades, the development of information technology has been advancing rapidly [1]. Various essential aspects of human life, including education, have transformed into digital media, making technology critical in education [2]. One of the initiatives in technology implementation in education is game-based learning.

Game-based learning points to the use of games to enhance students' experience in the learning process [3]. This achieved by applying game mechanics and related elements as media for education, to enhance engagement, entertainment and problem-solving processes [4]. The strategy itself combines activities or standard processes with the principle of meaningful experience and motivation by integrating game mechanics into a non-recreational environment and applied based on game concepts [5]. Few studies, such as Rahman et al. [6], defined game-based learning and gamification in the same term, but Al-Azawi et al. [3] stated that both terms have differences.

Gamification focuses more on applying the game's elements in not-game situations, while game-based learning uses the game to enhance the learning experience. In short, game-based learning focuses on enhancing the student learning experience via a game, while gamification is more into combining the existing process with specific characteristics [7]. The research about the game application in the learning process started when Clark Abt introduced the term serious game in the 1970s, defined as game development where entertainment was not the main concern but contained material that could be used as learning material [8]. In its development, the drawback of its point of view was found because it described computer game as the sweetener to deliver learning content, implying that game was fun but not learning [9]. This subject has become more expansive than before in the last few decades, where the term used to describe this approach became more variant, like serious games, gamified learning, and gamification [8].

In line with the development of information technology, instructors have more comprehensive options to apply

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game-based learning, where various online platforms such as Kahoot!, Quiz-izz, Socrative and Quizalize are available as a medium to apply game-based learning for the instructors [8]. On the other side, the advancement of information technology affects the wider range of platforms that are able to conduct game-based learning, from desktop [10]–[12], web [2], [13], [14], mobile [15]–[17] even Massively Multiplayer Online Role-Playing Game (MMORPG) [18]. Other than the platform, the game that applied game-based learning also advanced in terms of features, from offline [19]–[22] to support online activity [14], [23]–[25]. This development shows that the advance of technology also supports the advance of game-based learning as its medium also supported various features.

In order to properly apply game-based learning, it is crucial to understand the game's mechanics. Game mechanics consist of rules and procedures guiding the players [26]. In game-based learning, various game mechanics can be applied, such as rewards for compliance in various levels, scoring, leveling, chance element, theme, exploration and competition [4]. Among the mechanism, reward or achievement became one widely used mechanism [27]. To form engagement, game mechanics would be interrelated with other aspects, namely game elements and game dynamics. Game elements are defined as aspects that can influence gameplay, while game dynamics suggest how the player and game will evolve. Thus engagement between the player and the game can be build up [28]. The implementation of game elements aims to enhance the progression into desired behaviors, such as enhancement of student engagement and learning [5].

The engagement was one of the main elements that built the education system [29]. As the definition of engagement, Hookham et al. [30] define engagement as involvement in one specific activity. In education, the term called student engagement is defined by Henrie et al. [31] as commitment, participation and effort to participate in the learning process. This term describes a positive attitude shown by students. Henceforth, engagement is associated with a combination of student's attitude, cognitive and emotional aspect in a learning environment [32].

Enhancement of engagement followed by the increased possibility to develop a motivation toward particular behavior considered as the environment's goal [33]. In online learning, engagement and getting the learner's attention are among the essential issues in applying this learning method [34]. Based on the definition, it can be understood that student engagement is an essential component in building a learning environment, and it was a challenge for the institution to manage and emerge it to build a proper learning process [35].

For a teacher that aims to improve student engagement and motivation, the game became an exciting choice, presented by how convenient technology and computer game are in drawing student attention. In implementing a game to improve student engagement, a few attributes listed as essential factors, consist of focused goal, challenging tasks, explicit instruction, rapid feedback, affirmation of performance, social networking, safety from failure, curiosity and novelty, and fantasy [9]. Others, student engagement mediated by the game is also affected by the game mechanism applied to support the learning process, such as feedback, reward or in-game achievement, and in-game progress such as leveling felt by players [36]. This method has been the topic of research and published in multiple papers across the years.

