

## EFFECTIVENESS OF AUGMENTED REALITY TECHNOLOGY IN STRENGTHENING SCIENCE CONCEPTUAL LEARNING AT THE PRIMARY SCHOOL LEVEL

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### Abstract

This study examines the effectiveness of Augmented Reality (AR) technology in strengthening science conceptual learning at the primary school level through a systematic literature review. The review synthesizes recent studies published between 2021 and 2026 and indexed in major academic databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, ERIC, and Google Scholar. Relevant articles were selected based on criteria related to the use of AR in primary science education, conceptual understanding, learning outcomes, engagement, and science process skills. The findings indicate that AR contributes positively to students' understanding of abstract, microscopic, spatial, and dynamic science concepts by integrating three-dimensional visualization, real-world contexts, and interactive learning experiences. AR is particularly effective when combined with inquiry-based learning, flipped classroom strategies, collaborative activities, guided questioning, and teacher facilitation. In addition to conceptual understanding, AR supports motivation, curiosity, spatial ability, higher-order thinking, and active participation. However, its effectiveness is influenced by instructional design quality, content relevance, cognitive load, teacher competence, device availability, technical support, and school infrastructure. Poorly designed AR applications may distract students or increase cognitive overload without improving learning meaningfully. The study concludes that AR should be positioned as a pedagogical tool embedded within structured science instruction rather than as a standalone technological innovation. Future research should examine long-term concept retention, misconception reduction, transfer of learning, cost-effectiveness, inclusive access, and implementation across diverse primary school contexts. These findings provide practical implications for teachers, schools, developers, and policymakers seeking to integrate AR into science education effectively in equitable, sustainable, and developmentally appropriate ways.

**Keywords:** augmented reality; conceptual understanding; primary education; science learning; interactive learning media; systematic literature review.

### Introduction

Digital transformation in education has encouraged the use of various interactive technologies to improve the quality of learning, including at the elementary school level. One of the technologies that is gaining more attention is *Augmented Reality* (AR), which is a technology that integrates virtual objects in the form of images, animations, videos, and three-dimensional models into a real-life environment. In science learning, AR is considered relevant because many scientific concepts, such as the solar system, the structure of body organs, energy changes, forces, and biological processes, are difficult to observe directly by students. Through three-dimensional visualization and real-time