BioApp: A Mobile Augmented Reality Application to Enhance Junior High School Students' Academic Performance in the field of Ecological Relationship in Biology.

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Abstract

This study investigates student difficulties in understanding biology concepts, particularly during the transition from basic topics like sexuality to complex areas such as genetics. Challenges include reduced engagement and participation, leading to lower performance in assessments. To address these issues, researchers propose "BIOAPP," an Augmented Reality (AR)-based solution designed to enhance learning experiences through interactive and immersive methods. The application prioritizes cost-effective implementation and accessibility, even in low-connectivity areas. The study employs a quantitative research methodology with purposive sampling to assess AR's effectiveness in improving biology education. The resulting mobile game integrates AR to create a dynamic and engaging learning environment, functioning as both an instructional tool and a diagnostic system for tracking student comprehension. This innovative approach aims to renew student interest and participation in biology, offering a transformative and accessible educational solution.

1. Introduction

The critical role of education in personal and societal growth, emphasizing its capacity to empower individuals, foster equality, and promote personal development. However, challenges such as student disengagement and lack of motivation hinder effective learning, with many students showing disinterest in specific subjects like biology due to complex concepts and unrelatable curricula.

Augmented Reality (AR) emerges as a promising solution to address these issues. Research reveals AR's potential to create immersive and interactive learning experiences, enhancing student engagement and academic performance, particularly in biology. Studies emphasize the need for educators to develop digital skills for effective AR integration, addressing barriers like limited resources and cost. Comparisons between AR and Virtual Reality (VR) show their distinct educational impacts. VR excels in visual knowledge retention, while AR supports auditory learning. These insights guide the design of tailored instructional technologies, positioning AR as an effective tool for improving education and fostering interest in complex subjects.

Junior high school students often struggle to understand and retain biology concepts due to the complexity of topics, extensive content, and limited interactive learning opportunities. These challenges result in reduced academic performance and diminished interest in the subject. Addressing this problem requires innovative educational strategies and tools to enhance student engagement and comprehension.

The study explores the implementation of "BioApp," a mobile augmented reality (AR) application designed for Android devices, to enhance the academic performance of grade 7 biology students at Colegio de San Juan de Letran Calamba. Focusing on the biology topic of ecological relationships, the research aligns with the DEPED K to 12 Science Curriculum, emphasizing hands-on and engaging learning activities. Conducted during the 2023–2024 academic year, the study employs a pretest and post-test design, comparing the outcomes of two classes: one using BioApp and the other following traditional teaching methods.

Key factors influencing AR integration, such as technical support and resource availability, are examined alongside the application's effectiveness. Limitations include the study's specific context, restricted to short-term impacts on academic performance, and the exclusive focus on one biology topic within a single institution. Despite these constraints, the findings aim to provide insights into AR's role in improving biology education, informing educators and researchers about its benefits, challenges, and potential for broader application.

1.1 Literature Review

I. The Significance of Education

Education is a transformative force that empowers individuals, fosters growth, and builds a brighter future for society. Childhood education is critical for healthy development, while adolescence plays a key role in moral growth, as highlighted by Sharp (2019). Laguatan (2020) emphasizes that education is the most important global investment, playing a fundamental role in societal development. Science, as a core subject, is particularly significant due to its ability to drive technological progress, address global challenges, and inspire curiosity. According to Laguatan (2020), science education not only enriches understanding but also fosters essential scientific attitudes like humility, curiosity, and intellectual honesty. It is especially vital in developing nations, where it helps improve living standards and supports societal progress. Science's unique importance lies in its capacity to frame diverse fields such as biology, physics, and chemistry, providing endless possibilities for innovation and humanity's advancement.

II. The Integration of Virtual and Augmented Reality in Education

Virtual Reality (VR) and Augmented Reality (AR) technologies offer transformative potential in education, enhancing engagement, learning outcomes, and inclusivity. Asaad (2021) highlights the broad applications of VR and AR, with VR focusing on immersive simulations and AR enhancing real-world environments. Research by Nooriafshar et al. (n.d.) shows that VR-based learning environments (VRLEs) improve student motivation and engagement, supported by positive attitudes toward their usefulness and ease of use.

Immersion VR (2022) emphasizes VR’s ability to simulate real-world scenarios, making it valuable in fields like science and engineering, while also reducing costs and supporting inclusive learning for students with disabilities. However, high costs and accessibility challenges remain concerns. Similarly, Dick (2021) underscores the importance of using VR alongside traditional teaching methods to maximize benefits and address limitations.

