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INNOVATION IN ACTION: TURNING IDEAS INTO REALITY

Chapter 6
Breaking Boundaries: eXploreAR Science Transforms Learning Beyond the Lab

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ABSTRACT
eXploreAR Science is an innovative Augmented Reality (AR)-powered learning tool featuring interactive eXploreAR Science is an innovative Augmented Reality (AR)-powered learning tool featuring augmented pages designed to improve students' understanding of abstract scientific concepts in secondary-level science education. This digital tool addresses limitations in traditional lab-based learning through immersive simulations, 3D animations, and interactive quizzes. A pilot study involving 45 secondary students showed significant improvement in conceptual understanding based on pre- and post-test results, with average scores rising from below 40 to between 85 and 100 marks. This suggests strong potential for scalable implementation in various learning environments, making science education more inclusive, engaging, and effective. Designed to improve students' understanding of abstract scientific concepts in secondary-level science education. This digital tool addresses limitations in traditional lab-based learning through immersive simulations, 3D animations, and interactive quizzes. A pilot study involving 45 secondary students showed significant improvement in conceptual understanding based on pre- and post-test results, with average scores rising from below 40 to between 85 and 100 marks. This suggests strong potential for scalable implementation in various learning environments, making science education more inclusive, engaging, and effective.

Key Words: Augmented Reality, STEM Education, Interactive augmented pages, Linear Motion, Digital Learning

1. INTRODUCTION

Science education often faces challenges when students lack access to laboratory setups and hands-on resources, limiting their ability to visualise and grasp complex scientific principles. When students lack access to laboratory setups, these limitations hinder students'

ability to visualise and understand abstract scientific principles. eXploreAR Science addresses this issue through an innovative digital solution powered by Augmented Reality (AR). This approach transforms science learning into an engaging and accessible experience that enhances comprehension while being cost-effective and scalable across diverse educational settings.

2. LITERATURE REVIEW

The use of Augmented Reality (AR) in STEM education has grown due to its capacity to improve student outcomes. AR enables learners to visualise abstract concepts and interact with virtual elements, bridging the gap between theoretical content and practical understanding. Akçayır and Akçayır (2017) found AR significantly enhances motivation and comprehension in science topics. Bacca et al. (2014) further demonstrated that AR improves learning performance and engagement through immersive learning.

Ibáñez and Delgado-Kloos (2018) noted AR's ability to develop spatial reasoning and conceptual understanding in physics. Integrated with mobile technology, AR aligns with constructivist learning theories, offering hands-on digital experimentation. Radu (2014) emphasised AR's adaptability for inclusive education, supporting diverse learning styles with multimodal content (text, audio, animation). These findings support AR tools like eXploreAR Science in promoting deeper learning and broader accessibility in science education.

3. METHODOLOGY

eXploreAR Science was developed to support core science concepts, integrate multimedia content and 3D simulations to aid understanding across a wide range of scientific topics. AR-enhanced pages were created to overlay animations for accessibility via mobile devices. These pages also include interactive quizzes and simulations to engage students actively.

A pre-test and post-test design was implemented to evaluate the tool's effectiveness. A pilot study was conducted in a school environment, where students interacted with the AR materials and provided feedback for improvement. Development tools included an AR-enabled mobile app, 3D models and animations, interactive assessments, and mobile devices, such as smartphones and tablets.

3.1. DEMOGRAPHIC

The pilot involved 45 polytechnic-level students enrolled in science courses. This demographic was chosen to reflect the educational level most likely to benefit from improved conceptual visualisation.

Students first completed a pre-test to establish baseline knowledge. They then used the eXploreAR Science modules, combining digital AR experiences with traditional lab experiments. This blended model allowed students to connect theory with practice.