Furthermore, the effectiveness of this method in enhancing student engagement still needs to be proven. This can be seen by different results from various research about this field, with some supporting the theory and others not. Various research such as [2], [13], [37] supported this claim, but other research, such as that conducted by Shernoff et al. in [10] did not supported this finding. The result varied on whether the interrelation between game elements, game mechanics and game dynamics occurred [28]. This finding suggests that how the developer encourages the learning process, in this case by using game mechanics, became important [36].

In previous papers, the main issue was implementing game-based learning to enhance student engagement. Little attention focused on the game mechanics applied in those games. Thus, this study tried to identify game mechanics applied in various games used in recent papers about the effect of game-based learning on student engagement. Furthermore, identifying game mechanics was also incorporated with the current technological trend of applying game-based learning in this field.

Review questions (RQ) of the current study, RQ1: How are game mechanics applied to enhance student engagement in current game-based learning research?; RQ2: What is the current trend of technological utilization in recent research of game-based learning, specifically regarding platforms, online features and subjects course implemented this approach?.

2. Research Methods

This research used Kitchenham SLR method [38], to identify how each paper enhances student engagement in game-based learning environment. The Kitchenham SLR method consist of few phases: initiation, title and abstract selection, and full-paper selection. This method originated from the SLR method aimed at the medical field, and was later customized and developed into another field, such as computer science [39]. This method was selected based on previous research, which

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has proven fit to be used in the information system domain [40].

According to the Kitchenham SLR method [38], a literature review consists of three steps, that can be simplified as planning, structuring and results [41]. These phases covered the literature review process, from planning to writing the result of the study. All steps conducted in each phase of the current study can be seen in Figure 1.

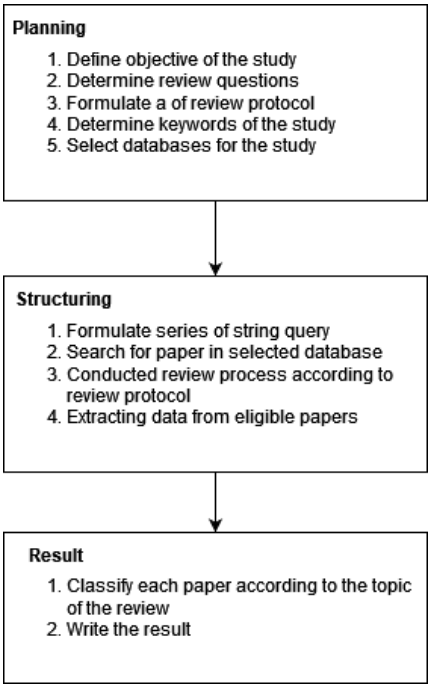

Figure 1. The Activity of Each Phase in the Current Study

In the planning phase, defining the objective and determining the review questions became the first step. The current study's objective and review questions are in the Introduction section. The subsequent phases will be explained below: formulating the review protocol, keywords, and selection of suitable databases.

Before the initiation phase, the review protocol of this research was decided and formulated. Review protocol became the primary factor in deciding whether a paper was sufficient or not with the goal of this research, and conducted in each phase of this research. The review protocol can be seen in Table 1.

The initiation phase began with formulating a string query that would be used to search papers among the selected databases. This query formed by the selected term matched the purpose of the research, synonym or another relevant term, specifically technological application in game-based learning. The string query formed for this research consisted of "Serious Game" OR "Educational Game" OR "Game-based Learning" AND "Education" AND "Student Engagement" with a range of years limited to 2012 to 2022. This range of years determined to see the development in the topic of game-based learning in recent years. The defined string query was then used to search in selected databases, that have been determined align with the objective of this study.