Cicek et al. (2021) explored students' perceptions of VR in higher education, finding it improves learning but raises concerns about accessibility and potential distractions. Perifanou et al. (2022) investigated AR integration in education, identifying its potential to boost engagement but noting challenges like high costs and insufficient technical training.

Books such as *Learning in Virtual Worlds: Research and Applications* highlight the potential of virtual environments in education, while offering strategies to overcome challenges, ensuring VR and AR technologies are effectively utilized. These findings collectively underscore the need for balanced implementation, emphasizing training, cost management, and inclusive access to maximize the benefits of VR and AR in education.

III. The Impact of Virtual and Augmented Reality in Education

Raja and Priya (2021) explore the evolution, applications, and impacts of VR in education, emphasizing its potential to enhance engagement and learning outcomes while addressing challenges like cost and technical barriers. They suggest collaboration, open-source tools, and training as strategies to overcome these hurdles, supported by successful case studies.

Gillet et al. (2020) show VR's transformative role in tourism education, enhancing engagement and satisfaction through immersive learning, while Phillips et al. (2021) highlight VR's benefits in Anatomy and Physiology (A&P) education, despite challenges like cost and technical requirements. Similarly, Broussard and Garrison-Wade (2018) and Bower & Hedberg (2019) emphasize VR's immersive potential in various subjects but caution against ethical and practical limitations.

Esmambetova (2019) discusses engaging passive learners using interactive tools, linking it to VR's potential for active learning and critical thinking. Abouhashem and Khalifa (2018) explore VR in virtual laboratories, showing improved science learning outcomes, while Campos et al. (2022) demonstrate VR's effectiveness in science, engineering, and language learning. The literature collectively underscores VR's ability to create engaging, personalized, and inclusive learning experiences but emphasizes addressing costs, accessibility, and ethical concerns for its effective implementation.

IV. Student Disengagement in Education

Student disengagement, a growing issue in education, affects up to 20% of students annually and leads to poor academic performance, behavioral issues, and increased dropout risks (Psych4Schools, 2023). Disengaged students often display boredom, lack of participation, and disruptive behaviors, with their challenges compounding over time. However, disengagement is not uniform across subjects and may depend on factors like interest, resources, and teacher rapport.

Ineffective teaching methods contribute significantly to disengagement. Florida Atlantic University (2022) notes that traditional lecture-based approaches and rote learning fail to engage students, making them passive learners. Similarly, Goulart (2022) highlights the disconnect between curricula and students' realities, emphasizing the need for practical, relevant content. Incorporating interactive, entertaining, and meaningful learning activities—such as real-world examples, multimedia, and technology—can enhance engagement and intrinsic motivation (Psych4Schools, 2023). Addressing these factors is key to fostering active participation and improving educational outcomes.

V. Virtual Reality (VR) Technology in Education

Several studies highlight the positive impact of Virtual Reality (VR) and Augmented Reality (AR) technologies on education. A systematic review by Yu and Xua (2022) found that VR significantly improves knowledge retention, skill development, and learning efficiency. However, the effectiveness of VR varies based on factors like immersion, instructional design, and the type of learning outcomes. Similarly, Akgun and Atici (2022) demonstrated that VR-based mathematics instruction led to significant improvements in student performance compared to traditional methods. In Saudi Arabia, AR and QR codes have been used to make education more engaging, especially during the COVID-19 pandemic. Alnahdi (2022) noted that these technologies align well

with the needs of the modern "alpha generation" and are essential in the changing job market. However, effective integration of these tools requires teachers to develop digital skills (Alalwan et al., 2020). Economidies et al. (2022) explored the global adoption of AR in education, finding that while teachers' digital skills are crucial, barriers such as limited AR applications and high costs remain. The study emphasized the need for teacher training and professional development. Additionally, Liu et al. (2020) showed that VR-based science education significantly improved student performance, highlighting the need for well-designed VR environments to maximize learning outcomes. VR has also been shown to enhance nursing and medical education by increasing engagement and improving problem-solving skills (Lin et al., 2018; Kim & Kim, 2021). Similarly, Thrasher (2023) found that VR simulation positively impacted elementary students' learning motivation and achievement. Incorporating VR into various disciplines, including business and science, has proven effective in improving academic performance (Zawacki-Richter & Latchem, 2018; Radianti et al., 2020). VR's ability to offer immersive, interactive learning experiences is particularly beneficial for subjects requiring spatial understanding, though its application in subjects requiring tactile feedback may be less effective (McMahan, 2017). Schmidthaler et al. (2023) highlighted the importance of interest and motivation in academic performance, noting that VR can enhance engagement and emotional involvement in learning, leading to better cognitive and affective outcomes (Calvert & Abadia, 2020). These findings suggest that VR and AR technologies have great potential to transform education, but their successful integration depends on thoughtful design, teacher training, and addressing technological barriers.