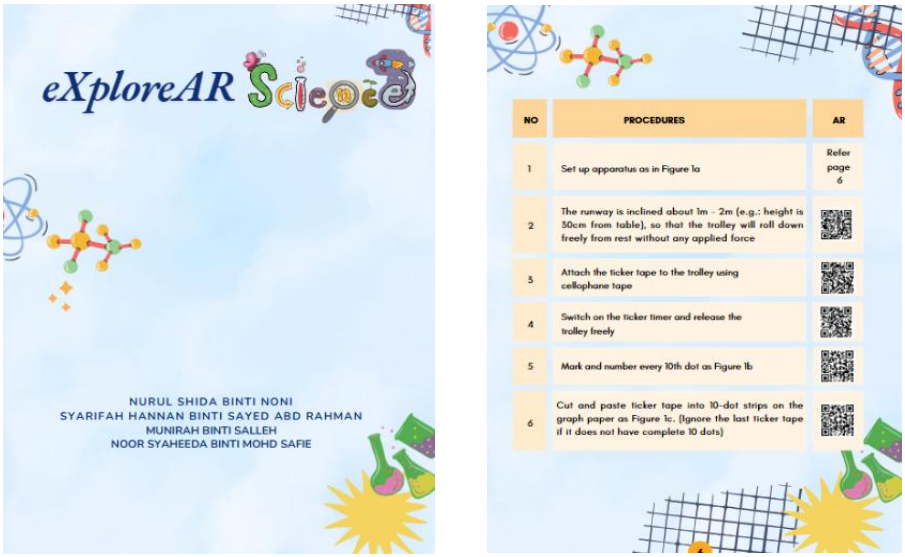

Figure 2: Example of Augmented Pages Used in eXploreAR Science

Figure 2: Students using eXploreAR Science

4. RESULTS

After the learning sessions, students completed a post-test. Comparative analysis showed a marked improvement. Many students initially scored below 40 marks, with some as low as 10 or 20. Post-test results ranged predominantly between 85 and 100 marks.

To quantify this improvement, the average pre-test score across the group was 31.6 with a standard deviation of 9.2, meanwhile, the average post-test score increased to 89.4 with a standard deviation of 6.8. This indicates a mean gain of 57.8 marks, which shows an average percentage improvement of approximately 183%. These statistical results support the effectiveness of eXploreAR Science in significantly enhancing students' academic

achievement in science. Many students initially scored below 40 marks, with some as low as 10 or 20. Post-test results ranged predominantly between 85 and 100 marks.

This significant gain highlights the value of interactive AR content in improving conceptual understanding. The tool helped students internalise abstract physics concepts through visual and immersive elements. Combining AR simulations with hands-on labs addressed various learning preferences, enriching the educational experience.

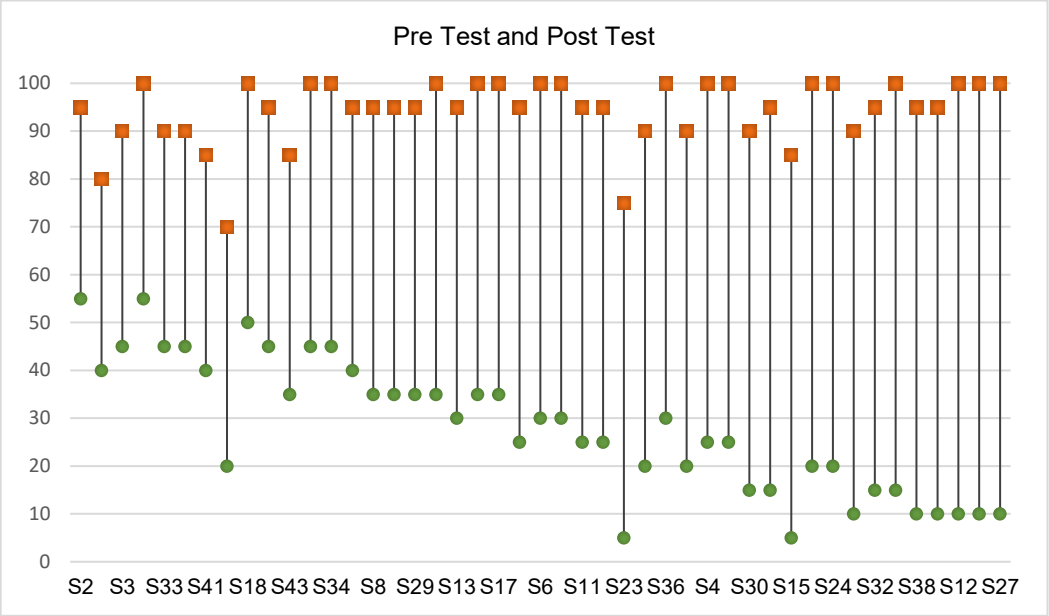

Figure 3: Comparison of Students' Pre-Test and Post-Test Scores

The graph (Figure 3) clearly illustrates consistent score improvements across all students. The green dots represent pre-test scores, while the orange squares represent post-test scores. Every participant showed progress, some by as much as 70 to 80 marks, indicating effective bridging of conceptual gaps.

5. CONCLUSION

eXploreAR Science significantly improved student understanding of science concepts through its AR-enhanced, interactive design. This innovation promotes active learning, better visualisation, and inclusive access to science education, especially where lab resources are scarce.

The pilot study validates eXploreAR Science as a scalable educational tool. Future iterations may expand to additional scientific topics and incorporate real-time feedback for

personalised learning. Further research can explore long-term impacts and broader curriculum integration.

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