Digital Game-Based Learning with the Integration of Artificial Intelligence in Physics: What Are the Implications in Teaching and Learning? A Review

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Abstract

Technological advances provide support to education in presenting more relevant and effective learning. One of the technological tools that is popularly implemented in physics learning as a learning medium is Digital Game-Based Learning (DGBL) and Artificial Intelligence (AI). These two technologies have various impacts on their use in the learning process. However, the review of the impact of learning from various previous researchers on the technology on physics learning is still limited. This literature review aims to identify the impact and challenges of applying DGBL and AI in physics learning. The method used for this article review is based on four stages. The first stage is the formulation of planning by determining the formulation of research questions. The second stage is the search for articles from Scopus, ProQuest, ERIC, Google Scholar, and open-access databases. Articles are obtained based on searches with keywords in the title and abstract and are in the range of 2020 to 2024. The third stage is to assess articles based on the focus of studies that discuss AI, DGBL, and physics. The search results resulted in as many as 20 articles that are worth reviewing. Based on the results of the literature review, the fourth stage is to write information about the impact and challenges of using technologies in physics learning. DGBL and AI have proven to be effective in supporting students' interest, motivation, and engagement in learning. AI supports features that can be personalized according to students' learning abilities, and DGBL supports interactive learning presentations. Those various features presented can enhance students' comprehension of concepts for better results in understanding abstract physics material. Those technologies also have their own challenges. The over-reliability of this technology can cause plagiarism in learning and affect students' focus in learning. In general, those technologies strongly support physics learning, especially to encourage interest and motivation in students' learning. This media is a form of technology recommendation for teachers and students to support physics learning.

Keywords: Digital Game-Based Learning (DGBL), Artificial Intelligence (AI), Physics Education

INTRODUCTION

Physics is a scientific discipline that requires students to apply their critical thinking abilities to solve problems. This is because physics works with both tangible and intangible natural occurrences and everyday situations. Proficiency in advanced mathematics is crucial for comprehending abstract concepts in physics,

particularly at the intermediate and advanced educational levels. Due to technological advancements, instructors now have multiple options to help students study physics more effectively. These alternatives are particularly useful for translating abstract concepts into real-world situations and increasing student involvement in the teaching and learning process. The Malaysian government prioritises this matter by implementing the Malaysia Education Development Plan 2013-2025, which designates 60% of resources to science topics and 40% to literature subjects. The results of the Program for International Student Assessment (PISA) 2022 science literacy test likewise demonstrate the inadequate scientific literacy abilities of Malaysian students [1]. The insufficient degree of scientific literacy suggests that students' capacity to comprehend physics is similarly inadequate, given that physics is a component of the scientific field. One explanation is the students' lack of enthusiasm for science disciplines in general, which are frequently regarded as challenging and uninteresting. Their learning process is impacted by these adverse perceptions, feelings, and lack of interest. Thus, it is imperative to prioritise science courses more assertively to captivate interest and promote student involvement in the learning process.

In the field of Physics education, despite the introduction of modern teaching methodologies since 2014, a significant number of teachers continue to rely on conventional teaching methods in their classrooms [2]. This also contributes to students' unfavourable attitudes, feelings, and involvement in the topic of Physics. In 2021, The proportion of students opting to sit for the Sijil Pelajaran Malaysia examination in the field of Physics has exhibited a consistent downward trend, decreasing from 25% in 2017 to 22% in 2021 [3]. This decline reflects a waning interest among students in this discipline. Interest or attitude is a constituent of student involvement, along with cognitive and emotional characteristics [4]. The global topic of student participation in learning has been raised [5]. To increase student involvement in the learning process, teachers employ many instructional techniques in the field of Physics, such as 3D simulations [6], Flipped-Classroom [7], and Game-based learning [8].

Technological advancements facilitate the utilisation on various forms of media in studying physics. The ramifications of incorporating game-based into physics education can be explored, as demonstrated by the past studies [9], [10]. DGBL is the acronym for game-based media in learning. Utilising games as a learning tool offers interactive assistance in the field of physics [11], [12]. AI can be used to offer popular tool that supports communicative learning. It offers consumers a direct and engaging learning experience that promotes communication. DGBL and AI offer multiple benefits that have a positive impact on the learning process.

