

LEARNM: AUGMENTED REALITY MOBILE APPLICATION IN LEARNING THE CONCEPTS OF BASIC BIOLOGICAL STRUCTURES

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ABSTRACT

This study explores the effectiveness of LearnM, an innovative augmented reality mobile application, in enhancing the comprehension and assimilation of molecular structures among Grade 12 Science, Technology, Engineering, and Mathematics (STEM) students. LearnM provides an immersive and interactive platform, allowing students to visualize and manipulate intricate three-dimensional models of molecular structures through their smartphones. By integrating cutting-edge augmented reality technology, LearnM seeks to surpass the traditional boundaries of textbook-based learning, offering an engaging and dynamic educational experience. The research design employed in this investigation is a quasi-experimental study with a pretest-posttest control group design. A cohort of 40 Grade 12 STEM students was selected, and participants were randomly assigned to either the experimental or control group. The experimental group utilized the LearnM application, while the control group received conventional instruction. Pretest and posttest assessments were administered to both groups, enabling a comprehensive analysis of the application's impact on learning outcomes. The significance of this research lies in its potential contribution to the body of knowledge in mobile learning and augmented reality, specifically in the context of molecular biology education. The integration of technology in education has become increasingly vital in the digital age, and this study aims to shed light on the effectiveness of such applications in enhancing students' understanding of complex scientific concepts.

Keywords: *Augmented Reality, Mobile Application, Molecular Biology, STEM Education.*

INTRODUCTION

On the advent of technology, novel learning strategies through the use of augmented learning emerge as a challenge where in developer are tasked to improve student learning and exploration. Advances in mobile Augmented Reality (AR) technology enable students and teachers to get a better understanding of basic biological systems through Augmented Reality

(AR) learning applications. Augmented reality enhances the actual environment by merging digital features with audio and visual input (Hayes, 2022). Many schools lack essential instructional tools to efficiently teach complicated topics like molecular biology. Students' increasing interest in virtual entertainment may be causing their declining engagement in studying. Molecular biology is an important field of study in the biological sciences, yet traditional approaches

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such as textbooks and seminars can be difficult to understand. The lesson basic biological structures were chosen as a focus due to the complexity of this topic for Grade 12 STEM students. Augmented Reality technology has the potential to transform molecular biology education by providing an interactive and immersive learning environment. Wu et al. (2018) and Chen et al. (2019) thoroughly investigated the application of Augmented Reality in education, revealing its efficacy in improving learning outcomes and student engagement. Augmented Reality (AR) delivers visual and interactive experiences that assist with understanding and information retention (Abdel-Rahman et al., 2018), including the development of interactive learning aids such as virtual flashcards for complicated subjects such as molecular biology (Manca & Ranieri, 2018). Flexible and easy learning experiences that are available at any time and from any location are provided by Mobile Augmented Reality applications. The increased possibility of innovative learning experiences is enhanced by the availability and affordability of mobile devices. Collaboration among engineers, AR/VR specialists, instructors, and education professionals is necessary for properly integrating AR technology (Elmqaddem, 2019). When implementing virtual 3-D visualizations in Augmented Reality (AR), careful consideration is necessary as their mere inclusion may not lead to the desired learning outcomes (Chang et al., 2022). Future study is needed to optimize the design and execution of 3-D visualizations for maximum learning advantages. Disadvantages for both teachers and students result from some educational institutions possessing a significant lack of instructional materials. In a study conducted by Mharjay Delacruz (2019), their public school (Bulacan State University) has a problem with the lack of classroom materials. This Capstone project's purpose is to create an Augmented Reality smartphone app based on molecular biology, especially basic biological structures. The program attempts to overcome the learning resource divide between public and private institutions by making use of Vuforia Studio, a renowned AR development platform. It aims to assist students through an interactive and

visually immersive learning experience in reviewing and understanding essential molecular biology concepts, hence increasing engagement. The use of augmented reality in the classroom improves retention through immersive experiences, interesting simulations, and enhanced engagement in the learning process.

