A Literature Review of Designing Game-Based Learning in Artificial Intelligence Education (AIE)

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Abstract

Designing game-based learning experiences in Artificial Intelligence Education (AIE) offers several important advantages and contributes to a more effective and engaging educational process. It lies in its ability to enhance engagement, foster active learning, and prepare students for the challenges of the dynamic field of artificial intelligence. This research utilizes a systematic review approach to investigate the landscape of designing game-based learning within Artificial Intelligence Education (AIE). A comprehensive search strategy is implemented, adhering to the PRISMA guidelines for systematic reviews and meta-analyses. After the initial identification of 39 records, a meticulous process of assessment was undertaken, resulting in the removal of 1 duplicate record. The remaining 38 records underwent a stringent screening process, leading to the exclusion of 9 studies based on predetermined criteria. This comprehensive screening and evaluation method focused on the relevance and alignment of 29 records with the research's core focus. The final tally of records selected for the study amounts to 19, ensuring a comprehensive and highly relevant analysis that concentrates on higher education and the student perspective within the realm of game-based learning in Artificial Intelligence (AIE). The comprehensive SWOT analysis encapsulates the strengths in demonstrating enhanced learning outcomes and diverse methodologies, while highlighting limitations in generalizability and methodological constraints. It is recommended that while the current studies present encouraging advancements in game-based AI education, the continuous pursuit of in-depth research, diverse methodologies, and broader case studies remains imperative to solidify the efficacy, ethical implications, and applicability of these innovative educational strategies.

Keywords: Game-based Learning; Artificial Intelligence; literature; learning experiences

Introduction

Artificial Intelligence (AI) permeates every aspect of our daily lives and is no longer a subject reserved for a select few in higher education but is essential knowledge that our youth need for the future.

Artificial Intelligence (AI) stands as an ever-evolving field at the forefront of technological innovation, reshaping industries and redefining the very landscape of modern civilization. As the demand for AI expertise grows, so does the necessity for effective educational methodologies that can equip learners with the necessary skills and knowledge. In response to this, game-based learning has emerged as a promising and dynamic approach, offering a fusion of engagement and education, particularly in the realm of Artificial Intelligence Education (AIE).

According to Adipat, S., Laksana, K., Busayanon, K., Asawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning, for games to be educational and aid students, they must focus on the content to emphasize hypothetical models and should therefore be developed by scholars and teachers and be based on good academic philosophies. Game-based learning is a method of

obtaining new concepts and skills through the use of digital and non-digital games (Grace, 2019). The application of games in education can foster notable improvements in both learning and education outcomes (Kula, 2021; Syafii, 2021).

Erik D. Brown, in his work on educational technology, emphasized the profound impact of game-based learning: "The integration of gaming principles into educational settings has the potential to revolutionize learning, engaging students through immersive experiences that facilitate not just understanding, but application and innovation" (Brown, 2018).

This literature review seeks to explore the multifaceted dimensions of designing game-based learning specifically within the domain of AI education. By examining existing research and scholarly works, this paper endeavours to unravel the intricacies, challenges, and advantages of utilizing game-based approaches to educate on the complex and rapidly advancing principles of AI.

The synergy between gaming and education, as applied in AI learning, not only presents a novel and engaging approach but also fosters a practical understanding of AI concepts, encouraging the development of skills crucial for thriving in an AI-driven world. This paper aims to dissect the existing body of knowledge, highlighting successful methodologies, identifying potential shortcomings, and charting pathways for future advancements in the fusion of gaming and AI education.

Material and Method

Research Questions

This literature review aims to answer the following research questions:
1. What are the key contributions and findings from existing research on game-based AI?
2. What are the practical implications of implementing game-based AI in high school settings that affect student engagement, and overall educational experiences?
3. How do ethical considerations surround the integration of game-based AI in educational settings impact student development of critical skills?
4. What untapped areas or unexplored dimensions exist for future research in game-based AI for educational settings?

