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BERONOVA: DESIGNING AN OFFLINE INTERACTIVE EDUCATIONAL ANDROID-BASED MOBILE GAME APPLICATION FOR ENHANCED STEM EDUCATION

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Abstract: This study introduces Beronova, an offline Android-based educational mobile game app designed to revolutionize Science, Technology, Engineering, and Mathematics (STEM) education. Targeting key challenges such as low student engagement, limited resources, and varying educational quality in rural areas, Beronova integrates gamified learning with STEM-specific content, including General Biology, Chemistry, Physics, Pre-Calculus, and Basic Calculus. Developed using the Rapid Application Development (RAD) model, the app provides an accessible, interactive, and immersive learning environment optimized for offline use, ensuring equitable access for all students. The research adopted a quantitative descriptive methodology, employing usability and player experience evaluations through feedback from STEM students, IT experts, and teachers. Results showed that Beronova achieved an overall usability score of 4.34 ("Excellent Quality"), excelling in learnability, operability, aesthetics, and accessibility. Similarly, the player experience was rated at 4.30 ("Excellent Quality"), highlighting the app's ability to foster trust, deliver engaging challenges, sustain user satisfaction, provide entertainment, and maintain relevance to STEM curricula. The game's innovative features, such as a test-style, multiple-choice question format and immersive gameplay, were found to significantly enhance user engagement and foster deeper comprehension of STEM concepts. This study concludes that Beronova is a transformative educational tool that bridges gaps in STEM education through its offline accessibility, gamified design, and curriculum-aligned content. Future developments may incorporate additional features, such as adaptive learning technologies, expanded subject coverage, and real-time analytics, to further amplify the app's educational impact and adaptability to evolving student needs.

INTRODUCTION

The Philippine educational system is beset with difficulties, particularly in STEM (Science, Technology, Engineering, and Mathematics) education, and based on recent results from the Programme for International Student Assessment (PISA), Chi (2023) noted that Filipino kids still score among the lowest worldwide in Math, Reading, and Science. The most recent test results show minimal improvement over the national performance in 2018. Right now, Region 12 ranks lowest in Science tests following the national mock test for PISA preparation. Therefore, in response to poor performance on the PISA simulated exam this year, 2024, the Department of Education (DepEd) firestorms changes and preparations.

Furthermore, one major problem related to the poor performance of students in Science is student involvement; many find conventional STEM courses uninteresting, but interactive games can make learning more interesting and inspire real enthusiasm in these disciplines. Also, resource constraints are common, particularly in rural locations like Maasim, Sarangani Province, where schools lack suitable teachers, technology, and enough laboratory equipment. Through virtual surroundings and experiments, interactive gaming apps allow students to investigate STEM ideas without depending on actual resources.

Moreover, the level of STEM education differs depending on the area, so educational games can assist in standardising learning opportunities and guaranteeing equal access to high-quality materials for every student. These challenges that call for students to use their knowledge help them to build critical thinking and problem-solving abilities as well. Effective learning depends on visual, aural, and kinesthetic possibilities; hence, interactive apps may also accommodate different learning styles.

Gee (2019) claims that major technological developments in the twenty-first century are changing many facets of life, including education. Especially in the classroom, teaching and learning depend on electronic tools, computers, and mobile devices. Educational games help to assist in knowledge reinforcement and learning. For people of many ages and backgrounds, they have transformed the ideas of enjoyment and leisure. In her research, she found that by offering instantaneous feedback, encouraging active learning, and therefore boosting a sense of achievement, educational games can help to establish a pleasant learning environment. Students who engaged in instructional games with an eye towards scientific inquiry demonstrated notable gains in

their knowledge of the scientific process as compared to those who got conventional training. This implies that there is a more interesting and efficient learning process available from educational games.

With this, the researchers designed Beronova, an offline Android-based educational mobile game app to enhance education for STEM students and aspirants in Science, Technology, Engineering, and Mathematics (STEM). Its content or subjects, including Pre-Calculus, Basic Calculus, General Biology, General Chemistry, and General Physics, were directly sourced from teachers who handled these subjects to ensure the validity, reliability, and accuracy of the game app. Developed with engaging and interactive challenges, Beronova provides multiple-choice questions to reinforce key concepts. This format enables users to engage in a game-like environment that simulates exam conditions, fostering knowledge in STEM subjects (Douglas, Wilson, & Ennis, 2012).

Besides, its design was optimized for mobile use and could be launched offline after downloading it online, making it a convenient and accessible tool for students aiming to strengthen their STEM knowledge anytime, anywhere. Although Beronova was developed specifically for STEM-focused learners, non-STEM learners may also access the game app, though its content is best suited for those pursuing STEM education.

Even though several educational apps aim to enhance STEM education through engaging, interactive experiences, like Beronova, each has unique features. These apps offer valuable tools in their niches, yet Beronova stands out by combining STEM-specific topics with a test-style, multiple-choice game format, making it particularly suited for high school STEM students preparing for exams and deepening their knowledge. Uniquely, Beronova is accessible offline, allowing students without consistent internet access to benefit from the app. This feature promotes greater educational equality by ensuring all students, regardless of internet availability, can engage with and learn from its specialized STEM content.

Objectives of the Study

This study designed an offline interactive educational game app to enhance STEM education and improve students' learning achievements.

Specifically, the researchers performed the following tasks:

1.) Design a STEM offline interactive educational game app using the adopted but modified protocol from Cagang, Gimena, Cuizon, Fujishiro, and Atamosa (2023).

2.) Test the designed STEM offline interactive educational game app by selected IT experts, STEM students, and Science and Mathematics teachers in terms of its:

2.1 Usability;
- 2.1.1 Learnability;
- 2.1.2 Operability;
- 2.1.3 Aesthetics;
- 2.1.4 Accessibility; and

2.2 Player Experience;
- 2.2.1 Trust;
- 2.2.2 Challenge;
- 2.2.3 Satisfaction;
- 2.2.4 Fun;
- 2.2.5 Focused Attention;
- 2.2.6 Relevance;
- 2.2.7 Perceived Learning.

Research Questions

Guided by the objectives of the study, the researchers answered these subsequent questions:

1.) How can a STEM offline interactive educational game app be designed using the adopted but modified protocol from Cagang et al. (2023)?

