Game-based Learning Model through Intelligent Agents

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Abstract

Game-based learning has been in existence for decades, and the importance of games as an instructional teaching tool can no longer be overemphasized. Due to its benefits as a teaching and learning tool, mostly when compared to the traditional teaching style, game-based learning received considerable attention. Many training institutions have adopted this contemporary mode of learning. However, despite its success in the learning sector, there have been some looming critics in terms of its degree of intelligence. The ease of use, responsiveness, dynamicity, predictability, and information dissemination strategy to learners formed part of the main critics who pointed out its drawbacks. Various researchers provided findings regarding what constitutes intelligent game-based learning models suitable for learning and teaching purposes. This diverted the focus of attention to intelligent agents in pedagogical game development. Intelligent agent programs make decisions or perform operations based on information collected on a programmed schedule, user input, experiences, or their environment. Artificial Intelligence allows the application of intelligent assistance through intelligent agents and identifies their degree of intelligence which is the best way of improving game-based learning models. This research performed a survey of scholarly reviews on game-based learning and found that educational game intelligence is the main hindrance behind the success of pedagogical games in the learning sector. Finally, this paper presents a framework for improving game-based learning models through intelligent agents, intelligent assistance, and rational intelligence for the benefit of learners, pedagogical game developers, trainers, and educational training institutes.

Keywords: Game-based learning, Intelligent Agents, Intelligence Assistance, Rational intelligence, Artificial Intelligence

1. Introduction

Game-based learning is a learning approach where educational games are used as an instructional teaching tool to enhance students learning or learning through games. Contrary to the commonly used traditional style of teaching, in this case, digital games are used in the course subject to meet the set learning outcomes. This is an innovative technique for boosting learners' morale by using video games as a learning and teaching tool. The teaching methods, practices, strategies, feedback provision to learners, and assessment strategies form the core components of educational pedagogy. However, these components when embedded within educational games make them pedagogical games suitable for teaching and learning. Delivering a pedagogical medium through a game makes its degree of intelligence an important element to assess. The intelligence level of an educational game encompasses a broad set of instructional requisites such as dynamicity, predictability, strategic decision-making, and advanced problem-solving. In the field of Artificial intelligence, intelligent agents make decisions and perform operations based on their environment, user input, or experiences. Through the parameters provided, they can extract specific information through sensors such as input devices and deliver output through actuators such as display screens. They are adaptive, solve problems, and give feedback in a very sensible way; therefore, embedding such traits in educational games makes them intelligent pedagogical 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 [13]. 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 computers, which can be used in game-based learning is a big advantage.

There are various types of such applications, however, the key feature of the proposed model is the ability to gradually improve, become more knowledgeable throughout gaming and use the feedback provided to determine how to improve i.e., learning agent.

Integration of these concepts in games ensures intelligent assistance as they exude features that were commonly found in human beings or teachers. Intelligent agents in game development are characterized by core features such as proper problem-solving, rational decision-making, and logical feedback mechanisms. According to [15], intelligent agents receive inputs and percepts from the environment and perform actions rationally or logically. Pedagogical games should exude logical or sensible problem-solving features if they are to break into the field of teaching and learning. Their inability to hold intelligent dialogue and assess their level of

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intelligence are some of the core issues affecting their success in the educational sector, hence we see multiple games developed but remaining unused. Investigating and providing ways of improving these concepts will greatly improve game-based learning for academic purposes. As result, this research focuses on clarifying how intelligence assistance, rational intelligence, and intelligent agents should be applied to improve pedagogical game models.

