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Review Article

Trends and gaps in empirical research on gamification in science education: A systematic review of the literature

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ABSTRACT

Digital technology development has led to the creation of various learning options in the science education field. Technology such as gamification has been used in several science areas, uncovering diverse benefits regarding its usage. However, more research is needed to understand how gamification enhances students learning in science fields. Therefore, this study review presented an overview of gamification usage in the science education field literature and focused on research indexed in several international databases. 31 studies were included for review. The results showed that most of the studies presented positive outcomes as gamification proved to be effective with science education students. The study also indicated that most gamification studies were mostly used to enhance students' learning skills in science education. The results of this study provide valuable data regarding technology techniques to enhance students' skills in science education. Further research is needed to cover areas that are not widely investigated in gamification literature.

Keywords: technology, gamification, science, education, learning

INTRODUCTION

In the field of learning and teaching, students are being exposed to several teaching options and alternatives thanks to the rise and development of digital technology (Jdaitawi, 2019; Muhaidat et al., 2022; Rasheed et al., 2021; Soliman et al., 2022). In addition, such digital technology developments have led to

innovative changes and transformations in teaching and learning (Chans & Castro, 2021; Jdaitawi, 2020a, 2020b; Jdaitawi et al., 2022a, 2022b). More specifically, in science education, which is considered as one of the top disciplines in the world, learning through technology has become easier (Cagande & Jugar, 2018; Tsai et al., 2018), which is why educational institutions need to shift from a traditional educational environment to new educational methods, like gamification-based educational environments (Chan et al., 2017; Chans & Castro, 2021).

Literature concerning education has been increasingly focusing on gamification, particularly in the context of its implementation in teaching and learning to assist teachers and students achieve their objectives and goals (Acosta-Medina et al., 2020). In the most basic sense, studies in the literature described gamification as the game elements in non-gaming objectives (Dicheva et al., 2015; Nadlifatin et al., 2020). According to Folmar (2015), gamification is not creating a game that imparts a lesson but rather it is the application of the game in a way that the lesson is imparted along with its development based on the player's feedback (p. 5). Others like Rabah et al. (2018) defined gamification as a mechanic-based game thinking whose main purpose is to attract attention, promote action and learning as well as problem-solution while learning. This type of learning has its basis on the premise of active learning in the context of higher education, where literature has evidenced its effectiveness in the students' learning experiences (e.g., Al Amri & Almaiah, 2020; Naji, 2019). In the same line of study, Wichadee and Pattanapichet (2018) revealed the influence of gamification on the spirit, motivation and learning outcomes of students in positive ways. Moreover, Papp (2017) found that gamification influenced the motivation, engagement and expressions of the students. Evidently, students and teachers in the educational environment have benefited from gamification through the promotion of productivity and the advantages it has to offer.

In addition to the above, science education is extensively deemed to be one of the major education of our current times as it creates citizens who are scientifically literate and promotes adaptability and problem-solving skills (Kalogiannakis et al., 2021; National Research Council [NRC], 2010). However, despite its importance in improving the knowledge and skills of students, the teaching method applied to teach science remains ineffective in inculcating knowledge in students (Lee & Kim, 2019). In this regard, there has been a focus on the tools and techniques used to bring about scientific thinking and educational science theories. For instance, gamification methods are among such tools used in science education (Kalogiannakis et al., 2021). Its implementation for science education teaching has remained an intriguing field for the majority of authors as students are familiar with it and are drawn to it (Kalogiannakis & Papadakis, 2017; Loganathan et al., 2017). Gamification promotes scientific thinking and is aligned with scientific theories and methodologies. Its learning strategies are also consistent with those in education (Morris et al., 2013; Vidakis et al., 2020).

Gamification benefits have been highlighted in literature and these included the flexibility of gamification, ease of access, the promotion of critical thinking skills and achievement of positive outcomes. Furthermore, it increases students' motivation, participation, engagement and collaboration throughout the learning process (Vanduhe et al., 2020), and these are crucial factors to be examined for enhanced training and learning (Stiegler & Zimmerman, 2015). According to Liu et al. (2016), elements of gamification lead to enhanced educational outcomes, resulting in a more enjoyable learning experience. Nevertheless, regardless of the positive outcomes, findings from other studies remain mixed, particularly concerning the gamification potential to facilitate the learning of students in various settings–for instance, in Landers and Armstrong (2017), the authors found no significant effects of gamification on the instructional outcomes when coupled with low attitudes of learners towards this type of learning. Also, Thornton and Francia (2014) revealed that gamification implementation may not apply to the entire curriculum, which may worsen learning outcomes (Alomari et al., 2019).

