International Journal of Inventive Engineering and Sciences (IJIES)
ISSN: 2319-9598 (Online), Volume-13 Issue-5, May 2026

Comparison of Existing Educational Game Framework and Improvement of Educational Game (EG) Framework

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Abstract: ***This paper compares and evaluates four existing educational game frameworks: Digital Game-Based Learning (DGBL) Framework, Educational Games (EG) Design Framework, Gamified Learning Framework, and Co.LAB Framework. The evaluation includes their strengths, limitations, and potential for improvement. Based on the analysis, an improved Educational Game (EG) framework featuring elements from the four frameworks is proposed. The proposed framework accounts for the unique requirements of educational games and aims to enhance players' learning outcomes. The paper provides insights for game developers, educators, and researchers interested in designing and implementing effective educational games.***

Keywords: Educational Game Framework, DBGL, co.Lab, EG Framework

Nomenclature:
EG: Educational Games
DGBL: Digital Game-Based Learning
DGBVL: Digital Game-Based Vocabulary Learning

I. INTRODUCTION

Educational games are an innovative and engaging way to improve learning outcomes for students. The use of educational games in the classroom can increase student engagement, motivation, and achievement while also promoting critical thinking, problem-solving, and collaboration skills. As such, there has been increased interest in developing educational game frameworks to guide the design and development of effective games [1].

Several educational game frameworks have been developed over the years.

Manuscript received on 23 March 2026 | First Revised Manuscript received on 30 March 2026 | Second Revised Manuscript received on 14 April 2026 | Manuscript Accepted on 15 May 2026 | Manuscript published on 30 May 2026.

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These frameworks provide a structured approach to designing and developing educational games, ensuring they align with learning objectives and effectively promote learning outcomes. The frameworks have been developed based on research and best practices in game-based learning and educational psychology [2].

One of the most prominent frameworks is the Digital Game-Based Learning (DGBL) Framework, which emphasises integrating game design principles with educational content to create engaging and effective learning experiences. The Educational Games (EG) Design Framework, on the other hand, focuses on the instructional design aspects of educational games, including the analysis of learning needs, the design of game mechanics, and the evaluation of learning outcomes. The Gamified Learning Framework incorporates elements of game design into traditional learning environments, while the Co. LAB Framework emphasises collaboration and social learning in game design and development.

This paper aims to compare and evaluate existing educational game frameworks, identify their strengths and limitations, and propose an improved framework that incorporates the best elements of each. The proposed framework will take into consideration the unique requirements of educational games and aim to enhance players' learning outcomes.

II. BACKGROUND OF RESEARCH

In the subsequent section, an extensive analysis will be conducted, delving into the currently established educational game frameworks. This meticulous examination will encompass an in-depth discussion of the merits and demerits of each distinct framework, providing a nuanced understanding of their respective strengths and weaknesses.

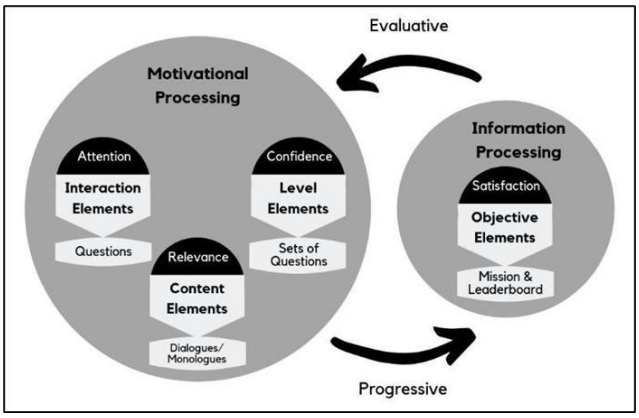
A. Existing Educational Game Framework

In the era of educational game development, a myriad of frameworks has been harnessed to facilitate the creation of enriching learning experiences. It is within this multifaceted landscape that the forthcoming paper seeks to contribute its insights. In pursuit of a thorough analysis, the paper will undertake a meticulous review of four distinct and noteworthy educational frameworks. These frameworks, namely Digital Game-Based Learning (DGBL), the Educational Games (EG) Design Framework, the Gamified Learning Framework, and the co. The LAB framework is a tapestry of methodologies artfully woven into the fabric

of modern pedagogical game design.