2. Literature Review

Game-based learning pedagogical

Game-based learning can be used in the academic setup for a variety of reasons ranging from improving learner engagement, motivation, cognitive skills development, knowledge creation, and strategy development to promoting critical thinking. There is limited research in terms of real-time strategy games due to complications that come alongside their design and as such that hinder their adoption in the learning field. Even so, others consider the rationale behind using games as an instructional teaching tool inappropriate. The academic discipline is still in search of solid methods and approaches to improve games for teaching purposes. Its failure to dominate the academic discipline is largely attributed to the inability to exude intelligence features demonstrated by teachers under the traditional style of teaching. A study by [7] explored game-based learning potential and found out that the process of developing a cognitive understanding of games, understanding the relations between its components, and the complexity of game mental models still needs to be reviewed to understand how players perceive games and transfer knowledge to another non-game context. It is also questionable how instructional game techniques facilitate learning. Intelligence in pedagogical games still lacks behind despite numerous improvements in Artificial Intelligence. Most available video games used 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. 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 [12]. Artificial Intelligence has been in existence for decades, and computer games have proven to be good test beds for it. It allows certain game features such as non-playing characters (NPCs) to behave as if they have their minds.

Games and Artificial Intelligence have a long history together [5], there has been an increasing need mostly for research centered around developing agents that play games with or without learning capabilities. There exists a gap that needs to be filled in academic Artificial Intelligence research, between academic researchers and game developers. Digital games support learning and teaching, they are accessible to a wide variety of learners, yet we do not see them dominating the educational sector. Although the intersection of game AI and teaching and learning is an important and challenging area, it is evident that enough literature review has not been conducted in this field [4], [11]. Dynamic scripting is an easier way of developing adaptive applications, algorithms augmented with a technique that adjusts the learning mechanism to the expected human player level is the best approach to use.

The inception of intelligent agents brought alongside the much-needed area to bring together the combination of intelligent assistance with rational intelligence in games and such game applications provide desirable human capabilities suitable to solve existing gaps in academic games research. Combining all these features forms a truly intelligent pedagogical game able to operate as an instructional teaching tool. This will help learners build a close relationship with gaming for academic purposes not just for fun as is the situation today. There has been a debate in terms of whether game design and models are effective learning tools, and various researchers critique it, the big advantage is that mostly they view game-based learning as a good teaching tool pending developments in certain areas. [17] Artificial Intelligence must be applied to create and understand intelligence as a general property of the system, rather than a human-based character. This will lead to producing artifacts that exude intelligence features the right way, even though we are not saying humans are not intelligent enough.

AI agents can be designed to work independently where necessary, to avoid collisions and overlapping that occur when operating as a team [2]. This makes it easier to add specific functionalities and improve gameplay and simulation. As noted, [14] for example, introduced PROSOLVE game to assist learners to understand Programming course concepts, and improve problem-solving skills, learning engagement, and cognitive skills development, upon results analysis it was found that game learning does improve learners' understanding, even though Programming is one of the most challenging computer science areas [20]. Instead of producing agents that were designed to beat the opponent, or produce human characters, it wise to develop the game with AI agents able to simulate automated playtesting, handle game evaluation and balancing. Pedagogically, learners reach a point where their concentration is at maximum level, and

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this is the point where learning increases, the learning curve. According to [18], as per the learning curve theory, the time needed to complete a task reduces with repetition. Adaptive Game-based Learning models are adaptive, which means they can adjust to a player's developing knowledge base by changing goal structure, problem complexity as well as game narratives [1]. Therefore, the learning curve concept of repetition will not be a problem as the element of adaptivity will handle such issues where learning engagement and motivation drop.

Preferably learners tend to opt for playing against other human players because if the contest is between computer-controlled opponents, the more they repeat play, the more they memorize game moves and get bored as the play progresses [8]. As stated, [19] Adaptive learning systems comprise hard and soft technologies that adjust pedagogy content presented to them through various approaches such as cognitive modeling or sensory input. This adjustment aligns with the player's behavior.

An effective approach to model autonomous features in-game agents is through rapid adaptive game AI because non-adaptive models bring alongside some drawbacks such as the fact that once the human player understands the game tactics, then they can forever manipulate the game to their advantage and there is no room for learning from mistakes.

According to [9] common elements of most educational games are Goals, Rules, Assets, Spaces, Play mechanics, and Scoring (GRASPS). They are core elements in the design process of game development and introducing them to learners raises awareness and allows learners to think from the designer's perspective. Intelligent systems need to be aware of such status to maximize learning. The importance of deploying video games in an educational environment is that they have already captured the attention of millions of loyal players across the world and therefore using the advantage for learning could be very beneficial. Even despite such considerable interest, the number of educators and researchers using game design as a platform to train young learners is very limited, moreover, literature reviews documenting the design and development of such learning experiences have been scarce [9].