In the same study caliber, Ding et al. (2018) and van Roy and Zaman (2018) opined that gamification methods may not be the most appropriate alternative for achieving the desired learning outcomes among students. On top of this claim, a call-in gamification literature finding pointed to the challenge of its implementation in various levels of education (Hamari et al., 2014; Koivisto & Hamari, 2014; Rapp et al., 2019; Zainuddin et al., 2020). In this regard, more studies are needed to examine gamification in different educational levels and fields, particularly in science education.

Considering the high demand for innovative tools and methods in science education, several methods have been proposed by academicians and IT specialists involving gamification in the hope of enriching both the learning and teaching processes. However, studies in literature such as Kim et al. (2018), Koivisto and Hamari (2014), Marín et al. (2019), and Zainuddin (2018) underlined the general nature of the gamification studies that barely examined the technology and called for in-depth exploration and its influence over the students' learning in light of science education and the required skills (Hursen & Bas, 2019; Kalogiannakis et al., 2021). The gamification techniques have been shown to promote student learning and motivation (Kapp, 2012; Zimmerling et al., 2019), improve their scientific thinking (Morris et al., 2013), as well as the effect they have on their learning and its outcomes (Subhash & Cudney, 2018; Zainuddin et al., 2020). Several reviews have been conducted in recent years in an attempt to explore and provide insights into the growing body of knowledge in gamification (Navarro-Espinosa et al., 2022). One of the first reviews was conducted by Subhash and Cudney (2018) and supported several benefits of gamification such as improved students' performance, motivation, and learning perception. Another review study was conducted in the English language field by Boudadi and Gutierrez-Colon (2020) and found that gamification enhanced students' motivation and their learning engagement. Another study in the social environment field conducted by Brito and Mena (2020) indicated that gamification enhanced students' engagement and motivation levels. Studies dedicated to gamification in general and in particular in science are still lacking. Furthermore, of those conducted, some indicated mixed findings as to the intervention's effectiveness (Boudadi & Gutierrez-Colon, 2020; Kalogiannakis et al., 2021). Recent studies on gamification to individual discipline are also still insufficient and further research is needed. Previous mixed results may be due to the subject nature and its contents and activities. In light of these, the present study aims to review the literature in the field and present a literature analysis finding relating to gamification and its role in science education.

LITERATURE REVIEW

Importance of Gamification in Science Education

In literature, gamification has been examined for its effectiveness in inculcating science courses to students, primarily focusing on their acquisition of various skills to succeed in life situations. These skills are linked with learning, cognitive, social and personal skills, which students face issues with and thus leading to the development of their negative emotions and experiences (Kalogiannakis et al., 2021). Students have been found to have difficulty understanding science subjects, which eventually leads to their rejection of the subjects and their total dropout from their institutions (Vidakis et al., 2020). Hence, the integration of innovative tools (e.g., gamification) may lead to clarifying the issues in science courses through the enhancement of students' learning engagement and motivation (Loganathan et al., 2019; Vidakis et al., 2019). In addition, gamification was also linked to the social skills of the students as it facilitates a constructive learning environment (Chans & Castro, 2021) and contributes to their inclination towards learning engagement in activities involving learning and teaching (Papadakis & Kalogiannakis, 2018). The lack of research concerning gamification, specifically examining the cognitive and thinking abilities of students was noted by Hugerat and Kortam (2014) and Lazonder and Harmsen (2016) despite the increasing use of the same in science education. Such studies have revealed mixed results in general, necessitating more studies to validate the results (Hamari et al. 2014; Kalogiannakis et al., 2021; Rapp et al., 2019). An analysis of literature in the present study attempts to enhance literature on the gamification implications in science education through the determination of the following questions:

1. What is the impact of gamification on the learning effectiveness of students?
2. What are the trends and tools used in gamification?
3. What are the top common skills used in science education regarding gamification?
4. What is the most common subject of science education for gamification techniques?
5. What are the advantages of using gamification in science education?
6. What are the disadvantages and challenges of using gamification in science education?