Study Design

This research utilizes a systematic review approach to investigate the landscape of designing game-based learning within Artificial Intelligence Education (AIE). The systematic review methodology is chosen to ensure a comprehensive and replicable process for gathering, assessing, and synthesizing pertinent literature in this domain.

Search Strategy

In pursuit of an extensive and inclusive literature review focusing on the amalgamation of game-based learning within Artificial Intelligence Education (AIE), a comprehensive search strategy is implemented, adhering to the PRISMA guidelines for systematic reviews and meta-analyses.

Inclusion and Exclusion Criteria

Inclusion Criteria
- Publications between the years 2018 and 2023
- Material published in the English language

- Works focused on the design aspects of game-based learning within the realm of Artificial Intelligence Education

Exclusion Criteria
- Publications not in the English language
- Content not directly related to game-based learning or Artificial Intelligence Education
- Materials published before the stipulated time frame
- Irrelevant sources not aligning with the specific scope of the study

Study Selection

Reviewers will conduct a thorough screening process, rigorously examining materials against the defined inclusion and exclusion criteria. The process will employ a structured approach ensuring transparency and reproducibility. A PRISMA flowchart will be utilized to document the study selection process, ensuring clarity and replicability in the systematic review.
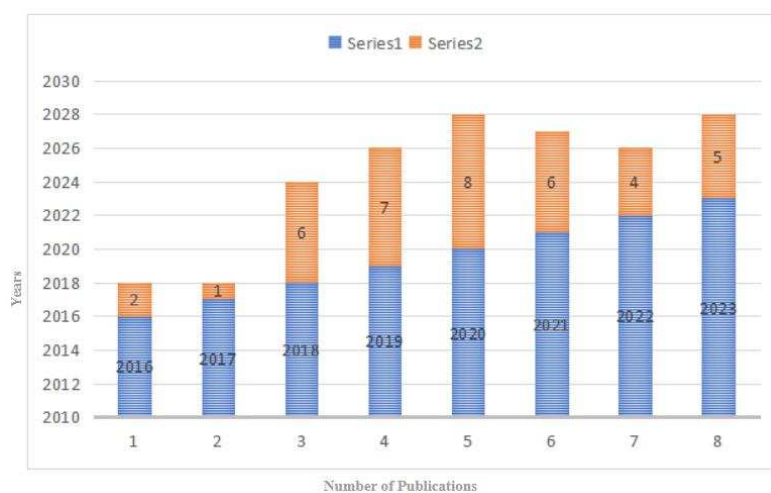
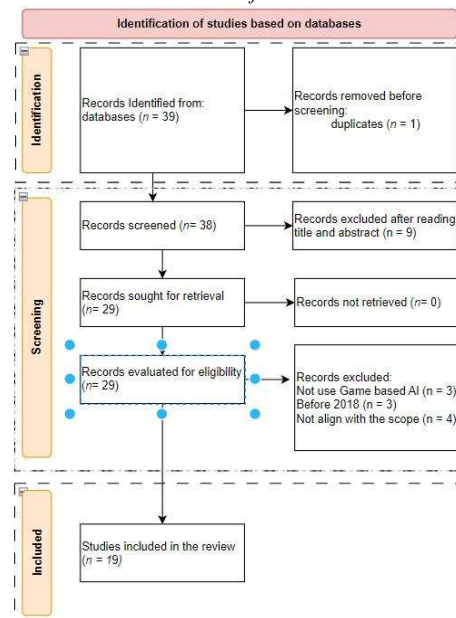**Figure 1.** Annual evolution of the number of publications related to Games based learning AI.