2.) What are the results of the testing performed on the designed STEM offline interactive educational game app as evaluated by selected IT experts, STEM students, and Science and Mathematics teachers in terms of its:

2.1 Usability
- 2.1.1 Learnability;
- 2.1.2 Operability;
- 2.1.3 Aesthetics;
- 2.1.4 Accessibility; and

2.2 Player Experience
- 2.2.1 Trust;
- 2.2.2 Challenge;
- 2.2.3 Satisfaction;
- 2.2.4 Fun;
- 2.2.5 Focused Attention;
- 2.2.6 Relevance; and
- 2.2.7 Perceived Learning?

Significance of the Study

This study is hoped to be beneficial to the following:

Technology Development. This study contributes to the development of innovative educational technology by exploring the use of offline educational interactive game apps for STEM education, aspiring STEM students, and STEM students themselves. This innovation may inspire the creation of new educational tools and platforms that provide immediate feedback to students, helping them understand their strengths and weaknesses. This feedback can be valuable for both students and educators, as it allows

for ongoing assessment and adjustment of instructional strategies. Similarly, technology allows for the creation of visually appealing and interactive game environments that can capture students' attention and make learning more engaging. Interactive graphics, animations, and sound effects can make educational content more enjoyable and immersive.

Policy Implications. The design of offline interactive educational game applications may have significant policy implications in the field of education. These implications may impact educational systems and institutions at various levels, from local to national. Educational games may be designed to align with curriculum standards and learning objectives. When these games are effectively integrated into the educational system, they can contribute to improved learning outcomes. Policymakers may consider this when setting educational standards and priorities. Also, policies related to access to educational resources are crucial. Designing offline games can help bridge the digital divide, ensuring that students without reliable internet access can still benefit from interactive learning experiences. This can inform policies aimed at addressing educational equity.

Simply put, the design and implementation of offline interactive educational game applications can have far-reaching implications for education policy. These implications can influence curriculum development, resource allocation, teacher training, and overall strategies for improving educational outcomes and equity. Therefore, policymakers need to recognize the potential of educational games and craft policies that support their effective use in educational settings.

To the Community. These offline interactive educational games may be used in community centers, libraries, and other public spaces, providing access to educational resources for individuals who may not have access to them at home or in school. This helps bridge the digital divide and supports lifelong learning. Furthermore, designing offline interactive educational game applications benefits the community by improving access to education, promoting lifelong learning, enhancing workforce skills, fostering community engagement, and contributing to the overall well-being and development of community members. These benefits extend beyond individuals and have positive effects on the community as a whole.

To the Teachers. Designing offline interactive educational games may make learning more engaging and enjoyable, which may help capture and maintain students' attention in the classroom. This may result in a more focused and participative learning environment. These educational games are designed with adaptive features, allowing them to tailor the content to individual student needs. This helps teachers provide differentiated instruction, addressing various learning styles and abilities in the same classroom. Furthermore, educational games may help manage classroom dynamics by keeping students motivated and on task. When students are actively engaged in learning, it may reduce behavior problems and disruptions. Certainly, designing and using offline interactive educational game applications may benefit teachers by enhancing student engagement, providing valuable assessment data, supporting differentiated instruction, and promoting the development of 21st-century skills. These benefits may lead to more effective teaching practices, increased job satisfaction, and improved student outcomes.

To the STEM Students and STEM Aspirants. Designing offline interactive educational game applications may offer several advantages to STEM (Science, Technology, Engineering, and Mathematics) students and aspirants. Many STEM concepts are difficult to grasp through text alone. Educational games may provide interactive visualizations and simulations that make abstract concepts more concrete and understandable. These offline interactive educational games may reinforce STEM concepts through repetition and practice, helping students retain and apply what they have learned. Generally, designing these offline interactive educational games makes STEM learning more engaging, interactive, and accessible. These games provide opportunities for hands-on learning, problem-solving, and career exploration, ultimately helping students build a strong foundation in STEM fields and fostering a lifelong interest in science and technology.

Future Researchers. Offline interactive educational games allow future researchers to engage in hands-on learning experiences that simulate real-world research scenarios. This may help them gain practical skills and apply theoretical knowledge. Designing offline interactive educational game applications benefits future researchers by providing skill development and exposure to the research process. These games may inspire, engage, and prepare the next generation of researchers for the challenges and opportunities of scientific inquiry.

Scope and Delimitation of the Study

The design and evaluation of an offline interactive Android-based mobile gaming application meant to improve STEM education took the front stage in the study. It especially targets STEM students and hopefuls from Colon National High School for the school year 2023–2024. To help students grasp fundamental STEM disciplines—including General Biology, General Chemistry, General Physics, Pre-Calculus, and Basic Calculus—the program combined interactive challenges and problem-solving activities. To guarantee correctness and fit with the current curriculum, the materials came straight from STEM teachers.

Methodologically, the research employed React Native, JavaScript, TypeScript for development, Figma for UI/UX design, and SQLite for data storage under the Rapid Application Development (RAD) approach. Using Android Studio and Expo Go, the testing stage guaranteed compatibility with several Android devices. An adopted MEEGA+ questionnaire was applied to evaluate important factors, including learnability, operability, aesthetics, accessibility, trust, challenge, satisfaction, enjoyment, focused attention, relevance, and perceived learning, to assess the usability and efficacy of the program. Selected STEM students, STEM aspirants, IT professionals, and STEM teachers from Colon National High School were among the respondents in this study who offered comments on the usability and instructional value of the app.

Limitations of the Study

The study included several restrictions. Conceptually, it did not investigate the application of substitute educational technologies such as artificial intelligence (AI)-driven learning aids or virtual reality (VR). Furthermore, limited to STEM disciplines, the study ignored other academic avenues. Methodologically, the study excluded iOS and other operating systems by limited testing of Android devices, therefore excluding longitudinal studies or experimental trials. The survey also eliminated professors or experts not closely engaged in STEM education, as well as students from non-STEM paths.

Moreover, time and financial limitations prevented several control actions from being reached. Dynamic backgrounds and high-level animations absent from the game may have improved the user experience. Besides, the application was not evaluated on a large-scale population, which would restrict the generalizability of the conclusions. Given respondents' different degrees of knowledge of educational gaming applications, certain prejudices in participant assessments could also emerge. Further influencing

usability scores are external elements such as personal learning styles and device features. Finally, technical and financial constraints prevented the inclusion of advanced interactive elements, including real-time multiplayer capabilities and adaptive AI-driven learning paths.