Table 1. Review Protocol

Phase	Inclusion Criteria	Exclusion Criteria
Initiation	Match Search Query English Published Published Around 2012-2022	Unmatched search query Other than English In Progress/ Unpublished Published Outside the Range
Title and Abstract Selection	Discussed Learning with Game Discussed Student Engagement	Not Discussed Learning with Game Not Discussed Student Engagement Duplicated Paper Review Paper
Full-Paper Selection	Discussed Student Engagement Method Accessible by Author	Not Discussed Student Engagement Method Inaccessible by Author

The databases used for this study consisted of ACM Digital Library, Emerald Insight, SAGE Journals, Science Direct, and Scopus. Results of the reference search were saved into Mendeley, a reference management system, before the next phase could be executed.

In title and abstract selection, the collected data from the previous step would be selected according to the review protocol criteria. The relevant papers were then passed on to the next phase. The full paper was selected using the previous phase's result, and the full-paper version was searched. If the full paper could not be accessed, the paper was automatically rejected from the list. All full-paper versions were collected from the search process and then reviewed according to the review protocol, resulting in papers relevant to this research's purpose. The result of each phase can be seen in Table 2.

Table 2. Result of Reference Search from Selected Databases

Database	Initiation	Title and Abstract Selection	Full-Paper Selection
ACM Digital Library	89	26	7
Emerald Insight	26	5	0
SAGE Journals	89	18	6
Science Direct	613	20	6
Scopus	171	43	11
Total	988	112	30

The selection process based on the review protocol resulted in 30 eligible papers for the current study. Data from selected papers would be extracted according to the purpose of the study, mainly about the game-based learning mechanism and the trend of the technological appliance in game-based learning from each paper.

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3. Results and Discussions

Based on the result of the previous step, 30 papers have been determined relevant to the purpose of this review study. In line with the purposes, the explanation was categorized into two subjects: game-based learning mechanisms and the current technological application in game-based learning.

3.1 Game-based Learning Mechanism

This part discusses the mechanism or model to enhance game-based learning. Thirty selected papers were used for the analysis process. The model used in this research was proposed by Pierce et al. [36]. Pierce proposed a model titled Learning Management Model of a Game, consisting of three sub models. Each sub-model was a mechanism that was applied to enhance the learning process. These sub-models consisted of Feedback Model, Incentive and Achievement Model and Progression Model.

The feedback model referred to the message displayed in the game as a response for the player and aimed to help the player recognize the in-game fault. The common form could be right-wrong verification, or elaboration about the player's mistake in-game. The incentive and achievement model had several applications, such as achievement style, social sharing style and social sharing type. Achievement style focused on how the player's performance was communicated to them, via score or ranking. The social sharing style indicated the system's support for sharing players' success outside the game. The social sharing type referred to how the achievement was shared outside the game. The progression model referred to how the player moved forward in the game, indicated by leveling, or a condition where a player could change some in-game aspects. It was common to find multiple sub-models applied in a game.

Based on the model and sub-models explained before, thirty papers have been collected and then processed. The sub-model applied in the game used in each paper was identified according to the definition explained above. The result of this step can be seen in Table 3.

Based on Table 3, it could be seen that each paper at least used one of the sub-models explained before. In terms of number, 12 papers only used one type of sub-model in the research. Seven papers combined two sub-models, while 11 papers used all three models in the game used for research. All three sub-models were a common method to be used in the research process of the application of game mechanics to improve the learning process.

Another finding emerged from the perspective of how each sub-models was applied in the papers. Among 30 papers in the current study, the feedback model was applied in 20 papers. Other sub-models, inventive and achievement and progression models were applied in 16 and 23 papers respectively. Among the papers that applied the feedback model in the study, in-game feedback became feature that was widely used. The leaderboard emerged as the widely applied game element for the incentive and achievement model, followed by badges and points. For the progression model, leveling became the game element that was applied in most in current study papers.