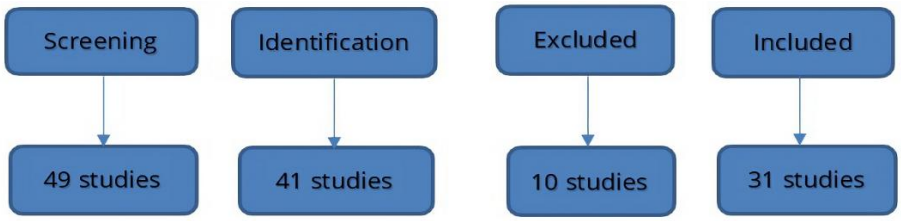

Figure 1. Review gamification studies following Kitchenham's (2004) model

METHODOLOGY

This study adopted Kitchenham's (2004) method of using an analysis review of gamification in several stages involving planning and conducting and reporting the review. With regard to the planning stage, relevant studies to the topic were screened based on the established exclusion and inclusion criteria for the studies (Kitchenham, 2004), ranging from 2015 to 2021. The studies were selected based on journals, research topics and methods, data analysis, findings, limitations, advantages and disadvantages of gamification and conclusion. The study carried out an extensive and robust literature review to determine gamification studies in the field of education and the current trends–this involved reviewing articles from various databases, with the inclusion of ERIC, EBSCO Host, ScienceDirect, Scopus, Elsevier, and ISI databases. Gamification is the keyword used to search for the relevant studies in the above databases, garnering several numbers of studies in different fields and levels.

Inclusion and Exclusion Criteria

The study review involved 31 studies that were deemed suitable based on the assessment of the variables. Study selection was performed through some criteria for excluding and including studies in connection to research questions. The criteria included the keywords gamification, video games, gamify and science fields. The criteria also included science topics studies using gamification published between 2015-2022, journal type, demonstrated research methods and topics, population and data analysis, as well as studied demonstrated findings, advantages, disadvantages, and limitations of gamification in the science field.

On the other hand, several criteria were defined to exclude some research from this study such as studies that did not mention the term gamification, studies conducted in several educational contexts, and studies not published in the proposed databases such as ERIC, EBSCO Host, ScienceDirect, Scopus, Elsevier, and ISI databases. Using gamification in the science field was the keyword, 41 studies are selected, but 10 studies are irrelevant as samples were unknown, represent researchers' opinions, and were published in some other databases not included in the above-mentioned databases (ERIC, EBSCO Host, ScienceDirect, Scopus, Elsevier, and ISI), as shown in **Figure 1**. **Table 1** presented the 31 studies included.

RESULTS

What is the Impact of Gamification on the Students' Learning Outcomes?

Some of the studies reviewed reported negative outcomes or insignificant results concerning gamification in the student's learning, while others supported its ability to enhance the learning, personal, cognitive and social interaction skills of students. With regards to enhanced academic skills, the authors showed that gamification did enhance the achievement of students, their learning outcomes and experience in different study fields, and contributed to their science education (e.g., Chans & Castro, 2021; Fleischmann & Ariel, 2016; Legaki et al., 2020; Smiderle et al., 2020). Specifically, Chans and Castro (2021) revealed that gamification is capable of increasing students' motivation and engagement, enhancing their attitudes and facilitating required actions, and eventually enhancing their learning achievement. Based on the analysis, there is a direct link between gamification and the enhancement of students' learning experiences and their understanding of the concepts in science courses, and as such, gamification enhanced their performance (Fleischman & Ariel, 2016; Legaki et al., 2020).