Notwithstanding these constraints, the study offered an insightful analysis of the evolution and potency of offline learning mobile games for STEM education. The results can provide a basis for the next studies and development, especially in improving the accessibility and involvement of STEM education through gamified learning technologies.

RESEARCH METHODOLOGY

In designing the STEM offline interactive educational mobile game app, the study adopted but modified the protocol from Gimena et al. (2023) and employed Rapid Application Development (RAD), which follows four steps: defining requirements, prototyping, constructing, and deploying. The quantitative method, specifically a descriptive design, was used to evaluate the STEM offline educational game app's usability and player experience based on feedback from selected IT experts from Mindanao State University-General Santos City Campus, STEM students, and Science and Mathematics teachers. In 2023 – 2024, the researchers conducted this study in Colon National High School situated in Brgy. Colon, Maasim, Sarangani Province in the land of Mindanao. According to McCombes (2019), the descriptive type of research is an appropriate choice when the research aims to identify characteristics, frequencies, trends, correlations, and categories. Further, she added that a descriptive research design could use various research methods to investigate one or more variables. Unlike in experimental research, the researcher does not control or manipulate any of the variables.

System Requirements

The process began with designing the app layout in Figma, a cloud-based design tool that allowed for collaborative design work and served as a blueprint for the app's user interface (UI) and user experience (UX). Additionally, during the development phase, JavaScript and TypeScript were used in VS Code, a source code editor with features like syntax highlighting and debugging to make coding more efficient. React Native, a framework for building cross-platform mobile applications using JavaScript, was employed to ensure compatibility with Android devices. SQLite, a lightweight, serverless database engine, was used for data storage within the app. Android Studio provided an emulation environment, offering tools for coding, testing, and debugging with virtual devices. Expo Go was used for testing the app on emulators and physical devices in real time, simplifying the development process. Laptops were the primary hardware used by developers, while Android devices were employed for testing the app in real-world conditions, ensuring its performance and compatibility. Lastly, Android Studio provided the tools needed to build the app android application efficiently, the visual performance of the app by tracking the coded language and performing optimized graphics and effects while finalizing

Equipment Used

A laptop or desktop technology was used to easily access and store information, data, and multimedia content and download information from the Web.

Paraphernalia Used

The face mask was used to protect the researchers from any communicable illness. Lastly, anti-radiation glasses protected the researchers from the radiation the desktop/laptop emitted.

PROCEDURES

A. Designing the STEM Offline Interactive Educational Game App

To begin the development of the offline interactive educational mobile game app, the process began with designing the app layout in Figma, a cloud-based design tool that allows for collaborative design work and serves as a blueprint for the app's user interface (UI) and user experience (UX). During the development phase, JavaScript and TypeScript were used in VS Code, a source code editor with features like syntax highlighting and debugging to make coding more efficient. React Native, a framework for building cross-platform mobile applications using JavaScript, was employed to ensure compatibility with Android devices. SQLite, a lightweight, serverless database engine, was used for data storage within the app. Android Studio provided an emulation environment, offering tools for coding, testing, and debugging with virtual devices. Expo Go was used for testing the app on emulators and physical devices in real time, simplifying the development process. Laptops were the primary hardware used by developers, while Android devices were employed for testing the app in real-world conditions, ensuring its performance and compatibility.

Furthermore, the educational mobile game app was designed and tested exclusively for Android devices (smartphone and tablet), with no support for other platforms like iOS. The development tools and languages were confined to React Native, JavaScript, TypeScript, and SQLite, without exploring alternative frameworks or databases, adhering strictly to the protocol for creating the offline interactive educational mobile game application. The app's content is centered solely on the specialized subjects of the STEM strand, including General Biology, General Chemistry, General Physics, Pre-Calculus, and Basic Calculus. To ensure the game's reliability and validity, these subjects were directly sourced from teachers currently teaching the said specialized subjects, making the game a trustworthy learning tool that accurately reflects the current STEM curriculum and educational practices.

Figure 1 below shows the procedure flow chart.