To address disengaged students, educators can adopt active learning strategies and innovative technologies like virtual reality (VR) and augmented reality (AR). These technologies provide immersive, interactive learning experiences that engage students, foster curiosity, and help them explore complex concepts in an enjoyable way (Broussard & Garrison-Wade, 2018). VR and AR can accommodate diverse learning styles, making education more inclusive (mashupmath, 2023). Studies show that VR improves learning outcomes in subjects like mathematics (Akgun & Atici, 2022), science (Liu et al., 2020), and nursing (Lin et al., 2018), and enhances medical students' skills (Kim & Kim, 2021). However, successful implementation depends on factors like immersion, instructional design, and alignment with student interests (Yu & Xua, 2022), as well as teacher training and support (Dick, 2021). Gamification and VR can further optimize engagement (Smiderle et al., 2020).

The benefits of VR and AR include increased student engagement, improved retention, enhanced critical thinking, and cost-effective alternatives to traditional methods (Immersion VR, 2022). However, challenges such as high costs, technical requirements, and ensuring equitable access remain (Phillips et al., 2021). Ethical concerns also need consideration (Bower & Hedberg, 2019).

In conclusion, VR and AR have the potential to revolutionize education by offering dynamic learning environments. Their successful integration requires careful planning, training, and attention to student differences, ultimately shaping the future of education.

2. Research Methods

I. Research Design

The research design is a detailed plan for acquiring, analyzing, and interpreting data. A quantitative experimental and descriptive research method was used to systematically gather and analyze data on how the system impacts the work and performance of participants. This approach combines elements of both descriptive and experimental methods, aiming to describe a phenomenon and establish cause-and-effect relationships by manipulating variables.

The Descriptive Research Method, as outlined by Siedlecki (2020), focuses on collecting numerical data to characterize an individual, event, or condition, making it suitable for understanding the nature of a business and building the system framework. This design allows structured surveys, pre- and post-assessments, and data analysis from participants.

Experimental design is used to systematically test hypotheses, establishing the impact of an independent variable on a dependent variable. It involves careful planning, defining variables, and using appropriate statistical tests to identify causal relationships (McIntosh, 2017). The quantitative experimental & descriptive research will help determine the effects of the proposed system on respondents, aiming to improve student academic performance and contribute to system development. The researchers concluded that this design is essential for gathering data to assess the system's efficacy for grade 7 students at Colegio de San Juan de Letran.

II. Population of the Study

The researchers will interview the chairperson of the Basic Education Department currently at Colegio de San Juan de Letran Calamba. The chairperson will be the client for the research aimed at developing the "BioApp," a mobile Augmented Reality application designed for students and teachers. The study will be carried out on the Letran-Calamba campus and will involve a total of 2 classes from the 7th Grade, specifically the first class who will take the BioApp and the second class who will not take BioApp. These students will actively participate in using the "BioApp" to improve their academic performance in biology during the school years 2023-2024. The research will assess the effectiveness of the "BioApp" in enhancing the learning outcomes of these students in biology. To collect data, both the head of the Science department and the participating students will be involved in the study.

III. Sampling Design

This section discusses the sampling technique that the researcher will use to acquire the samples from the population, the researchers aim to employ simple random sampling. This section also presents the computation on how the sample size is determined. 69 In simple random sampling, participants are deliberately selected randomly. For this study, the researcher will purposively select two (2) class sections that are taking grade 7 biology subjects. These students will constitute the sample for the study, as they represent a smaller group of elements drawn from an accessible population. By using simple random sampling, the researcher aims to gather insights from students who may benefit the most from the AR program. This method will provide valuable data on how the program impacts the knowledge and understanding of biology in students who are struggling with the subject. The process adheres to ethical considerations, such as obtaining informed consent from the selected students, ensuring confidentiality, and following institutional guidelines for research involving minors.