Table 1. A summary of the articles' information

Title	Author	Year
The use of mobile gamification technology for sustainability learning in Saudi higher education	Al Amri and Almaiah	2020
Exploring graduate students' perspectives towards using gamification techniques in online learning	Alabbasi	2017
Educational gamification vs. game-based learning: Comparative study	Alazawi et al.	2016
Evaluation of gamification in e-learning systems for elementary school students	Alshammari	2020
Gamification patterns: A catalog to enhance the learning motivation	Arango-Lopez et al.	2017
The effect of gamified STEM practices on students intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills	Asigigan and Samur	2021
Gamification in higher education: Impact on student motivation and the acquisition of social and civic key competencies	Campillo-Ferrer et al.	2020
Gamification as a strategy to increase motivation and engagement in higher education chemistry students	Chans and Castro	2021
Towards the gamification of learning: Investigating student perception of game elements	Cheong	2015
Self-efficacy for self-regulated learning and chines students intention to use online learning in COVID-19: A moderated mediation model	Cui	2021
Addition to "a hybrid board game to engage students in reviewing organic acids and bass concepts": Using the game remotely during the COVID-19 pandemic	da Silva Junior et al.	2020
Learning and engagement in a gamified course: Investigating the effect of student characteristics	Davis et al.	2018
Gamification in science education: Gamifying learning of microscopic processes in the laboratory	Fleischmann and Ariel	2016
Use of gamification application in science education	Hursen and Bas	2019
Implementation of the gamification concept using Kahoot! among TVET students: An observation	Ismail et al.	2018
The effect of challenge-based gamification on learning: An experiment in the context of statistics education	Legaki et al.	2020
Game-based application for helping students review chemical nomenclature in a fun way	Lima et al.	2019
An open-source web application for the organization of large-scale biological treasure hunts	Lobet et al.	2020
Factors affecting students intention of gamification for learning model in the COVID-19 pandemic era at Indonesia: A confirmatory factor analysis	Nadlifatin et al.	2020
Enhancing the student learning experience with gamification: The case of "GRH, mundialization et innovation" course	Naji	2019
Gamification approach in teaching web programming courses in PHP: Use of Kahoot application	Ouahbi et al.	2021
Online chemistry crossword puzzles prior to and during COVID-19: Light-hearted revision aids that work	Pearson	2020
The negative effect of gamification in e-learning in the eyes of university students	Phung	2020
Gamification and effects on students science lesson achievement	Sahin and Namli	2016
Gamification of in-class activities in flipped classroom lectures	Sailer and Sailer	2020
Student teachers' intention to use gamification	Sanchez-Mena et al.	2016
Gamification based on local stories effect on students learning motivation	Sari et al.	2020
The effect of challenge-based gamification on learning: An experiment in the context of statistics education	Smiderle et al.	2020
Engaged cohorts: Can gamification engage all college students in class?	Song et al.	2017
The use of gamification in higher education: An empirical study	Varannai et al.	2017
Gamification and education: A pragmatic approach with two examples of implementation	Wiilig et al.	2021

Some other findings reported the positive effect of gamification on the cognitive abilities of the students, including their thinking and problem-solving abilities (e.g., Asigigan & Samur, 2021; Sahin & Namli, 2017). In particular, Asigigan and Samur (2021) stated that learning activities integrated with gamification methods may serve as a meaningful and lasting learning technique, promoting problem-solving during the learning process. Cognitive abilities studies also include Samur (2019) who found gamification feedback to be useful in sending feedback to the students regarding their mistakes while practicing their activities, enhancing their knowledge and improving their cognitive skills (Asigigan & Samur, 2021).

Additionally, gamification has been found to promote and develop other skills. Personality and psychological skills have also been shown to be positively impacted by gamification in that it influences the behaviors, personalities and motivation of students (Chans & Castro, 2021; Smiderle et al., 2020). Thus, it can

Table 2. Gamification studies based on educational level

Educational level	Number	Percentage (%)
Preschool	0	0.0
Primary	6	19.3
Secondary	5	16.2%
Higher education	20	64.5

Table 3. Gamification studies based on learning tools

Learning tools	Number	Percentage (%)
Self-created	11	36.7
e-learning platforms	7	23.3
Patform	6	20.0
Badges	2	6.67
Kahoot	3	10.0
Puzzles	1	3.33

Table 4. Gamification studies based on skills

Skills	Number	Percentage (%)
Learning skills	18	58.0
Cognitive skills	5	16.2
Social skills	4	12.9
Personal-psychological skills	4	12.9

be stated that gamification facilitates the gaining of personality traits and desirable behaviors among students. Past studies also revealed that gamification has a positive impact on the social skills, engagement and social interactions of students because of the group activities it provides (Chans & Castro, 2021; Song et al., 2017). Specifically, Sanchez-Martinez et al. (2019) and Song et al. (2017) supported the effectiveness of gamification in getting people engaged in social situations by comparing individual and social interactions.

What are the Current Trends and Tools Used in Gamification?

This study examined gamification in the field of education at different levels. It conducted a review analysis of the education level of the target group that participated in past studies (preschool, primary, secondary, and higher education).

Table 2 tabulates the results of the review and based on it, the majority of past studies on gamification focused on university students (64.5%), with the main objective being to encourage students, clarify topics, enhance students' overall learning experience, motivate them and last but not least engage them through system features (Asigigan & Samur, 2021; Chans & Castro, 2021). Other studies focused on primary education students with 19.3% (Hursen & Bas, 2019), and secondary education students with 16.2% (Lima et al., 2019), while none of the studies targeted preschool students.

