GEOSPHERE: A MOBILE AUGMENTED REALITY APPLICATION FOR ENHANCING GRADE 10 STUDENTS' ACADEMIC PERFORMANCE IN THE FIELD OF GEOLOGY

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Abstract: Earth Science is important in helping students understand the planet and the natural processes that shape it. However, Grade 10 students may find plate tectonics difficult to understand because many concepts are hard to imagine using traditional learning materials. This study aimed to develop and evaluate GeoSphere, a mobile augmented reality application for learning geology. A quantitative descriptive approach was used, involving 20 Grade 10 students, two Science teachers, and five IT experts. The system was evaluated using ISO/IEC 25010:2023 standards, focusing on functional suitability, usability, reliability, and performance efficiency. Results showed strong user satisfaction, with an overall mean of 4.49. Functional suitability received the highest mean of 4.67, while performance efficiency and usability scored 4.62 and 4.60. Reliability received the lowest mean of 4.29, showing that some improvements are still needed. Overall, the results showed positive respondent evaluations of the application, particularly in functional suitability, performance efficiency, and usability. The findings suggest that GeoSphere has potential as a learning support tool for presenting plate tectonics concepts. Future developers may improve device support and system reliability.

Keywords: augmented reality, mobile learning, Earth Science, plate tectonics, GeoSphere

INTRODUCTION

Earth science allows students to gain an understanding of the planet and the natural processes that are constantly reshaping it. But subjects like plate tectonics can be difficult when instruction is mostly textbooks and classroom discussion. Students can have difficulty visualizing moving plates, plate boundaries, landforms, and the interior layers of the Earth. These difficulties may affect both comprehension and interest. In the study by Hidayat and Wardat (2023), the effectiveness of augmented reality in education may vary based on the learning context and subject area. Additionally, the length of time spent on technology-based activities might impact learning outcomes.

Mobile learning and game-based activities are also part of technology-based learning. Wang et al. (2023) studied a mobile augmented reality learning system demonstrating how mobile devices can offer interactive learning experiences and easier access to digital materials. Digital game-based learning may support achievement in STEM subjects, Wang et al. (2022), and teachers' planning and implementation of digital game-based learning has been examined, Hayak & Avidov-Ungar (2023). Similarly, Camuñas-García et al. (2022) confirmed the educational value of mobile game-based learning, and Kula (2021) showed that the teachers recognized the use of interactive games for supporting learner engagement.

The interest in educational technology is increasing, but students in Grade 10 who take up plate tectonics at Colegio de San Juan de Letran Calamba need learning tools that are appropriate to their context. Thus, this study investigates GeoSphere, a mobile augmented reality application that reveals plate boundaries, processes, landforms, and Earth's internal structure using interactive 3D content, quizzes, and progress tracking to facilitate learning and teacher monitoring.

Literature Review

Previous studies suggest that technology can strengthen science learning by giving students more opportunities to observe, explore, and interact with lesson content. Hidayat and Wardat (2023) reviewed the use of augmented reality in STEM education and demonstrated the growing interest in using this technology to support learning. In science classrooms, augmented reality can help students examine concepts that may be difficult to observe or imagine through traditional

instructional materials. Kalemkuş and Kalemkuş (2022) examined the effects of augmented reality applications on students' academic achievement in science education and found that AR-supported learning positively influenced student achievement. These findings indicate that augmented reality can provide a more interactive way for students to explore scientific concepts while supporting their understanding of lessons. Yenioğlu et al. (2023) similarly showed that augmented reality can encourage students to engage more actively with science lessons and explore learning content in meaningful ways. Collectively, these studies suggest that technology can make science learning more active, engaging, and accessible to students.