i. Digital Game-Based Learning (DGBL)

At the forefront of the discourse stands the Digital Game-Based Learning (DGBL) framework, a seminal cornerstone of technology-mediated instructional methodologies. Within the expansive spectrum of pedagogical approaches, Digital Game-Based Learning stands resolute as an exemplar of efficacy, renowned for its capacity to endow learners with an immersive, enjoyable, and intellectually stimulating milieu, as affirmed by various scholarly investigations [3]. This multifaceted framework, meticulously designed to synergise education and entertainment, not only supports cognitive growth but also cultivates essential skills. A visual representation of the intricate architecture underpinning the DGBL framework is shown in Figure 1, which encapsulates the interplay of elements that harmoniously coalesce to foster enhanced learning outcomes.



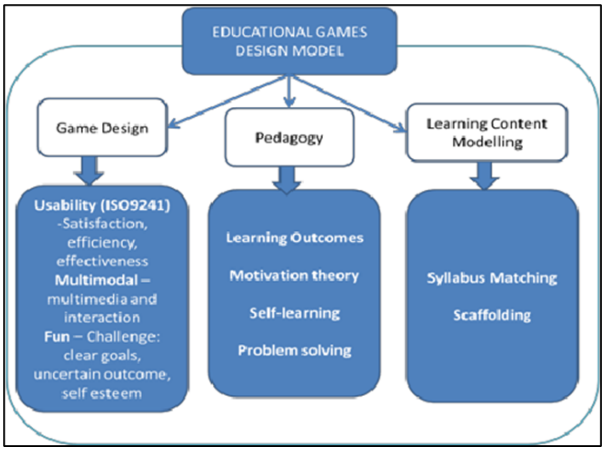
[Fig.1: DGBL Framework Model]

Many academics have emphasised the importance of incorporating appropriate learning techniques when designing educational computer games. Furthermore, it was argued that there was a dearth of research on the efficacy of educational computer games aligned with learning principles and guidelines for game-based science learning, particularly in critical thinking. The results of this study, however, confirm a similar conclusion: DGBL had no appreciable influence on students' extrinsic and intrinsic motivation for learning. The findings of a meta-analysis by researchers who reached the same conclusion after reviewing 39 publications, which found that DGBL apps are less motivating than the traditional teaching approach, also supported this conclusion. Students' responses to the self-efficacy for science learning questionnaires also contradict earlier studies, such as those claiming that using DGBL applications might boost students' self-efficacy for science learning.

However, another study related to DGBL, digital game-based vocabulary learning (DGBVL), confirmed earlier research in the DGBVL literature that documented the beneficial effects of DGBVL tasks [4]. This study also suggests that a DGBVL exercise may improve the acquisition of word knowledge, including receptive, productive, and recognition/recall abilities, as well as orthographic, semantic, and associative knowledge. The contextual impact is a viable explanation for this beneficial result. Digital games offer a rich multimedia context where players can readily access textual, visual, and aural information. In these situations, the richness of the input can enable efficient word learning. This claim is supported by the dual coding theory, which contends that simultaneous availability of both visual and verbal information promotes long-term retention [5].

ii. Educational Games (EG) Design Framework

Researchers continue to investigate several views in game design, spanning psychological and learning theories, as well as the foundations of game design, drawing on the techniques and frameworks described. The field of education remains relatively new, especially in local contexts, according to interviews with several Malaysian educational game developers. As a result, many localised studies are required to generate more knowledge about educational games, including their design, development, and effectiveness among our students. More empirical studies on the efficiency of educational games are required, and thus, an educational game design framework was proposed [7]. Figure 2 is the model for the EG design framework.



[Fig.2: Educational Game (EG) Framework Model]

This framework inspired a study of the crucial design components—immersion, cooperation, and debriefing—related to each of these issues. The ratings of each design feature and the actual knowledge gained from the games positively correlate with how much the activity was enjoyed. Even while students' participation was successfully encouraged, 76% of the time was spent on content knowledge, which hardly resulted in collaborative learning during gameplay, the so-called "reflection-in-action" that is necessary for deeper understanding [6]. Because educational game frameworks for immersion are centred on digital game research, they do not include escape boxes or physical objects that promote immersion. The framework for educational escape games will assist educators and researchers in designing and assessing escape games for science education, resulting in immersive games that not only expose players to sociocentric, or real-world, science-related settings but also yield learning benefits.