Table 3 showed that the studies implemented several games activities such as gamified apps, self-created games activities and other gamification software in science education contexts. The majority of them incorporated self-created games activities for the study (da Silva Junior et al., 2020; Lima et al., 2019; Pearson, 2020), whereas other studies conducted with the help of e-learning platforms (Alamri, 2020; Campillo-Ferrer et al., 2020; Cheong et al., 2015; Sanchez-Mena et al., 2016), and apps. Computer software such as QuoVidi, Kahoot, Wechat GAQ, and ClassDojo were among the most popular tools used (Hursen & Bas, 2019; Ismail et al., 2018; Lobet et al., 2020; Ouahbi et al., 2021; Smiderle et al., 2020; Song et al., 2017; Varannai et al., 2017) since they are free and can be easily used and accessed using computer and mobile devices.

What are the Top Common Skills Used in Science Education Regarding Gamification?

Table 4 shows that based on the 31 reviewed studies, 18 examined learning skills outcomes constituting 58% of the total studies, albeit only a few were focused on the effect of gamification on cognitive abilities (five studies, 16.2%). Moreover, the same was revealed concerning studies on the effects of gamification on social abilities with four studies (12.9%), and on personal-psychological abilities with four studies (12.9%) (refer to **Table 4** for details).

Table 5. Gamification studies based on subject/course

Course	Number	Percentage (%)
General sciences	12	38.7
Computer	7	22.4
Chemistry	6	19.3
Biology	3	9.6
Statistics	1	3.3
Physics	1	3.3
Multimedia	1	3.3

What is the Common Subject of Science Education in Gamification?

Table 5 shows that based on the 31 reviewed studies, 12 (38.7%) studies were conducted in a general science course, seven (22.4%) in computer science, six (19.3%) studies in chemistry, three (9.6%) studies in biology, one (3.3%) study in every course such as multimedia, physics and statistics, as shown in **Table 5**.

What are the Advantages of Using Gamification in Science Education?

As for the benefits that gamification offers to the science education environment, past studies supported its role in enhancing students' learning activities, motivational outcomes, positive attitudes, engagement and learning achievement (e.g., Lima et al., 2019; Lobet et al., 2020; Pearson, 2020). Added to this, past studies revealed the positive influence of gamification on the cognitive abilities of students through the enhancement of their thinking skills, acquisition of skills, perception and understanding of scientific concepts (Asigigan & Samur, 2021; da Silva Junior et al., 2020).

Also, gamification was revealed to promote participation and engagement in the students' learning activities (Lobet et al., 2020) and was related to the learning and social environment of the students, supporting their social interactions. Such benefits are aligned with the definition of gamification proposed by Alsawaier (2018) who found gamification to contribute to the engagement and motivation of students. As past studies indicated, gamification has a positive influence on the cognitive and social skills of students, as a result of which they can effectively carry out their learning tasks. Evidently, it is a useful and invaluable tool in improving the knowledge retention of students, providing them with feedback on their performance and errors, thus allowing them to self-correct. This eventually leads to their enhanced learning performance.

What are the Disadvantages and Challenges of Using Gamification in Science Education?

Regardless of the several advantages highlighted in some of the past studies when it comes to the use of gamification in the science education environment, other studies underlined its limitations and disadvantages. For instance, Drolia et al. (2020) discussed its time effectiveness, mentioning gamification only has short-term effects. Others like Bjaelde et al. (2014) and Kalogiannakis et al. (2021) showed weaknesses in internet speed, computer equipment and game designs, which are all issues relating to the technical aspect of gamification.

Moreover, Hamari et al. (2014) mentioned the negative effects of gamification, which included issues relating to the evaluation of tasks and design features of the system. Similarly, Yapici and Karakoyun (2017) reported the preparedness in the use of applications, proper student preparation and acquiring technological skills required in the learning process for positive academic outcomes. The gamification application use is dependent on the experiences of both instructors and students. Finally, past studies generally concentrated on learning outcomes and experiences, with only a few considering cognitive, social and personal skills.