Prior studies have employed the use of DGBL and AI to facilitate the learning process. This technique has had a wide-ranging impact on the acquisition of knowledge in the field of physics. The complete investigation on the display of broad effect information in the use of the technology is lacking. This problem presents a chance to examine its impact on the acquisition of physics knowledge by conducting a review of existing literature. The incorporation of literature review material is a recent advancement in the examination of the intersection between DGBL and AI in the context of physics education. The effects, consequences, and problems of using DGBL and AI in physics learning can be demonstrated through a literature study.

RESEARCH OBJECTIVES

1. Identifying the effectiveness of DGBL and AI in improving student engagement in physics education
2. Identify students' understanding when taught or learn to use DGBL and AI in Physics education based on previous research.
3. Identifying the strengths, weaknesses, and challenges in implementing DGBL and AI in Physics Education

RESEARCH QUESTIONS

This research aims to answer the following research questions:

1. What is the effectiveness of DGBL and AI in improving student engagement in physics learning?
2. How do DGBL and AI help students understand physics material?
3. What are the advantages, disadvantages, and challenges of implementing DGBL and AI in Physics education?

METHODS

This research utilizes the Systematic Literature Review (SLR) method, which involves planning, searching, evaluating, and writing. SLR is generally the foundation for synthesizing existing studies, particularly in systematically and structurally combining findings from various studies [13]. The information in this study is based on the synthesis results from similar research. The steps of the literature review are shown in Figure 1.
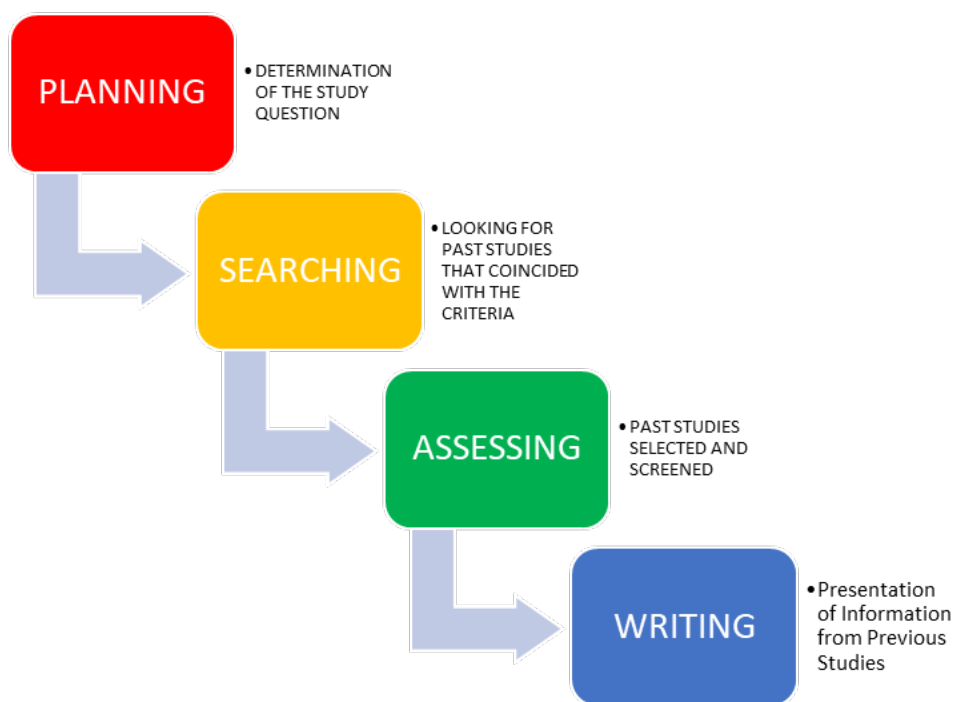

Figure 1. Four Steps in Literature Review Analysis

Figure 1 shows the literature review steps carried out through four stages: planning, searching, assessing, and writing. In the planning stage, research questions are determined to outline the research scope and goals. While in the searching stage, several database sources are used to find articles that match those keywords 'DGBL,' 'AI,' 'Physics Learning,' 'Game-Based Learning' and 'Student Engagement' which are contained in abstracts and titles. Article searches are conducted through databases such as Scopus, ProQuest, ERIC, Google Scholar, and open-access journals from 2020 to 2024. The articles that have been searched are then assessed according to the focus of research on the impact of AI in physics learning.