OBJECTIVES OF THE STUDY

This study seeks to accomplish several objectives by the conclusion of the course. Firstly, the aim is to develop a prototype for an Augmented Reality mobile application with a specific focus on Molecular Biology, providing three-dimensional visual aids for enhanced learning. Secondly, the study intends to assess the effectiveness of the Augmented Reality application across various dimensions, including functionality, usability, reliability, and performance. The evaluation will contribute to understanding the overall impact and potential of the developed application in facilitating a comprehensive and effective learning experience in the field of Molecular Biology.

METHODOLOGY

This study employed a developmental quasi-experimental quantitative research design to examine how an augmented reality mobile application enhanced students' understanding of basic biological structures. The study involved conducting pre-assessment and post-assessment evaluations, as well as using a control group, to measure changes in the developmental outcomes of the intervention group compared to the control group.

A developmental quasi-experimental research design was utilized—a type of research design that involves manipulating an independent variable to measure the effects of that manipulation on a dependent variable, but without random assignment to groups. This design was chosen as random assignment was not feasible, given the nature of developmental or educational interventions (Shadish, Cook, & Campbell, 2018). The end-users of the study were the grade 12

students of Mapua Malayan Colleges Mindanao (MMCM) from the STEM Strand. The developers used a random sampling method to select the end-users for this study.

In this study, the developers utilized a FURPS type questionnaire as an assessment tool to evaluate the developed product. FURPS stands for Functionality, Usability, Reliability, Performance, and Supportability. It is a research assessment tool commonly used in software engineering to evaluate the quality of software products. The FURPS model proved to be an effective tool for assessing software quality attributes and identifying issues related to software development (Lane, n.d.).

The Agile methodology process model for augmented reality mobile applications represented an approach to designing and developing Augmented Reality mobile applications that emphasized collaboration, flexibility, and iterative development. This approach was particularly useful in developing Augmented Reality applications because the technology was still relatively new and evolving, necessitating an agile approach to keep up with changes and meet user expectations (Khan et al, 2021).

The product of this study utilized a combination of hardware and software tools. The developers used smartphones as the primary hardware tool to test and showcase the augmented reality applications, followed by a computer. The software tools used in the project included Vuforia Studio and Android Studio.

Table 1
System Development Tools

Hardware		
Development Tool	Description	Function
Android Smartphone	A cellular telephone that has a camera device for scanning and has the ability to run software applications.	Test the augmented reality mobile application prototype
Laptop/Computer	A programmable electronic device that can store, retrieve, and process data.	Use to write the source code and develop the mobile application
Software		
Vuforia Studio	Is a software development kit (SDK) for creating Augmented Reality applications	To create an augmented reality basic biological structure model. The main technology for developing augmented reality.
Android Studio	Provides a unified environment where you can build applications for Android phones	Where the source code will be written

Project Design. The learning flashcard, 5x7 inches in size, is intended to provide an interactive and interesting learning experience by combining visual and text-based information. The flashcard is made of a flat sintra board, which is a lightweight, strong, and rigid PVC foam board.