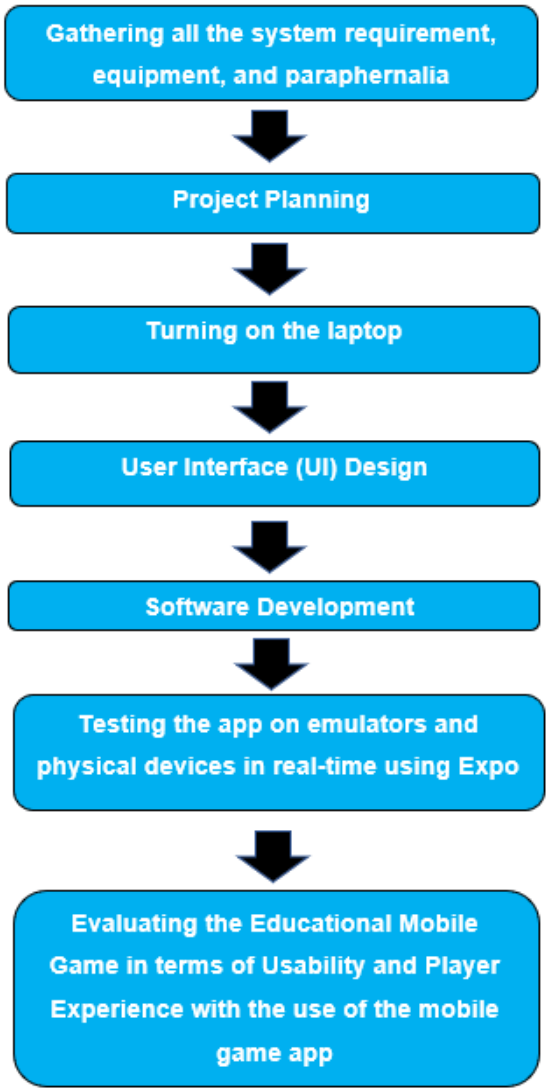

Figure 1. Procedure Flow Chart

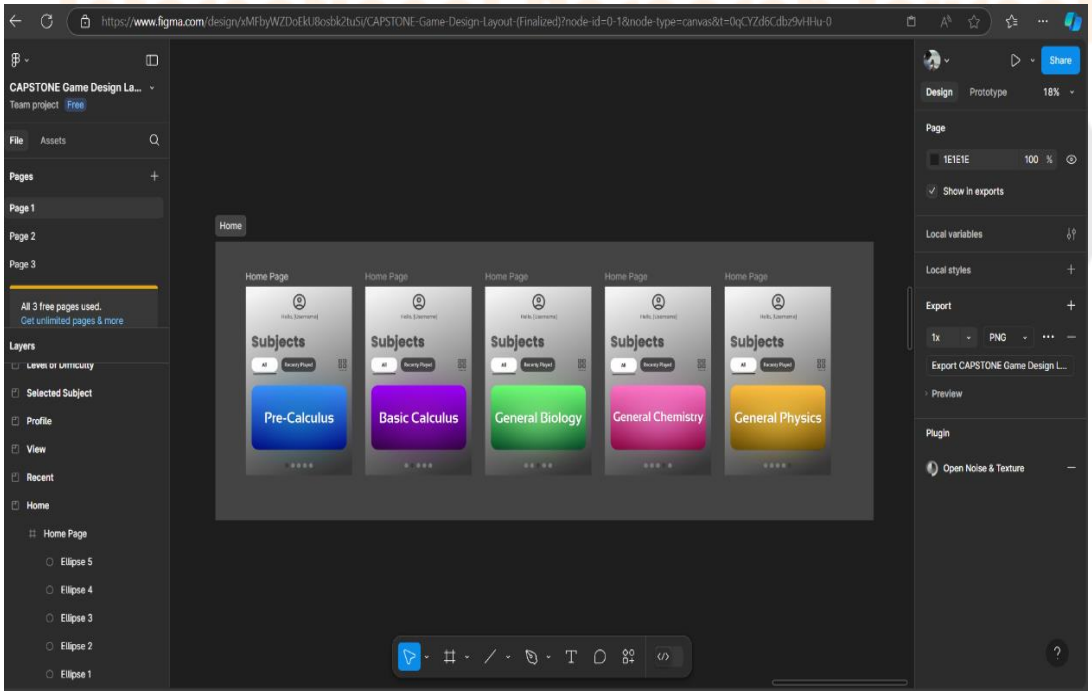

Figure 2. Initial Design Layout

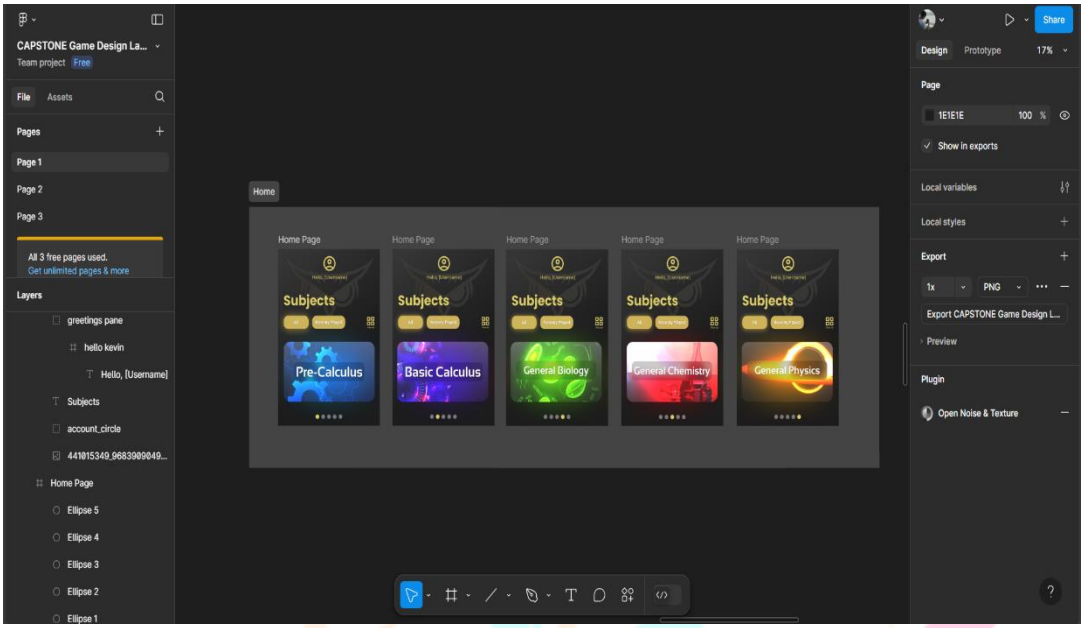

Figure 3. Final Design Layout

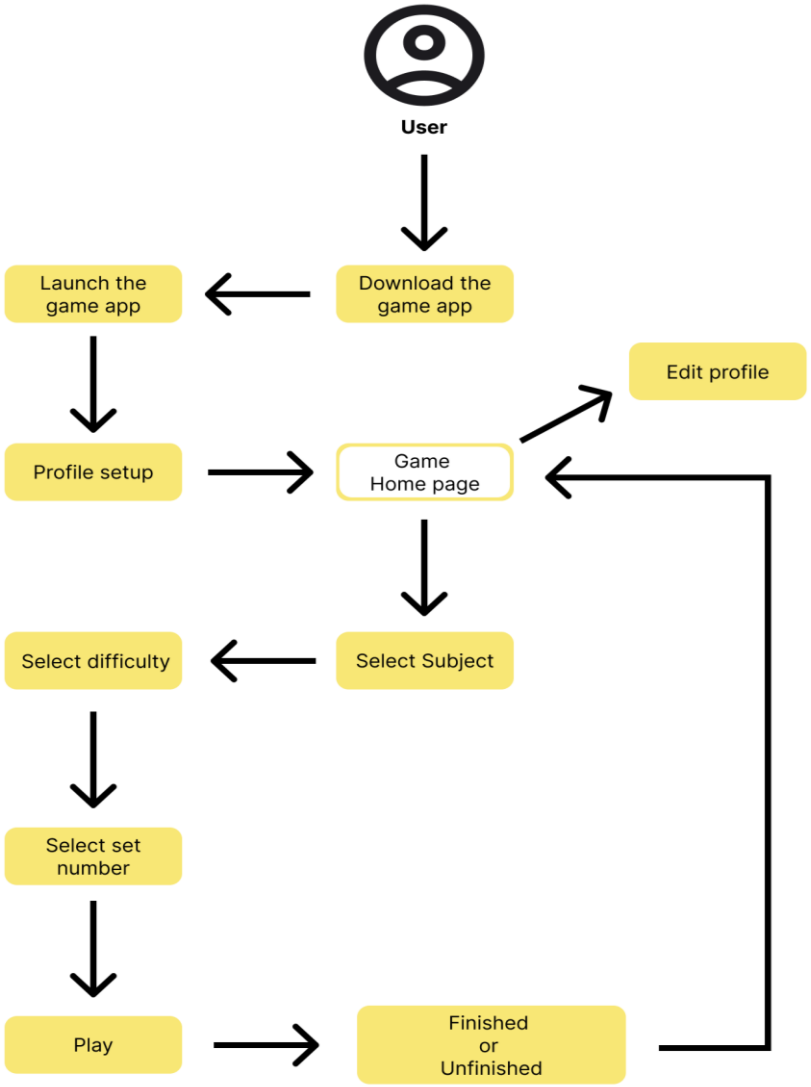

Figure 4. Direction for Using the Mobile Game App

B. Evaluating the STEM Offline Interactive Educational Mobile Game App In terms of Usability (Learnability, Operability, Aesthetics, Accessibility) and Player Experience (Trust, Challenge, Satisfaction, Fun, Focused Attention, Relevance, Perceived Learning).

Before the evaluation took place, the researchers instructed the respondents to launch the educational game app and explore the entire game app for them to have a basis when they evaluate the app. Using paper questionnaires, the researchers disseminated the survey to fifty (50) respondents, inclusive of 20 IT experts i.e., graduating IT students of Mindanao State University, 20 STEM students, and 10 teachers, i.e., 5 Science teachers and 5 Mathematics teachers of Colon National High School in the evaluation after the gameplay. These respondents were purposively selected because of the same characteristics as experts in developing software and other apps. According to Crossman (2018), purposive sampling is a non-probability sample selected based on a population's characteristics and the study's objective. Purposive sampling is also known as judgmental, selective, or subjective sampling. This type of sampling can be beneficial when you need to reach a targeted sample quickly and where sampling for proportionality is not the primary concern.

Along with these IT experts, selected teachers, STEM students, and STEM aspirants were also requested to evaluate the designed STEM offline interactive educational mobile game app in terms of usability which included learnability, operability, aesthetics, and accessibility, and aspects of the player experience considering aspects such as trust, challenge, satisfaction, fun, focused attention, relevance, and perceived learning. For this purpose, the researchers applied an adopted MEEGA+ questionnaire by Petri, Von Wangenheim, and Borgatta (2017). A questionnaire often solicits respondents' opinions about a particular topic or issue (Ben-Shlomo, Brookes, & Hickman, 2013). This study's close-ended questions included all possible answers or prewritten response categories. Respondents were asked to choose their answers among the options. This type of question was used to generate statistics in quantitative research. Also, because these followed a set format, most responses could be entered easily into a computer for easy analysis (Dawson, 2016).

This study's survey questionnaire was administered in English and interpreted using a scale, as shown below.

Table 1. *Scale Used in Evaluating the STEM Offline Interactive Educational Mobile Game App*

MEAN RANGE	DESCRIPTION	INTERPRETATION
4.21 - 5.00	Strongly Agree (Excellent Quality)	The designed STEM Offline Interactive Educational Mobile Game App is very highly learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool.
3.41 - 4.20	Agree (Very Good Quality)	The designed STEM Offline Interactive Educational Mobile Game App is highly learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool.
2.61 - 3.40	Fair (Good Quality)	The designed STEM Offline Interactive Educational Mobile Game App is fairly learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool.