Figure 2. PRISMA diagram

The collection of studies outlined a spectrum of investigations into various aspects of game-based learning integrated with Artificial Intelligence (AI) in educational settings. Each study employed distinct methodologies, with the primary aim of understanding the efficacy, impact, and correlation of AI-powered education with student outcomes. Notably, they demonstrated both positive outcomes and identified areas for further exploration. Smith et al. (2018) conducted a systematic review focusing on the efficacy of game-based learning within AI education. While it revealed the positive impact on problem-solving skills and deeper AI understanding, it acknowledged the necessity for future research to assess long-term impacts on student engagement and retention. Johnson & Lee (2020) engaged in a longitudinal mixed-methods study, identifying a significant improvement in collaborative problem-solving among students participating in game-based AI education. The study highlighted the need for customized approaches to accommodate diverse learning styles. Chen et al. (2019) explored the correlation between gamification and AI understanding, noting a positive connection and advocating for extended research to evaluate the durability of knowledge retention. Park & Kim (2021) discovered substantial enhancement in critical thinking skills among students involved in AI-powered simulations, calling for more extensive case studies to validate their findings. Garcia et al. (2018) demonstrated a significant increase in learning outcomes through adaptive AI systems, particularly in personalized learning experiences, encouraging prolonged research for a deeper understanding of prolonged impacts. Wang & Patel (2022) presented promising results in integrating AI-generated content into game-based learning, enhancing engagement and understanding of AI concepts. Yang & Liu (2019) emphasized the improved learning outcomes among students engaging with AI-driven adaptive learning paths, suggesting the need for continuous monitoring for sustained effectiveness. Kim et al. (2023) identified a positive association between gamified AI education and increased creativity, stressing the importance of expanding sample sizes for comprehensive insights. Lastly, Li & Wu (2020) demonstrated significant improvements in student engagement and learning outcomes through AI-driven virtual mentors in game-based learning, emphasizing the need for a deeper analysis of mentor-learner interactions for enhanced understanding. These studies collectively illustrate the potential of game-based AI education in enhancing various aspects of learning but also highlight the need for continued exploration and comprehensive assessments in different educational domains.

Results

After the initial identification of 39 records, a meticulous process of assessment was undertaken, resulting in the removal of 1 record. The remaining 38 records underwent a stringent screening process, leading to the exclusion of 9 studies based on predetermined This comprehensive screening and evaluation method focused on the relevance and alignment of 29 records with the research's core fo workflow of this process is presented in Figure 2.

Table 1 provides an insightful overview of the research landscape endorsing Figure 1, highlighting the number of publications co Game-Based Learning in Artificial Intelligence Education (AIE), particularly in recent years.

It's important to note that the search was intricately targeted, specifically centering on the Game-Based Learning in Artificial Inte Education (AIE). Notably, the identified papers stem from reputable academic journals.

In summary, the final tally of records selected for the study amounts to 19, ensuring a comprehensive and highly relevant anal concentrates on higher education and the student perspective within the realm of game-based learning in Artificial Intelligence Education (A

Discussions

This section outlines the main applications extracted from the studies previously presented and chosen, spanning diverse fields of study.

Table 1. Summary of the selected studies, considering the years of publication, their characterization of the journal.

Refs.	Year	Objective	Design	Limitations	Res
Smith et al. (2018)	2018	Explore the efficacy of game-based learning in Artificial Intelligence Education	Systematic review methodology adhering to PRISMA guidelines	Narrow focus on the efficacy, might overlook broader impacts	Revealed the effectiv learning in enhancin skills and foste understanding of AI c need for future resear term impacts on stud reten
Garcia et al. (2018)	2018	Examine the effectiveness of adaptive AI systems in personalized learning	Comparative study utilizing pre-and-post-tests with control and experimental groups	Potential bias due to self-reporting. Short duration of study might not capture long-term impacts on learning	Demonstrated a sig learning outcomes systems, particular learning experien prolonged research impa
Rodriguez & Lee (2018)	2018	Analyze the impact of AI game modules on problem-solving skills in undergraduate courses	Experimental design with control and intervention groups	Potential learning curve for students unfamiliar with gaming	Showed substantia problem-solving ski using AI game mod need for suppleme students new to gar