Visual learning tools are also valuable when students need to understand objects, spaces, and processes that are difficult to imagine using conventional instructional materials. Castro et al. (2021) and Chaker et al. (2021) both found that 3D models can support teaching, learning, and student motivation. Similarly, Teplá et al. (2022) showed that 3D models and animations can increase students' interest and motivation in natural science subjects, including Geology. Chen et al. (2022) also demonstrated that 3D-based learning activities can provide students with greater opportunities to interact with and explore concepts in ways that ordinary classroom materials may not easily provide. Hain and Motaref (2023) further found that augmented reality can improve students' understanding by offering clearer and more interactive ways to view concepts that are difficult to visualize.

In Earth Science, Conrad and Libarkin (2021) focused on students' understanding of plate tectonics and emphasized the importance of addressing misconceptions that may affect learning. McLaughlin and Bailey (2023) reviewed research on spatial thinking in geoscience education and highlighted the value of modelling and other forms of spatial representation. Their findings suggest that students need regular opportunities to practice understanding geological concepts in three-dimensional ways. Barth-Cohen and Braden (2021) also emphasized the importance of developing students' observation skills when learning geological concepts and interpreting Earth's features. These findings are relevant to the present study because GeoSphere uses augmented reality and interactive 3D content to help students explore plate boundaries, related landforms, and the internal structure of the Earth.

Technology-based learning can also incorporate mobile devices, augmented reality, and game-based activities. Wang et al. (2023) explored a mobile augmented reality learning system and found that interactive features and feedback can support students' learning experiences and improve their perceptions of learning. Albahli (2023) suggested that mobile learning can support educational activities by giving learners flexible access to instructional materials through their devices. Adipat et al. (2021) likewise explained that game-based learning can encourage students to become more active participants by engaging directly with lesson activities. Mobile augmented reality also allows students to access interactive learning materials through devices they already use and understand.

Gnanasagaran et al. (2023) highlighted that students' readiness to use mobile learning is an important consideration when mobile devices are integrated into the learning process. Casebourne (2024) also emphasized that the effectiveness of mobile learning depends on the context in which learners use their devices, highlighting the importance of considering how mobile technologies fit within actual learning environments. Wang, L.-H., Chen, B., Hwang, G.-J., Guan, J.-Q., and Wang, Y.-Q. (2022) reviewed mobile game-based learning in STEM education, while Hayak and Avidov-Ungar (2023) examined how teachers plan and implement digital game-based learning in classrooms.

Taken together, these studies show that mobile applications, interactive activities, quizzes, and immediate feedback can encourage students to participate actively and monitor their own understanding. Huang (2022) suggested that learners' anticipated emotions can influence mobile learning outcomes, indicating that enjoyable and engaging experiences may contribute to positive responses. Shi (2022) further found that the pedagogical role assigned to mobile users can influence science learning outcomes, emphasizing that mobile devices become more meaningful when interactive features are connected to clear educational activities and purposes.

Overall, existing studies support augmented reality, mobile devices, 3D models, and game-based learning. However, limited attention has been given to a mobile application combining these features for Grade 10 students learning plate tectonics in the local context of Colegio de San Juan de Letran Calamba. This study addresses this gap through GeoSphere, which combines augmented reality, interactive 3D content, quizzes, and progress tracking to support Earth Science learning. The literature also emphasizes that technology becomes most effective when aligned with clear learning goals and the actual needs of students and teachers within their classroom environment.

Significance of the Study

This study is significant because it may provide a more engaging way of teaching and learning plate tectonics through the GeoSphere mobile augmented reality application. Grade 10 students may benefit from clearer visual learning, interactive activities, quizzes, and progress tracking. Teachers may gain another tool for presenting difficult Earth Science topics and monitoring student learning. Colegio de San Juan de Letran Calamba may use the findings as a basis for improving technology use in science instruction. Finally, future researchers and developers may use the study as a reference for creating or improving educational applications for Earth Science and other subjects.

Objectives of the Study

The general objective of this study is to design, develop, and evaluate GeoSphere, a mobile augmented reality application that supports Grade 10 students in learning plate tectonics and support learning and improve the learning experience. Specifically, the study aims to: (1) develop interactive augmented reality and 3D learning content about plate boundaries, related processes and landforms, and the Earth's internal structure; (2) include quizzes and game-based activities to support learning and assessment; (3) provide students and teachers with a way to track learning progress; and (4) evaluate the application based on functional suitability, performance efficiency, compatibility, usability, reliability, and security.

