

Digital Comic-Based Learning Media Using AI Tools: Improving Student Comprehension in Geometric Reflection

Research Overview

This design-based research investigates AI-powered digital comic development for teaching geometric reflection to Indonesian eleventh-graders. Using Dashtoon Studio and Canva, we created narrative-based learning media addressing visualization challenges in abstract mathematics. Expert validation and quasi-experimental design with 25 participants assessed validity, practicality, and effectiveness of this innovative pedagogical approach.

Purpose

The study aimed to develop, evaluate the validity, assess the practicality, and measure the effectiveness of AI-powered digital comic learning media for geometric reflection instruction using Dashtoon Studio and Canva platforms

Research Questions:

1. What validity level does the AI-powered digital comic achieve according to media, content, and language experts?
2. How do students perceive the practicality and usability of the digital comic learning media?
3. To what extent does the digital comic improve student comprehension and achievement in geometric reflection?

Methods

Theoretical Framework

This study is grounded in Mayer's Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2021), which posits that people learn more deeply from words and pictures than from words alone through dual-channel processing. We integrated Paivio's Dual Coding Theory (Clark & Paivio, 1991), suggesting verbal and visual information are processed through separate cognitive channels, enhancing retention when combined. The narrative approach aligns with situated learning theory (Lave & Wenger, 1991), embedding mathematical concepts within authentic problem-solving contexts.

Research Design

We employed design-based research (McKenney & Reeves, 2021) following Thiagarajan's 4-D model: Define, Design, Develop, and Disseminate.

Define Phase: Needs analysis through classroom observations, teacher interviews, and student surveys (September-December 2024) at SMAN 5 Lhokseumawe revealed low motivation due to conventional media and difficulties with reflection properties.

Design Phase: We created "Labirin Cermin" (Mirror Maze), a narrative-based digital comic featuring six characters navigating a mirror labyrinth while encountering reflection principles. Develop Phase: Iterative validation involved six experts: mathematics educator (n=2), educational technology expert (n=2), and linguistic expert (n=2), using structured 4-point Likert instruments.

Participants

Twenty-five grade XI students (14 female, 11 male; ages 16-17) from SMAN 5 Lhokseumawe participated.

Instruments

Expert Validation Sheets: Media (19 items), content (13 items), language (6 items). Practicality Questionnaire: 18 items (usability, accessibility, engagement). Achievement Test: 10 essay questions (Cronbach's $\alpha = 0.84$)

Data Analysis

Validity and practicality used percentage formulas: $V = (\Sigma x / \Sigma n) \times 100\%$. Effectiveness calculated learning mastery: $E = (\Sigma t / \Sigma s) \times 100\%$ (SMAN 5 Lhokseumawe mathematics threshold $\geq 70\%$). Paired-samples t-test assessed pre-post differences ($\alpha = 0.05$).

Results

Validity

Expert validation demonstrated exceptional validity: media design (M=98.05%, SD=0.91), content accuracy (M=93.25%, SD=6.75), language appropriateness (M=93.7%, SD=2.10), all categorized "very valid." Student readability trials (n=5) yielded 92.04% validation, confirming age-appropriate design and conceptual clarity.

Practicality

Field assessment (n=25) produced $M=95.4\%$ ($SD=3.2$), indicating "highly practical" media. Dimensional analysis: visual appeal (95.75%), content quality (93.8%), accessibility (96.5%). Students valued multi-device compatibility, intuitive navigation, and self-paced learning affordances. Qualitative feedback highlighted how narrative contextualization made abstract concepts tangible aligning with situated cognition principles (Brown et al., 1989).

Effectiveness

Pre-test mastery (64.4%; $M=65.2$, $SD=22.3$) increased to post-test 84.8% ($M=85.2$, $SD=14.6$), yielding significant improvement: paired $t(24)=6.73$, $p<0.001$, Cohen's $d=1.08$ (large effect). Students demonstrated enhanced conceptual understanding distinguishing reflection properties and applying matrix transformations rather than procedural memorization, supporting deep learning objectives (Hiebert, 2007).

Discussion

Results validate CTML predictions (Mayer, 2021): integrating visual narratives with mathematical content enhanced comprehension through dual-channel processing. The mirror maze metaphor provided embodied cognition experiences (Lakoff & Núñez, 2000), connecting abstract geometric properties to physical intuitions about mirrors.

AI integration via Dashtoon Studio enabled rapid, high-quality illustration production while maintaining pedagogical integrity demonstrating generative AI's potential for scalable educational content (Zawacki-Richter et al., 2019). However, pedagogical oversight remained essential for mathematical accuracy, echoing concerns about AI content validation (Holmes et al., 2022).

Theoretical Contribution: This study extends multimedia learning research into AI-assisted content development, demonstrating that generative tools can support—not replace—pedagogically informed design when guided by established learning theories.

Limitations: Single-site implementation, absence of control group, and narrow focus on reflection concepts limit generalizability. Future research should examine: (a) transferability across mathematical domains, (b) long-term retention effects, (c) comparative effectiveness studies, and (d) cognitive load implications of narrative complexity.

Practical Implications: The replicable development model offers educators a framework for creating AI-assisted learning media. Findings suggest digital comics effectively address abstract concept visualization challenges in mathematics education (Hosler & Boomer, 2011)

Keywords: digital comics, AI-powered learning, geometric transformation, educational technology, mathematics education