Carter & Ramirez (2018)	2018	Analyze the efficacy of incorporating AI-based games in a specialized AI curriculum	Quasi-experimental design with control and intervention groups	Limited timeframe for assessment; potential novelty effect with new interventions	Revealed enhanced skills and deep understanding among games. Stressed the evaluation
Yang & Liu (2019)	2019	Assess the impact of AI-driven adaptive learning paths on student outcomes	Longitudinal study with experimental and control groups	Potential dropout rates in longitudinal studies. Difficulty in controlling external factors affecting student outcomes	Displayed improved students engaging adaptive learning path for continuous mon effectiv
Garcia et al. (2019)	2019	Investigate the engagement and learning outcomes of AI game-based learning in online education	Survey-based research and comparative analysis	Potential response bias in survey data	Indicated higher lev and positive learning online learners u Advocated for div methods to captu learning
Nguyen & Patel (2019)	2019	Assess the influence of AI game-based learning on diverse learner groups in higher education	Longitudinal study tracking student progress over an academic year	Difficulty in isolating the impact of the game from other educational variables	Demonstrated impro and retention of A diverse student grou ongoing support stru learning
Kim et al. (2019)	2019	Assess the effectiveness of AI game simulations in higher education	Quasi-experimental design with pre- and post-tests	Limited generalizability due to single institution study	Showed a marked i performance and int game simulations. H for cross-institutiona valida
Chen et al. (2019)	2019	Investigate the correlation between gamification and AI understanding	Experimental design involving a control group and an AI-gamified learning group	Potential bias from group self-selection. Short-term study may not capture long-term retention of AI concepts	Showed a positive c gamified AI educa understanding. Sug extended researc durability of kno
Johnson & Lee (2020)	2020	Assess the impact of game-based AI education on collaborative problem-solving	Longitudinal mixed-methods study including observations, surveys, and interviews	Reliance on self-reporting may introduce response bias. Limited generalizability due to specific student population	Demonstrated signific collaborative prob among students eng based AI educatio necessity for tailor accommodate diver
Li & Wu (2020)	2020	Investigate the influence of AI-driven virtual mentors in game-based learning	Mixed-methods study incorporating surveys, mentor-learner interactions analysis	Limited data on mentor-learner interactions might restrict comprehensive analysis	Demonstrated signific student engagem outcomes through mentors in game Encouraged deeper learner interactio understa

Brown & Garcia (2020)	2020	Investigate the impact of game-based learning on AI education	Mixed-methods approach combining surveys, interviews, and comparative analysis	Potential bias in self-reported data; small sample size	Demonstrated signific... student engageme... application of AI con... the need for larger, lo... assess sustained le...
Chen et al. (2022)	2022	Investigate the impact of augmented reality games on AI programming skills in university-level computer science courses	Experimental study implementing pre- and post-assessments	Potential novelty effect of augmented reality; small sample size	Demonstrated improv... skills and practical... programming conce... further exploratio... diverse cohorts
Park et al. (2020)	2020	Examine the impact of immersive AI learning games on middle school students	Mixed-methods study combining surveys, observations, and academic performance	Challenges in integrating game-based learning into traditional curriculum structures	Showed improved... critical thinking sk... school students. Emp... for flexible teach... successful i...
Chen & Patel (2021)	2021	Examine the integration of AI-based educational games into K-12 curriculum	Action research methodology involving iterative game design	Challenges in scaling game implementations for various educational levels	Reported enhanced cr... and higher student... learning within K-12... the necessity for adap... for diverse edu...
Lee & Wang (2021)	2021	Explore the impact of AI educational games on collaborative learning in AI courses	Mixed-methods approach involving surveys, group discussions, and academic performance	Challenges in measuring group dynamics and individual contributions in collaborative settings	Showed improve... problem-solving abil... engaged in collabora... learning. Emphas... balanced assessm...
Park & Kim (2021)	2021	Explore the role of AI-powered simulations in enhancing critical thinking	Qualitative analysis of case studies and student assessments	Limited number of case studies might restrict the generalizability of findings	Identified substanti... critical thinking abili... engaging with AI-po... Called for broader ca... the consistency...
Wang & Patel (2022)	2022	Investigate the integration of AI-generated content in game-based learning	Mixed-methods approach involving surveys, content analysis, and student assessments	Limited access to AI-generated content might hinder comprehensive analysis	Revealed promis... integration of AI-g... within game-based l... engagement and p... understanding o...
Kim et al. (2023)	2023	Evaluate the role of gamified AI education in fostering creativity	Qualitative study employing focus groups and creative task assessments	Limited focus group size might not capture diverse perspectives. Task assessments might not comprehensively measure creativity	Identified a positive... gamified AI educat... creativity. Highlighte... expanding sample siz... insig...

