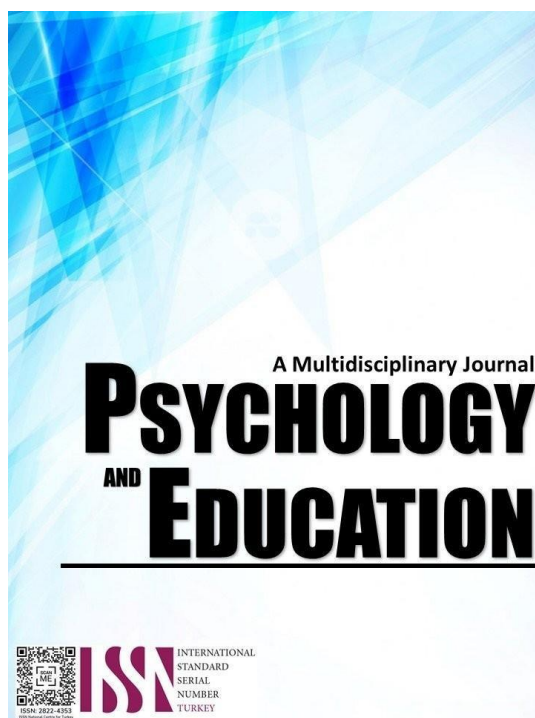


**AUGMENTED REALITY-BASED LEARNING AID (AR-BLA) IN
ENHANCING THE GRADE 7 STUDENTS' LEARNING
PERFORMANCE IN BIOLOGY AT GUINAYANGAN
NATIONAL HIGH SCHOOL, GUINAYANGAN
DISTRICT, DIVISION OF QUEZON**



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Augmented Reality-Based Learning Aid (AR-BLA) in Enhancing the Grade 7 Students' Learning Performance in Biology at Guinayangan National High School, Guinayangan District, Division of Quezon

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Abstract

This true experimental study investigated the impact of augmented reality-based learning aids (AR-BLA) on the students' learning of Grade 7 in Biology. Conducted at Guinayangan National High School, Quezon, the research employed a rigorous experimental design to assess the efficacy of AR-BLA compared to traditional classroom instruction. The study revealed that both the control and experimental groups exhibited comparable pretest scores, indicating a baseline equivalence in understanding. However, posttest results demonstrated a significant improvement in the experimental group, which utilized AR-BLA. Notably, a notable reduction in students falling below expected learning levels was observed in the AR-BLA group. This research underscores the substantial potential of AR-BLA to enhance educational outcomes in Biology instruction. The findings emphasize the importance of incorporating advanced educational technologies to optimize learning experiences and outcomes. Initially, the study revealed no statistically significant difference in the pretest scores between the control and experimental groups. The students' performance in the two MELCs showed an upward trend, indicating that some students acquired knowledge through traditional instructional approaches. The study observed an improvement the students' performance of students who utilized the Augmented Reality-Based Blended Learning Approach (AR-BLA).

Keywords: *augmented reality, biology education, learning aids, educational technology*

Introduction

In the context of the 21st-century perspective, scientific education encounters several challenges, particularly with the advent of the fourth industrial revolution (FIRe). Anderman's study (2022) illustrates that science education grapples with inadequate teaching resources, unprepared educators, and resistance to innovative pedagogical methods. Moreover, Kaptan and Timurlenk (2020) identified issues encompassing a shortage of science teachers, low student motivation and confidence in learning science, large class sizes, the lack of integration across subjects, insufficient laboratory equipment and facilities, and inadequate time allocation despite a rigorous curriculum. The emergence of Education 5.0 also demands proficiency in technology among students.

Consequently, despite the rising scientific literacy rates across generations in Southeast Asia, the region faces significant challenges. As highlighted in a report from September 8, 2017, although there has been remarkable progress, over two-thirds (68%) of the world's scientifically illiterate adults reside in Southeast Asia. Specifically, South Asia accounts for nearly half (49%) of the world's adult illiterate population. In comparison, East and Southeast Asia and West Asia have a lower percentage of the global adult illiterate population, at 10% and 9%, respectively. Despite advancements in scientific literacy rates, the region grapples with substantial obstacles ("Literacy rates rise from one generation to next, but challenges remain in the region," 2018).

The Department of Education (DepEd) shoulders the responsibility of ensuring access to and enhancing the quality of primary education in the Philippines, mandated by the "Governance of Basic Education Act of 2001" and the "Enhanced Basic Education Act of 2013." In line with these mandates, DepEd implements various programs, projects, and activities while developing the Basic Education Development Plan (BEDP) 2030. Aligned with global and national education commitments such as the Sustainable Development Goals (SDG) 2030, the BEDP 2030 is a long-term strategy addressing primary education issues and challenges. Anchored on the Sulong Edukalidad Framework, Philippine Development Plan, and Ambisyon Natin 2040, the plan aims to ensure that all Filipinos can fulfill their potential and contribute meaningfully to the nation by promoting and safeguarding the right to education. The BEDP 2030 offers a strategic roadmap for enhancing the delivery and quality of primary education, including learners' experiences in virtual educational environments.

Despite concerted efforts to enhance scientific education in the Philippines, international and local studies indicate persistent areas needing improvement. The poor performance of Filipino students in international and national examinations underscores the lag in scientific education. In 2018, the Philippines scored poorly on the Programme for International Student Assessment (PISA) in Science and Mathematics Literacy. Similarly, in the 2019 edition of the Trends in International Mathematics and Science Study (TIMSS), the Philippines garnered the lowest score among 58 countries in evaluating mathematics and science for Grade 4 students. These assessments indicate limited understanding of scientific concepts and fundamental science facts among Filipino students. Additionally, National Achievement Test (NAT) results reveal a significant portion of Grade 9 and 10 students demonstrating "Poor Proficiency" in science, with only a small percentage meeting intermediate or high standards. These findings emphasize the need for improvements in

teaching methodologies, curriculum design, and educational resources in scientific education in the Philippines (de la Fuente, 2022).