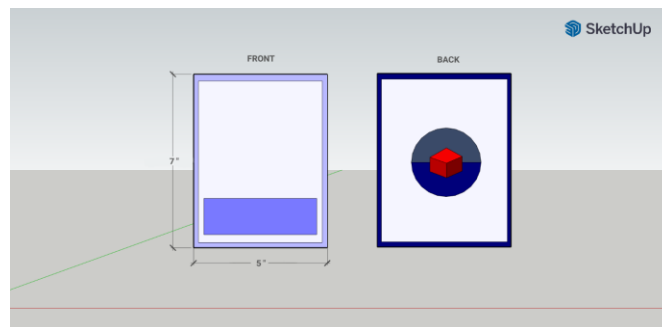


Figure 1. Front views of LearnM Flashcards

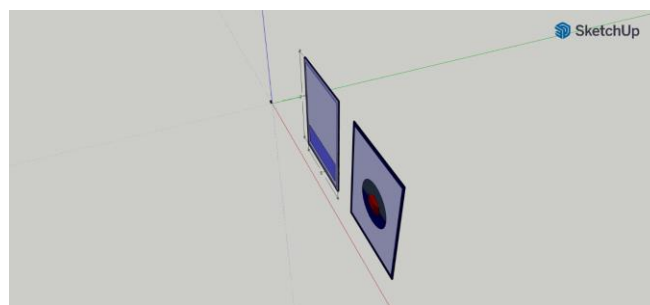


Figure 2. Top views of LearnM Flashcards

The augmented reality mobile application is powered by Unity studio and created in Vuforia studio. The application provides an immersive experience to learners by enabling them to interact with 3D models of basic biological structures and understand the complexities of chemical compounds through a visual and tactile experience. Students must have a smartphone with a compatible operating system and a camera and should hold the phone within 1.5 meters away from the flashcard for the augmented reality model to show up. The students can move, rotate, and resize the 3- 3-dimensional model, as well as trigger animations, sound effects, and specified descriptions for the model.



Figure 3 LearnM's Phone Application Blueprint

Table 2
LearnM's Application Requirement

LearnM: Application Details	
PHONE APPLICATION	
Operating System	Android version 8.0 'Oreo' and higher (API Level 26) (Not compatible with IOS)
Camera	Resolution at least 8 megapixels
Processor	Minimum speed of 1.8 GHz
Storage	200 MB of free storage space
Memory (RAM)	Memory (RAM) Minimum 2GB
Internet	No internet connection is required for software activation
Flash Card	<ul style="list-style-type: none"> Printed card for animal cell Printed card for plant cell Each card should have at least 3 inches Length and 2 inches Width dimension. The surroundings should be well-lighted when scanning

RESULTS AND DISCUSSION

1. The effectiveness of the Augmented Reality prototype application

1.1 Functionality of the Augmented Reality prototype application

Table 3
The descriptive statistics of the functionality of the Augmented Reality prototype application

	Mean	Std. Deviation	Variance
Can the application perform the tasks required?	4.100	0.803	0.645
Is the result as expected?	4.167	0.834	0.695
Quality of the three-dimensional molecular structure	3.833	1.085	1.178
Animation of the three-dimensional model	3.667	1.269	1.609
Accuracy of Scanning	3.633	1.033	1.068

Table 3 exhibits the results of a survey conducted to evaluate the functionality of the LearnM mobile application. The survey users were asked to rate the application's performance

on a scale of 1 to 5, with 1 being the lowest score with a result interpretation of "Strongly Disagree" and 5 being the highest score with a result interpretation of "Strongly Agree". The following are the interpretations of the results based on the means, standard deviation, and variance of each question under the functionality of LearnM.

The first question, "Can the application perform the tasks required?", with a mean score of 4.100 indicates that the users generally believe that the application can perform the required tasks. The standard deviation of 0.803 and variance of 0.645 suggest that there is relatively low variability in the responses, indicating that the users were generally in agreement about the application's functionality. Additionally, the second question "Is the result as expected?" has a mean score of 4.167 suggests that the respondents generally believe that the results of using the application were as expected. Questions 3,4, and 5 which have a mean = 3.833, mean = 3.667, and mean = 3.633 respectively indicate that the users were moderately satisfied with LearnM when it comes to its quality, animations, and scanning.

Overall, the data shows that users generally have positive opinions of the LearnM mobile application, with the majority of the mean ratings lying between 3 and 4. Although there is some variation in the responses, as shown by the standard deviations and variances, some users may have had more positive or negative experiences with certain aspects of the application's functionality.

