Game-based learning platform for kindergarten

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The incorporation of digital game-based learning and other technological innovations in education has received considerable attention in recent years (Castillo, 2019; Konok et al., 2021; Yang et al., 2018). The widespread accessibility of devices such as tablets and smartphones has provided children with greater opportunities to engage with educational resources and interactive games (Liao et al., 2019). Many children today demonstrate a high level of familiarity with these technologies, suggesting strong potential for their integration into the learning process (Konok et al., 2021). However, it is equally important to recognize the risks associated with excessive video game use. Studies indicate that video game addiction can disrupt daily routines and negatively affect both academic performance and social relationships (Newport Academy, 2021; World Health Organization, 2018). These concerns highlight the need for a balanced approach that maximizes the benefits of game-based learning while addressing its possible drawbacks.

Education plays a central role in children's holistic development, shaping their personality, confidence, and sense of responsibility as future citizens (Ranjan, 2021). Consequently, it is essential to identify innovative

methods that leverage technology and gamification to make learning more engaging and meaningful. Game-based learning, in particular, has been recognized as an effective strategy for fostering critical skills such as problem-solving, collaboration, and analytical thinking. By embedding learning activities within interactive games, students are more likely to participate actively and retain knowledge.

Over the years, research has increasingly emphasized the value of game-based learning for children. This approach transforms video games, traditionally perceived as distractions to academic success, into powerful educational tools. When designed appropriately, digital game-based platforms provide immersive and interactive environments that not only capture children's attention but also support skill development and conceptual understanding.

In this study, we developed a digital game-based learning platform tailored for kindergarten students. The platform takes advantage of the interactive and engaging nature of video games to deliver age-appropriate educational content in alignment with the curriculum. By integrating gaming elements into formal learning, this approach fosters higher engagement, improves motivation, and creates opportunities for meaningful learning experiences at an early stage of education.

Theoretical Framework

This study used relevant theories as the foundation for implementing the game-based learning platform for kindergarten students. These theories provide the guiding principles that explain how games can foster motivation, engagement, and learning among young learners.

Motivation Theory by McClelland

According to McClelland's Motivation Theory, every individual is driven by three primary motivators, which are developed through one's environment and life experiences. These motivators are achievement, affiliation, and power. Achievement refers to the emotional drive to progress quickly, complete tasks successfully, and attain higher levels of performance. Individuals with a strong need for achievement often display behaviors such as striving to win at all costs, seeking to be on top, and desiring recognition for their accomplishments. Affiliation, on the other hand, is the drive to be liked and accepted by others. Those with a high need for affiliation prefer to be in environments where they feel welcomed and included. Finally, power represents the emotional drive to gain influence, status, and control over others. Individuals with a strong need for power often thrive on competition, seek authority, and aim to dominate in order to feel successful.

Theory of Gamification by Jared Fulton

Jared Fulton's Theory of Gamification highlights that gamification in education is a strategy designed to motivate students to learn academic content more effectively. Unlike games that are solely intended for entertainment, gamified educational platforms use the principles of games, such as challenge, rewards, and progression, to foster engagement and learning. Through gamification, learners are encouraged to strategize, apply information, and reach objectives, while at the same time experiencing enjoyment similar to playing games.

Theoretical Foundations of Game-Based Learning for Kindergarten

One key foundation is constructivism, which emphasizes active

participation and problem-solving. Game-based learning aligns with constructivist principles by allowing children to construct knowledge through exploration and interaction.

Another important foundation is play-based learning, which recognizes the role of play in early childhood development. By integrating play-like elements into academic activities, game-based learning ensures that children remain engaged, motivated, and immersed in a positive learning environment.

Finally, cognitive development theories highlight how game-based learning supports the growth of essential mental skills in young learners. Through educational games, kindergarten students can enhance their critical thinking, problem-solving abilities, memory, and attention span, all of which are crucial for their overall academic and personal development.

Game-based Learning

Game-based learning has emerged as a promising educational approach for acquiring new concepts and skills through both digital and non-digital games (Grace, 2019). Research has shown that the use of games in education can significantly improve learning outcomes (Kula, 2021; Syafii, 2020). By integrating games into the learning process, game-based learning provides a balanced approach that combines theoretical content with interactive and engaging gameplay (Chen et al., 2018).