During the second quarter of the 2022-2023 school year, Guinayangan National High School recorded a total MPS in science of 55.20 percent, with the Grade 7 department achieving 49.6 percent. Topics such as identifying microscope elements and their functions and distinguishing between plant and animal cells based on specific organelles have been identified as the least mastered skills by students over the past years.

Recent years have seen significant strides in the field of education, including the adoption of new technologies like augmented reality-based learning aids. As Weng et al. (2019) noted, there has been a notable surge in leveraging innovative technologies, including multimedia and augmented reality, in education. Augmented reality (AR) enriches the real-world environment with digital information, 3D models, animations, and other digital content. Hung et al. (2019) highlighted the potential of AR-based learning aids in improving student engagement, motivation, and learning outcomes across various subjects, including Biology.

DepEd order no. 35, s. 2016 emphasizes that the quality of teaching significantly impacts the quality of learning. To address educational gaps, teachers must establish professional learning communities that generate new knowledge about instruction, challenging traditional educational beliefs. Effective teaching necessitates employing suitable strategies for systematic delivery and assessment of learning objectives. According to UNESCO GMR (2014), successful teachers possess a robust understanding of the taught content, apply effective instructional strategies and materials, make informed decisions based on formative assessment results, foster their students' performance and holistic development, and exhibit professionalism and ethics.

The unsatisfactory scientific literacy performance of Grade 7 students in Biology in Guinayangan District, especially in Guinayangan National High School, motivated the researcher to develop an innovative solution - an Augmented Reality-Based Learning Aid in Biology. The primary objective was to explore this novel technology's potential in enhancing students' knowledge acquisition, retention, and application. The study aimed to investigate the effectiveness of augmented reality-based learning aids in Biology education and their impact on students' learning at Guinayangan National High School, Guinayangan, Quezon.

Research Questions

This study sought to determine the effectiveness of Augmented Reality-Based Learning Aid (AR-BLA) in enhancing the Grade 7 students' learning performance in Biology at Guinayangan National High School, Guinayangan, Quezon. Specifically, this study sought to answer the following research questions:

1. What is the performance of students' learning in Biology of the control and experimental group of Grade 7 learners before the implementation of the localized Augmented Reality-Based Learning Aid (AR-BLA) based on the result of pretest, particularly in the following Most Essential Learning Competencies (MELCs):
 - 1.1 Identify parts of the microscope and their functions; and
 - 1.2 differentiate plant and animal cells according to presence or absence of certain organelles?
2. What is the performance of students' learning in Biology of the control and experimental group of Grade 7 learners after the implementation of the localized AR-BLA based on the result of posttest in the above-mentioned MELCs?
3. Is there a significant difference between the pretest and posttest scores of the control and experimental group of Grade 7 students in the above-mentioned MELCs in Biology?
4. Based on the study's findings, what intervention program could be developed by the researcher?

Literature Review

Biology as a Discipline

The inclusion of Biology in school curricula is essential for advancing education and equipping students to understand the complexities of our world. It's a cornerstone of natural science alongside chemistry and physics, delving into the structure and function of living organisms (Timothy, 2021). Biology's scope ranges from microscopic to macroscopic levels, impacting social, economic, and political goals globally (Boh, 2021). It explores life's organization, evolution, and interactions, acting as a prerequisite for various tertiary science programs (Kurniawan et al., 2018). Furthermore, Biology addresses critical cultural issues like health, poverty, and environmental preservation (Chukwuka, 2022). Emphasizing student-centered strategies in teaching aids in ensuring result-oriented learning (Chukwuka, 2022). However, challenges persist in student performance and attitudes toward Biology, often linked to the pivotal role of teachers in shaping effective learning outcomes (Boh, 2021; Timothy, 2021). This study aims to reinforce Biology education's significance through innovative teaching approaches and assessments, highlighting the need for current knowledge and proficiency among students to harness its benefits for nation-building.

Students' Performance

Student performance in Biology education serves as a critical benchmark for educational success (Baraiywo, 2019). According to Boh (2021), scores from assignments, assessments, and examinations measure learning outcomes and knowledge acquisition. Also, learning

in Biology is evaluated based on cognitive domains like remembering, understanding, and applying knowledge (Anderson & Krathwohl, 2001). Assessments often utilize a percentage scale to convey students' understanding, emphasizing Biology's importance as a prerequisite for higher education (Bloom, 1956). Academic achievement, a crucial facet of the learning process, is affected by various factors such as socioeconomic status, social skills, and knowledge retention (Quinn-Nilas, 2019; İzgi Onbaşılı, 2018). Knowledge retention is integral to learning, and augmented reality (AR) emerges as a transformative instructional method, enhancing retention by enabling students to interact with real-world visuals using mobile devices (Rosas et al., 2019). These findings resonate with secondary education's focus on Biology content and knowledge retention, reinforcing the relevance of investigating AR-Based Learning Aids (AR-BLA) in this context.

Augmented Reality in Education

The progression of technology has transformed augmented reality (AR) from specialized equipment to widely accessible tools on personal computers and mobile devices (İzgi Onbaşılı, 2018). Today, AR finds applications across various sectors like tourism, military, health, advertising, and notably, education (Girgin, 2018). Within the educational sphere, technological advancements open new possibilities, particularly with the prevalence of smartphones among adolescents (Avci & Taşdemir, 2019). While smartphones are largely used for games and socializing, integrating augmented reality technology into educational settings offers the potential to make learning more engaging and relevant (Avci & Taşdemir, 2019). AR brings forth a bridge between the real and virtual worlds, displaying three-dimensional representations that aid in understanding abstract concepts (Siegle, 2019). Despite being relatively new in education compared to other fields, AR exhibits substantial promise in positively impacting learning outcomes (Erbaş & Demirel, 2019; Yılmaz, 2018). By blurring the boundaries between reality and virtual elements, AR enables students to witness and interact with content that might otherwise be inaccessible, fostering engagement, motivation, and various cognitive abilities (Weng et al., 2019; Akcayr & Akcayr). While further empirical studies are needed to gauge its full impact, AR applications in education seem poised to address the evolving needs of 21st-century learners, offering innovative pedagogical solutions (Kurniawan et al., 2018). Nonetheless, the usability of these applications is crucial, as complex AR materials could potentially overwhelm learners with excessive cognitive demands (Kurniawan et al., 2018).