1.81 - 2.60	Disagree (Fair Quality)	The designed STEM Offline Interactive Educational Mobile Game App is marginally learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool.
1.00 - 1.80	Strongly Disagree (Poor Quality)	The designed STEM Offline Interactive Educational Mobile Game App is not learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool.

Variables of the Study

The study's independent variable was the designed STEM Offline Interactive Educational Android-Based Mobile Game App. The dependent variables were Usability, which includes Learnability, Operability, Aesthetics, and Accessibility, and aspects of the Player Experience, such as Trust, Challenge, Satisfaction, Fun, Focused Attention, Relevance, and Perceived Learning.

Statistical Analysis

In determining the usability and player experience of the designed offline interactive educational mobile game application, the Weighted Mean was used.

IV. RESULTS AND DISCUSSION

Designing the Offline Educational Game Application

The Offline Educational Game App for STEM students and aspirants was developed using adopted but modified protocols. The research team commenced the project by meticulously assembling all the necessary system requirements and tools essential for the development process. This included software such as Figma for design prototyping, Visual Studio Code (VSCode) as the primary integrated development environment (IDE), React Native for cross-platform mobile application development, and programming languages including JavaScript and TypeScript. Additionally, SQLite was selected for data storage within the application, Android Studio was employed as the Android emulator, and version control was maintained through Git, with

repositories hosted on GitHub. The team also secured the required hardware, including laptops, Android devices (tablets and smartphones), and supplementary paraphernalia, such as anti-radiation glasses.

Following the setup of the development environment, the team proceeded to use Figma to design the user interface and layout of the application, which served as a foundational blueprint for the game application's architecture. Subsequently, the researchers initiated the coding phase within VSCode, leveraging JavaScript and TypeScript to implement the application's functionality. SQLite was integrated for efficient data management, while Android Studio facilitated the emulation of the Android environment. Git was employed to track code modifications, ensuring version control, with GitHub serving as the centralized repository for the project.

During the application development phase, React Native was utilized to construct the mobile application, ensuring compatibility with Android devices. The development process involved iterative testing, using Expo Go to deploy and assess the application both on the Android emulator and on physical devices, ensuring the application's functionality and reliability as each module was developed.

The coding phase was particularly pivotal, as it involved translating the designed blueprint into a fully operational application. Each component of the application was developed incrementally, adhering to the predetermined design and logic. Finally, the researchers conducted comprehensive testing with actual users to evaluate the application's performance against the expected outcomes. Feedback from these tests was systematically documented and used to refine the application by addressing any identified bugs and incorporating necessary enhancements, thereby improving the overall user experience and application reliability before the final deployment.