RESULT

Based on the results of a literature search on DGBL and AI in physics learning, as many as 20 articles were obtained that met the criteria. All articles are from 2020 to 2024, sourced from Scopus, ProQuest, ERIC, Google Scholar, and open-access journals. All information in the article is synthesized to obtain results according to the research question. The results of the synthesis of

article information are grouped into references, objectives, issues, and conclusions. The results of the literature review are presented in Table 1.

Table 1. Findings of DGBL and AI literature review

Reference	Objective of Study	Issue	Conclusion
[14]	Reviewing the DGBL development process to support practical development	The tool's effectiveness was initially limited by students' low baseline science literacy.	The DGBL developed can be practically used to support and enhance science literacy
[15]	Developing DGBL assessments to improve science literacy.	Students' science literacy skills are low and require effective assessment.	The DGBL assessment must be valid, practical, and effective to improve science literacy.
[16]	Investigating the effectiveness of DGBL in improving students' understanding of concepts, achievements, and attitudes.	The low interest and understanding of students in learning physics requires a more interesting approach.	DGBL learning with an inquisitive approach aims to improve learning outcomes and student interests.
[17]	Investigating the effectiveness of DGBL applied in learning by teachers.	The lack of interactive learning media, such as DGBL, requires a more effective solution.	DGBL can be developed to support teachers' material delivery and improve teaching quality.
[18]	Testing the effectiveness of DGBL in improving critical thinking skills.	The lack of high creative and critical thinking skills requires innovative learning approaches.	DGBL, which presents puzzles and quizzes, can improve students' critical and creative thinking skills.
[19]	Investigating the effects of DGBL in the form of Augmented Reality (AR) on increased student engagement in learning.	Students' understanding of concepts is low.	DGBL with AR can improve concept understanding and student engagement in the learning process.
[20]	Investigate the effects of DGBL in motivating and encouraging students to learn.	Lack of interest and motivation in learning requires an approach that can increase student enthusiasm.	DGBL can potentially increase student motivation through a more engaging and interactive learning experience.
[21]	Exploring student engagement in learning using DGBL	The lack of student engagement in learning requires a more interactive approach.	The design of learning with DGBL was able to encourage the involvement of 61 students in learning Newton's laws more

Reference	Objective of Study	Issue	Conclusion
			engagingly and effectively.
[22]	Development of DGBL on style and motion materials.	The lack of interactive media in learning requires more innovative solutions.	The development of DGBL media for style and motion materials aims to create practical and effective learning tools in the teaching process.
[23]	Investigating the impact of DGBL in increasing student engagement, interest, and motivation.	Lack of motivation and involvement of students in learning requires a more engaging approach.	DGBL has the potential to increase student motivation and engagement in learning, compared to traditional learning methods.
[24]	Students' perception of the use of ChatGPT as a tool in physics classes shows that ChatGPT is often inaccurate, but students generally believe it.	ChatGPT is often inaccurate, but students generally believe it	Trust in ChatGPT has an impact on student perceptions, and there needs to be improvements in AI literacy teaching to overcome these misconceptions.
[25]	ChatGPT's Potential to Improve Physics Education in Vietnam high schools	The use of ChatGPT in the context of physics education in Vietnam, as well as its integration with information technology and a student-focused pedagogical approach	ChatGPT can improve physics education in Vietnam by applying technology and a student-centered approach.
[26]	Design an AI-based education system to improve physics learning through adaptation, gamification, and personalization.	Low student motivation and conceptual understanding	AI increases student motivation and engagement and aids in understanding physics concepts through a personalized approach
[27]	To assess the effectiveness of AI-based chatbots in improving learning outside the classroom.	Limited access to academic support immediately outside of school hours.	AI chatbots provide ongoing support, helping students clarify doubts directly, leading to more effective self-paced learning.
[28]	To analyse potential risks, rely too much on AI technology in education.	Concerns related to students losing critical thinking skills due to	AI can provide immediate solutions but may reduce the

