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LITERATURE REVIEW OF GAME-BASED LEARNING AS AN EDUCATIONAL TOOL

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Abstract

Purpose*. The use of games as an instructional teaching tool is increasingly receiving attention. This paper presents a systematic review of relevant literature sources to identify the ways of improving game-based learning using artificial intelligence (AI).*

Design/Methodology/Approach*. A total of 84 literature sources were systematically analyzed and evaluated.*

Findings*. The review found that despite the continuous advancement of game-based learning, games are still not fitting the educational landscape as expected. Lack of intelligence capabilities and pedagogical affordances were found to be the main limitations behind the pedagogical game's abilities to teach, understand, and respond as required in academic learning.*

Practical Implication*. To achieve the needed improvement in game-based learning careful analysis of contemporary needs and required innovativeness in game based learning (GBL) is needed. This involves a proper understanding of contemporary learning, Artificial intelligence, and intelligent pedagogical gaming. Based on critical evaluation and analysis of various sources, it is evident that there could be the misuse of terms relative to concepts in game-based learning resulting in inefficiency of standard explanation of game based AI from a perspective of human-based character rather than pedagogical intelligence according to process, strategy, logic, and coherence to game based learning.*

Keywords: *Game-based learning, Pedagogical models, Artificial intelligence, Adaptive Systems*

.

Introduction

Preamble

Since 1950, different ways of helping students learn emerged, and teaching machines have drastically changed(Nuri & Sevim, 2013). Adaptive Contemporary learning is a learning approach that is technology-based, as opposed to the traditional style of teaching. In this case, modern information processing devices, digital equipment, and the use of supportive technologies are used to disseminate academic information to learners in a digital way. Traditionally teachers, lecturers, or trainers were expected to deliver classroom lectures manually using traditional methods. However digital learning is rapidly replacing the traditional style due to its efficiency and productivity as it engages, motivates, and promotes critical thinking in the learning environment. In addition to that, going digitally, some institutions opted for digital games as an instructional teaching tool. The use of digital games in teaching and learning may be considered pedagogical games. Therefore, Digital Game-based learning (DGBL) is a learning approach in which pedagogical games are used in a course subject as a teaching tool to meet the set learning outcomes amicably. As noted by (Prez et al., 2018) "Game-based learning is an innovative methodology that takes advantage of the educational potential offered by videogames in general and serious games in particular to boost training processes, thus making it easier for users to achieve motivated learning" To enhance learning, digital games encourage critical thinking because learning comes from playing(Connolly et al., 2012). The adoption of pedagogical games as a teaching and learning tool provides motivation, ensures engagement, and collaboration, and enhances problem-solving skills among learners making them adaptive to the environment. Adaptive learning in GBL as the word suggests "Adaptive" refers to a learning mode that enables personalized or customized learning to engage learners efficiently and effectively. Hence adaptive devices and technology are useful in aiding the learning process. Pedagogical games as a mode of teaching (in this case digital video games)

are the central heart of information delivery strategy to learners.

1.2 Statement of the Problem

The academic discipline of pedagogy is still in search of solid pedagogical methods and approaches for the integration of games into teaching and learning(Bado, 2019a). While cognitive theories, and intuition point to game-based learning as holding a great deal of promise, games were not fitting into the educational landscape with the ease anticipated by champions of game-based learning. Moreover as observed by (Plass et al., 2015) several technical, cultural, and ethical factors demand attention as the role of game-based learning in formal education evolves. This in addition to the failure of the game learning industry is largely attributed to the inability to fulfill its promise of producing expert systems and intelligent dialogue(Wasserman & Banks, 2017; Westera et al., 2020), resulting in the "knowledge paradox" which has left so many scientific findings unused. Therefore, the main problem is that game-based learning is currently not fitting into its mandate of teaching and learning as expected.

1.3 Aim and Objectives

This study is aimed at investigating the state of game-based pedagogy by reviewing the literature, and hence make recommendation to improve game-based learning to enable them to fit into teaching and learning effectively.