The effectiveness of game-based learning, however, varies depending on the domain of knowledge. Kucher (2021) noted that game-based approaches are particularly effective for interdisciplinary subjects requiring critical thinking, interpersonal communication, and debate skills. Students who participate in game-based learning are more likely to retain knowledge due to the active and immersive nature of these experiences.

Similarly, Kühn et al. (2019) emphasized that the core elements of successful video game play, such as persistence, creativity, and problem-solving, can also be cultivated in educational contexts. When students engage deeply with the narrative and characters in learning games, they enhance their deductive reasoning while fostering a sense of immersion.

The integration of Information and Communication Technology (ICT), particularly digital game-based learning, has become increasingly vital in modern education (Barrera et al., 2020). Digital games create interactive and dynamic learning environments that can be applied across various disciplines (Al Fatta et al., 2019). Beyond improving learning outcomes, they also generate enthusiasm, motivation, and experiential learning opportunities. Abdulrahim and Mabrouk (2020) further argued that digital game-based learning not only enhances student achievement but also strengthens the instructional competencies of educators. Through such platforms, students develop essential skills in critical thinking, cognition, and problem-solving, all of which contribute to achieving academic goals (Talib et al., 2019).

Empirical studies have highlighted the potential of digital game-based learning in primary education, where it has been shown to accelerate knowledge acquisition while making learning enjoyable (Vélez-Agosto & Rivas-Vélez, 2018). By incorporating innovative teaching strategies and advanced technologies, digital games enrich the teaching and learning process (Campos et al., 2020). The positive influence of game-based learning on knowledge achievement, motivation, and engagement has been consistently observed in primary-level classrooms (Fokides & Chachlaki, 2019; Yeh & Liao, 2018). Bers (2018) also underscored its role in providing young learners with a richer learning experience and fostering a deeper understanding of the digital world.

The literature strongly supports the effectiveness of game-based learning, particularly in its digital format, in enhancing academic outcomes, student engagement, and critical thinking skills. By offering interactive and immersive experiences, game-based learning enriches educational practices and encourages deeper subject comprehension, making it a valuable innovation in contemporary teaching and learning.

Game-based Learning Platforms

In the realm of game-based learning platforms, Bookworm and Math Prodigy serve as noteworthy examples. Analyzing these systems provides valuable insights into their strengths and limitations, which in turn inform the design and evaluation of our proposed system.

Bookworm. Bookworm excels in promoting literacy and language skills through its engaging word-building and puzzle-solving gameplay. Its intuitive interface, progressive challenges, and enjoyable rewards foster a positive user experience and sustained engagement. However, its scope is primarily confined to language development, which limits its applicability to other subject areas or broader educational objectives.

Math Prodigy. Math Prodigy, on the other hand, effectively integrates gamification elements with a comprehensive library of math exercises to engage students in mathematics learning. Key features such as adaptive assessments, personalized learning paths, and real-time feedback provide students with tailored learning experiences. Nevertheless, its exclusive focus on mathematics restricts its relevance to other educational domains.

Our proposed system seeks to combine the strengths of both Bookworm and Math Prodigy while addressing their limitations. Unlike these platforms, which are subject-specific, our system is designed to

encompass a wider range of subjects and learning content. It integrates interactive gameplay, adaptive assessments, personalized learning pathways, and progress tracking, thereby offering a versatile and holistic learning experience.

While Bookworm and Math Prodigy have each demonstrated strong user engagement and positive educational outcomes within their respective domains, our proposed system aims to provide greater adaptability and inclusivity. By extending game-based learning to multiple disciplines, it seeks to foster a more comprehensive and engaging educational experience. Ultimately, by drawing upon and expanding the effective features of Bookworm and Math Prodigy, our platform aspires to deliver an interactive, adaptable, and student-centered learning environment that supports diverse educational goals across multiple subject areas.

Research Framework

Dataset

The dataset consists of information collected from selected and willing kindergarten schools in Sariaya, Quezon, comprising a total of 63 pupils and 3 teachers. The data provided by the students serve as the foundation for the development of the proposed system. Based on the collected data, the following is a brief:

Preferred language: The majority of students (60 out of 63) prefer to learn in Tagalog, reflecting their comfort and familiarity with the language.