DISCUSSION

The main objective of this study is to systematically review and present the empirical studies dedicated to gamification use in science education. Specifically, the effect of gamification on the skills and abilities of the students. Most studies supported positive outcomes, which may be attributed to the potential of gamification use in enhancing science students' skills, such as enhancing outcomes, motivating participation and engagement, promoting activities and fun while learning, and increasing achievement levels at the same time (e.g., Asigigan & Samur, 2021; da Silva Junior et al., 2020; Davis et al., 2017; Legaki et al., 2020; Pearson, 2020;

Sahin and Namli, 2016; Song et al., 2017; Wiilig et al., 2021). Therefore, this study highlights the importance of gamification applications usage in science learning. It is expected that students can reap the benefits of these applications and obtain new learning experiences (Asigigan & Samur, 2021; Fleischmann & Ariel, 2016). This result may also be attributed to the fact that most teaching-learning sessions are practised-based instruction and as such, technology-assisted instruction is an effective teaching method for science learning among students. The results supported the previous studies (Asigigan & Samur, 2021; Chans & Castro, 2021; Fleischman & Ariel, 2016; Legaki et al., 2020). According to Chans and Castro (2021) and Lozano-Rodríguez et al. (2020), gamification enhances teaching science. It also promotes engagement, motivation and learning outcomes. Literature also reported that gamification activities help science students to be proactive, facilitate students' scientific thinking, and increase cognitive achievement as well as enjoyment (Amold, 2014; Morris et al., 2013). Brito and Mena (2020) also supported that gamification improved students' interaction and engagement.

The results of this study also revealed that most past studies were carried out among science students in higher education because teaching-learning lessons are based on technology and gamification applications are too pricey for schools to afford. Also, most gamification technologies and applications may not be suitable for the entire science course curriculum and such technology may be difficult for school students to access compared to university students, who all have smartphones. The results may also be related to the fact that there are several courses in higher education, which give more leeway to use gamification features, unlike schools that are limited in resources (Kalogiannakis et al., 2021). Added to this, the result also indicated that general science knowledge is more suitable compared to specific courses when it comes to gamification app implementation since students gain the latter knowledge faster and easier in comparison to learning specific courses. Prior reviewed studies supported positive gamification activities in physics and biology courses, which students find challenging (Kalogiannakis et al., 2021; Sharma & Sharma, 2007) and this is one of the barriers to conducting in-depth studies on such courses. The content of the curriculum may also have a key role as a determinant of gamification implementation in science courses as mentioned by Kalogiannakis et al. (2021) and Papadakis and Kalogiannakis (2018).

Moreover, it appears that gamification has been evidenced by literature as a useful tool in improving students' learning, social, personal and cognitive skills, but limitations and disadvantages remain considering its relative novelty in the learning environment, and the lack of studies concerning its operations and its potential. The limitation was also evidenced by the skills, perceptions and experiences in gamification use, specifically for learning. Thus, the gamification system needs to be more user-friendly. Another limitation may relate to technical issues, as studies reported that technology equipment may influence the learning experience and learners' feelings (Sanmugam et al., 2016). Nonetheless, gamification applications are useful and have promising potential in science education as it facilitates learning and skills development. This study recommends that future studies further examine the topic and extend the literature to various settings, fields and educational courses.

CONCLUSIONS

Implications

In this study, literature dedicated to gamification implementation in science education, spanning 6 years from 2015 to 2021 was thoroughly reviewed, whereby a gap was highlighted (Hursen & Bas, 2019). The study carried out an analysis review of the literature to explain the gamification status in science courses among higher education students. The study found the effectiveness of gamification applications in science education settings, with the majority of past works supporting the positive outcomes and potential of gamification to meet science educational requirements with regard to learning, social, cognitive and psychological abilities and skills.

Based on the results, gamification is useful in science education learning and development as it contributes to social interaction, engagement, motivation, and positive attitudes towards science courses among students. This is true for students in various levels of academia in science courses. Despite such

usefulness, gamification activities design and features are still challenging to use during the learning process and thus, it needs further evaluation and refinement of design.

Limitations and Suggestions

There are several limitations to this study, not unlike other studies of its caliber. The first limitation pertains to the examined studies obtained from data sources based on the objectives–thereby rendering the findings inapplicable to all published journals in science education. In the past several years, the number of gamification studies has increased manifold, and those studies have not been included in the review and thus, the results may not be generalized to the current situation and status of the application. Only a few studies have focused on cognitive, personal and social skills among science education students when it comes to gamification and thus, future studies need to address this gap. This study is also limited to the examined studies in terms of the number of participants, levels of education, and design, which calls for unearthing more information on the above while focusing on gamification in science courses and education. Although previous studies highlighted the importance of gamification in the education context, its application in the science context has been scarce and exploratory. A relatively small body of the studies identified in this study review suggests more investigations in science fields are needed. Additionally, the scope of studies on gamification-supported science students should be further expanded. Replicated studies in different science fields can further boost the importance of gamification in science courses.

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