Intelligent Agents

Intelligent agents perform operations and make decisions based on their environment, user input, or experience. Due to its ability to collect information, either requested or not, learn from experiences and give feedback autonomously, this makes it dynamic, adaptive, and able to gradually improve, and become more knowledgeable by learning from users. This learning component is a typical model suitable for inclusion in game-based learning frameworks to ensure they fit their mandate of teaching. According to [6] AI is designed to enhance human players' experience, mostly controlling the NPCs to look intelligent. In the 1990s, used algorithms were generalizing every behavior, for example, consider the commonly used Finite State Machine (FSM) which has a limited number of conditional states. This structure came alongside drawbacks of predictability, and preprogrammed behavior, therefore such games are not engaging leading to a loss of interest among learners. However, when compared to the currently used algorithms such as Monte Carlo Search (MSCT), offers new gaming experiences, is not preprogrammed, and can learn and evolve. A study by [3] argues that for agents to "act", it first needs to be given a logical representation of a theory of action(i.e. how to operate) and get to do a bit of theorem proving. This verifies how important logical reasoning guided by a relevant theorem is.

Exploring the functionalities of intelligent agents as well as the problematic ideological assumptions surrounding them is a step in the right direction.

Intelligence Assistance

The use of intelligent agents to assist human beings is referred to as intelligence assistance. Though it may be easier to confuse the two terms (Artificial intelligence AI and Intelligence Assistance IA) the two differ in terms of their deployment and usage. The former attempts to mimic human beings while the latter assists human beings. IA involves cognitive computing capabilities and problem-solving capabilities executed by intelligent agents throughout the gaming process. Equipping pedagogical games with intelligence assistance features means they will be able to deliver content, perform an assessment, track learner performance, and manage data autonomously. One huge drawback that has been frequently cropping up is their predictability and ability to learn throughout game learning. According to research by [6], only the digital pet game Petz exudes learning capabilities, evolves, and becomes more knowledgeable throughout the play. IA should focus not only on defeating human players but rather generating a better and unique user experience by bringing together real-world user experience and virtual reality to improve the learning process.

Rational Intelligence

There has been confusion regarding what constitutes ideal rationality and as such too many equate AI to human-based characters, which is too ambiguous. Rational Intelligence involves critical thinking, logical or sensible decision-making, and goal-oriented behavior with an unbiased approach, it

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plays an important role in game-based learning. A study by [16] applied the intelligence agent continuum theory which helped differentiate applications that think rationally as opposed to those that think like human beings. Logical reasoning based on ideal rationality builds pedagogical games that act sensibly. Simulating interesting, challenging nonplaying characters with advanced computational capabilities to enhance and improve learners' experiences while learning from them is an ideal proposed model for this research. This will be much more different from attempting to develop pedagogical games that mimic biological intelligence. The field of computer science has drastically improved, and algorithmic game designs could offer a big boost to the existing applications. Most institutions are now using technology-based styles of teaching as opposed to traditional teaching. Improving educational games will be an indispensable asset to the trend as it brings the virtual world to life. The use of AI to create smarter pedagogical games is challenging but with the right approach and proper frameworks, it is possible to attain. Game-based learning has been praised on several occasions, playing games have been attributed to cognitive skills development in different learners which in turn improves learners' ability to imagine, memorize, remember, critically think, and understand with an engaged mind, not a passive one as maybe the case with a non-game learning environment.

3. Theoretical Framework

The literature review section highlighted the research gap that needs to be filled, however, it will be relevant to select a good theorem that details a theoretical perspective to solve the gap. Therefore, this part introduces the Intelligence Agent Continuum, outlines how it behaves, how it was used before, its relevance to the objectives, the relationship amongst the concepts, and finally how it will be operationalized. The plan is not necessary to repeat the scholarly reviews but rather outlines how the theorem has been adapted and adopted to the fields of game-based learning.