1.4 Significance of the Study

The improvement of game-based learning will specifically benefit educational training providers, students, educational game developers, and society as well. To the learners, a satisfactory solution will provide a flexible, customized way of learning; improve strategic thinking and problem-solving skills which will positively aid academic performance. To programmers and educational game developers, this will help deal with computational complexity, a situation that reduces intractable programs. To the education training providers and trainers, this will provide an alternative complementary mode of teaching, especially for technical subjects. This will transform players into learners, enabling them to utilize game resources that will otherwise be used for fun purposes, drawing their curiosity during play while nurturing important skills such as problem-solving and critical thinking.

2 Literature Review

2.1 Introduction

This chapter explores the existing ideas, views, opinions, and scholarly research findings, that already exist in the field of game-based learning in higher institutions. The review of relevant literature was done by looking at the three game-based learning perspectives namely adaptive contemporary learning, implementation of pedagogical affordances, and intelligent games in pursuit of improving game-based learning through Artificial Intelligence (AI).

2.2 Adaptive Contemporary Learning

Adaptive Contemporary learning is a learning approach that is technology-based, and customized to suit the needs of users through numerous ways such as just-in-time feedback, responsiveness, and adapting to changing requirements of learners. In this approach, adaptivity is key, with supportive game-based technologies being used to disseminate academic information to learners in a digital mode. In contrast, the traditional mode of teaching and learning allows teachers, lecturers, and trainers to use traditional teaching and learning methods to deliver classroom lectures and assessments. Interestingly, digital game-based learning is rapidly replacing the traditional style due to its efficiency and productivity. Equally, there have been several criticisms, debates, and arguments regarding this teaching approach.

In (Pugliese, 2016) the question was raised as to whether game-based learning platforms correctly perform adaptive sequencing, continuously collect learner performance, and use the same to change the learning experience. The insistence is that the foregoing is the most prominent issue in adaptive learning systems. Therefore, pedagogically, an adaptive system must comprise methods that structure the

modular content to be learned, various forms of assessment, and track and evaluate learner abilities. In(Holland, 1960) emphasis on the role of teaching machines dates back to the 1960s when such machines were able to provide a finely graded set of solvable problems and provided feedback as rewards for correct answers. The approach benefited both learners and teachers. Learners also evaluated their confidence and received timely feedback. This way both learners and teachers identified their deficiencies and adopted some useful strategies throughout the learning process. Training institutions also considered it an alternative instructional teaching tool. However, with the current advancement in technology, a lot is needed to revolutionize the approach (Hallifax et al., 2021). Currently, most approaches use the "static" adaptation, where game elements are adapted to the player's behavior only once, but this does not scale up to today's growing game-based or gamification pace thereby disadvantaging learners' preferences.

Furthermore, a report by (Mirata et al., 2020) applied the four-stage Delphi design to empirically examine the challenges preventing the adoption of adaptive learning in higher institutions. The study found several drawbacks ranging from technological infrastructure, implementation issues, and pedagogical affordances. In addition, another technical issue that contributes to the drawback is poor system design. This negatively impacts learners, while on the other hand, clever design has positive impacts but appears difficult to implement as it is challenging to achieve because technology-based supported models should allow the construction of own knowledge with collaborative pedagogical affordances.