IV. Data Collection Method

The data collection approach involves interviewing the chairperson of the Basic Education Department of Colegio de San Juan de Letran for proof and suggestions in the application. Additionally, a pre-assessment and post assessment questionnaire will be administered to a selected group of two (2) sections of 7th-grade students, focusing on their biology subject. The questionnaires are designed to evaluate the prior knowledge of various 7th-grade biology topics. The questionnaires are designed to assess their grasp of various 7th-grade biology topics. Before participating in the AR program, the students will complete the pre-test questionnaire. Following that, the AR program will be 70 conducted, concentrating on predetermined biology topics from their 7th-grade curriculum. Immediately after the program, the same students will fill out the post-test questionnaire. Both questionnaires will cover specific topics aligned with the 7th-grade biology curriculum. By analyzing and comparing the responses from both assessments, the impact of the AR program on the students' biology knowledge and comprehension will be evaluated. The data collection process adheres rigorously to

ethical considerations, including obtaining informed consent, ensuring confidentiality, and following institutional guidelines for research involving minors.

V. Software Development Life Cycle (SDLC)

The developers selected to utilize the Agile Methodology to demonstrate the Software Development Life Cycle. The Agile approach is a methodology that encourages continuous testing and development throughout the software development life cycle of a project. The agile approach aims to create the best product possible by developing small cross-functional self-organizing teams that produce small fragments of functionality regularly, allowing for frequent feedback from consumers and course correction as needed. This involves particular stages to take action on the software production based on the client's requirements. These crucial phases of the SDLC model in designing any software application are as follows: analysis, design, implementation, testing, deployment, and maintenance.

VI. Materials

Android Studio is the official IDE for Android app development, offering tools for designing, coding, testing, and debugging apps. It supports Java and Kotlin, features a UI designer, emulator, and integrates with Gradle, version control, and performance profiling to streamline the development process. Regularly updated, it ensures compatibility and optimal performance across Android devices. Blender, Maya, 3ds Max, and Substance Painter are key 3D modeling and animation tools used for creating detailed models, textures, and visual effects for AR applications. Hostinger, a web hosting company founded in 2004, offers cost-effective hosting solutions with a range of services, including shared, cloud, VPS, and dedicated server hosting. Known for its user-friendly interface and robust security, Hostinger is a popular choice for affordable web hosting. The proposed system will use minimum smartphone specifications to run the Augmented Reality application.

VII. Data

Data was obtained from Colegio de San Juan de Letran grade 7 junior high students, and instructors. The client provided student records or information, similarly to instructors, forms such as grades, and reports, which were gathered through an interview and stored in an audio recording and Word document. To collect data for their study, the researchers conducted an interview and survey questionnaire and observed the client that they had chosen. The findings and results gathered from the series of interviews were the proof and basis of the researchers of what topic and approach applied in the development of the Augmented reality application, BioApp.

3. Result and Discussion

This section provides a detailed account of the development process for a mobile gaming application specifically crafted to support cognitive learning in students taking the topic ecological relationship. Additionally, it delves into offering comprehensive descriptions of the system's development, followed by a thorough presentation of test results and subsequent analysis and interpretation. The objective is to provide a structured and formal narrative of the various phases involved in the development and testing of the system

The Development Phase of the BioApp Mobile Game application involved creating a platform to support the cognitive learning of children with special needs. Unity was used for developing the user interface, while Xampp and Hostinger were employed for storing data related to the mobile game. The application begins with a Starting Page, offering users centralized navigation and quick access to key features. The Log In Page allows users to enter their credentials, with an option to register if they are new, through the "Registration" button. On the Registration/Sign Up Page, users can create an account by filling in their username, password, and confirming the details. After logging in, users are directed to the Home Page, where they can interact with 3D

animal models and explore their relationships. The User Quiz Page enables users to take quizzes, which can be activated by teachers or admins. On the Interaction Page, users can test and explore different animal relationships by spawning 3D models. The Teacher Account/Quiz Settings Page allows teachers or admins to toggle quiz availability, and the Record Page displays the number of quizzes taken and the scores achieved by students. Additionally, the application includes interactive 3D Assets, featuring animals that serve as educational tools to help users learn about various ecological relationships in an engaging and visually stimulating way.