3.1. The intelligent Agent Continuum by Russel and Norvig

This theorem explained, clarified, and summed up the three key areas: Artificial Intelligence, Rational Intelligence, and Intelligent Agents. Even though the theorems were applied from a different field other than implementation in pedagogical games, using them, in this case, will yield good results to solve the existing gap of improving the intelligence of educational game applications. As noted in [4], [16] the Intelligent Agent Continuum 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". In this case, Intelligence has been explained from a perspective of rationality i.e., building intelligent agents that act rationally [15]. According to [2] intelligent agent program is a key technology of artificial intelligence. They take inputs from the environment and produce a behavior based on those inputs-acting rationally (see Figure 1).

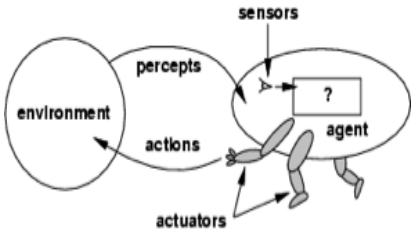

Figure. 1. Intelligent Agent by Russels and Norvig

The aim is to improve the intelligence level of pedagogical games to enable them to teach and learn. Therefore, this theorem is a perfect match as it fully integrates the key concepts (artificial intelligence, Intelligence Assistance, and Rational Intelligence) that have been hugely criticized for negatively affecting the success of game models. Currently, to our knowledge, there are no pedagogical game designs or algorithmic models guided by the IAC theorem that is structured behind the combination of all these concepts. Operationalizing this framework produces models suitable for improving educational games' intelligence levels. The approach fully covers the ontological and epistemological perspectives, visualizes our views, and guides our actions. This greatly boosts the developmental models thereby enabling them to fit their mandate as instructional teaching tools. However, apart from such benefits, careful consideration is mandatory. This is because the proposed model carries scary destructive drawbacks if not properly managed, it aims to produce powerful, intelligent agents which may not only cheat during game learning but also, worse escape human control as they act autonomously. This will result in an intelligence explosion; the situation where intelligent systems escape human control and act on their own or their intelligence surpasses human intelligence as they learn from experience.

4. Methodology

4.1. Systematic Literature Search

A systematic search process was performed to gather, read, analyze, interpret, and identify the

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relevant key literature representatives. Analyzing and summarizing scholarly materials, to look for patterns followed the logic outlined in the pseudocode and flowchart below:

Pseudocode Algorithm: Search

1. *Start*
2. *Search using keywords*
3. *Assess results, match patterns, verify sources*
4. *Use concatenation operators, if failed*
5. *Or else if passed check peer-reviewed, and authors authenticity*
6. *Discard if not, else go to abstract, conclusion*
7. *Select for reviewing if good or maybe read for general knowledge*
8. *End*