METHODOLOGY

Research Design

This study used a quantitative descriptive research design to evaluate the GeoSphere mobile augmented reality application based on the experiences and assessments of Grade 10 students, Science teachers, and IT experts. The evaluation focused on the application's functional suitability, performance efficiency, compatibility, usability, reliability, and security using the criteria of ISO/IEC 25010:2023.

Participants and Sampling Technique

The participants were Grade 10 students from Colegio de San Juan de Letran Calamba who were enrolled in Earth Science. Selected students used the GeoSphere AR application during geology learning activities, particularly those related to plate tectonics. The application was designed to help make difficult topics easier to understand and more interesting. Two Earth Science teachers were also included and completed surveys based on their observations of student learning and participation. The study used stratified random sampling. Students were grouped according to their class sections, specifically the BEC and SSC sections. Ten students were randomly selected from each section, resulting in a total of 20 student respondents. The study also gathered the opinions of five IT experts regarding the possible benefits and challenges of using an AR application in schools. These different perspectives helped provide a broader view of how GeoSphere may support Earth Science learning.

Research Instrument

The study used a researcher-made evaluation questionnaire based on the applicable quality characteristics of ISO/IEC 25010:2023. The questionnaire evaluated GeoSphere in terms of functional suitability, performance efficiency, compatibility, usability, reliability, and security. A five-point Likert scale was used to gather the respondents' evaluations.

Table 1. Geosphere Respondents

Respondents	
Grade 10 Students	20
Science Teachers	2
IT Experts	5
Total Number of Respondents	**27**

Data Gathering Procedure

Information regarding the GeoSphere application was gathered for this study through surveys. Grade 10 students, Earth Science instructors, and IT specialists from Colegio de San Juan de Letran Calamba responded to questionnaires based on their perspectives and experiences. Students provided feedback regarding their learning preferences, difficulties encountered while using the application, and their understanding of Earth Science lessons. Earth Science instructors evaluated how GeoSphere could support instruction and student learning. IT specialists assessed the application's usability, ease of use, performance, and overall functionality. The responses gathered through the questionnaires were used to identify the strengths, limitations, and areas for improvement of the GeoSphere application.

Data Analysis Procedure

A five-point Likert scale was used to assess the GeoSphere application in order to gain insight into the thoughts and experiences of both teachers and students. The scale assessed user satisfaction, usability, and the usefulness of the application's learning features. Outstanding, Very Satisfactory, Satisfactory, Fair, and Poor were the corresponding interpretations for the five (Strongly Agree), four (Agree), three (Neutral), two (Strongly Disagree), and one (Strongly Disagree) responses. This made it easier to pinpoint the application's advantages and potential areas for development.

Based on ISO/IEC 25010, the evaluation also took into account six key areas. Functional suitability, performance efficiency, compatibility, usability, reliability, and security are a few of these. These areas looked at whether GeoSphere offers accurate and helpful learning materials, functions well, can be used on compatible devices, is simple to use, performs consistently, and safeguards user data. The overall goal of the evaluation was to ascertain whether GeoSphere could offer Grade 10 geology students a useful, interesting, and reliable learning experience

Table 2. Five-Point Likert Scale

Numerical Rating	Rating Scale	Verbal Interpretation
5	4.20 - 5.00	Strongly Agree (SA)
4	3.40 - 4.19	Agree (A)
3	2.60 - 3.39	Neutral (N)
2	1.80 - 2.59	Disagree (D)
1	1.00 - 1.79	Strongly Disagree (SD)

Ethical Considerations

The study will follow ethical guidelines to guarantee everyone's safety. The goal and methods of the study will be explained to participants prior to the start of data collection, and they will always have the choice to decline or withdraw. It will be entirely voluntary to participate. The data and reports will not contain names or personal information. Only the researchers will have access to all information, which will be kept confidential. The results will be summarized and utilized exclusively for scholarly purposes. After transcription, the interview recordings will be securely stored and erased.

