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The Role of Interactive Technology and Constructivism-Based Electronic Teaching Materials in Mathematics and Science Learning

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Abstract

Science and mathematics learning requires the active involvement of students in constructing their own understanding. This study aims to examine the role of interactive technology, electronic teaching materials, and constructivism-based learning models in improving learning outcomes, problem-solving skills, and critical thinking ability. The research method used is a literature review by synthesizing nine reputable scientific articles indexed in SINTA. The results show that the utilization of electronic teaching materials and digital media effectively facilitates independent knowledge construction. Furthermore, the integration of active learning models such as Problem-Based Learning (PBL), Auditory Intellectually Repetition (AIR), Problem Posing, STEAM, and local cultural adaptation such as Bahtsul Masail consistently improves critical thinking skills and problem-solving abilities in physics and mathematics. However, the implementation of technology-based learning still faces challenges regarding social interaction limitations and technical infrastructure in online learning environments.

1. INTRODUCTION

Constructivism asserts that knowledge is actively built by learners through experience, reflection, and social interaction rather than passively absorbed. In mathematics and science education, constructivist principles help students master abstract concepts through meaningful problem-solving. The rapid evolution of digital technology has transformed traditional instructional media into interactive electronic tools capable of activating prior knowledge and encouraging student autonomy.

Numerous studies highlight the effectiveness of these constructivist interventions. (Herianto & Lestari, 2021) demonstrated that electronic teaching materials effectively facilitate science learning. Problem-Based Learning (PBL) using student worksheets (LKPD) significantly enhances physics problem-solving and critical thinking (Muslimin & Purwaningsih, 2023), as well as learning outcomes in straight-line kinematics (Nurrahmah et al., 2026). Constructivist problem-solving approaches consistently boost student achievement (Asy'ari & Muhali, 2022).

Beyond PBL, variations such as Auditory Intellectually Repetition (AIR) sharpen critical thinking in physics (Ariyani & Jumini, 2025), while STEAM integration reinforces constructivist learning (Kartika et al., 2022). Furthermore, differentiated instruction grounded in constructivism has been successfully applied to entrepreneurship projects to accommodate diverse student readiness and learning profiles (Iswahyudi et al., 2023). Local cultural adaptations like Bahtsul Masail also foster analytical reasoning (Insiyyah et al., 2020). In mathematics, constructivism is operationalized through Problem Posing under Vygotsky's framework within the Merdeka Curriculum (Hartiningrum & Abdul Wahab, 2024; Prabawati et al., 2024) and foundational constructivist approaches (Dhani et al., 2022). Comparative evaluations between behaviorism and constructivism show distinct advantages for active learning in face-to-face and online formats, although online settings present specific implementation hurdles (At Thaariq, 2022; Supinah & Nuriadin, 2022). This study synthesizes the roles of interactive technology and constructivism-based learning models in science and mathematics education.

2. METHOD

This study uses a narrative literature review method. The research involved gathering 15 scientific articles published in reputable journals indexed in SINTA, focusing on constructivism, digital teaching tools, and instructional strategies in science and mathematics. The articles were analyzed to evaluate learning models, technological interventions, and their outcomes on cognitive performance, critical thinking, and problem-solving skills. The findings were organized thematically and presented via narrative synthesis and comparative tables.

3. RESULT AND DISCUSSION

The integration of constructivist principles with interactive technology and electronic teaching materials marks a significant shift in modern science and mathematics education. Rather than relying on traditional, passive knowledge transmission, contemporary instructional design leverages digital environments to foster active cognitive engagement, conceptual understanding, and higher-order thinking skills. This section synthesizes key findings regarding the role of interactive electronic materials, the practical challenges encountered during technology-enhanced instruction, and the empirical effectiveness of various constructivist learning models across physics and mathematics contexts.

3.1. Interactive Technology and Electronic Teaching Materials Based on Constructivism

Interactive digital tools and electronic teaching materials provide learners with flexible platforms for self-directed exploration. (Herianto & Lestari, 2021) highlighted that electronic materials aligned with constructivism continually support knowledge building through real-world scenarios and interactive tasks. However, online environments introduce operational challenges. (Supinah & Nuriadin, 2022) and (At Thaariq, 2022) noted that online constructivist instruction often struggles with limited technical infrastructure, diminished interpersonal teacher-student interaction, and obstacles in delivering real-time cognitive scaffolding. In comparative analyses, constructivist face-to-face and online environments offer superior cognitive engagement over behaviorist transmission models, provided digital interaction tools are properly utilized (Fardhany et al., 2022).

3.2. Effectiveness of Constructivism-Based Learning Models in Science and Mathematics

Standard learning theories can be integrated with interactive technology to optimize students' conceptual understanding. The relationship between learning approaches, technological tools, and instructional implications is summarized in Table 1.

Table 1. The Relationship between Learning Models, Interactive Media, and Instructional Implications

Learning Models / Approaches	Interactive Media & Technology	Implications for Instruction
Problem Based Learning (PBL)	Interactive E-Books & Digital Student Worksheets	Learning focused on authentic problem solving, active conceptual understanding, and critical thinking.
Auditory Intellectually Repetition (AIR)	Audio-Visual Media & Simulation Tools	Emphasizing active listening, high-level reasoning, and meaningful repetition to build critical thinking.
Problem Posing (Vygotsky Framework)	Interactive Learning Platforms & Digital Tools	Encouraging student autonomy in formulating problems and co-constructing mathematical knowledge.
STEAM & Local Wisdom (Bahtsul Masail)	Digital Interactive Tools & Scientific Forums	Facilitating interdisciplinary exploration, structured scientific debate, and analytical skills.

Based on Table 1, constructivist learning models supported by interactive tools directly enhance student engagement and higher-order thinking. Problem-Based Learning (PBL) remains a primary model. (Nurrahmah et al., 2026) found that PBL helps students connect abstract physics concepts in kinematics to real-world contexts, a finding supported by (Muslimin & Purwaningsih, 2023) meta-analysis confirming PBL's positive impact on critical thinking.

Empirical findings from (Dhani et al., 2022; Rosita et al., 2024) confirm that constructivist teaching significantly improves learning outcomes across basic and secondary levels. Furthermore, implementing constructivism through differentiated instruction within entrepreneurship projects provides tailored learning experiences that align with individual student needs and foster practical problem-solving capacities (Iswahyudi et al., 2023). In elementary education under the Merdeka Curriculum, constructivist approaches encourage active knowledge construction and peer collaboration (Prabawati et al., 2024). Specialized models such as AIR foster critical thinking via intellectual repetition (Ariyani & Jumini, 2025), while integrating Bahtsul Masail adapts cultural discussion into scientific debate. In mathematics, Problem Posing under Vygotsky's framework empowers students to formulate questions independently, strengthening conceptual mastery (Hartiningrum & Abdul Wahab, 2024).

4. CONCLUSION

Constructivism-based electronic teaching materials and interactive technologies play a vital role in enhancing science and mathematics education. Integrating models such as PBL, AIR, STEAM, differentiated project-based learning, Problem Posing, and Bahtsul Masail consistently improves student achievement, analytical skills, and critical thinking. While digital platforms offer flexible learning opportunities, addressing technical infrastructure needs and social interaction limitations in online settings remains essential for effective instruction.

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