It is argued by (Blumberg et al., 2019) that the use of dedicated video game consoles remains indisputable as learning extends beyond the classroom environment. As the adoption of game-based learning is growing, 47% of grade teachers reported using digital games for teaching(Vega & Robb, 2019), yet pedagogical digital games are still sparsely investigated (Flynn et al., 2021). Of note in this regard is that modern games use artificial intelligence (AI), and they require tactics, challenges, engagements, feedback, and various adjustments based on the player's behavior. The AI approach when applied to the educational field coupled with the right pedagogical affordances provides an adaptive experience strategy needed for learning. As a result, design issues need to be properly covered. Designers should ensure that adaptive GBL adjusts to the player's behavior by changing game narratives, problem complexity, or goal structures(Adcock & Van Eck, 2012a). Adaptive systems are emerging. Adaptive intelligence systems need to adjust to student abilities, update content, and accelerate both learners' and instructors' performances. Transformation of first-generation digital learning applications is vital, conformance to the expected levels is necessary, with real-time comprehensive feedback, unlike the traditional style where both learner and instructors wait too long for the responses. A combination of real-time responses and learner-specific feedback radically forms the core part of the learner-centered approach.

The core fields of the adaptive system comprise various key areas such as improved automation as a way of reducing manual processes, proper sequencing, real-time player data collection, and the right techniques that match assessments. This feature, when properly embedded within a game learning system enables it to fully fulfill its main mandate. It is quite impressive that this feature can be modeled in a game learning system; For example, implementing the real-time data collection and feedback approach can be handled by manipulating string arrays such as:

String [] feedback = {"win", "draw","loose"};

System.out.println(feedback [0])//indexed from 0 for first element

feedback.length;

Although manipulating string array has its demerits, especially in an object-oriented programming paradigm, the best alternative is the use of Vectors as they can scale to the required level forming the core trait of adaptiveness useful in a game model. More adaptive features need to be explored and combined to formulate a fully-fledged application. In comparison arrays are unable to scale with an increase in storage demand whereas vectors are resizable sequential data containers, unfortunately, most games use the

latter. Algorithms with advanced adaptive features such as pattern recognition are useful, while on the other hand, the rule-based adaptive approach needs proper assessment before adoption as they might work against adaptive features due to their preconceived rule set-style of coding. Therefore, it is another call to programmers to ensure that a game dynamically manipulates variable contents to fit well with any model.

Another benefit of game-based learning is that playing games has been attributed to cognitive skills development which in turn improves learners' ability to imagine, memorize, remember, critically think, and understand with an engaged mind, not a passive one as may be the case with a non-game learning environment. An actively engaged mind answers the question of "why," and "how," understands concepts of why option A, not B or C, how to avoid losing, and studies the opponents' tactics which will otherwise not be the case with traditional classroom teaching. Cognitive thinking is a combination of various core features such as optimization, approximation, estimation, attention, and engaged mind, and all of these form the key requisite of success in an educational environment(Alsawaier, 2018; Pratama & Setyaningrum, 2018).

2.3 Adaptive Sequencing

Every learner during their learning process reaches a point where the learning curve is at maximum level. At this advantaged level, Adaptive Sequencing becomes very necessary to properly insert a mechanism that identifies changes in the learning curve, updates and provides necessary feedback. Automatic and dynamic detection of pattern changes in player behavior is critical in identifying the level of performance. An algorithm that matches, adapts, and adjusts the difficulty level of the game 'Low,' 'Medium,' and 'High' ratings would improve the cognitive capabilities of the players. This forms the core of the adaptive features in game-based learning and needs to be properly implemented. Equally, there is a strong correlation between the learners' performance and the time required to complete the task. This implies that as learners' efficiency improves with time, the more learners perform the task, As shown in Table 1, the learning curve helps to visualize the change in learning over time. It is important in the sense that it shows whether the performance of learners matches the resources, and this guides the decision such as whether learning improves or not, and identifies improvement areas.

Table1.Learning Curve

Learning Point= Learner Performance + No of attempts

Adapted from the learning Curve Theory: The Definitive Guide 2021

As noted in(Robbins, 2019; Yeolekar & Qadri, 2018)**,** Learning has an evolutionary purpose among species and individuals that adapt to their environments. It justifies the reason human brains retain surprising information.