Augmented Reality in Biology

Understanding the distinct characteristics of the new generation and adapting teaching techniques to accommodate modern technology has become crucial in education (Oyoo, 2019). Traditional methods like chalk-and-talk have often led to disengagement among students due to the dense and abstract nature of textbooks, particularly in complex subjects like Biology (Soe, 2018). Augmented reality (AR) technology, as highlighted by Timur & Ozdemir (2018), introduces an innovative approach to education, rendering abstract concepts concrete and inaccessible items visible. It transforms learning from abstract to tangible, particularly in science subjects, offering cognitive and emotional development benefits such as improved retention, engagement, and interest (Timur & Ozdemir). The integration of AR into education enhances learning experiences, motivating students and providing a more interactive and immersive understanding of abstract topics (Erbaş & Demirel, 2019). Its application in subjects like Biology sparks greater interest, improves comprehension, and facilitates active learning experiences, aligning with the diverse learning styles of students (Ültay & Ültay, 2020). Furthermore, AR's potential extends across various scientific domains like chemistry, physics, and mathematics, offering promising avenues for enhancing scientific literacy and easing the comprehension of challenging subjects (Demitriadou et al., 2020). By offering an engaging and 3D visual representation, AR technology reduces cognitive burdens, fosters creativity, and transforms the science classroom into a student-centered, interactive space (Khan et al., 2019). Overall, AR emerges as a powerful tool capable of revitalizing the teaching of complex scientific topics, providing an array of alternatives in education and integrating digital elements seamlessly into the learning environment (Girgin, 2018).

Related Studies

Augmented Reality (AR) technology enhances learning experiences by presenting 3D representations, engaging students in immersive activities, and lessening cognitive burdens (Khan et al., 2019; Girgin, 2018). Its integration in various fields, including Medicine, Physics, Chemistry, and Biology, concretizes abstract concepts and offers realistic simulations (Saidin et al., 2018). Also, studies highlight AR's role in fostering critical thinking, problem-solving skills, accommodating diverse learning styles, and actively engaging students through multimedia features (Demitriadou et al., 2020; Erwinsah et al., 2019). In Biology, AR facilitates interactive learning and comprehension of complex structures (Garzon et al., 2018).

AR technologies serve as cost-effective alternatives, stimulating student interest, enhancing laboratory abilities, and making content learning more accessible and enjoyable (Nesterov et al., 2018; Akcayr et al., 2016). Applied in topics like metabolism, AR aids in deciphering abstract concepts and fostering collaborative learning (Erbaş & Demirel, 2019). Additionally, integrating AR with databases assists in teaching complex biological structures like proteins, enhancing users' perceptions and understanding through 3D

visualizations (Safadel & White, 2019). AR activities in Biology laboratories positively impact academic achievement and attitudes toward digital technology among prospective teachers (Kalana et al., 2020). Lastly, augmented Reality not only improves academic performance but also enhances learning experiences by promoting engagement, entertainment, and repeated interaction with subject matter (Diamantaras et al., 2022). Its use in science education shows promise for improved learning outcomes, sustained knowledge retention, and increased academic confidence among students.

Methodology

This study employed a true experimental research design to assess the effectiveness of Augmented Reality as a Biology 7 learning aid for the second quarter of the 2023-2024 school year. As mentioned by Damyanov (2023), a true experimental study involves the random allocation of participants to control and experimental groups, with manipulation of the independent variable. This design aided in determining the effect of AR-BLA in enhancing the students' performance of Grade 7 in Biology, which was the basis for accepting or rejecting the research hypothesis. In this study, the control and experimental groups were purposefully assigned by utilizing the pre-existing class structure for practicality. Quantitative methods were employed to collect data through pre- and posttests administered to both groups. This study aimed to contribute to the existing knowledge regarding the effectiveness of augmented reality-based learning aids in the context of Biology education in Guinayangan, Quezon.

Respondents

Using purposive sampling, this study was participated in by 86 heterogeneously grouped Grade 7 learners enrolled during the academic year 2023-2024 at Guinayangan National High School, Guinayangan, Division of Quezon. Grade 7 department of GNHS consists of 8 sections with 3 science teachers; 2 sections are handled by the researcher, namely Grade 7 – Bonifacio and Grade 7 – Aguinaldo. Grade 7 – Bonifacio was assigned as the experimental group that received augmented reality-based learning aids in Biology education, while Grade 7 – Aguinaldo was the control group and received traditional classroom instruction.

Instruments of the Study

To facilitate the achievement of the learning competencies, a localized Augmented Reality-Based Learning Aid in Biology was utilized as the main instrument for this study. In addition, the researcher designed an assessment tool consisting of fifty items of departmentalized diagnostic tests and thirty items of pretests and posttests aligned with the Most Essential Competencies as stated in the Budget of Work of the Department of Education that corresponds to the content of the learning aid. To ensure that the assessment tool is well-constructed, a table of specifications was created to guarantee that the questions represent a fair and comprehensive sample of the competencies. Prior to the actual administration of the test, the validity of the instrument was established through thorough validation procedures. It was validated by five experts.