Reference	Objective of Study	Issue	Conclusion
		over-reliance on AI assistance.	deeper cognitive engagement required to solve complex problems.
[29]	To assess the accuracy and fairness of AI algorithms in the context of education.	The risk of biased or inaccurate recommendations is caused by flawed AI algorithms.	A well-designed AI can improve learning while less effective design can confuse the students.
[30]	Analysis of ChatGPT performance on Force Concept Inventory (FCI) to understand its impact on students' understanding of physics concepts	ChatGPT's popularity among students raises concerns about plagiarism and misinformation.	ChatGPT has the potential to provide precise information, but it can also reinforce common misconceptions. Therefore, students need to understand these limitations of AI in the learning process.
[31]	The use of ChatGPT 3.5 by prospective physics teachers for the development of kinematics assignments in grade 10	A comparison of ChatGPT 3.5's effectiveness with textbooks in generating clear and contextual tasks shows that there is no significant difference in question accuracy.	Textbooks are superior in terms of clarity and context, while ChatGPT is considered easier to use but have problems in output quality.
[32]	The use of ChatGPT in physics education, especially on the topic of projectile motion, from a student's perspective.	ChatGPT offers benefits such as assisting in teaching and providing lesson plans, but there are limitations in mathematical calculations and potential misunderstandings.	ChatGPT can be very beneficial in physics education with proper use, provided that attention is paid to detailed calculations and explanations.
[33]	Development of NewtBot, GPT-3.5-based physics education chatbot	Low level of students' self-confidence in learning physics	ChatGPT boosts confidence in helping physics work among students.

Table 1 presents objective information from studies, issues, and conclusions from articles on DGBL and AI. Studies on using DGBL and AI in Physics education show that these two tools have great potential to increase student engagement and understanding of Physics concepts. DGBL focuses on learning that integrates digital games, offers an interactive and engaging approach, and motivates students through a more enjoyable learning experience. AI provides practical and interactive explanation support to help people understand difficult concepts better. The use of AI in physics learning is dominated by utilizing chatbots such as ChatGPT. ChatGPT is generally used to answer questions about abstract problems and require

detailed explanations in a short time. However, the challenges in the use of AI technology have the risk of dependence on learning. The use of AI requires good control management to obtain optimal results in learning. This is because this condition will be at risk of reducing students' cognition in learning.

DISCUSSION

What is the effectiveness of DGBL and AI in improving student engagement in physics learning?

Utilising the methodologies of DGBL and AI in physics education has numerous beneficial effects on enhancing student comprehension. There are four key factors that contribute to the success of student learning: motivation, curiosity, confidence, and cognitive enhancement [34]. This medium is designed for educational purposes, specifically to facilitate interactive learning and discussion of physics concepts among students. Diversifying the learning experience can be achieved by delivering information using puzzles, quizzes, and other interactive games. Furthermore, AI serves to bolster students' self-assurance in their physics education by providing a platform for answering their queries. This technology promotes active and collaborative student engagement in the process of acquiring knowledge. AI and DGBL facilitate interactive learning experiences and foster student motivation and cognitive development.

The incorporation of interactive features in DGBL fosters the enhancement of students' cognitive faculties in comprehending concepts, fostering motivation, and honing problem-solving skills. Prior research has influenced the use of game-based interactive multimedia in teaching to facilitate students' comprehension of physics [35], [36]. The use of DGBL is grounded in the Theory of Constructivism, which aims to facilitate student supervision within the learning setting [37]. This medium can provide diverse feedback to students, which promotes interaction and fosters a strong sense of curiosity in the learning process. The findings validate that this approach offers engaging and interactive learning experiences, fostering students' capacity to actively participate in the learning process [38], [37].

Utilising AI in education enhances students' capacity to gather information with greater efficiency. AI fosters students' self-assurance in problem-solving during the process of learning physics. The presence of AI in education fosters student motivation to tackle intricate problems. Chatbots enable personalised learning by facilitating interactive exchanges between users and AI, tailored to the specific demands of each user [39]. Chatbots like ChatGPT offer comprehensive knowledge to help students articulate their comprehension of physics. ChatGPT allows users to request a wide range of information, which assists students in thoroughly exploring physics materials [27]. The dependability of technology supports diverse learning experiences by adjusting to each student's unique abilities. [25]. Nevertheless, AI faces obstacles and need further scrutiny for its application in education [40].

How do DGBL and AI help students understand physics material?

