Integrating Digital Simulations into Secondary Science Education: Effects on Students' Conceptual Understanding and Engagement

This study investigates the impact of digital simulations on students' conceptual understanding and engagement in secondary-level science education. Grounded in constructivist learning theory and technology-enhanced learning frameworks, the research aims to explore how interactive simulations support students' understanding of abstract scientific concepts.

A quasi-experimental research design was employed with 72 ninth-grade students from two public secondary schools. The experimental group received instruction supported by digital simulations, while the control group followed traditional textbook-based instruction. Data were collected through a concept achievement test, a student engagement scale, and semi-structured interviews. Quantitative data were analyzed using descriptive statistics and ANCOVA, while qualitative data were analyzed through thematic analysis.

The findings indicate that students exposed to digital simulations demonstrated significantly higher conceptual understanding and engagement levels compared to those in the control group. Qualitative results further revealed that simulations helped students visualize complex processes, increased motivation, and supported meaningful learning.

The study highlights the potential of integrating technology into science education to enhance both cognitive and affective learning outcomes. Implications are discussed for science teachers, curriculum developers, and teacher education programs, emphasizing the effective use of digital tools in science and technology education contexts.