Procedure

The study employed quantitative data collection, conducting pretest and posttest assessments for both control and experimental groups to gauge students' initial understanding and subsequent knowledge acquisition, retention, and application of Biology concepts. Procedures included pre-study interviews, sessions for informed consent with participants and parents, administration of pretests using validated assessment tools, implementation of Augmented Reality-Based Learning in the experimental group, and a subsequent posttest to measure competency attainment in both groups following different learning approaches. Data were treated with frequency, arithmetic mean, standard deviation, and Shapiro-Wilk Test.

Ethical Considerations

Prior to the conduct of the study, ethical clearance was obtained from the school head of the school, and informed consent was obtained from the Grade 7 student-participants and their parents or guardians. For this study, the privacy and confidentiality of the participants' data have been ensured.

Results and Discussion

This section provides a comprehensive presentation of the results, analysis, and interpretation of data obtained from the respondents during the experimentation with AR-BLA in teaching Biology to Grade 7 students at Guinayangan National High School. The data is systematically organized and presented.

Table 1 details the distribution of the experimental group's performance in Biology learning, specifically focusing on the "Identify Parts of the Microscope and Their Functions" MELCs before the integration of AR-BLA, as indicated by their pretest scores. None of the participants in the experimental group reached the levels of "Outstanding," "Very Satisfactory," "Satisfactory," or even "Fairly Satisfactory."



Table 1. *Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Control Group Before the Implementation of the AR-BLA in the MELCs “Identify Parts of the Microscope and Their Functions”*

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	0	0.00
85-89	Very Satisfactory	0	0.00
80-84	Satisfactory	0	0.00
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	43	100.00
Total		43	100.00
Mean	5.05		
SD	2.17		
MPS	34.44		

With all 43 participants scoring below the expected level, accounting for 100% of the group, it's evident that the set learning expectations for this topic were not met. The mean score of 4.28 and a standard deviation of 2.15 emphasize the significant performance gap and moderate dispersion in scores, while the mean percentage score of 28.53 further confirms the considerable need for improvement, particularly in comprehending the “Identify Parts of the Microscope and Their Functions” MELCs among the experimental group.

Table 2. *Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Control Group Before the Implementation of the AR-BLA in the MELCs “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles”*

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	0	0.00
85-89	Very Satisfactory	0	0.00
80-84	Satisfactory	0	0.00
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	43	100.00
Total		43	100.00
Mean	3.00		
SD	1.79		
MPS	29.76		

Table 2 presents the breakdown of the control group's Biology learning classification, focusing on the MELCs “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles” before the AR-BLA implementation, based on their pretest scores. Similar to prior MELCs and participant groups, none in the control group reached the levels of "Outstanding," "Very Satisfactory," "Satisfactory," or even "Fairly Satisfactory." All 43 participants, constituting 100% of the control group, scored below the anticipated level, indicating a failure to meet the established learning expectations for this MELCs. With a mean score of 3.00 and a standard deviation of 1.79 indicating moderate variability, the overall performance was significantly below the desired level. Furthermore, the mean percentage score (MPS) of 29.76 reaffirms the pressing need for improvement and instructional intervention in mastering the “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles” MELCs within this specific group.

Table 3. *Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Experimental Group Before the Implementation of the AR-BLA in the MELCs “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles”*

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	0	0.00
85-89	Very Satisfactory	0	0.00
80-84	Satisfactory	0	0.00
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	43	100.00
Total		43	100.00
Mean	3.00		
SD	1.79		
MPS	29.76		

Table 3 illustrates the distribution of the experimental group's Biology learning classification in the MELCs “Differentiate Plant and

Animal Cells According to Presence or Absence of Certain Organelles” before the AR-BLA implementation, based on their pretest scores. Similar to previous topics and participant groups, none attained levels of "Outstanding," "Very Satisfactory," "Satisfactory," or even "Fairly Satisfactory." All 43 participants, comprising 100% of the experimental group, scored below the expected level, signifying a failure to meet the established learning expectations for this MELCs. With a mean score of 3.00 and a standard deviation of 1.79 indicating moderate variability, the overall performance was significantly below the desired level. Moreover, the mean percentage score (MPS) of 29.76 emphasizes the urgent need for improvement and pedagogical intervention in grasping the “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles” MELCs within this specific group.

Table 4. Cross-Referencing of Pretest of the Control and Experimental Group of Grade 7 Students

MELCs	Groups	Test Scores	Mean	SD	MPS
Identify Parts of the Microscope and Their Functions	Control Group	Pretest	5.05	2.17	34.44
	Experimental Group		4.28	2.15	28.53
Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles	Control Group	Pretest	3.00	1.79	29.76
	Experimental Group		3.00	1.79	29.76

Table 4 compares Grade 7 students' pretest scores between the control and experimental groups regarding Biology's Most Essential Learning Competencies (MELCs). In the MELCs “Identify Parts of the Microscope and Their Functions,” the control group attained a mean score of 5.05, slightly higher than the experimental group's 4.98. Both groups exhibited similar standard deviations (control: 2.17, experimental: 2.15), with mean percentage scores below the expected level of 75%. This underscores the insufficient knowledge of both groups in this competency. Conversely, in the MELCs “Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles,” both groups obtained identical mean scores of 3.00, showing similar expertise on this subject matter, as reflected in the standard deviation (SD) of 1.79 and mean percentage score (MPS) of 29.76.

Table 5. Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Control Group After the Implementation of the AR-BLA in the MELCs “Identify Parts of the Microscope and Their Functions”

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	7	16.28
85-89	Very Satisfactory	0	0.00
80-84	Satisfactory	6	13.95
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	30	69.77
	Total	43	100.00
Mean		9.63	
SD		2.99	
MPS		64.92	

Table 5 displays the control group's posttest scores for the MELCs “Identify Parts of the Microscope and Their Functions” following the AR-BLA intervention in Biology. The results indicate considerable improvement, with 7 students (16.28%) achieving an "Outstanding" classification and 6 students (13.95%) reaching a "Satisfactory" level. Notably, the mean score of 9.63 signifies significant advancement from pretest scores, reflecting an overall positive impact of the AR-BLA implementation. However, the majority, 30 students (69.77%), still scored below the anticipated level, signifying a need for continued improvement in meeting the learning expectations for this competency. The mean percentage score (MPS) of 64.92 further confirms the substantial progress in learning outcomes for the MELCs “Identify Parts of the Microscope and Their Functions” due to the AR-BLA intervention.