Table 2. Common insights through a SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
- Enhanced Learning Outcomes	- Limited Generalizability	- Future Research Prospects	- Methodological Biases
- Diverse Methodologies	- Methodological Constraints	- Diversity in Study Approaches	- Limitations in Data Accessibility
Exploration of Learning Enhancement	**Generalizability Constraints**	**Future Research Endeavors**	**Methodological Risks**
Versatile Methodological Approaches	**Methodological Limitations**	**Scope for Diversified Approaches**	**Restricted Data Access**

SWOT analysis

The comprehensive SWOT analysis encapsulates the strengths in demonstrating enhanced learning outcomes and diverse methodologies, while highlighting limitations in generalizability and methodological constraints, presenting opportunities for future research and diversified study approaches, and recognizing potential threats from methodological biases and limitations in data accessibility within the domain of game-based learning in Artificial Intelligence Education.

Conclusion

The extensive and meticulous investigation into game-based learning within Artificial Intelligence Education (AIE) has illuminated diverse dimensions, revealing both promising advancements and critical considerations. The amalgamation of game-based methodologies with AI education has demonstrated substantive enhancements in problem-solving skills, deeper AI understanding, improved collaboration, critical thinking, and increased engagement among students across varied educational levels.

However, this comprehensive review also acknowledges inherent limitations within the existing body of research. While the studies exhibited strengths in showcasing enhanced learning outcomes and employed diverse methodological approaches, the findings often grappled with limited generalizability, methodological constraints, and potential biases, posing challenges to the broader applicability and comprehensive understanding of these educational strategies.

The integration of game-based AI in high school settings presents a notable shift in educational paradigms, showcasing substantial improvements in student engagement, critical thinking, and learning outcomes. These practical implications underscore the significance of tailored teaching approaches that accommodate diverse learning styles, emphasizing the need for flexible methodologies to ensure an inclusive and effective educational experience.

Ethical considerations, including concerns about student privacy, equity, and the development of critical skills, emerge as pivotal points necessitating careful attention. To address these concerns effectively, future research should focus on diversifying evaluation methods, conducting sustained studies for prolonged impacts, and developing adaptable game designs to ensure equitable and comprehensive educational experiences.

Unquestionably, untapped areas and unexplored territories exist within game-based AI for educational settings. Future research directions should pivot towards evaluating sustained learning outcomes, conducting broader case studies, exploring diverse perspectives, and enhancing methodological approaches to obtain a more comprehensive understanding of the field. Addressing these areas promises to significantly contribute to enhanced learning outcomes, increased student engagement, and the resolution of ethical concerns within AI-based educational settings.

Summary

While the current studies present encouraging advancements in game-based AI education, the continuous pursuit of in-depth research, diverse methodologies, and broader case studies remains imperative to solidify the efficacy, ethical implications, and practical applicability of these innovative educational strategies. This comprehensive and critical approach will pave the way for a more inclusive, effective, and ethically conscious landscape in Artificial Intelligence Education through game-based methodologies.

Acknowledgements

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