Table 3. Sub-models of Game in Selected Papers

References	Learning Management Model in Game		
	Feedback Model	Incentive and Achievement Model	Progression Model
[42]	✓	✓	✓
[43]	-	✓	-
[44]	✓	✓	✓
[13]	✓	✓	✓
[15]	✓	✓	✓
[37]	✓	✓	✓
[14]	-	-	✓
[45]	✓	✓	✓
[46]	-	-	✓
[26]	✓	-	✓
[20]	✓	✓	✓
[25]	-	✓	-
[21]	✓	-	-
[22]	✓	-	-
[47]	-	✓	-
[11]	-	-	✓
[32]	✓	✓	-
[48]	✓	-	✓
[24]	✓	✓	✓
[12]	✓	-	✓
[49]	✓	-	✓
[50]	✓	✓	✓
[51]	-	-	✓
[10]	-	-	✓
[18]	✓	-	✓
[16]	✓	✓	✓
[17]	-	-	✓
[52]	-	✓	-
[23]	✓	✓	✓
[2]	✓	-	✓

3.2 The trend of Technological Appliance in Game-based Learning

The next part would describe technological aspects applied in game-based learning based on the yearly result described in the previous part. Aspects to be described consisted of technology used in a game, online features in the game, and subject or course using game-based learning in its learning process. The detailed result can be seen in Table 4.

Based on the result, desktop and web became the platform that widely to implement game-based

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learning. Other platforms used also consisted of the mobile, virtual world and MMORPG.

Table 4. Game Aspects from Selected Papers

Year	Number of Selected Papers	References	Platform	On-line	Subject/ Course
2012	1	[42]	Mobile	-	College Orientation
2013	0	-	-	-	-
2014	2	[43]	Virtual World	-	Computer Science
		[44]	Mobile/ Web	✓	Sport
2015	1	[13]	Web	✓	Construction
2016	5	[15]	Mobile	-	Physics
		[37]	Web and Desktop	✓(1), -(2)	Computer Science
		[14]	Web	✓	Physics
		[45]	Web	✓	Physics
		[46]	Web	✓	Economy
2017	5	[19]	Desktop	-	Chemical
		[20]	Desktop	-	Astronomy
		[25]	Web	✓	Business
		[21]	Desktop	-	Microbiology
		[22]	Desktop	-	Microbiology
2018	4	[47]	Unspecified	-	Co-curricular
		[11]	Desktop	-	Linguistic
		[32]	Desktop	✓	Information Literation
		[48]	Desktop	-	Computer Science
2019	2	[24]	Web	✓	Writing and Critical Thinking
		[12]	Desktop	-	Physics
2020	5	[49]	Web	✓	Medical
		[50]	Unspecified	✓	Computer Science
		[51]	Mobile	✓	Psychology
		[10]	Desktop	-	Engineering
		[18]	MMORPG	✓	Linguistic
2021	3	[16]	Mobile	✓	Culture
		[17]	Mobile	-	Introduction to Number
2022	2	[52]	Web	✓	Pharmacy
		[43]	Web	✓	Math
		[44]	Web	✓	Business

In terms of trend, research published in the last three years showed that web platforms that could be accessed via mobile or desktop have become more favorable. Overall, web platform was utilized in 38% research in current study. This number was the highest, followed by desktop (31%) and mobile platform (19%). Other than these three, another platform such as virtual world and MMORPG (3% each) also have implemented game-based learning, and few research not specifically named the platform, so the platform grouped as unspecified (6%). The comprehensive data of utilized platform for current study can be find in Figure 2.