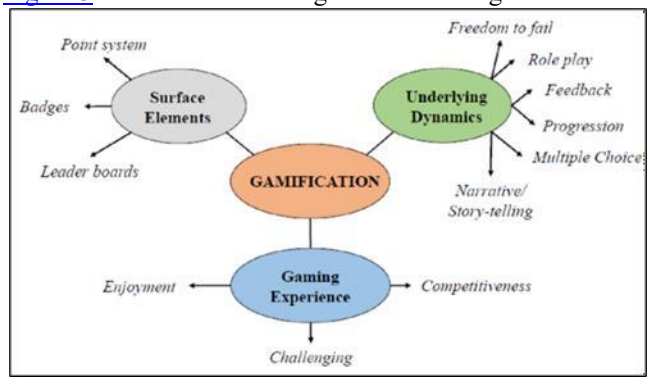
The most important part of the learning goals, as previously defined by the game developer or the client who ordered the game's development, is the key factor in determining the effectiveness of DGBL. These goals can be to impart knowledge or skills,

or to encourage attitudinal or behavioural change. This, however, entails that the game creators or the clients commissioning the game's development should provide a clear explanation of the learning goal. Rehearsing fractions from the second grade provides more information and indicates what should be examined, while the purpose of "teaching math" is too general. This statement should be as specific as possible. The necessity of providing a measurable description of those aims was emphasised, particularly in the broader context.

iii. Gamified Learning Framework

The current educational issues stem from students' lack of enthusiasm and interest in taking an active role. role in their own education. A user's ability to learn new skills is increased by 40% when game components are used, according to a prior study by Gabe Zichermann. Applying player interaction with game experiences to the educational context can help students learn and impact their behaviour. This strategy increases users' commitment and motivation to the tasks and procedures they are a part of. Players like spending hours upon hours playing games; therefore, teachers should use this as encouragement [8]. Gamified learning initiatives have so far yielded mixed, but primarily positive, results for learners' motivation, engagement, and cognitive outcomes. Gamification also appears to be an effective way to boost interpersonal and practical skills, such as teamwork, decision-making, and problem-solving [9].

Studies on the effects of gamification on learner motivation, engagement, and cognitive outcomes generally find that these effects are beneficial. Gamified therapies incorporate game features intended to satisfy a learner's fundamental psychological needs, and research on the effects of gamification frequently draws on SDT to explain its effects. The outcomes of a gamified intervention, however, also depend on the setting, users' perceptions, and the combination and interaction of the game elements [10]. Figure 3 is the model for the gamified learning framework.



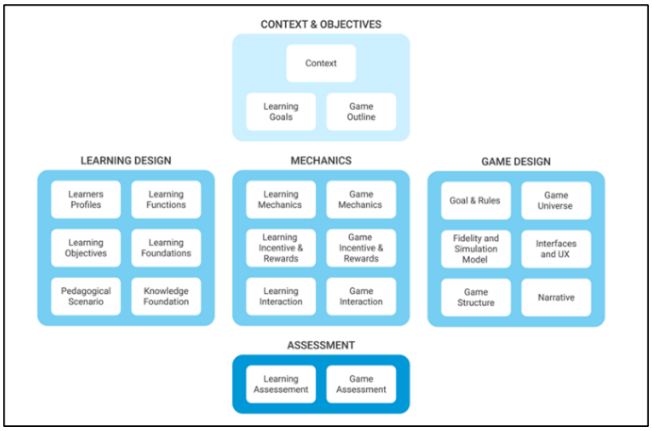
[Fig.3: Gamified Learning Framework]

This framework demonstrates how gamification can be used in classes not only to surprise and disrupt students, but also to help them think differently and open their mental models of learning. Other than that, it can also motivate students to participate actively in class, leading to high levels of engagement. Moreover, it can make learning enjoyable. To analyse how gamification functions in practice, the cognitive, performative, and normative elements of gamification provide a valuable framework. This framework was created because of the study of gamification in higher education, making it a significant contribution.