Device accessibility: Sixty out of sixty-three students have access to the necessary devices for using the game-based learning platform.

Internet accessibility: Most students (56 out of 63) have internet access, which is essential for the game-based learning platform.

Students' game preferences: The most popular games among the students include Minecraft, Roblox, and Robot Fight. These games span different genres such as building, virtual worlds, and combat, indicating diverse interests among the students. This also suggests that digital games are highly appealing to kindergarteners.

The data generated from the teachers include the perspectives and practices regarding difficult subjects or topics, students' interests, teaching strategies, suggestions for enhancing student engagement, and their views on the most effective language for teaching.

Difficult subject/topic for the students: Reading, writing and numeracy

Subjects/topics where students are passionate about: Storytelling, playing and watching

Strategies used by the teachers: Repeat lessons, learning through play, and teaching with patience

Suggestion from the teacher: Play-based learning, manipulatives, videos, and interactive teaching

Most effective language for teaching: Tagalog or mother-tongue.

Experimental Design Process

Although the current study did not directly implement the experimental design, it is important to highlight its potential impact in assessing the integration of game-based learning platforms for kindergarten students. The design aimed to investigate the effects of game-based learning on student engagement and learning outcomes.

Experimental group: Kindergarten students using the game-based learning platform.

Control group: Kindergarten students receiving instruction through traditional teaching methods without the game-based learning platform.

Kindergarten students were randomly assigned to either the experimental group or the control group. The experimental group was provided with access to the game-based learning platform, which was incorporated into their teaching sessions. Meanwhile, the control group was taught using traditional methods without the integration of the game-based learning platform. Data were then collected on the engagement levels and learning outcomes of both groups to compare the effectiveness of the two teaching approaches.

Research Instrument

This study employed questionnaires for data collection. The survey was designed to gather factual information and user feedback. It evaluated the system according to ISO 25010 criteria, focusing across eight quality attributes: functionality, performance, compatibility, usability, reliability, security, maintainability, and portability. The system's quality was evaluated using questionnaires based on the ISO 25010 standard. To ensure statistical validity, the sample size formula was applied to determine the appropriate number of respondents.

Modelling

For the implementation of the system, the study utilized the ADDIE Model as the instructional design framework to guide the execution of the overall plan. The ADDIE Model was specifically chosen due to its flexibility, which allows to modify and adapt the system plan at each phase while continuously refining it throughout the process. This adaptability is valuable in complex projects where requirements may evolve or unforeseen

information may arise during implementation.

By following the systematic approach of the ADDIE Model, the researchers ensured that all essential steps were addressed, including thorough analysis, thoughtful design, effective development, smooth implementation, and comprehensive evaluation. Furthermore, the model's support for iterative development enabled the integration of feedback and evaluation into the implementation plan, promoting continuous improvement and alignment of the final system with the intended objectives and requirements.

In addition, the well-established nature of the ADDIE Model, supported by extensive research in instructional design, allowed to draw on existing knowledge and best practices in system implementation. The choice to employ the ADDIE Model provided a structured and adaptable framework that effectively guided the planning, execution, and refinement of the system implementation process.

Figure 1
ADDIE Model
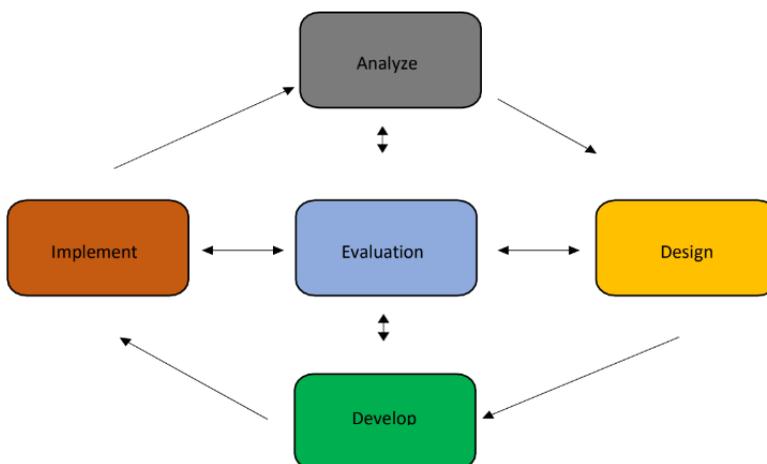
Analyze: In this phase, data were collected through surveys conducted with kindergarten teachers and pupils. These data served as the foundation for the proposed system, guiding its overall direction and essential components.