2.3 Pedagogical Affordances

Pedagogy is an educational paradigm that encompasses a broad set of teaching beliefs, methods, and approaches combined to ensure effective and efficient learning in an educational setup. The use of digital games in pedagogy is currently being accepted as they are responsive, engaging, and motivating, which are the benefits of gaming in academic pedagogy. In comparison, the use of game learning as a pedagogical medium brings more valuable benefits when coupled with the traditional style, especially for certain subjects. As a result, a philosophy that promotes learning using video games, embedded with teaching principles and gamified concepts forms the core mandate of game-based learning and connects learning theory to practice.

A study by (Bado, 2019b) reviewed published journals with three categories of pedagogy which are pregame, games, and post-games. The study recommended that to achieve maximized learner engagement and learning outcomes attainment, the integration of video games in learning and teaching should be prioritized.

3. Pedagogical games as a teaching and learning tool.

Game-based learning has been highly praised in terms of bringing positive outcomes to learning, and its effectiveness, especially in terms of academic achievements, critical thinking capabilities, and learners' attitudes (Fürnkranz, 2017; Yu et al., 2021). However, game AI is still in its infancy, and as such popular games lack AI and ML features (Giannakos et al., 2020; Xu, 2014). A study by (Sitzmann & Ely, 2011) suggests that games are the best way to learn, adding that when compared with traditional learning, game-based learning (GBL) increases the self-confidence of learners by 20%, improves conceptual knowledge by 11%, and improves learning retention. Interesting, fun games like Robocode enable learners to master difficult concepts (Hartness, 2004). Most learners hate school, not because the work is too hard but rather simply because it is boring (Ali Ramsi, 2015). Games fail to achieve their teaching mandate because they lack pedagogical design and proper learning principles applied to a real educational environment(Tobias et al., 2015). Therefore, a considerable level of intelligent optimization needs to be applied to deal with the quality improvement of pedagogical games without increasing their complexity (Safadi et al., 2015).

As teachers and learners' perception of DGBL is a concern that impacts on quality of teaching and learning environment, very thought-provoking research about instructional design directed towards improving game-based design and pedagogical practices is mandatory (S. Chen et al., 2020; Slussareff & Šisler, 2020). It is argued that some challenging tasks such as the EU Law cannot easily be taught through traditional knowledge-based learning but rather easily attainable through pragmatic problem solving~ digital game-based learning. This implies that games can be useful in education. In(Ross et al., 2014) the role of games as a pedagogical medium, states that even though the effectiveness of games as a teaching tool is still being established but the implementation may be ahead of research as the adoption of games in learning rests upon various aspects inherent in the game construct. Apart from the growing interest, the failure of DGBL is a result of various reasons such as wrong data collection methods and results interpretation, improper strategies of measuring how effective they are, or questionable game design(All et al., 2014). As a result, most games used fail to achieve their teaching mandate because they lack pedagogical design and proper learning principles applied to an educational environment thus, we see digital games not filling the gap that exists as expected. It is necessary, therefore, to ensure that automated pedagogical affordances that support knowledge development and account for player variability are given considerable attention in GBL(Adcock & Van Eck, 2012b; Seel, 2011).

In another significant study (Haystead, 2009) it is noted that although games are part of the instructional repertoire, most teachers do not use them, and if they do it is at their potential. Having examined the benefits of games, their findings strongly conclude that games do improve student learning achievement. Digital games provide teaching, and learning opportunities, are easily accessible, and affordable, and have gained significance as a new paradigm in education(Giannakos et al., 2020). Game theory enables better management of complex interconnected control systems (Shamma, 2020). While other researchers believe that games are beneficial because of the competition element, there are still some contradicting findings that criticize too much randomness and competition element. Hence, when learners are competing, they work harder thereby improving their knowledge, without competition only the best class would be successful (Kollöffel & de Jong, 2016).In addition, a study by (C.-H. Chen et al., 2018) with student participants was given a learning achievement test with two conditions; competition and non-competition. The findings of the study revealed that non-competition students performed better than those with competition though they both acquired knowledge. It was stated that non-competition learners were able to read instructions carefully and repeatedly, calling for more investigation into the pros and cons of competition in gaming.