Table 6. Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Experimental Group After the Implementation of the AR-BLA in the MELCs “Identify Parts of the Microscope and Their Functions”

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	12	27.91
85-89	Very Satisfactory	5	11.63
80-84	Satisfactory	5	11.63
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	21	48.84
	Total	43	100.00
Mean		11.60	
SD		2.62	
MPS		80.85	

Table 6 demonstrates the posttest scores of the experimental group in Biology's MELCs "Identify Parts of the Microscope and Their Functions" post AR-BLA implementation, revealing substantial progress in their performance. Notably, 12 students (27.91%) achieved an "Outstanding" classification, while 5 students (11.63%) attained a "Very Satisfactory" level and another 5 students (11.63%) reached a "Satisfactory" level. The absence of any "Fairly Satisfactory" classifications indicates marked improvements. Although 21 students (48.84%) did not reach the anticipated level, this represents a significant decrease from the pretest, showcasing positive advancement. With a mean score of 11.60—considerably higher than the pretest mean—and a moderate standard deviation (SD) of 2.62, it emphasizes substantial improvement and moderate score variability. Moreover, the mean percentage score (MPS) of 80.85 strongly supports significant progress, showcasing the positive impact of AR-BLA on their learning outcomes. The majority of students demonstrated satisfactory to outstanding levels of understanding, reflecting the intervention's effectiveness in enhancing learning.

Table 7. *Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Control Group After the Implementation of the AR-BLA in the MELCs "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles"*

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	6	13.95
85-89	Very Satisfactory	3	6.98
80-84	Satisfactory	5	11.63
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	29	67.44
Total		43	100.00
Mean	9.42		
SD	3.32		
MPS	64.55		

Table 7 displays the posttest scores of the control group in Biology's MELCs "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles" following the AR-BLA implementation, reflecting noteworthy progress in comparison to their pretest performance. Specifically, 6 students (13.95%) achieved an "Outstanding" classification, 3 students (6.98%) reached a "Very Satisfactory" level, and 5 students (11.63%) attained a "Satisfactory" level. Notably, no students were categorized as "Fairly Satisfactory." Despite these improvements, the majority of participants, comprising 29 students (67.44%), still scored below the expected level, indicating a partial fulfillment of the learning expectations for this MELCs post-intervention. With a mean score of 9.42—substantially higher than the pretest mean—and a moderate standard deviation (SD) of 3.32, it suggests significant enhancement and moderate score variability. Furthermore, the mean percentage score (MPS) of 64.55 supports notable progress, indicating the positive impact of AR-BLA on their learning outcomes. Although there's room for further improvement, most students showcased satisfactory to outstanding levels of understanding, denoting the intervention's effectiveness.

Table 8. *Frequency, Percentage, Mean, and Standard Deviation of the Performance of Grade 7 Experimental Group After the Implementation of the AR-BLA in the MELCs "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles"*

Percentage Range (Descriptor)	Performance Level (Grading Scale)	Frequency	Percentage (%)
90-100	Outstanding	12	27.91
85-89	Very Satisfactory	9	20.93
80-84	Satisfactory	5	11.63
75-79	Fairly Satisfactory	0	0.00
Below 75	Did Not Meet Expectations	17	39.53
Total		43	100.00
Mean	11.70		
SD	2.73		
MPS	80.83		

Table 8 outlines the experimental group's posttest performance in Biology's MELCs "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles" following AR-BLA application, showcasing significant improvement. Specifically, 12 students (27.91%) achieved an "Outstanding" classification, while 9 students (20.93%) reached a "Very Satisfactory" level, and 5 students (11.63%) attained a "Satisfactory" level. Notably, no students were classified as "Fairly Satisfactory." Although 17 students (39.53%) did not reach the anticipated classification, this represents a marked decrease compared to pretest scores, indicating substantial progress. With a mean score of 11.70—considerably higher than the pretest mean—and a moderate standard deviation (SD) of 2.73, it confirms a significant enhancement and moderate score variability. Furthermore, the mean percentage score (MPS) of 80.83 supports substantial progress, highlighting AR-BLA's positive impact on their learning outcomes. The majority exhibited satisfactory

to outstanding understanding levels, emphasizing the effectiveness of the intervention.

Table 9. *Cross-Referencing of Posttest of the Control and Experimental Group of Grade 7 Students*

MELCs	Groups	Test Scores	Mean	SD	MPS
Identify Parts of the Microscope and Their Functions	Control Group		9.63	2.99	64.92
	Experimental Group	Posttest	11.6	2.62	80.85
Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles	Control Group		9.42	3.32	64.55
	Experimental Group	Posttest	11.7	2.73	80.83

Table 9 depicts Grade 7 students' posttest scores in selected Biology MELCs for the control and experimental groups. In the MELCs "Identify Parts of the Microscope and Their Functions," the control group achieved an average score of 9.63, while the experimental group scored 11.6 pre-test. Both groups displayed moderate score distributions, with standard deviations of 2.99 and 2.62, respectively. Notably, the experimental group surpassed the 75% benchmark with an MPS of 80.85, while the control group attained an MPS of 64.92. In the MELCs "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles," the control group scored an average of 9.42 post-test, displaying a less spread-out score distribution with an MPS of 64.55 and a standard deviation of 3.32. Conversely, the experimental group achieved an average score of 11.7 post-test, with a standard deviation of 2.73 and an MPS of 80.83, indicating a more concentrated distribution and higher than standard MPS. The comparison between the posttest results of the Control and Experimental groups underscores the significant skill development observed in the experimental group due to the substantial impact of AR-BLA in enhancing students' learning performance.