Design: This phase focused on determining the graphical user interface (GUI) and the overall structure of the platform. The study also identified and tested programming languages and software required for system development. This ensured the feasibility of the plan based on the researchers' skills and expertise. The design phase also emphasized the clear presentation of content.

Develop: After collecting and analyzing the data, a prototype of the platform was created. The prototype was tested at various stages, especially when new functions were added. Based on test results, the researchers either continued development at the current stage or made necessary modifications. The system underwent multiple stages of development and testing to achieve the desired outcomes.

Implement: Once the desired results were achieved, the system entered its implementation phase. At this stage, the system became available for use by the intended users.

Evaluate: The evaluation phase focused on identifying areas for improvement or change within the system. Each phase of the development process underwent evaluation before progressing to the next stage.

Technical Framework

Software Specifications

MySQL – a database management system. This is used by the researchers to manage the database and the tables used by the system to

store and retrieve data.

RPG Maker MV – a software development program used to create role-playing video games. This third-party software is used to create "Pixellana", one of the games in the system.

Gimp – an open-source photo editing software. The software is mainly used for editing and photo manipulation according to resources used by the system.

HTML – the html is the code used to build the GUI or graphical user interface of the platform.

CSS – the language used by the researchers to manipulate the HTML, such as changing its shape, color, and how it would be positioned.

JavaScript – used to create the modals, loading screen and other functions a platform needed.

PHP – the server-side scripting language used by the researchers to store and retrieve data from the database.

WEB Speech API – used for the speech recognition of the game, Abakada Journey. This is used to compare the stored word in the array list retrieve in the database of the platform, with the help of this API checking the speech pattern of the user, it is able to check whether it matches from the word stored.

Hardware Specification

Device	ASUS VivoBook X542U
Processor	Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz 1.80 GHz
Installed RAM	4.00 GB
System type	64-bit operating system, x64-based processor
Operating System	Windows 10 Pro

System Design

Use case. Figure 2 illustrates how a guest, someone who visits without login credentials, interacts with the platform. Guests have limited access; they can play normally, but their progress and achievements are not stored in the database.

Figure 3 shows how a user with login credentials interacts with the platform. The user can log in and play, and their data is stored and retrieved from the database. This allows their progress and achievements to be displayed on the leaderboard.

Figure 4 presents the admin's use case. The admin logs in using administrator credentials, granting access to the admin dashboard. This dashboard allows the admin to upload and modify content and resources in the game. The admin also has the authority to add, edit, or delete user credentials.
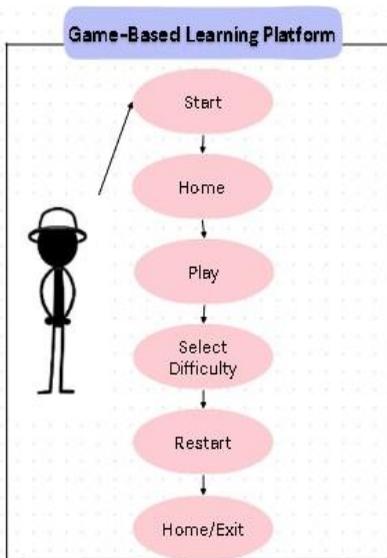
Figure 2