There is also substantial evidence that gamification successfully raises students' interest in their coursework and their involvement and participation. It was shown that these gamification-enhanced courses and study activities attracted and engaged more pupils. In addition, compared with earlier non-gamified courses, several studies have reported improved performance and scores, as well as increased participation in labs, practical assignments, and research activities. Gamification increases students' course satisfaction, according to feedback data and satisfaction questionnaires. Gamification is a useful tool in this context because higher satisfaction may help draw more kids to STEM fields [11].

iv. co.LAB framework

By fostering collaboration among all members of the interdisciplinary development team, the company. The LAB project, supported by the Swiss National Science Foundation, seeks to increase the efficiency and relevance of serious game design and development. By creating a methodological framework linked to a collaborative web platform for the co-design, co-development, and co-evaluation of serious games, this objective should be achieved [12]. Each design element has been assigned a category. The author reorganised the design elements into 23 building pieces for readability and uniformity. Most design components were copied exactly. Some components were either renamed ("structure and progression" became "game structure") or combined to align with the category they were assigned to (e.g., fidelity and simulation model). One construction piece ("game universe") that was not specifically specified in any of the chosen frameworks but was present in the general game design literature was added based on the author's discussions. Figure 4 is the model for co.LAB framework.



[Fig.4: co. LAB Framework]

Serious games are created for a primary aim rather than sheer amusement, with learning as the primary function. To accomplish the intended goal while designing for learning, a precise specification of the learning functions is required. The serious game's use as an exercise to test or apply information or skills, to support knowledge or skill acquisition, or to prepare for upcoming courses must be

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specified by the development team [13].

The co. The LAB framework is based on a survey of the most significant and pertinent frameworks in the authors' judgment and experience, rather than on a thorough systematic review of serious game design frameworks. However, if any specific design aspect is missing from the framework's current iteration, its adaptability should enable development teams to add it. The LAB framework offers certain novelties compared to other frameworks. First, this framework acknowledges the variety in serious game creation and is made to be flexible for different situations. Second, a collaborative web platform was intended to support the framework's use. Finally, the systemic approach to the design process is the foundation for this implementation on the web platform [14].

B. Comparison of the Existing Framework

After comparing the components of each framework, it is concluded that the most important components of a game framework are Pedagogy Knowledge, Content Knowledge, Game Design, and NPCs. After further comparison with all existing frameworks, it is found that the Educational Games (EG) Design Framework comprises all 4 important components. This can be seen through Table 1 below.

Table I: Comparison of Existing Educational Framework

Components/ Frameworks	Digital Game-Based Learning (DGBL) Framework	Educational Games (EG) Design Framework	Gamified Learning Framework	Co.LAB Framework
Pedagogy Knowledge	✓	✓	✓	
Technological Knowledge	✓			
Content Knowledge	✓	✓	✓	
Game Design		✓		✓
System Gamification			✓	
Learning Gamification			✓	✓
Game Mechanic				✓
Context & Objectives				✓
Assessment				✓
NPC	✓	✓	✓	

Within the expansive landscape of instructional innovation, a diverse array of models emerges, each bearing the profound potential to serve as guiding constellations, charting a course for the conception and realisation of transformative learning journeys. These luminaries, encompassing the Digital Game-Based Learning (DGBL) Framework, the Educational Games (EG) Design Framework, the Gamified Learning Framework, and the Co.LAB Framework, collectively illuminate a path toward the realisation of efficacious pedagogical paradigms. Despite their shared mission to leverage the intrinsic allure of games for educational enrichment, the divergence of their methodologies and underlying priorities creates a canvas of contrasting strokes, each imbued with distinct hues of innovation and insight. Within the intricate tapestry they weave, the intricate interplay of these frameworks becomes a tableau of discernible variations and compelling harmonies, and it is within this intricate juxtaposition that the crux of their comparative analysis finds its abode, offering a vista of enlightenment into their respective attributes, approaches, and implications.:

i. Focus

- The DGBL Framework places a strong emphasis on combining educational material with game mechanics to provide engaging learning environments using digital games.
- Designing educational games is the emphasis of the EG Design Framework, which considers factors including learning objectives, game mechanics, and narrative components [16].
- To increase motivation and engagement in learning activities, the Gamified Learning Framework investigates the integration of game aspects into non-game environments.
- The Co.LAB Framework places an emphasis on experiential and collaborative learning in game-based settings, encouraging cooperation and problem-solving.