Table 10. *t-Test for Dependent Sample: Pretest and Posttest Scores of the Control and Experimental Group of Grade 7 Students*

MELCs	Groups	Test Scores	Mean	Increase of Pre- and Posttest in Percentage	t value	Decision	Remarks
Identify Parts of the Microscope and Their Functions	Control Group	Pretest	5.05	90.96	-26.880	Reject Ho	Significant
		Posttest	9.63				
	Experimental Group	Pretest	4.28	171.02			
		Posttest	11.6				
Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles	Control Group	Pretest	3.00	214	-25.061	Reject Ho	Significant
		Posttest	9.42				
	Experimental Group	Pretest	3.00	272.33			
		Posttest	11.7				

The t-tests results presented in table 10 compare the pretest and posttest scores of Grade 7 students in selected Biology MELCs for both control and experimental groups. In the MELCs "Identify Parts of the Microscope and Their Functions," both groups showed significant improvements from pretest to posttest. The control group had an increase from 5.05 to 9.63 (90.96%), with a t-value of -26.880 and p-value of 0.000, while the experimental group increased from 4.28 to 11.60 (171.60%), with a t-value of -50.877. Similarly, for "Differentiate Plant and Animal Cells According to Presence or Absence of Certain Organelles," the control group increased from 3.00 to 9.42 (214%) with a t-value of -25.061, and the experimental group increased from 3.00 to 11.70 (272.33%) with a t-value of -42.661. These outcomes support prior studies, illustrating AR's positive impact on learning outcomes and indicating its superiority over traditional methods, especially in complex subjects like microscope functions and cell differentiation.

An action plan, intervention matrix, and fifteen (15) item guide and step-by-step procedure was crafted to guide the user, both teachers and learners in using an AR-BLA in teaching basic microscopy and cell Biology. This tool will help the user to navigate and use the learning aid at its fullest for the institutionalization of the learning app.

Conclusion

The study initially found no significant difference in pretest scores between the control and experimental groups, indicating similar levels of understanding in the targeted Most Essential Learning Competencies (MELCs). Although both groups showed some improvement during the study, a considerable number of students still required further progress to reach desired proficiency levels. However, the group utilizing Augmented Reality-Based Blended Learning Approach (AR-BLA) displayed fewer students struggling to meet learning outcomes, suggesting that integrating AR tools enhances educational effectiveness compared to non-AR methods. The rejection of the null hypothesis highlighted this distinction. Notably, the control group's conventional instructional techniques led to

improved posttest outcomes, emphasizing the relevance of traditional pedagogical approaches. In contrast, the experimental group using AR-BLA demonstrated substantial improvement from pretest to posttest, aligning with past research indicating educational aids positively impact student performance and comprehension. The posttest results revealed the experimental group outperformed the control group, underscoring the significant influence of AR-BLA on student performance. Lastly, implementing an Action Plan, Intervention Matrix, and a comprehensive user guide is crucial for effective utilization and navigation of a newly introduced AR-BLA.

The study's findings suggest several impactful recommendations for educational advancement. Firstly, the Department of Education (DepEd) should champion ongoing research into innovative pedagogical methods, particularly funding improvements in learning aids and promoting Augmented Reality-Based Blended Learning Approach (AR-BLA) through official memoranda. Education Supervisors can aid teachers in adopting AR-BLA, while School Principals may consider institutionalizing AR-BLA in Biology classes to bolster science education. Educators should receive comprehensive AR training to effectively integrate this technology into challenging subjects. Additionally, parents and students could utilize AR-BLA for at-home learning in Biology, leveraging its potential to enhance comprehension and performance. Lastly, future research focusing on tailored augmented reality applications using provided guides and frameworks will further improve learning experiences.

References

- Akpan, I. (2020, February 2). *The influence of school environment on academic performance of biology students in secondary schools in Ukanafun local government area of Akwa Ibom state*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3530562.
- Akçayır, M., Akçayır, G., Pektaş, H. M., & Ocak, M. A. (2018). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, 57, 334-342.
- Alvarez Jr, A. V. (2020). Learning from the Problems and Challenges in Blended Learning: Basis for Faculty Development and Program Enhancement. *Asian Journal of Distance Education*, 15(2), 112-132.
- Anderman, E. M. (2022). *The challenges of teaching and learning about science in the 21st century: Exploring the abilities and constraints of adolescent learners* [Unpublished doctoral dissertation]. National Academy of Education.
- Arslan, R., Kofoglu, M., & Dargut, C. (2020). Development of augmented reality application for biology education. *Journal of Turkish Science Education*, 17(1), 62-72. <https://www.tused.org/index.php/tused/article/view/874>
- Avcı, A. F., & Taşdemir, Ş. (2019). Periodic table teaching with augmented and virtual reality. *Journal of Selcuk-Technic*, 18(2), 68-83. <http://sutod.selcuk.edu.tr/sutod/article/view/468>
- Baraiywo, S. K. (2019). Relationship between selected students' background characteristics and academic performance in secondary school biology in Nandi County, Kenya. *Egerton University Institutional Repository*. <http://41.89.96.81/handle/123456789/2155>
- Boh, SA. (2021). Teachers' variables and academic performance of senior secondary school students in economics in Shongomi local government area of Gombe State. *Al-Hikmah Journal of Arts and Social Sciences Education*, 3(2):37-45.
- Bowers, B., Rukangu, A., & Johnsen, K. (2020, March). Making it simple: Expanding access and lowering barriers to novel interaction devices for virtual and augmented reality. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)* (pp. 1-6). IEEE.
- Chien, Y. C., Su, Y. N., Wu, T. T., & Huang, Y. M. (2019). Enhancing students' botanical learning by using augmented reality. *Universal Access in the Information Society*, 18(2), 231-241. doi:10.1007/s10209-017-0590-4.
- Chukwuka, R. E. (2022). Application of novel instructional strategies and learners' academic performance in Biology. *Innovations*, 68(2022). https://www.researchgate.net/profile/Chukwuka-Ewere/publication/362234112/Application_of_novel_instructional_strategies_and_learners_academic_performance_in_Biology/links/62de9d0d3c7d190316aa852b/Application-of-novel-instructional-strategies-and-learners-academic-performance-in-Biology.pdf
- Damyranov, M. (2023, February 6). The use and interpretation of quasi-experimental design. Dovetail. Retrieved May 20, 2023, from <https://dovetail.com/research/quasi-experimental-design/>.
- De la Fuente, J. (2022, August 9). *Overview of student learning outcome assessments in the Philippines*. TeacherPH.

