Chapter 11
Augmented Reality Learning Tool for Learning Electric Circuit Topics on Engineering Students

Aldo Uriarte-Portillo
https://orcid.org/0000-0001-7812-962X
TecNM-Instituto Tecnológico de Culiacán, México

Ramon Zatarain-Cabada
https://orcid.org/0000-0002-4524-3511
TecNM-Instituto Tecnológico de Culiacán, México

María Lucía Barron Estrada
https://orcid.org/0000-0002-3856-9361
TecNM-Instituto Tecnológico de Culiacán, México

Luis Marcos Plata-Delgado
TecNM-Instituto Tecnológico de Culiacán, México

ABSTRACT

Studying complex topics in engineering, such as "Electric Circuits" and "Ohm's Laws," frequently presents challenges for students and can affect their motivation. Although some technological tools are used for learning management, they are not always effective in fully engaging students. This study aims to enhance the learning experience for first-year higher students by incorporating Augmented Reality (AR) technology. AR provides an interactive platform that helps students grasp and apply complex concepts at their own pace, supported by fuzzy logic techniques that adapt to individual learning interactions. Analysis using pretest-posttest comparisons and motivation surveys reveals that integrating AR with fuzzy logic significantly improves learning outcomes and increases student motivation. Students who engage with AR to visualize and interact with abstract concepts experience greater learning gains and heightened emotional involvement. Therefore, AR technology stands out as a valuable tool in the classroom, enhancing both comprehension and student engagement in challenging subjects

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1. INTRODUCTION

Technology has advanced rapidly in recent years, and education is no exception. The teaching and learning process has seen significant improvements with the integration of technology both inside and outside the classroom. In the majority of the 20th century, teaching tools were limited to the blackboard, pencil, and paper. Over time, however, the range of devices and support tools used in the classroom has expanded considerably. Over the years, several devices have been used in the classroom, including overhead projectors, typewriters, televisions, and VHS. However, it was not until the advent of computers, the internet, mobile devices, and virtual classrooms that significant changes were seen.

The increasing prevalence of technology in everyday life has enabled the automation of certain tasks, thereby enhancing the efficiency and convenience of human activities. In the current era, the majority of young people are accustomed to engaging with mobile devices for extended periods. This presents an opportunity for educators to leverage that time by providing educational guidance.

The importance of STEM (Science, Technology, Engineering, and Mathematics) education for the labor market and the performance of daily activities has led to its immense popularity. One of the key benefits is the promotion of inclusion and integration from preschool to the professional level. This facilitates the enhancement of individuals' abilities, fostering a positive and complementary interaction with their surroundings. Consequently, it encourages citizens to become more informed and prudent in their decision-making processes.

The development of logical reasoning ability is a key benefit of learning STEM-related topics (Nur'aeni & Sumarmo, 2012). However, mathematics and science tend to be more complex and abstract, which presents a challenge for many students. They may experience difficulties in solving problems, feel frustrated, and consequently, obtain poor results (Halat et al., 2008). The complexity and abstraction of these topics often lead to confusion and apathy among students, which hinders their ability to learn effectively. In this case, some researchers argue that to improve students' spatial reasoning skills, learning activities should maintain their motivation and adapt to their knowledge and psychological conditions (Alfat & Maryanti, 2019; Idris, 2007) using emerging technology such as Augmented Reality.

Augmented Reality (AR) is a technology that adds digital elements such as images, videos, animations, sounds, and data to the real-world environment (Azuma, 1997). This fusion of digital and physical environments enriches the user's experience by adding extra context, information, or interactive elements that are not physically present. This technology has been a trigger that has improved students' learning outcomes and has allowed them to increase their motivation while solving or learning about a given topic.

Marker-based AR involves the use of specific markers and physical elements embedded with unique patterns that serve as intermediaries between the real world and the virtual environment. These markers are detected by a camera integrated into the mobile device. The AR engine recognizes these patterns and overlays virtual content on top of them, creating a mixed-reality experience. Marker-less AR, on the other hand, does not rely on physical markers. Instead, it uses sensors and components within the mobile device, such as GPS, accelerometer, and digital compass, to determine the device's location and orientation of the device. This method leverages the device's integrated technologies to provide an accurate AR experience without the need for physical markers. Most modern mobile devices are equipped with these sensors, making AR markerless a convenient option for users.

AR technology is potentially useful in reducing the cognitive load of students when they are engaged in tasks related to STEM topics. Therefore, the impact of AR on the learning outcomes and motivational state of students from Mexican public and private schools can be studied. In addition, a learning