ii. Application

- Digital game-based learning experiences are created and implemented using the DGBL Framework.
- It relates specifically to the creation of instructional games, whether they are digital or not.
- The framework for gamified learning applies to the integration of gaming features into a variety of non-digital and digital educational environments.
- Co.LAB Framework: It can be used to create cooperative learning scenarios in game-based settings.

iii. Key Elements

- Learning objectives, gaming mechanics, feedback systems, challenge progression, and assessment techniques are all parts of the DGBL Framework.
- The EG Design Framework is made up of components such as player interactions, narrative components, game mechanics, and learning objectives.
- The goal of the Gamified Learning Framework is to introduce game components like points, levels, leaderboards, and prizes into situations that are not gaming-related.
- Through cooperative games, the Co.LAB Framework aims to promote cooperation, problem-solving, and communication skills.

iv. Emphasis

- The DGBL Framework places a strong emphasis on combining instructional content with gaming mechanics to produce enjoyable and successful learning experiences.
- The EG Design Framework places a focus on the ideas and techniques of design

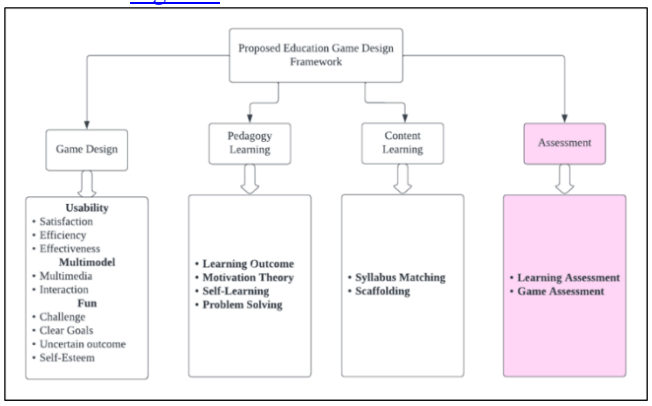
that are unique to producing educational games that are in line with learning objectives.

- The framework for gamified learning stresses motivation, engagement, and advancement by incorporating game components into non-game environments.
- Co.LAB Framework: *This approach places a strong emphasis on teamwork, experiential learning, and interactive problem-solving.*

In conclusion, these frameworks present a range of viewpoints and methods for using games in learning. While the Gamified Learning Framework investigates the application of game components in non-game contexts, the DGBL Framework and EG Design Framework concentrate on building game-based learning experiences. The Co.LAB Framework places a strong emphasis on group learning in game-based settings. Each framework offers concerns and insights for creating successful and interesting game-based learning experiences.

C. Proposed Framework Design

After further investigation into the current EG Design Framework, it was found that some improvements are needed. For example, the EG Design framework lacks an assessment component, a limitation shared by other frameworks. This can be seen in [15], which noted that the findings of their research demonstrate a general lack of independent evaluation of given frameworks for game-based learning. For the assessment part, learning and game assessment should be added to the existing framework. This is shown in Figure 5 below.



[Fig.5: Proposed EG Design Framework]

According to [15], there are four aspects of an educational game that must be evaluated using features from existing frameworks for evaluating educational games: purpose, reason, realness, and subjectivity. The first component, purpose, describes the educational objective that games offer and the method by which they impart knowledge to players. To ensure effective delivery of educational content, players need to engage with an educational game for a set period. For players to continue playing the game, they need a Reason. This element is supported by the Motivation component, one of the GBL Evaluation Framework's main elements. Realness, or how closely the game resembles reality, is another crucial component.