DGBL and AI fosters a more captivating and engaging method for acquiring knowledge in the field of physics. Overall, the utilization of this medium in education promotes students' comprehension of physics, particularly in elucidating intricate and abstract concepts through interactive and communicative means [41]. The DGBL technique facilitates the delivery of physics content through the utilization of 3D simulation games, which aid in the comprehension of abstract physics concepts. This educational presentation aims to foster students' comprehension by surpassing the mere observation of objects in pictorial depictions [14]. This medium assists students in autonomously learning a range of additional skills to enhance their comprehension of physics topics [42]. AI facilitates the comprehension of physics for students by offering detailed explanations that cater to their interest, hence promoting a deeper understanding of the subject matter. AI's presence alleviates students' concerns over asking questions, so enabling them to pose a diverse range of inquiries to enhance their comprehension in accordance with their cultivated imagination.

Prior studies have also indicated that the integration of DGBL and AI in physics education facilitated students in acquiring comprehension. DGBL is a method that combines games with virtual labs to enhance students' comprehension and performance in doing physics experiments [43]. The customizing feature of ChatGPT allows students to have greater flexibility in exploring additional support and addressing questions that they currently do not comprehend. AI technology enhances students' comprehension and problem-solving abilities more effectively than conventional learning methods [44], [45]. The potential for AI to help physics learning according to user needs is significant. The integration of AI in education enhances the learning experience by providing a captivating, interactive, and communicative platform that facilitates student comprehension.

What are the advantages, disadvantages, and challenges of implementing DGBL and AI in Physics education?

DGBL and AI provide various positive benefits in their implementation in physics learning. This media provides an advantage for students in learning physics material in an interesting and interactive way. Physics learning can be with an experimental approach that supports the understanding and development of students' skills in the process of scientific inquiry [6]. Learning with DGBL and AI provides better time efficiency in the learning process. DGBL and AI support material explanations and expand students' concepts with a variety of abilities [39]. DGBL and AI support students' critical and creative thinking skills in physics teaching [46]. In physics learning, students can explore learning with a variety of informative presentations through AI [47]. The presence of AI supports students' confidence in learning and answering a variety of complex questions.

DGBL and AI can also have bad effects on physics learning when not properly controlled. Previous researchers have also reported that dependence on AI can damage students' cognition. The uncontrolled use of AI encourages students to be lazy when thinking. This is driven by AI's ability to answer various questions in a short time. The tendency to use AI can raise concerns about plagiarism. In addition, DGBL, which is not presented with good learning management, will have an impact on game-focused learning. Thus, it will have an impact on deviations from the focus of learning outcomes.

AI and DGBL have a variety of positive and negative impacts based on its usage. The implementation of those media brought challenges for teachers and students in physics. Those media have great potential in supporting interactive and communicative learning. However, AI and DGBL in physics learning require organized usage management to match the learning goals that need to be achieved. In addition, AI does not always provide answers that are 100 percent accurate [48]. Users must be thorough and have a good understanding of information filtering and confirmation through evidence. Concerns about plagiarism and data leakage become a challenge for teachers and students in using AI [49]. Hence, with all the advantages that DGBL and AI can present, they also have concerning challenges at hand.

CONCLUSION

This literature review presents information about the effects and challenges of the implementation of DGBL and AI in learning physics. The media has a positive effect on students' physics learning by supporting interest, motivation, cognitive ability, and confidence. DGBL in physics learning supports student involvement in learning physics in the form of more interactive learning. Meanwhile, AI supports personalized learning according to students' cognitive abilities. One popular form of AI used in learning is ChatGPT. Meanwhile, the form of DGBL that is often applied is a quiz. These two media have a better effect than conventional learning in supporting increased students' understanding of concepts. DGBL and AI support the explanation of abstract physics material to be simple, which has an impact on students' understanding of concepts in a better direction. The reliability of this technologies in presenting interactive and communicative learning has challenges in its implementation in physics learning. Uncontrolled use has

an impact on play-focused learning management and dependence on technology. The implementation of AI in physics learning provides access to students in committing acts of plagiarism. Organized and systematic learning is one form of facing the challenges of implementation in learning. In general, those technologies have a significant influence on supporting learning. Thus, the utilisation of DGBL and AI is one of the innovative ways that teachers can use to explain physics in a more interactive and communicative way to achieve optimal learning outcomes.

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