Most available deterministic games are very predictable, and they cannot teach, evolve, learn, and adapt to new conditions as lecturers or teachers do. This shows that to improve the quality of pedagogical games, an element of intelligence needs to be introduced. Human

intelligence needs to be simulated to deal with issues of reasoning, thought processes, and behavior. This is because, for adaptive contemporary learning to extend traditional learning, games will have to think, and behave more like or even better than humans. As a result, artificial intelligence techniques will become an indispensable asset in dealing with the shortcomings of pedagogical games(Ross et al., 2014; Skinner & Walmsley, 2019; Yannakakis & Togelius, 2018). Despite the challenges to ensure maximum benefits of integrating games, learning, and Artificial Intelligence, we need to appreciate some efforts already in place such as those of the jointure venture between the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) modeled guidelines from teachers and AI experts with intention of promoting, understanding teaching and learning by AI (Comi, 2018; Touretzky et al., 2019; von Struensee, 2021).

4. Recommendations and Benefits

4.1 Intelligent Games

An intelligent system is a machine that perceives and responds to its surrounding world, while Game-based learning refers to learning that is facilitated using games(Whitton, 2011). Intelligence in-game learning encompasses a broad set of concepts ranging from adaptation to changing conditions, learning from experience, problem-solving, reasoning, perceiving, and comprehension of ideas. Converting such benefits to the field of computers which then be used in game-based learning is a big advantage. This, however, comes with scary drawbacks of destructive superintelligence is the possibility of intelligent games escaping our control and then reprogramming leading to an intelligence explosion. As noted (Nichols, 2017), playing video games does not only change how our brains work but their structure as well.

4.2 Intelligent Pedagogical Games

Game-based learning improves cognitive abilities such as memory retention, spatial navigation, perception, and thinking which is quite impressive, even though it has been emphasized by (Granic et al., 2014) that not all games bring such benefits citing role-playing games as an example. This is quite a concern because most research agrees with game-based learning but questions their information delivery strategy and pedagogical affordances and this is one of the reasons why the traditional teaching style is preferred. It is suggested by (Boyle et al., 2016), that future research, examines game features that are most effective in promoting engagement and supporting learning. The establishment of storylines, player modeling, balancing game complexity, and addition of intelligent behaviors to characters can easily be attained through the incorporation of AI in computer games (Yannakakis & Togelius, 2018). Games require physical, mental, or both simulations to help develop practical skills and perform an educational exercise; psychological role needs to be built on key features such as goals, rules, and challenges and made interactive, adaptive, and intelligent through AI techniques(Ranjitha et al., 2020). “Equally, there are numerous limitations of game learning that keeps on reoccurring, for which solutions with machine learning methods are desirable, including opening book learning, learning of evaluation functions, and player modeling” (Fürnkranz, 2017). This will be more beneficial as an algorithm that can learn will not require programming all key functionalities as is the situation now. It is suggested by (Giannakos et al., 2020) that enough research on the combination of AI/ML and game-based learning is still lacking. Although incorporating technology into learning is vital (AI/ML) can be very complex and difficult to trust and therefore it is wise to pick the right techniques with less risk, validation techniques, and higher accuracy(Eaton et al., 2018). This widens the scope of research but cannot be ignored as all the social, ethical, and technical dimensions need to be properly monitored to avoid producing uncontrollable systems.

A study by (Flogie et al., 2020) was conducted on the development and evaluation of intelligent serious games, particularly for students with disabilities integrated into an educational system. The study found that games provide the opportunity for personalized learning and are adaptive to individual learner preferences. The study strongly recommended that games can be adapted to students’ capabilities and specially developed curricula.