This feature is supported by findings from the GBL Assessment Framework, which examines instructors' and students' views on how realistic games should be. The evaluator's subjectivity is the last factor to consider. The major factors for the four aspects of the GBL Evaluation Framework, which vary depending on the standards used by each evaluator, are these four. Because educational games have distinct target audiences and a range of educational resources, subjectivity is essential. The framework must account for variations in player demographics and educational resources.

D. Pre-Liminary Study with Robo Escape

For educational purposes, particularly in mechanical engineering, with a focus on Statics, we are developing 'Robo Escape,' an adaptation of the comic 'Survival Statics.' The primary goal of this project is to inspire and engage students in learning about statistics by presenting the subject in a captivating gaming format. By playing this single-player, third-person shooter, puzzle, and strategy game, students will have the opportunity to enhance their interest in Statistics. Additionally, the game will incorporate comic-related elements and challenge players with 8 levels, divided into 2 categories, evaluating both their agility and critical-thinking skills.

The proposed framework will then be used to design Robo Escape and assess its effectiveness. The game will be developed by adhering to the key elements of the proposed framework. Table 2 below will show the key elements.

Table II: Key Elements of Robo Escape

No	Robo Escape (Survival Statistics)		Proposed Educational Game (EG) Design Framework Components
1	Pedagogical Knowledge	/	Pedagogical Knowledge
2	Content Knowledge	/	Content Knowledge
3	Game Design	/	Game Design
4	NPC	/	NPC
5	Assessment	/	Assessment

The first key element included is pedagogical knowledge. The theory and application of education and instructional approaches are referred to as pedagogy. Understanding the theories and methods that support efficient teaching and learning is part of pedagogical knowledge. It comprises familiarity with a range of instructional practices, educational theories, evaluation tools, and classroom management procedures. Teachers who are well-versed in pedagogy may create and implement instructional strategies that meet the requirements of a variety of students, increase engagement, and foster meaningful learning.

The second key element is content knowledge. A thorough understanding of the subject matter being taught is referred to as content knowledge. In the context of an educational game, content knowledge would entail proficiency in the academic subjects or concepts the game aims to impart. To enable an accurate portrayal and efficient conveyance of the material through gaming, game developers and educators working on the project need a thorough understanding of the subject. Without a thorough understanding of the subject, the game may not accomplish its intended educational goals.

The third key element is game design. The process of constructing a game's rules, mechanics, graphics, and

general structure is known as game design. It entails creating a game that integrates educational goals with fun gameplay within an educational framework. To create an engaging and instructive experience, game designers consider the target audience, learning objectives, and desired results. Effective game design strikes a balance between enjoyment and education, ensuring that instructional material is effectively incorporated into gameplay.

The fourth key element is NPC. An NPC, or non-player character, is a character that is controlled by the game's artificial intelligence rather than by a player in video games and educational games. NPCs can play a variety of roles in the game, including supplying information, presenting missions or challenges, acting as enemies or allies, and enhancing the overall story and environment. NPCs can be created to serve as virtual instructors or mentors in educational games, guiding players through their learning, providing feedback, and situating the learning material in the proper context. By providing players with individualised interactions and support, thoughtfully designed NPCs can enhance the game's immersive and instructional elements.

The last key element, added to the original EG framework, is Assessment. Further research has found that assessment is also an important component of the educational game framework. The way students interact with educational content has changed dramatically due to the incorporation of educational games into learning environments. The unique combination of fun and education found in educational games creates captivating learning experiences. The success of these games, though, lies not only in their enjoyable gameplay but also in their ability to accurately gauge students' development and learning outcomes. This essay examines the critical role of assessment in educational games and emphasises its importance for assessing progress, providing feedback, detecting learning gaps, and fostering motivation [17].

Figure 6 below shows the Robo Escape, which is still in development.

[Fig.6: Part of Robo Escape]

III. CONCLUSION

Three key components make up the original framework: game design, pedagogic learning, and learning content modelling. These components are essential for developing successful and interesting instructional games. Adding assessment as a fourth component is a useful way to guarantee a thorough and worthwhile learning experience. The following details the importance of assessment in instructional games:

A. **Game Design:** The goal of game design is to produce an engaging gaming experience. It includes components such as the user interface, music, visual aesthetics, and level design. To keep players interested and encouraged to participate, the game must be fascinating, interactive, and fun to play.