1.2. Usability of the Augmented Reality Prototype Application

Table 4
The descriptive statistics of the usability of the Augmented Reality prototype application

	Mean	Std. Deviation	Variance
Does the user comprehend how to use the application easily?	4.033	0.964	0.930
Can the user learn to use the application easily?	4.133	0.937	0.878
Does the interface look good?	3.200	1.349	1.821

Table 4 displays the results of a survey conducted to evaluate the Usability of the LearnM mobile application. The survey users were asked to rate the application's



performance on a scale of 1 to 5, with 1 being the lowest score with a result interpretation of "Strongly Disagree" and 5 being the highest score with a result interpretation of "Strongly Agree". The following are the interpretations of the results based on the means, standard deviation, and variance of each question under the Usability of LearnM.

The first question, "Does the user comprehend how to use the application easily?", obtained a mean score of 4.033. This indicates that respondents appeared to agree that the application was simple to use in general. The comparatively low variance (0.930) and standard deviation (0.964) values suggest that there was not much difference in the respondents' ratings of ease of use. The second question, "Can the user learn to use the application easily?", obtained a mean score of 4.133. This indicates that most respondents believed the application was easy to learn. The variance (0.878) and standard deviation (0.937) figures were likewise rather low, showing little difference in the responses from the respondents. The third question, "Does the interface look good?" had a mean score of 3.200, indicating that respondents had a more mixed opinion of the interface's visual design. The significantly higher standard deviation (1.349) and variance (1.821) numbers indicate that there was a wider range of opinions on the visual appeal of the interface. These results reveal that the LEARNM application is well-designed and user-friendly in general, but the visual design of the interface might be improved to better appeal to users with numerous aesthetic preferences.

1.2. Reliability of the Augmented Reality prototype application

Table 4

The descriptive statistics of the reliability of the Augmented Reality prototype application

	Mean	Std. Deviation	Variance
Is the application capable of handling errors?	3.133	1.279	1.637
Can the software resume working and restore lost data after failure?	3.067	1.143	1.306

The table provides the results of the survey conducted to evaluate the reliability of the LearnM mobile application. Users were requested to rate the app's performance on a scale of 1 to 5, with 1 representing "Strongly Disagree" and 5 representing "Strongly Agree." Based on the means, standard deviation, and variance of each question, the following interpretations were made regarding the Reliability of LearnM.

The first question, "Is the application capable of handling errors?" had a mean score of 3.133, indicating that users believe the application is capable of handling errors. However, the standard deviation was 1.279 and the variance was 1.637, indicating that the survey participants' responses were somewhat varied. This means that some respondents strongly agreed with the statement, while others strongly disagreed or were somewhere in the middle. The second question, "Can the software resume working and restore data after failure?", had a mean of 3.067, which indicates that the users generally neither strongly agreed nor strongly disagreed with the statement and that the reliability of this application is just satisfactory to them. The standard deviation was 1.143 and the variance was 1.306, indicating that there was moderate variation in the survey participants' responses. This suggests that some users had more positive or negative experiences with the software's capacity to resume working and restore data after a failure, and others had more neutral experiences.

The application's reliability was just acceptable. This can be interpreted as a moderately positive rating with room for improvement. In a study conducted by Billingham and Kato (2022), they highlighted that it is possible for Augmented Reality applications to experience 3D objects that do not always connect well with learners and work as intended, which results in content glitches.

1.3. Performance of the Augmented Reality Prototype Application



Table 5

The descriptive statistics of the performance of the Augmented Reality prototype application

Descriptive Statistics			
	Mean	Std. Deviation	Variance
Does the application utilize resources efficiently?	3.400	1.404	1.972
Does the application respond quickly?	3.267	1.230	1.513

Table 5 shows the outcomes of a survey aimed at assessing the performance of the LearnM mobile application. Survey participants were requested to score the application's performance on a scale of 1 to 5, where 1 represents the lowest score, indicating "Strongly Disagree," and 5 represents the highest score, indicating "Strongly Agree." Based on the mean, standard deviation, and variance of each question, the survey results were interpreted to evaluate the performance of the LearnM application.