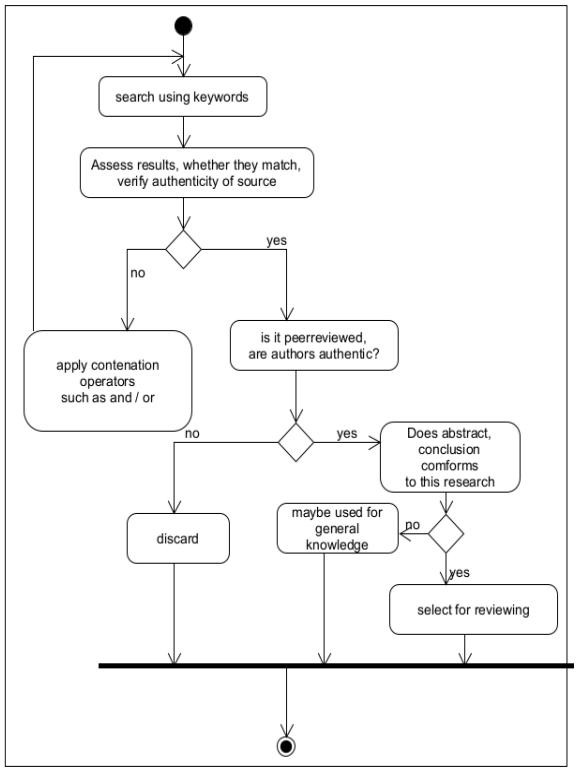

Figure 2. Search Flowchart

4.2. Content Analysis Method

It is always a challenge to measure and analyze qualitative data from the above-selected literature sources. Though at least 20 sources were selected for review, the process involved analyzing, examining, and interpreting data solicited through keywords, related subject areas, relevant abstracts, introduction, and conclusions. The research is centered on the intersection between rational intelligence, Intelligence Assistance, and Intelligent Agents all under Artificial Intelligence for improving game-based models. The process is aimed at peer-reviewed sources from various databases and digital libraries. For this research, content analysis is the main suitable methodology as it allows for soliciting qualitative data which can eventually turn into quantitative data. For example, subject areas, and abstracts provide detailed information related to the research under study and could eventually be turned into numeric information when counted. The approach enabled the comparison of similarities and variations between concepts with logical reasoning. Secondly upon selection as outlined by the flowchart logic, the quality criteria below were applied.

Table 1. Logical Criteria

Criteria	Yes	No
What problem is being addressed and has it been solved	Yes	
Do aims and objectives conform to the conclusion	Yes	
Are the arguments valuable for this research	Yes	
Are stated facts reliable	Yes	
Are the identified themes relevant	Yes	

5. Proposed Framework

The lack of success in academic games is attributed to the failure of key features such as the ability of game applications to learn from users, experience, adapt, reason with logic, and solve problems. All these issues defeat the intelligence capability of game learning models. To solve these problems this research identified, explained, and clarified key areas of concern impeding progress. It proposes the introduction of intelligent agents within academic models. From the perspective of Artificial Intelligence, an automated decision-making entity interacts with its surrounding environment through input sensors(keypads) and responds through actuators called an agent. Therefore, it needs to be employed in digital game-based learning to deal with the shortcoming of improper problem-solving, predictable game tactics, delayed feedback mechanisms, and unfair randomness. It is designed such that it receives the request through input devices from learners or players then process them and gives feedback through effectors. These agents receive sensory data from file contents, and keypads and respond. Currently, there is a high demand for games with adapting intelligent behavior, especially in the educational field. They should be designed such that they operate with ideal rationality rather than human-based characteristics as outlined in the literature review section. This involves building

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pedagogical game agents that act logically according to a defined academic criterion, with the right sequencing of concepts as in the course outline, proper chronological information dissemination strategy, and timely feedback response to learners. Their assessment functionality is designed such that they assess the ability of a learner per course concepts, for example during gameplay it should radically divert to challenging or technical areas where students are not performing well. Those that demonstrated good performance in certain areas be upgraded as well. The game algorithm should be able to learn from experience such that during gameplay it identifies fast learners from slow learners, gauges performance per area, and adjust automatically to boost the learning pace.

Research by [10] emphasizes that the aim is not to produce agents that outsmart human players, but rather those that provide fun and engagement. Virtually trained agents help us to optimize and approximate various academic processes, different game levels, and exciting course components. Learning agents learn what actions maximize or minimize the reward and eventually assist human players during game learning play. Algorithms are coded such that when the games commence, the agent gathers information about the current state and performs an action based on such data. To ensure maximum exploration, the first phase of learning selects random actions. Though this architecture is best, programmers need to be mindful of the possibility of learning agents outsmarting humans and presenting unexpected outcomes. The aim is to produce a truly intelligent pedagogical game, therefore, to solve gaps identified it is vital to combine key concepts; intelligence assistance, rational intelligence, and Artificial Intelligence to produce a robust framework suitable for improving the intelligence capacity of pedagogical games. All these concepts combined guided by a theoretical framework outlined above (The intelligent agent continuum) form a formidable framework suitable for solving huge gaps existing in the field of academics and game development.

