



Development of Augmented Reality Based Digital Teaching Module for the Human Reproductive System in Class XI Science

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Abstract: Biology learning on the topic of the reproductive system in high schools still faces challenges due to the limited availability of learning media that can visualize abstract concepts interactively and contextually. Commonly used learning media are conventional, resulting in low student engagement and a lack of conceptual understanding. This study aims to develop an Augmented Reality (AR)-based digital learning module for the reproductive system and to test its validity, practicality, and effectiveness in Biology learning. The novelty of this research lies in the integration of Augmented Reality technology into the Biology learning module to provide interactive three-dimensional visualizations of the structures and processes of the reproductive system. This study used a Research and Development (R&D) approach with the ADDIE development model. The subjects were 11th-grade students at SMA Negeri 23 Makassar. The research instruments consisted of expert validation sheets, teacher and student response questionnaires, and learning achievement tests in the form of pretests and posttests. Data were analyzed using Aiken's V-index to determine validity, percentage analysis to assess practicality, and N-Gain analysis to evaluate effectiveness. The research results show that the AR-based digital teaching module has very high validity, practicality, and effectiveness. Therefore, the developed module is suitable for use as an innovative learning medium in biology education.

Keywords: Augmented reality; Digital teaching module; Effectiveness; Practicality; Validity

Introduction

The use of technology in education has now shifted toward digital learning (Siskayanti et al., 2022), where material is delivered through an integration of text, images, and video, keeping up with current developments (Nadeak, 2024). Digital media is not only designed to broaden students' horizons (Umroh et al., 2025), but also serves as a tool for teachers to create more modern learning processes that meet the needs of today's generation (Fadhilah & Thahir, 2023). The use of interactive digital modules has been shown to help students understand the material more easily and can be used independently (Wulandari et al., 2021).

Haria et al. (2024) stated that although digital technology offers various advantages in the learning process, the reality in schools shows that the availability

of innovative digital learning modules is still limited. This results in a lack of variety in learning support devices (Wardani et al., 2024), resulting in a passive classroom atmosphere that is unable to fully encourage active student participation as expected in the Merdeka curriculum (Astuti et al., 2024).

Without the support of learning tools such as systematically designed digital teaching modules, teachers often struggle to convey material clearly (Indriani et al., 2022). This ultimately results in suboptimal student learning outcomes (Setiyadi et al., 2017). This is most often seen in biology, particularly in abstract material (Hajiriah et al., 2019). Understanding biological concepts, such as the reproductive system, becomes less engaging if learned solely through text due to the complex processes involved (Ramadhani et al., 2025; Sugianto et al., 2023). This limited visualization

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