It is quite impressive that intelligent games support learners with disabilities. Therefore, the implementation of pedagogical theories, instructional design, and artificial intelligence embedded in game-based learning is to ensure the development of cognitive skills for a truly intelligent pedagogical game. Other contributions of AI have also been discussed (El Rhalibi et al., 2009; J. Li et al., 2012), but the effect of educational games on motivation remains inconsistent, and sometimes contradictory(Yu et al., 2021). This indicates that game learning is still surrounded by a lot of controversies especially as some findings are very recent and new, which calls for investigations into this field(Giannakos et al., 2020; Skinner & Walmsley, 2019; Yannakakis & Togelius, 2018).

4.3 Game Intelligence: Theoretical Perspective

In addresses the research gap in game based learning, focus should be from the perspective of an intelligence theorem. In this regard, three important concepts that have not been properly addressed in literature sources include intelligent game-based approach, static rather than dynamic scripting, and unfair randomness in pedagogical games. All this may be addressed with reference to proper theoretical framework. Thus, game-based learning needs to be looked at through a theory that will help guide and situate the research on the right path. On such theorem is discussed below.

4.3.1. The Intelligent Agent Continuum Theorem

The Intelligent Agent Continuum by Russell and Norway (2009) states that an "intelligent agent receives percepts from the environment and performs actions, such that an agent implements a function that maps percepts sequence to actions" Selmer, B. & Govindarajulu, N.S. (2018).In this case, Intelligence has been explained from a perspective of rationality i.e. building intelligent agents that act rationally. It is acutely difficult to explain concepts of AI in game learning, philosophers provided different sets of explanations but what matters most is to define it in terms of its goals because generally aiming to implement intelligence in computers has been hugely criticized. For example, Mariya Yao (2017) once if we define "intelligence" in terms of human-level thinking then we do not have artificial intelligence today.

Two competing definitions have been cropping up i.e., firstly AI is explained as a system that imitates human beings or systems that act rationally. Therefore, going forward through this paper, one would notice that there is confusion as to what really constitutes AI here, a good theorem that can clarify the matter is necessary, thus paving a clear pathway to apply **the Intelligent Agent Continuum by Russell & Norway** to structure the aspects of the research. The commonly used concepts of artificial intelligence result in various questions such as "Does machines imitating human characters equate to artificial intelligence in game learning? AI is the ability of digital computers to perform tasks that are commonly associated with intelligent beings according to Copeland, B. (2021), or leveraging computers to mimic the problem-solving and decision-making capabilities of the human mind-IBM Cloud Education, (3 June 2020) https://www.ibm.com/cloud/learn/what-is-artificial-intelligence

It is acutely difficult to explain the concepts of AI in game learning, philosophers provided different sets of explanations but what matters most is to define it in terms of its goals and ability to learn, generally aiming to implement intelligence in computers has been hugely criticized.

Russell and Norvig (1995, 2002, 2009) defines AI in a simple, more understandable way, emphasizes that AI should be explained in terms of its goals i.e., "AI as a field that aims at building …" and this poised out two dimensions being "whether the goal is to match human performance", as already said by others or, instead, ideal system rationality. Are we building a game system that reason/think, or rather that acts? If we go with human-based theory, it will reason or think like human beings (is every human behavior acceptable?) or act like humans. Secondly, if we go with the ideal rationality perspective, then it will think rationally and act rationally, this sounds perfectly well for a game learning model. Now what does Rationality mean? acting with logic or sensibly. This is much better suited as

compared to the commonly used human-based explanation.

Russell and Norway (1995, 2002, 2009) summed up AI in the simple definition of AI by applying four possible answers placed under two dimensions; Human-based and Ideal Rationality and this is how the logic is depicted in table 2.

Table 2

	Human-Based	**Ideal Rationality**
Reasoning-Based:	Systems that think like humans.	Systems that think rationally.
Behavior-Based:	Systems that act like humans.	Systems that act rationally.

Conclusion.

In conclusion, this review has provided useful insight into the current state and application of game based learning. With current advances in Artificial Intelligence, it is suggested that intelligent games will go a long way in improving and extending the role of game based learning.

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