Guest's use case
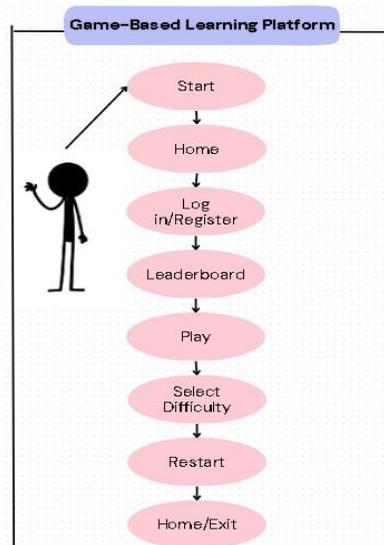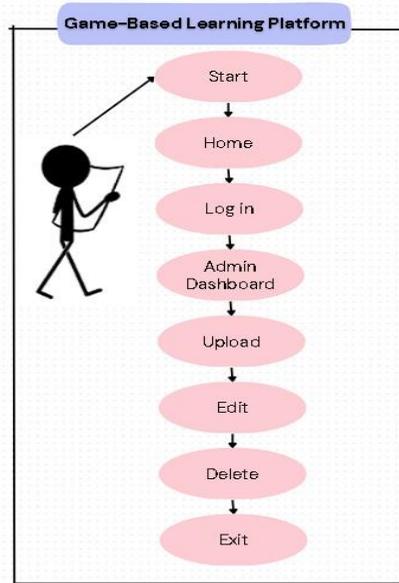

Figure 3

User's use case

Figure 4

Admin's use case

Database Schema

The database schema defines the organization and structure of the database used to store and manage data. It specifies the tables, columns, and relationships that form the database foundation. The schema consists of multiple tables, each representing a specific entity or concept relevant to the research.

Figure 5

Database schema
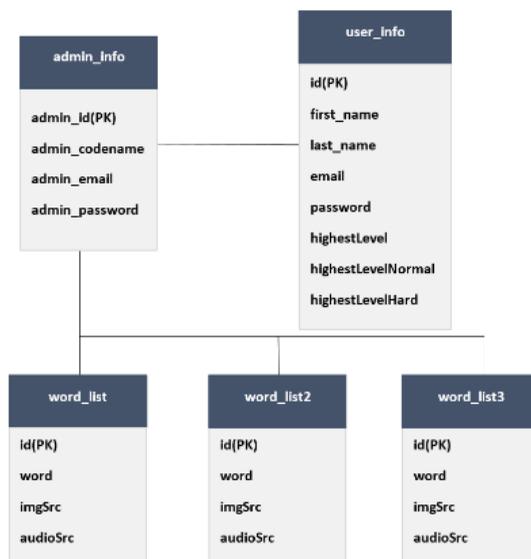
Development

During the development phase, the programmer utilized several programming languages, including PHP and JavaScript, to build an efficient and functional system. These languages provide robust functionality and flexibility for web-based applications.

To support development, various tools and technologies were used. Visual Studio, a powerful integrated development environment (IDE), streamlined coding tasks and improved productivity. HTML was used to structure the user interface, while CSS was applied for styling to ensure a visually appealing and intuitive design.

APIs (Application Programming Interfaces) were integrated to enable seamless communication with external services, enhancing system functionality. XAMPP, a cross-platform web server solution, was employed to create a local development environment with Apache, MySQL, and PHP. This setup facilitated efficient testing, debugging, and iterative development.

MySQL served as the database management system, providing reliable data storage and retrieval. The programmer used its query language and tools to design and implement database structures and interactions. Additionally, image-editing software like GIMP was used to enhance visuals, ensuring high-quality graphics. RPG Maker MV, a third-party software, was utilized for game creation, offering features tailored to interactive and engaging game development.

By combining these languages, tools, and technologies, the development team created a system designed to meet user requirements and deliver a positive user experience. Thorough testing and quality assurance were conducted to ensure system stability, reliability, and functionality.

Testing

To ensure that the system met the researchers' intended functionality, it underwent a thorough testing phase. Every aspect of the system was tested to confirm proper operation.

The test approach outlined the strategy and methodologies used to guarantee system quality and reliability. The primary objectives were to detect and correct defects, validate the system against requirements, and ensure a satisfactory user experience. The approach included:

Test planning – A comprehensive plan defined the scope, objectives, activities, required resources, and team responsibilities.

Test types – Several testing types were applied, including: functionality testing, verified that each function worked as specified; security testing, identified and addressed vulnerabilities and risks; and usability testing, evaluated ease of use, navigation, and overall user experience.

Test environment – A dedicated environment simulated real-world usage with appropriate hardware, software, and network configurations.

Test execution – Test cases were executed per the plan, and results were documented. Any issues were logged for resolution.

To confirm that the system functioned correctly, several tests were performed on functionality, security, and usability.