Figures 5 to 6 show the homepage for the user and the user activity flow of the developed game application.

Figure 5. Offline Game Application Homepage for User

Process in Using the Game Application for User

The users of this offline educational gaming application are primarily intended for STEM students and aspirants. With access to the gaming application, individuals might be able to study their subjects and learn new things in addition to exploring the unique platform to widen and enhance their understanding of various subjects. By engaging with this application, users not only have the opportunity to gain and reinforce their existing knowledge but also to explore new concepts interactively and enjoyably. In today's world, technology has revolutionized the learning landscape, allowing individuals to study virtually anywhere and at any time. As a result, developing a STEM-based offline educational game application for students' supplementary subjects plays a vital role for STEM students and aspirants.

Moreover, the user experience with this game application begins with a registration process. Users must fill out a form capturing essential information, including their full name, chosen username, and birthdate. Once this step is completed, users gain access to a user-friendly interface that allows them to navigate the app while simultaneously engaging in meaningful learning processes. Within the app, users can select a variety of subjects, including Pre-Calculus, Basic Calculus, General Chemistry, General Biology, and General Physics. This set of subjects ensures that the users can focus on areas that align with their academic needs and interests. Once comfortable with the chosen subject, users are prompted to specify their preferred level of difficulty.

As users engage with the application, they will encounter challenging questions designed to test their existing knowledge and encourage deeper understanding. This approach not only makes learning enjoyable but also motivates students to explore concepts further and develop critical thinking skills essential for success in STEM fields.

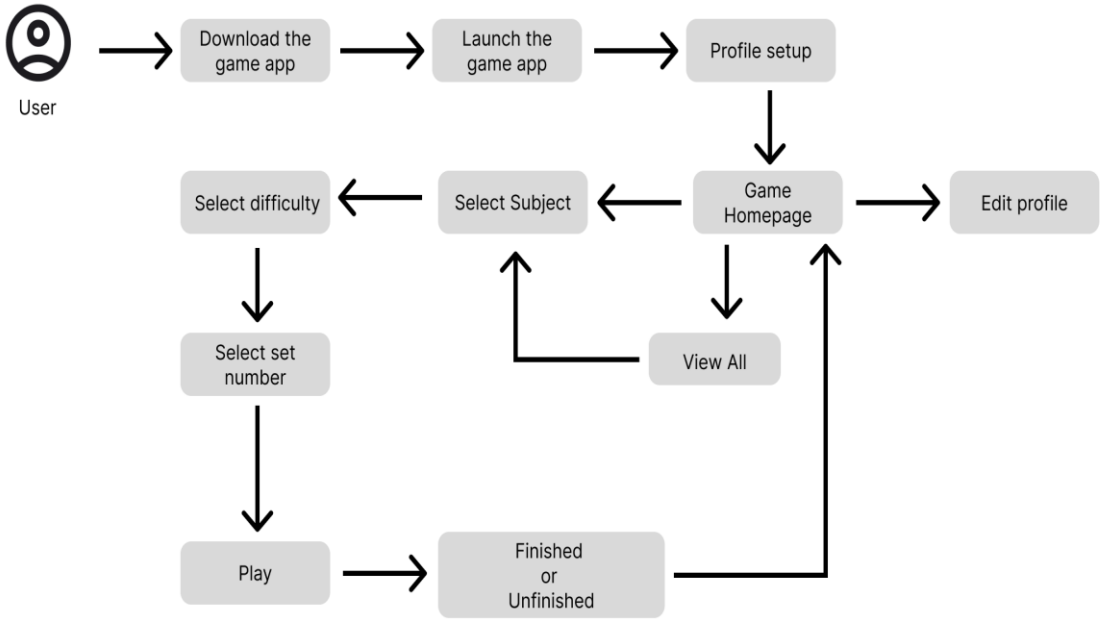

Figure 6. The User Activity Flow

The figure illustrates the user flow diagram for navigating the offline interactive educational game app. It presents a step-by-step sequence of interactions that a user follows from downloading the game to completing gameplay.

The process begins with the user downloading and launching the game application. Upon opening the app for the first time, the user is required to set up a profile, ensuring a personalized experience. From the profile setup, the user is directed to the game homepage, where they have the option to either edit their profile or proceed with selecting a subject. The game homepage also includes a "View All" option, which likely provides access to available subjects or game sets.

To begin playing, the user must select a subject from the available options. After selecting a subject, they are prompted to choose a difficulty level, followed by a specific set number of questions or challenges within that difficulty. Once these selections are made, the user proceeds to the gameplay phase.

The game session ends with an evaluation of whether the game is finished or unfinished, which may imply tracking progress for incomplete sessions. This structured navigation ensures a smooth and intuitive experience, allowing users to engage with the game in an organized manner while maintaining flexibility in selecting subjects and difficulty levels and managing their profiles.

According to Basham, Marino, Rice, and Xie (2010), mobile technologies come with great potential to be a learning medium. As technologies are dynamic, lightweight, and portable, they give the owner of some technology with benefits. Users can access the STEM offline educational game app through the Play Store. Android-based game applications often require longer development cycles, larger and more specialized teams, and rigorous testing. They can be built using cross-platform frameworks like React Native, which utilizes JavaScript for logic and IU components, and TypeScript for type safety and improved code management. For data storage and management, SQLite can be integrated with React Native apps to handle local databases and support offline functionality. This combination of technologies enables developers to build robust applications.

Evaluation of the Offline Educational Mobile Game App In terms of Usability

This study conducted evaluations from chosen respondents, i.e., selected IT experts, selected teachers, STEM students, and STEM aspirants as users of the Offline Educational Game Application, to validate its Usability, Learnability, Operability, Aesthetics, Accessibility, Player Experience, Trust, Challenge, Satisfaction, Fun, Focused Attention, Relevance, and Perceived Learning. The evaluation was made possible through questionnaires, which took place on May 17, 2024. Using the Weighted Mean, the following results were yielded. Tables 2 and 3 show the complete results of the evaluation.