RESULTS AND DISCUSSION

Weighted Mean of System Performance Efficiency

The results show a positive learning experience. The weighted mean of 4.65 shows that respondents strongly agree that the AR features help engage and improve their learning. Visualizations received a mean of 4.75 for being clear and interactive, while quizzes received 4.60 for being accessible and easy to use. Gris and Bengtson (2021) emphasized the importance of using appropriate assessment measures in game-based learning to evaluate how interactive activities and quizzes support the learning experience.

Table 3. Weighted Mean of System Performance Efficiency

Questions	Mean	Interpretation
1. The AR features are engaging and effectively enhance the learning of plate tectonics concepts.	4.65	Strongly Agree
2. The visualizations, including 3D models, animations, and simulations, are clear, interactive, and accurate in delivering educational content.	4.75	Strongly Agree
3. The application's quizzes and gamified features are accessible, user-friendly, and motivate students to improve their learning performance.	4.60	Strongly Agree
Mean	**4.67**	**Strongly Agree**

Weighted Mean of System Functional Suitability

The application received a high overall mean of 4.62. Users found it easy to navigate, with a weighted mean of 4.60. The gamified quizzes scored 4.65 for motivation and enjoyment, while the leaderboard scored 4.60 for helping improve performance. These results show a positive learning experience. Zeng et al. (2024) found that gamification has a moderately positive effect on students' academic performance.

Table 4. Weighted Mean of System Functional Suitability

Questions	Mean	Interpretation
1. During interactive learning sessions, the system's response time is adequate for real-time rendering of 3D models, animations, and simulations.	4.60	Strongly Agree
2. Resource utilization of the application is optimized for smooth performance while rendering complex visualizations and running quizzes.	4.65	Strongly Agree
3. The system effectively handles simultaneous operations of interactive simulations, quizzes, and real-time user inputs without lag or performance degradation.	4.60	Strongly Agree
Mean	**4.62**	**Strongly Agree**

Weighted Mean of System Compatibility

The system showed good compatibility, with an overall mean of 4.48, interpreted as Strongly Agree. It worked smoothly across multiple devices, with a weighted mean of 4.4, and its features were also accessible on different devices, scoring 4.4. Integration with classroom technologies received the highest score of 4.65. These results show strong user satisfaction. According to Omer (2021), compatibility helps learners access and use courses smoothly.

Table 5. Weighted Mean of System Compatibility

Questions	Mean	Interpretation
1. The system operates seamlessly across multiple mobile devices and platforms (e.g., Android).	4.40	Strongly Agree
2. The application's features, including 3D models and quizzes, are accessible and functional on various devices (e.g., smartphones, tablets).	4.40	Strongly Agree
3. The application integrates well with existing classroom technologies and infrastructure, ensuring smooth performance during educational use.	4.65	Strongly Agree
Mean	**4.48**	**Strongly Agree**

Weighted Mean of System Usability

The system was found easy and pleasant to use. Its interface received a weighted mean of 4.55, while the clear 3D models, simulations, and quizzes received 4.75. The simplicity of the content, instructions, and feedback received 4.50. These results show that the system supports learning well for Grade 10 students and teachers. Similarly, Hain and Motaref (2023) found that augmented reality can make difficult concepts easier for learners to understand by allowing them to view and interact with the content more clearly. This supports the positive evaluation of Geosphere's usability, as its interactive features and visual content helped users understand and navigate the application more easily.