Table 1

Test case

Test Case Type	Description	Test Step	Expected Result	Status
Functionality	Ensure that the game would run in the platform	The tester launch or play the game using the platform	The game should launch without any problem	Pass

Test Case Type	Description	Test Step	Expected Result	Status
Security	Confirm that the Log in/Register process is working correctly	Created The tester would input the Username and Password/Register with a pseudo credentials	The data should be stored in hashing method when storing the data/The system should be able to decrypt the encrypted password when logging in	Pass
Usability	The navigation button should link to other webpages	The tester clicks on the navigation buttons of the Platform	The buttons should take the tester to other webpages where it is linked to	Pass

Deployment and Maintenance

For deployment, the HTML, JavaScript, CSS, and other resources (e.g., images, audio) were uploaded to the hosting service. The database required for the system was also created within the hosting service. Hostinger was selected for deployment due to its user-friendly and manageable services, making it suitable even for first-time developers testing web-based systems.

For ongoing maintenance and support, Hostinger was chosen for its reliable features and ease of use. The maintenance plan included:

Bug tracking and issue resolution – A bug tracking system captured and managed user-reported issues. The development team prioritized and fixed bugs promptly.

Regular updates and enhancements – Periodic updates improved system functionality and added new features, tested in a development environment before live deployment.

Performance monitoring and optimization – System performance was regularly tested, with adjustments made as needed.

Database maintenance – Routine backups and optimizations

ensured data integrity and security. Hostinger's MySQL tools supported efficient management.

Security maintenance – Regular software updates and security patches were applied, and users were educated on best practices.

System backup and disaster recovery – Full system backups, including databases, were scheduled and tested to ensure reliable recovery in case of failure.

Cost Benefit Analysis

Table 2 shows the monthly operational costs of running the platform. Actual expenses may vary depending on services used and the location of operations.

Table 2

Monthly operational cost

Services	No. of Months	Cost	Total
Internet fee	1	₱ 1,700.00	₱ 1,700.00
Hosting Services	1	₱ 349.00	₱ 349.00
Domain Name (1 year)	12	₱ 50.00	₱ 50.00
Electricity	1	₱ 890.00	₱ 890.00
Total			**₱ 2, 989.00**

System Evaluation

Table 3 presents the results of the evaluation of the game-based learning platform based on responses from a total of 107 participants. The weighted mean formula was used to analyze and interpret the collected data.

Table 3

Weighted mean distribution of the criteria for developed system

Criteria	Weighted Mean	Remarks
Functionality	3.20	Agree
Performance	3.42	Strongly Agree
Compatibility	3.42	Strongly Agree
Usability	3.27	Strongly Agree
Reliability	3.35	Strongly Agree
Security	3.03	Agree
Maintainability	3.07	Agree
Portability	3.25	Agree
Average	**3.25**	**Agree**

The results present the total average weighted mean of the system based on the evaluation using ISO 25010. The results gathered from respondents show an average weighted mean of 3.25. Using the Four-Point Likert Scale, this corresponds to "Agree," which indicates that the developed system is functional, performs well, is user-friendly, and can be used across different devices, although there is still room for improvement.

Economic feasibility. To assess whether the system is economically feasible, a cost-benefit analysis was conducted to identify and present the expected expenses. The services required to maintain the platform's operation are deemed economically feasible.

Technological feasibility. Since the system does not require additional hardware or specialized tools to run, anyone with access to the internet, a smartphone, or a computer can use the platform. The system relies only on commonly available devices that are widely used today, making it technologically feasible.

Operational feasibility. Based on the results of the ISO 25010

evaluation, respondents found the game-based learning platform for kindergarten to be satisfactory. From this, it can be concluded that the system is operationally feasible based on user feedback.

Conclusion

The findings indicate a commendable level of satisfaction and confidence in the system across these aspects. They validate the effectiveness of the design and development efforts, confirming that the system meets user needs and expectations. However, it is important to note that while respondents expressed agreement, further analysis and continuous feedback should be considered to better understand the system's strengths and areas for improvement. Overall, the positive consensus among respondents demonstrates the system's success in meeting user requirements, providing a satisfactory user experience, and exhibiting commendable qualities.

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