Table 2. *Evaluation of the Usability of the Designed Offline Educational Game Application*

COMPONENTS	INDICATORS	WEIGHTED MEAN	DESCRIPTION
LEARNABILITY	I needed to learn a few things before I could play the game.	3.57	Very Good Quality
	Learning to play this game was easy for me.	4.47	Excellent Quality
	I think that most students would learn to play this game very quickly.	4.43	Excellent Quality
	OVERALL MEAN	**4.16**	**Very Good Quality**
OPERABILITY	The game prevents me from making mistakes.	4.43	Excellent Quality
	When I make a mistake, it is easy to recover from it quickly.	4.37	Excellent Quality
	The game rules are clear and easy to understand.	4.37	Excellent Quality
	OVERALL MEAN	**4.39**	**Excellent Quality**
AESTHETICS	The game design is attractive (interface, graphics, etc.).	4.43	Excellent Quality
	The text font and colors are well-blended and consistent.	4.40	Excellent Quality
	OVERALL MEAN	**4.42**	**Excellent Quality**
ACCESSIBILITY	The fonts (size and style) used in the game are easy to read.	4.30	Excellent Quality
	The colors used in the game are meaningful.	4.40	Excellent Quality
	The game allows customizing the appearance (font and/or color) according to my preferences.	4.40	Excellent Quality
	OVERALL MEAN	**4.37**	**Excellent Quality**
GRAND MEAN		**4.34**	**Excellent Quality**

Based on Table 2, the usability of the STEM Offline Interactive Educational Mobile Game App was evaluated using feedback from 50 respondents, consisting of 20 IT experts (graduating IT students from Mindanao State University), 20 STEM students, and 10 teachers (5 Science teachers and 5 Mathematics teachers). The evaluation focused on several components: learnability, operability, aesthetics, and accessibility.

In terms of Learnability, it received an overall mean of 4.16, categorized as "Very Good Quality". The slightly lower weighted mean for "I needed to learn a few things before I could play the game" (3.57) implies that some users found initial navigation challenging. However, the high scores for ease of learning (4.47 and 4.43) indicate that once familiarized, users found the game relatively straightforward to play, suggesting minor improvements could help make the introduction phase smoother.

Moreover, in terms of Operability, it scored an overall mean of 4.39, classified as "Excellent Quality". High ratings indicate that users generally found the game rules easy to understand and that the game prevented them from making mistakes. This suggests that the operability features, such as user guidance and error prevention, were well implemented. The implication is that the game offers effective support mechanisms that are crucial for an educational tool, especially beneficial for STEM and IT students who may face complex learning scenarios.

Similarly, Aesthetics achieved an overall mean of 4.42, rated as "Excellent Quality". Respondents were satisfied with the game's visual elements, such as interface and text consistency, which suggests a strong appeal in visual design. Attractive graphics can enhance engagement, particularly important for students, as it makes learning more appealing.

In addition, Accessibility also scored highly, with an overall mean of 4.37 ("Excellent Quality"). High ratings for customizable features and meaningful color choices indicate the game was inclusive, accommodating diverse user preferences, which is critical in educational settings involving mixed audiences, such as students and teachers from different disciplines.

The Grand Mean for the usability evaluation was 4.34, indicating that the STEM Offline Interactive Educational Mobile Game App was of "Excellent Quality" overall with a descriptive implication that the designed STEM Offline Interactive Educational Mobile Game App is very highly learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool. These results suggest that the game successfully meets its intended usability goals, providing an effective learning tool with robust support, engaging aesthetics, and accessible features.

The positive usability ratings imply that the game is well-suited to diverse audiences, including IT experts, STEM students, and teachers. The high scores suggest that the game can effectively support learning in STEM areas, making it a valuable resource

for teachers seeking interactive tools to supplement traditional instruction. Minor improvements in the learnability component may further enhance the onboarding experience for first-time users, leading to even greater overall satisfaction and usability across different educational settings. According to Souza and Dourado (2015), the use of educational games can be of great value to aid teaching and improve the learning process. They provide more student engagement since such games stimulate problem-solving in a practical, playful, and often collaborative way.

Furthermore, the game's positive reception highlights its potential to bridge gaps in traditional STEM education by offering an engaging and interactive learning experience. This is aligned with the findings of Gee (2007), who emphasized that well-designed educational games encourage critical thinking and active learning through interactive challenges. With continued refinements based on user feedback, the game can further solidify its role as an effective educational tool that enhances STEM instruction and student engagement.

Table 3. *Evaluation of the Player Experience of the Designed Offline Educational Game Application*

COMPONENTS	INDICATORS	WEIGHTED MEAN	DESCRIPTION
TRUST	When I first looked at the game, I thought it would be easy for me.	3.73	Very Good Quality
	I think that the game is easy to play.	3.57	Very Good Quality
	The contents and structure helped me to become confident that I would learn STEM-related topics with this game.	4.63	Excellent Quality
	OVERALL MEAN	**3.98**	**Very Good Quality**
CHALLENGE	This game is appropriately challenging for me.	4.53	Excellent Quality
	The game provides new challenges (offers new obstacles, situations, or variations) at an appropriate pace.	4.43	Excellent Quality
	The game does not become monotonous as it progresses (repetitive or boring tasks).	4.43	Excellent Quality
	OVERALL MEAN	**4.46**	**Excellent Quality**
SATISFACTION	Completing the game tasks gave me a satisfying feeling of accomplishment.	4.41	Excellent Quality
	It is due to my personal effort that I managed to advance in the game.	4.17	Excellent Quality
	I feel satisfied with the things that I learned from the game.	4.47	Excellent Quality
	I would recommend this game to my colleagues/friends.	4.63	Excellent Quality
	OVERALL MEAN	**4.42**	**Excellent Quality**
FUN	I had fun with the game.	4.53	Excellent Quality
	Something happened during the game (game elements, competition, etc.) that made me smile.	4.07	Excellent Quality
	OVERALL MEAN	**4.30**	**Excellent Quality**
FOCUSED ATTENTION	There was something interesting at the beginning of the game that captured my attention.	4.73	Excellent Quality
	I was so involved in my gaming task that I lost track of time.	4.37	Excellent Quality
	I forgot about my immediate surroundings while playing this game.	4.37	Excellent Quality
	OVERALL MEAN	**4.49**	**Excellent Quality**
RELEVANCE	The game contents are relevant to my interests.	4.37	Excellent Quality
	It is clear to me how the contents of the game are related to the STEM course.	4.73	Excellent Quality
	This game is an adequate teaching method for the STEM course.	4.53	Excellent Quality
	OVERALL MEAN	**4.54**	**Excellent Quality**
PERCEIVED LEARNING	I prefer learning with this game to learning through other ways (e.g. other teaching methods).	3.83	Very Good Quality