B. **Pedagogy Learning:** Is the term used to describe the educational ideas and techniques used within the game to promote efficient learning. Implementing instructional strategies, scaffolding, and feedback mechanisms that support the learning objectives is required. Educational games can promote improved skill development and knowledge retention by utilizing pedagogical principles.

C. **Content Knowledge**: Modelling of learning content entails organising and arranging the educational material that players receive from the game. It involves breaking down complicated ideas

into smaller, more accessible chunks and ensuring that the game's difficulty progresses logically. The learning process is supported, and educational information is made clearer through effective content modelling.

D. Assessment: The addition of assessment as a new component is crucial since it gauges the development and comprehension of the educational material that is offered in the game by the learners. Quizzes, challenges, puzzles, and performance-based assessments are just a few examples of the ways instructional games might assess players. These evaluations have several functions.

i. *Feedback and Adaptation:* Assessments give students timely feedback on how they performed, assisting them in identifying their areas of strength and development. The game can then adapt the educational experience to the player's development, offering challenges tailored to their learning level and pace.

ii. *Learning Efficacy:* By evaluating the players' knowledge and abilities, game creators and educators may gauge the success of the educational content and spot any areas that may need development.

iii. *Engagement and Motivation:* Well- designed examinations can act as motivating tools by inspiring students to work harder and get higher grades. This gamification feature can foster a sense of accomplishment and motivate players to keep playing.

iv. *Data Collection and Analysis:* To obtain an understanding of learners' behaviour, learning patterns, and areas of difficulty, assessment data can be gathered and examined. The game's educational impact can be improved by using this information to guide future upgrades and enhancements.

From a holistic perspective encompassing the broader landscape of educational enhancement, integrating assessment seamlessly into the fabric of educational games is a pivotal catalyst, orchestrating a symphony of pedagogical ingenuity. This integration not only serves as a testament to the harmonious convergence of instructional methodologies but also underscores its profound potential to refine the educational paradigm. By intricately weaving assessment mechanisms into the tapestry of educational game frameworks, a harmonious equilibrium is achieved, culminating in an enriched learning journey rooted in the balance between didactic exposition and interactive engagement. The multifaceted potential of educational games is further amplified through the orchestration of evaluations, which, when synergistically entwined with the nuanced aspects of game design, the subtleties of pedagogical instruction, and the intricate architecture of learning content modeling, engenders a veritable renaissance in the realm of skill cultivation, fostering an environment where learners are not only enlightened but are also empowered through an immersive and dynamically evolving educational odyssey.

- *Future Improvement*

Anticipating a trajectory of continuous refinement and innovation, the horizon holds a tapestry of in-depth inquiries yet to be undertaken, poised to unfurl a comprehensive panorama of insights from the culmination of Robo Escape—a game meticulously crafted in adherence to the tenets of the innovative Educational Game Framework. The forthcoming endeavours are poised to transcend the preliminary assessment, delving into the intricate nuances of Robo Escape's outcomes, thereby demonstrating a commitment to scholarly rigour in the pursuit of enriched pedagogical methodologies.

The confluence of minds, comprising developers and educators alike, stands poised to embark on a profound journey of exploration at the nexus of inquiry and practice. By undertaking an extensive, meticulously designed research study, a bounteous reservoir of knowledge awaits acquisition, revealing the intricate interplay between the virtues and limitations of Robo Escape and the nuanced intricacies underpinning the recommended Educational Game Framework itself.

The revelations unfurled through this exhaustive study will inevitably open the gates to a realm of evidence-centric enhancements, poised to usher in a new epoch of refined educational game design. These enhancements, meticulously cultivated and informed by empirical insights, shall undoubtedly germinate into a tapestry of innovation that invariably begets a more triumphant and impactful educational game paradigm. In doing so, the quintessential essence of student learning experiences, whether in statistics or any other subject, shall be enriched and enlivened, thereby perpetuating a legacy of inspiration and academic advancement.

DECLARATION STATEMENT

Some of the cited references are older and are noted explicitly as [1], [2], [7], [13], and [17]. However, these works remain significant for the current study, as they are pioneering in their fields.

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted objectively and without external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

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