<https://www.teacherph.com/student-learning-outcome-assessments-philippines/>.

Demitriadou, E., Stavroulia, K.-E., & Lanitis, A. (2020). Comparative evaluation of virtual and augmented reality for teaching mathematics in primary education. *Education and Information Technologies*, 25(1), 381–401. <https://doi.org/10.1007/s10639-019-09973-5>

Diamantaras, K., Evangelidis, G., Keramopoulos, E., & Lampropoulos, G. (2022). Augmented reality and Gamification in education: A systematic literature review of research, applications, and empirical studies. *Applied Sciences*, 12(13), 6809. <https://doi.org/10.3390/app12136809>

Draus, P. (2020). IMPACT OF STUDENT ENGAGEMENT STRATEGIES ON VIDEO CONTENT IN LEARNING COMPUTER PROGRAMMING AND ATTITUDES TOWARDS VIDEO INSTRUCTION THAT WAS DEVELOPED BASED ON THE COGNITIVE THEORY OF MULTIMEDIA LEARNING. *Issues in Information Systems*, 21(3).

eLGU. (2018). Zoning map - Municipality of Guinayangan [Map]. www.guinayangan.com. <http://www.guinayangan.com/zoning%20map1.jpg>

Erbas, C., & Demirer, V. (2019). The effects of augmented reality on students' academic achievement and motivation in a biology course. *Journal of Computer Assisted Learning*, 4244, 1–9. <https://doi.org/10.1111/jcal.12350>.

Erwinsah, R., Aria, M., & Yusup, Y. (2019). Application of augmented reality technology in biological learning. *Journal of Physics: Conference Series*. <https://doi.org/10.1088/1742-6596/1402/6/066090>.

Fidan, M., & Tuncel, M. (2019). Integrating augmented reality into problem-based learning: The effects on learning achievement and attitude in physics education. *Computers & Education*, 142, 103635.

Girgin, S. (2018). The effect of augmented reality technology on the academic success of science course. *Journal of Social and Humanities Sciences Research (JSHSR)*, 5(30) 4283-4290. <https://www.researchgate.net/profile/Soenmez-Girgin/publication/330323405>

Garzón, J. C., Magrini, M. L., & Galembeck, E. (2018). Using augmented reality to teach and learn biochemistry. *Biochemistry and Molecular Biology Education*, 45(5), 417-420. <https://doi.org/10.1002/bmb.21063>

İzgi Onbaşılı, Ü. (2018). The effect of augmented reality practices on the attitudes of primary school students towards augmented reality practices and science motivation. *Ege Journal of Education*, 19(1), 320-337. <https://doi.org/10.12984/egeefd.390018>.

Jordan, M. (2021). Purposive sampling 101: Alchemer blog. Alchemer. <https://www.alchemer.com/resources/blog/purposive-sampling-101/>

Kalana, M. H., Junaini, S. N., & Fauzi, A. H. (2020). *Mobile augmented reality for biology learning: review and design recommendation* [Master's thesis]. https://www.researchgate.net/profile/Syahrul-Junaini/publication/342378869_Mobile_augmented_reality_for_biology_learning_Review_and_design_recommendations/links/5ef19b6aa6fdcc73be96d096/Mobile-augmented-reality-for-biology-learning-Review-and-design-recommendations.pdf.

Kanellopoulou, Kermanidis, & Giannakouloupoulos. (2019). The dual-coding and multimedia learning theories: Film subtitles as a vocabulary teaching tool. *Education Sciences*, 9(3), 210. <https://doi.org/10.3390/educsci9030210>

Kamal, A. A., & Junaini, S. N. (2019). The effects of design-based learning in teaching augmented reality for pre-university students in the ICT competency course. *International Journal of Scientific and Technology Research*, 8(12), 2726–2730. <http://www.ijstr.org/paperreferences.php?ref=IJSTR-1219-27322>.

Kaptan, K., & Timurlenk, O. (2020). Challenges for science education. *Procedia - Social and Behavioral Sciences*, 51, 763-771. <https://doi.org/10.1016/j.sbspro.2012.08.237>

Khan, T., Johnston, K., & Ophoff, J. (2019). The impact of an augmented reality application on learning motivation of students. *Advances in Human Computer Interaction*, 1–14. <https://doi.org/10.1155/2019/7208494>.

Kiryakova, G., Angelova, N., & Yordanova, L. (2018). The potential of augmented reality to transform education into Smart

education. *TEM Journal*, 7(3), 556–565. <https://doi.org/10.18421/TEM73-11>.

Kurniawan, M. H., Suharjito, Diana, & Witjaksono, G. (2018). Human anatomy learning systems using augmented reality on mobile application. *Procedia Computer Science*, 135, 80–88. <https://doi.org/10.1016/j.procs.2018.08.152>.

Liem, G. A. D., & Tan, S. H. (Eds.). (2018). *Asian education miracles: In search of sociocultural and psychological explanations*. Routledge.