As outlined in the literature review section, an intelligent game application should exude features suitable for filling the gaps that have been identified. To achieve this, proposed digital game-based learning applications employed Artificial Intelligence mechanisms. Employing such features in a logical or sensible structure or framework from a perspective of rational intelligence, modeled with assistance intelligence functionalities is a big breakthrough in the pedagogical games field. This agent can work independently or autonomously alongside other game components adding to the missing part of the application. As this improves the design and implementation, the various advantages carried along such as the concept of reusability and allowing usage of the existing application. As a result, the programmer will not worry about having to recode the entire system or every component new is being incepted but rather reuse the existing algorithms, additionally, there is no need to modify the entire existing application which may bring additional costs, but rather just add a new developed intelligent agent component to the existing main application. This admits and appreciates the efforts currently in place and seeks a way to improve without discarding everything. However, the interaction processes need to be properly monitored to avoid complications that may be encountered because of additional components interaction. A combination of all key concepts; rational intelligence, intelligence assistance, and intelligent agents using artificial intelligence mechanisms implemented in a platform where they are supported by the Intelligent Agent Theorem is the backbone of intelligent pedagogical game models that can solve the existing problems. The structure is outlined below.

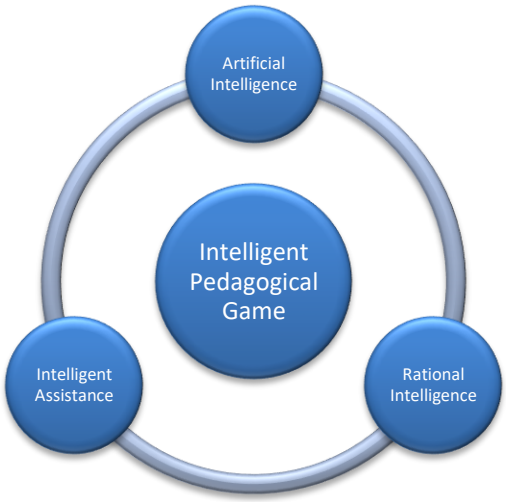

Figure 3. Intelligent Pedagogy Framework

6. Future Work

The research in game-based learning needs to further explore the three key areas: Intelligence Explosion, Computational Complexity, and Components Integration issues. Intelligence Explosion can be referred to as artificial superintelligence, a situation where the pedagogical games level of intelligence, keeps evolving and growing as a result of the addition of intelligent agents to a point where they surpass human cognition capabilities. Exploration of this area is important as it can occur either during game learning or system development, hence we get stuck with a system that is more intelligent than humans hence they may fail to control them. This might be very hazardous if not properly managed.

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Secondly, we need to explore the computational complexity of algorithms. As more agents are added, programmers need to be aware of the drawbacks that come along with such models as they require more resources.

Finally, the research needs to be extended to investigate the cons and benefits that may emerge because of integrating new additional agents into the existing game-based learning models.

7. Conclusion and Recommendation

In conclusion, the rationale behind the use of pedagogical games as an instructional tool has been reiterated. However, despite such recognition, the literature review pointed out that the still some areas that need improvement. As areas of concern were identified, the introduction of intelligent agents through Artificial intelligence became the main proposition dominating as the way forward to the solution. As Artificial Intelligence is a broad area it was necessary to narrow it down to the relevant concepts. Due to this reason, the introduction of Intelligence Assistance and Rational Intelligence emerged as the top area to be explained, clarified, and broken down for implementation as the pedagogical medium of information dissemination. For proper direction, it was vital to apply the theory that addresses or makes sense of the existing gap to be filled. The failure of educational games to perform was identified as the research gap, as critics in the literature sources emphasized, and the intelligent agent continuum provided insights into how to operationalize the identified tools for the betterment of digital game-based learning. A systematic literature review helped identify and analyze key representative literature sources, with content analyses used to quantify and analyze the presence of keywords, their meanings, and the association between key concepts. It was found that the intelligence level of educational games is the main hindrance to their success. Therefore, a robust framework was proposed, which involves the development of Intelligent Pedagogical games using Artificial Intelligence mechanisms through Rational Intelligence and Intelligence Assistance directed by the Intelligent Agent Continuum Theorem. To our knowledge, there are currently proposed models or frameworks with all these propositions. Finally, this research strongly recommends the adoption of the study for use to improve problem-solving, critical thinking, motivation, and engagement during game-based learning.

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