Table 6. Weighted Mean of System Usability

Questions	Mean	Interpretation
1. The user interface is intuitive and easy to navigate for Grade 10 students and teachers with varying levels of technical expertise.	4.55	Strongly Agree
2. The system provides clear and understandable visualizations of 3D models, simulations, and quizzes to support learning.	4.75	Strongly Agree
3. The educational content, including instructions and feedback, is simple to interpret and effectively guides users through interactive simulations and quizzes.	4.50	Strongly Agree
Mean	**4.60**	**Strongly Agree**

Weighted Mean of System Reliability

Geosphere was generally reliable, though some areas still need improvement. Users gave a weighted mean of 3.48 for uninterrupted operation, 4.65 for accurate teacher feedback, and 3.75 for 3D models, animations, and simulations. These results show good performance with occasional issues. Gris et al. (2021) emphasized that reliability, validity, engagement, and usability should be carefully measured to strengthen evidence of learning effectiveness.

Table 7. *Weighted Mean of System Reliability*

Questions	Mean	Interpretation
1. The system operates without unexpected failures or interruptions during continuous use, ensuring smooth and uninterrupted learning sessions.	3.48	Agree
2. The application consistently delivers accurate feedback from teachers on students' performance in quizzes and interactive simulations without errors or	4.65	Strongly Agree

delays.		
3. The system reliably renders 3D models, animations, and simulations without frequent crashes or performance issues during use.	3.75	Agree
Mean	**4.29**	**Strongly Agree**

Weighted Mean of System Security

The security evaluation received positive results. Preventing unauthorized modifications and enforcing access controls both received a mean of 4.30, while secure storage and protection of user data received a mean of 4.35. The overall security mean was 4.31

Table 8. Weighted Mean of System Security

Questions	**Mean**	**Interpretation**
1. The system prevents unauthorized modifications or tampering with educational content and user data.	4.30	Strongly Agree
2. The system enforces strict access controls, accurately validating user credentials to ensure that only authorized students and teachers can access specific features and information.	4.30	Strongly Agree
3. The system ensures secure storage and protection of user data and educational progress from unauthorized access.	4.35	Strongly Agree
Mean	**4.31**	**Strongly Agree**

Overall Weighted Mean System Evaluation Result

Based on ISO 25010:2023, Table 9: Overall Weighted Mean System Evaluation Result, the system received an overall mean of 4.49, showing strong user satisfaction. Performance Efficiency had the highest mean of 4.67, while Functional Suitability scored 4.62. Usability also received a high mean of 4.60, showing that users found the system easy to use. Compatibility scored 4.48, while security received 4.31. Reliability had the lowest mean of 4.29, although it remained positive and may need improvement. Overall, the results show that the system meets user needs and follows ISO 25010:2023 standards.

Table 9. Overall Weighted Mean System Evaluation Result

ISO 25010:2023 STANDARDS	**Mean**	**Interpretation**
1. Functional Suitability	4.62	Strongly Agree
2. Performance Efficiency	4.67	Strongly Agree
3. Compatibility	4.48	Strongly Agree
4. Usability	4.60	Strongly Agree
5. Reliability	4.29	Strongly Agree
6. Security	4.31	Strongly Agree
Mean	**4.49**	**Strongly Agree**

Conclusion

The evaluation results showed that respondents generally viewed the GeoSphere mobile application as a useful and engaging learning tool for presenting geology concepts, particularly plate tectonics. Its interactive features, including visual models, short descriptions, quizzes, and a leaderboard, helped make topics such as plate boundaries, landforms, and the structure of the Earth easier for students to explore and more interesting to learn.

The evaluation also identified areas that still need improvement. Some users experienced problems when using the application on older devices, and the feedback suggested that additional user guidance and better system performance may be needed. Despite these concerns, respondents generally found the application more engaging than traditional classroom materials because it allowed them to interact directly with concepts that are often difficult to visualize.

The results further showed that the system was generally easy to use and provided sufficient protection for user information. Overall, the evaluation findings suggest that GeoSphere has potential as a supplementary learning tool for presenting plate tectonics in an interactive and visual way. Future development may focus on improving device compatibility and system performance, adding more lessons and learning content, and including features such as progress reports and additional customizable learning tools.

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