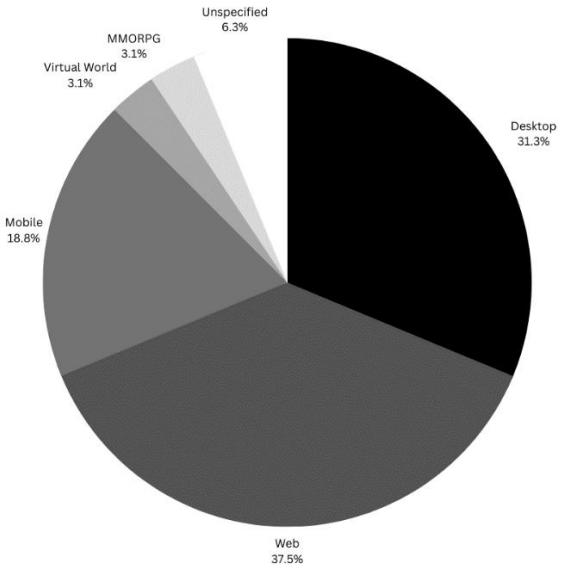

Figure 2 Platform Utilized in Current Study

In terms of online features, these features were presented in most games. Specifically, online features implemented in 17 games studied in research (55%) of the researches in current study, leaving 14 game (45%) not implemented. An interesting finding was that none of the desktop games had implemented these online features. Online features have become more favorable in the last five years. This was probably affected by the broad and easy access to the internet that developed in recent years. Also, this development made the research about web and mobile platform became more considerable, since these two platform more familiar to implement online features.

Another finding in the current study also showed in subject or course that implemented game-based learning. In this study, most subjects that implemented game-based learning were rooted in Science, Technology, Engineering and Mathematics (STEM) subjects. Examples of this subject included computer science, physics, chemistry, and microbiology. In recent years, however, despite STEM subjects still being featured in the research, another subject was also starting to implement game-based learning. A few subjects also come from non-STEM backgrounds, such as business, linguistics, and culture. This development shows that the range of implementation in game-based learning also becomes more expansive, and that is now starting to be implemented in non-STEM subjects.

3.3 Future Recommendation

This part will discuss the direction for future research about game-based learning. These topics are based on

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the results that have been discussed in previous parts.

First, the result from this study discovered that game-based learning had been integrated into different platforms, from the desktop, web, and even mobile. However, the current result showed that only three papers discussed the implementation of game-based learning in mobile platforms. This domain still has many topics to be discussed and is also relevant to the situation in current years, where everyone in their everyday life, largely uses mobile platforms. In addition, many forms of the learning management system that mainly operate in web-based, also provide a mobile version of their system. This trend shows that learning via mobile platforms can be conducted, so there is a possibility to implement game-based learning in the mobile environment.

Second, the current study also found that much of the game-based learning used for the research had implemented online features. Yet less research discussed how this feature affected the learning process. In the current research, the discussion mainly focused on the effectiveness of game-based learning itself. The effect of a feature, for example the online features, was still open for future research. One example was to explore whether the in-game interaction between learners in the game-based learning environment affected the learning process. This approach could maximize the usability of a particular feature in a game-based learning environment.

4. Conclusion

This research purposed to map the research about the implementation of game mechanics to support the learning process and enhance student engagement published in the range of 2012 to 2022. In terms of numbers, 2016, 2017 and 2020 became the most productive year for this subject, with five papers published each year. The number of research had improved in 2018 forward, showing that this subject gathered quite a lot of attention from the researcher.

Among the research papers reviewed for this research, almost all papers concluded that using the game mechanisms in learning improved student engagement. This result proved that game mechanism helped students feel connected with the learning process, but still needed to be apparent how it affected the learning process.

Implementation of the game mechanism in this research was divided into Feedback Model, Incentive and Achievement Model and Progression Model. The mapping result showed that all papers in this research used at least one model in the game used for the research. Even more, 12 papers used all three models in the research. Combination the three models was the most used method to engage the students.

In terms of the trend in research, the number of research on game-based learning increased in recent years. Technologically, the platform used in this subject became wide, with web platforms as widely used and the online feature complementary to the game. The subject implemented this method showed to be wider than before, from usually used in science and technology, the subject also covered social, business, and psychology.

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