The first question, "The application responds quickly" had a mean of 3.267, meaning the application's response is satisfactory. The same goes for the second question which states that the application utilizes resources adequately. The low standard deviation and variance means that there is only a slight difference from the responses of each alpha-tester. Although the application functions just okay, there are a few setbacks on the performance, this is analogous to (Barto, 2021) which states that Augmented Reality systems can sometimes experience issues with the connection between 3D objects and learners, causing glitches in the content and preventing it from working as intended.

1.4. Average Mean of FURP

Table 6

Average mean of FURP of LearnM

	Mean	Std. Deviation	Variance
FUNCTIONALITY	3.880	NaN	NaN
USABILITY	3.100	NaN	NaN
PERFORMANCE	3.333	NaN	NaN
RELIABILITY	3.789	NaN	NaN

The functionality, usability, reliability, and performance of the LearnM application were evaluated in accordance with the findings shown in the table. The mobile application has an excellent level of functionality, as indicated by the mean functionality score of 3.880 out of 5. However, the average usability score is only 3.100, indicating that there may be some issues with the application's usability and user experience. The application's reliability score, which is now 3.789 on average, shows that it is relatively reliable. The average performance score is 3.333, which indicates that there may be some room for improvement in the application's speed and responsiveness.

Overall, results of the FURP survey suggest that the LearnM mobile application has an outstanding degree of functionality and reliability. While the usability and performance of the mobile application may have concerns that need to be resolved to enhance the overall interaction. It is essential to remember that these test findings may not accurately reflect the experiences of all users with the program because they are based on a small sample. Nevertheless, these results offer insightful information about the components of the mobile application that need additional research and development to improve their overall effectiveness and ease of use.

CONCLUSIONS

The evolution of an Augmented Reality (AR) mobile application shows great promise as a valuable tool, especially for Biology enthusiasts seeking three-dimensional visual aids. The survey findings highlight the LearnM mobile app's exceptional usefulness and dependability. However, there is a need to address certain user experience issues by improving the application's performance and usability.

When extrapolating such results to the whole user population, it is important to keep in mind the researchers concluded the results based on a small sample size. Nevertheless, the study provides significant insights into areas

that require further enhancement in both the efficacy and usability of the app's components. Through interactive and experimental technology, this application has the potential to significantly enhance students' understanding of Basic Cellular Structures, motivating them to explore the subject beyond traditional textbooks.

RECOMMENDATION

The capstone project findings indicate significant potential in the LearnM mobile application for enhancing students' comprehension of basic biological structures. Augmented reality (AR) integration has positively impacted user engagement and understanding. The researchers suggest including a user-friendly voiceover feature in order to promote inclusion and assist impaired and students with disabilities. This addition aims to provide visually impaired students and those with reading disabilities equal access to the interactive learning experience. The voice-over should offer clear and concise descriptions, emphasizing key concepts and properties. Careful consideration of the voice-over's pace and tone is essential for optimal comprehension and engagement. Collaboration with accessibility and assistive technology experts is advised to ensure effective implementation. Their insights and guidance can foster an inclusive learning environment within the LearnM app. Usability testing and feedback from impaired individuals are crucial steps to refine the voice-over feature and enhance its effectiveness.

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studies. Besides her academic achievements, Andrea possesses a deep passion for the arts. She loves exploring her creative side by indulging in music, experimenting with cosmetics, and expressing herself through various forms of artistic expression.



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Fergievon Alaika B. Teves is a senior high school graduate of Mapua Malayan Colleges Mindanao in Davao City under the STEM program and is currently enrolled in Ateneo De Davao University, taking up the Bachelor of Science in Computer Engineering program. She is known for her exceptional academic performance and active participation in different events, clubs, and organizations. She graduated with high honor recognition and was the top 1 student in her class section. Furthermore, she actively volunteers and engages in community service with local organizations such as SheLead and the Youth Organization of Purok 29 in General Santos City.



Andrea Nicole Torres is an 18-year-old upcoming freshman at Mapua Malayan Colleges of Mindanao, where she's eagerly embarking on her journey to become an architect. Throughout her high school and senior high school years, she achieved honor awards, showcasing her dedication to her



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