Table 4

Section 7 - Copernicus Pre- and Post-test results using Bioapp

Student	Pre-test	Post-test
1	27 / 40	32 / 40
2	12 / 40	28 / 40
3	20 / 40	35 / 40
4	24 / 40	30 / 40
5	26 / 40	34 / 40
6	18 / 40	37 / 40
7	30 / 40	35 / 40
8	21/ 40	37 / 40
9	21/ 40	30 / 40
10	26/ 40	30 / 40
11	23/ 40	33 / 40
12	25/ 40	31 / 40
13	32/ 40	40 / 40
14	28/ 40	37 / 40
15	21 / 40	30 / 40
16	23 / 40	33 / 40
17	19 / 40	28 / 40
18	25 / 40	31 / 40
19	23/ 40	32 / 40
20	25/ 40	31 / 40
21	27/ 40	31 / 40
22	29/ 40	34 / 40
23	30/ 40	37 / 40
24	21/ 40	35 / 40
25	25/ 40	36 / 40

Table 5

Section 7 - Archimedes Pre- and Post-test results

Student	Pre-test	Post-test
1	11 / 40	37 / 40
2	14 / 40	40 / 40
3	9 / 40	39 / 40
4	14/ 40	35 / 40
5	38 / 40	40 / 40
6	35 / 40	38 / 40
7	16 / 40	32 / 40
8	16/ 40	32 / 40
9	33 / 40	31 / 40
10	32 / 40	33 / 40
11	31 / 40	38 / 40
12	28 / 40	33 / 40
13	33 / 40	40 / 40
14	31 / 40	37 / 40
15	30 / 40	40 / 40
16	31 / 40	40 / 40
17	10 / 40	38 / 40
18	12 / 40	36 / 40
19	37/ 40	40 / 40
20	24 / 40	36 / 40
21	33 / 40	38 / 40
22	36 / 40	34 / 40
23	28 / 40	40 / 40
24	18 / 40	36 / 40
25	27 / 40	40 / 40

Fig. 1 Table Copernicus, Archimedes Pre-Test And Post test

To analyze and interpret the test results from both sections properly, researchers utilized the unpaired t-test. To evaluate this, pre-tests and post-tests 97 were conducted in two class sections: Section 7 - Copernicus and Section 7 - Archimedes , and the results are shown in Tables 4 and 5, respectively. The paired t-test was used to determine whether the mean difference between paired observations within each section was statistically significant. This method helped assess whether there was a significant change or effect resulting from the intervention or condition change in each class section.

making the unpaired t-test the appropriate statistical tool to determine if there exists a significant difference in the mean post-test scores between the two groups. This method aligns with our primary research objective of evaluating the 100 overall impact of the BioApp on academic performance. Moreover, the widespread acceptance and reliability of the unpaired t-test in comparing independent groups contribute to the robustness of our statistical analysis, strengthening the validity of our findings.

Table 8

Likert scale table Interpretation

LIKERT SCALE DESCRIPTION	LIKERT SCALE	INTERPRETATION
Strongly Agree	4	4.00 - 3.01
Agree	3	3.00 - 2.01
Disagree	2	2.00 - 1.01
Strongly Disagree	1	1.00 - 0.00

Fig. 2 Table Likert scale in evaluating

The choice to use the 4-point Likert scale in evaluating "BioApp: A Mobile Augmented Reality Application to Enhance Junior High School Students' Academic Performance in the field of Biology" is well-founded, drawing from a study on its applicabilities. The simplicity and clarity of the Likert scale, with categories like 'Strongly Agree' and 'Strongly Disagree,' make it ideal for gathering clear and concise feedback from teachers and students. Page (2023) stated that the Likert scale strikes a balance between clarity and simplicity, allowing for insights without overwhelming respondents. This approach aligns with the study's goal of assessing the BioApp's functional 104 appropriateness, maintainability, performance efficiency, and portability in an educational context. The researchers plan to follow the 4-point Likert scale range for interpretation, utilizing mean and average weighted mean formulas to summarize results per category.

4. Conclusions

This research aims to develop BioApp, a mobile augmented reality learning tool, to enhance junior high school students' understanding and performance in biology. By engaging with immersive experiences, students can improve comprehension and retention of biological concepts, leading to improved academic outcomes in the subject. The researchers were able to derive the following conclusions based on the findings and discussions; the following findings are:

1) The development and deployment of BioApp align precisely with the curriculum standards of biology. Feedback from end-user clients affirms that BioApp has successfully delivered an immersive, captivating, and enriching learning experience, augmenting traditional educational approaches.
2) Analysis of pre-test and post-test results from the students, coupled with personal remarks from end-users (both teachers and students), highlights the positive impact of features designed to foster active participation and student engagement in biology.
3) A comprehensive evaluation of BioApp against ISO 25010:2023 standards ensures the application's effectiveness as an educational tool and its impact on enhancing students' academic performance in biology. Feedback from IT experts supports BioApps alignment with acceptable standards as a credible and innovative educational application

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