	The game contributed to my learning in this course.	4.37	Excellent Quality
	The game allowed for efficient learning compared with other activities in the course.	4.07	Very Good Quality
	The game contributed to teaching software testing.	3.50	Very Good Quality
	OVERALL MEAN	**3.94**	**Very Good Quality**
GRAND MEAN		**4.30**	**Excellent Quality**

Based on the evaluation of the player experience of the designed offline educational game application, the results in Table 3 provided insights into the components of trust, challenge, satisfaction, fun, focused attention, relevance, and perceived learning as experienced by 50 respondents, including 20 IT experts (graduating IT students from Mindanao State University), 20 STEM students, and 10 teachers (5 Science and 5 Mathematics teachers).

Concerning Trust, it had an overall mean of 3.58, rated as "Very Good Quality". While the visual impression of the game initially seemed slightly challenging (3.73), most respondents felt that the game structure (4.63) and the content's ability to help them learn STEM topics (4.41) were effective. This suggests that while some users might initially hesitate about the difficulty, the content effectively builds user confidence, particularly for educational contexts that require trust in the material.

Furthermore, Challenge received an overall mean of 4.46, classified as "Excellent Quality". The game presented challenges at an appropriate pace (4.53) and avoided monotony (4.43), suggesting that it managed to balance difficulty with engagement effectively. The implication is that the game is well-suited to maintain the interest of IT experts, STEM students, and teachers, catering to varying levels of expertise without overwhelming or under-challenging them.

In terms of Satisfaction, it achieved an overall mean of 4.44, rated as "Excellent Quality". Users reported a sense of accomplishment upon completing tasks (4.41) and felt personal pride in advancing within the game (4.43). The high satisfaction levels imply that the game effectively reinforces learning through an intrinsic reward system, which is vital for maintaining motivation, especially in self-paced educational environments.

Likewise, Fun was also rated highly, with an overall mean of 4.30, labeled as "Excellent Quality". The game was perceived as enjoyable, and while unexpected game events were slightly less rated (4.07), the respondents generally found the game entertaining (4.53). The high fun factor is crucial for ensuring prolonged engagement, making the game an appealing educational tool that competes with non-educational entertainment alternatives.

Also, Focused Attention scored an overall mean of 4.45 ("Excellent Quality"), indicating that players remained deeply engaged with the game. The highest score was for the interesting aspects at the beginning of the game (4.73), suggesting that a strong introduction is crucial for capturing players' attention. Players were able to stay involved in the game and occasionally lost track of time, showing the immersive quality of the game, which is beneficial for maintaining educational focus.

Additionally, Relevance had an overall mean of 4.54, rated as "Excellent Quality". The high scores (4.57) for aligning game content with STEM course materials and providing an understandable relationship with the topics being taught indicate that the game is effectively integrated with the users' academic needs. This makes the tool highly useful for educators who are looking for resources that directly complement their existing curricula.

Moreover, Perceived Learning received a lower but still "Very Good Quality" rating with an overall mean of 4.13. Users felt that the game supported learning and that it contributed to their learning compared to other methods (4.30). However, there is room for improvement in the depth of perceived learning outcomes, particularly in terms of making learning efficient and complete. Finally, the Grand Mean for the player experience evaluation was 4.30, classified as "Excellent Quality". This overall rating indicates that the designed STEM Offline Interactive Educational Mobile Game App is very highly learnable, operable, aesthetic, accessible, trustworthy, challenging, satisfying, fun, focused, relevant, and perceived as a learning tool. Also, the educational game provides a very positive user experience across various dimensions, effectively engaging users and supporting learning in an enjoyable and relevant manner.

The positive ratings suggest that the game effectively engages IT experts, STEM students, and teachers by providing appropriate levels of challenge, satisfaction, fun, and relevance. The game's alignment with educational content and its ability to immerse users make it a valuable learning tool that can supplement traditional educational methods. Improvements in perceived learning outcomes could further enhance the tool's educational impact, particularly by adding features that support more in-depth comprehension and efficient learning strategies. This will ensure that the game not only captures attention but also solidifies its role as a powerful educational resource.

Additionally, at this level, the game is challenging for students and has no monotonous activities. It is highly relevant to students' interests and provides excellent, focused attention, satisfaction, and fun. It allows the student to be confident that he/she will learn from the game and contribute to efficient student learning. In this context, educational games have specific objectives related not only to fun and recreational character but also, primarily, to learning. Considering this type of game as educational material, its evaluation is considered essential for the learning process (Savi, 2010).

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REFERENCES

[1] Blakely, D., Skirton, S., Cooper, B., Allum, N., & Nelmes, O. (2010) *Use of educational games in the health professions: a mixed-methods study of educators' perspectives in the UK*. https://pubmed.ncbi.nlm.nih.gov/204873 Retrieved on: March 21, 2024

[2]Chi, A. (2023). *Philippines still lags behind world in math, reading and science — PISA 2022*. https://www.philstar.com/headlines/2023/12/06/2316732/philippines-still-lags-behind-world-math-reading-and-science-pisa-2022/amp/

[3]Douglas, M., Wilson, J., & Ennis, S. (2012). Multiple-choice question tests: a convenient, flexible and effective learning tool? A case study. *Innovations in Education and Teaching International*, 49(2), 111–121. https://doi.org/10.1080/14703297.2012.677596

[4]Gee, M. (2019). *The 21st century: a time of significant technological advancements.* https://www.researchgate.net/publication/359849731_The_role_of_technology_in_the_21st_century_education_of_learners

[5]Petri, G., Wangenheim, C.G., & Borgato, A.F. (2017). *Evolution of a model for the evaluation of games for software engineer*. https://www.taylorfrancis.com/chapters/edit/10.1201/b224046/evolution-model-evaluation-games-software-engineering-education giani-petri-christiane-gresse-von-wangenheim-adriano-ferreti-borgatto.