Literacy rates rise from one generation to next, but challenges remain in region. (2018, September 8). UNESCO Bangkok. <https://bangkok.unesco.org/content/literacy-rates-rise-one-generation-next-challenges-remain-region>

Mayer, R. E. (2021). Cognitive theory of multimedia learning. *The Cambridge Handbook of Multimedia Learning*, 57-72. <https://doi.org/10.1017/9781108894333.008>

National Geographic Society. (2022, May 22). Microscopes. Education | National Geographic Society. <https://education.nationalgeographic.org/resource/microscopes/>

National Library of Medicine. (2021, February 22). What is a cell? <https://www.nature.com/scitable/topicpage/what-is-a-cell-14023083/>

Nesterov, A., Kholodilin, I., Shishkov, A., & Vanin, P. (2018). Augmented reality in engineering education: Opportunities and advantages. *Communications-Scientific letters of the University of Zilina*, 19(4), 117-120.

Oyoo, S. (2019, July). *Science teaching in Africa: enhancing and sustaining teacher efficacy*. UPspace Home. https://repository.up.ac.za/bitstream/handle/2263/80078/Oyoo_Science_2015.pdf?sequence=1&isAllowed=y

Paul, S., Reardon, C., Williams, T., & Zhang, H. (2020). Designing augmented reality visualizations for synchronized and time-dominant human-robot teaming. *Virtual, Augmented, and Mixed Reality (XR) Technology for Multi-Domain Operations*. <https://doi.org/10.1117/12.2559402>

PhilAtlas. (2018). Map of the Philippines highlighting Quezon [Map]. <https://www.philatlas.com/luzon/r04a/quezon.html>

Purnama, G. R. R., Hansun, S., & Kristanda, M. B. (2019). Gamified chemistry learning AR application for 10th grade student in Indonesia. *International Journal of Recent Technology and Engineering*, 8(2), 6100– 6105. <https://doi.org/10.35940/ijrte.b3853.078219>

Quinn-Nilas, C.; Kennett, D. & Maki, K. (2019). Examining explanatory style for failure of direct entry and transfer students using structural equation modeling. *Educ. Psychol.* 39, 749–767.

Rosas, R.; Pérez-Salas, C.; Olguín, P. Interactive Whiteboards for Motivated Learning in Children with Cerebral Palsy. *Study Pedagogical*. 36, 191–209.

Safadel, P., & White, D. (2018). Facilitating molecular biology teaching by using augmented reality (AR) and protein data bank (PDB). *TechTrends*, 63(2), 188-193. <https://doi.org/10.1007/s11528-018-0343-0>

Saidin, N. F., Abd Halim, N. D., & Yahaya, N. (2018). A review of research on augmented reality in education: Advantages and applications. *International Education Studies*, 8(13). <https://doi.org/10.5539/ies.v8n13p1>

Siegle, D. (2019). Seeing is believing: Using virtual and augmented reality to enhance student learning. *Gifted Child Today*, 42(1), 46–52. <https://doi.org/10.1177/1076217518804854>

Soe, H. Y. (2018). A study on high school students' perceptions toward biology learning (Myanmar). *International Journal of Applied Research*, 4(9), 248–251.

Sweller, J. (2019). Cognitive load theory and educational technology. *Educational Technology Research and Development*, 68(1), 1-16. <https://doi.org/10.1007/s11423-019-09701-3>

Tempo. (2018). Map of Quezon [Map]. tempo.com.ph. <https://www.philatlas.com/luzon/r04a/quezon.html>

Timothy, O.B. (2021). Science experience as correlate of student learning outcome. *International Journal of Theory and application in Elementary and Secondary School Education*, 3(1): 15-24.

Timur, B., & Özdemir, M. (2018). Teachers' views on the use of augmented reality environments in science education. *International Journal of Turkish Education Sciences*, 6(10), 62-75. <https://dergipark.org.tr/tr/pub/fmgtded/issue/61510/882023>.

Ültay, N., & Ültay, E. (2020). A comparative investigation of the views of pre-school teachers and teacher candidates about STEM. *Journal of Science Learning*, 3(2), 67-78. <https://doi.org/10.17509/jsl.v3i2.20796>.

Umali, J. B. (2020). *School map* [Map].

Vygotsky, L., & Cole, M. (2018). Lev Vygotsky: Learning and social constructivism. *Learning theories for early years practice*, 66, 58.

Weighted mean [Formula]. (2023, March 17). <https://www.indeed.com/career-advice/career-development/how-to-calculate-weighted-average>

Weng, C., Otanga, S., Christiano, S. M., & Chu, R. J. (2019). Enhancing students' biology learning by using augmented reality as a learning supplement. *Journal of Educational Computing Research*, 58(4), 747-770. <https://doi.org/10.1177/0735633119884213>

Weng, N. D., Bee, O. Y., Hsia, T. E., & Yew, L. H. (2019). An Augmented Reality System for Biology Science Education in Malaysia. *International Journal of Innovative Computing*, 2(2019).

Yapici, I. U., & Karakoyun, F. (2021). *Using augmented reality in biology teaching* [Master's thesis]. <https://mojet.net/index.php/mojet/article/view/286/225>

Yeztiani, O. L., Adrian, Q. J., & Aldino, A. A. (2022). Application of augmented reality as a learning media of Mollusca group animal recognition and its habitat based on android. *JURNAL TEKNOINFO*, 16(2022), 420-426. <https://ejurnal.teknokrat.ac.id/index.php/teknoinfo/index>

Yılmaz, R. M., & Göktaş, Y. (2018). Using augmented reality technology in education. *Cukurova University Faculty of Education Journal*, 47(2), 510-537.

Yoon, S. A., Anderson, E., Park, M., Elinich, K., & Lin, J. (2018). How augmented reality, textual, and collaborative scaffolds work synergistically to improve learning in a science Museum. *Research in Science & Technological Education*, 36(3), 261-281. <https://doi.org/10.1080/02635143.2017.1386645>

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