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Integrating E-Comics and Problem-Based Learning (PBL) to Foster Higher-Order Thinking Skills in Elementary Students

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Abstract

The demands of 21st-century education necessitate that students develop Higher Order Thinking Skills (HOTS) to thrive in a dynamic and complex digital era. Nevertheless, elementary-level instruction frequently remains dominated by conventional approaches that inadequately foster critical, creative, and problem-solving competencies. Technology-based learning innovations offer a promising solution, particularly through the integration of E-Comics with Problem-Based Learning (PBL). This study examines the effectiveness of combining E-Comics and PBL to enhance higher-order thinking skills among elementary school students. A quasi-experimental design was employed, utilizing both control and experimental groups. Participants comprised fifth-grade students from two elementary schools in Surakarta, Central Java, Indonesia. Research instruments included HOTS-aligned assessments and structured classroom observation sheets. Data were analyzed using descriptive statistics and inferential t-tests. Results demonstrated that the experimental group, taught using the E-Comic-PBL integration, exhibited a statistically significant improvement ($p<0.05$) in higher-order thinking skills compared to the control group. These findings indicate that integrating interactive digital media such as E-Comics with PBL can serve as an innovative strategy to cultivate students' critical thinking, creativity, and problem-solving abilities. Pedagogical implications and recommendations for further research are also discussed.

Keywords:

E-Comic, Problem-Based Learning, Higher Order Thinking Skills, Elementary School, Digital Learning Media

Introduction

Research Background

Digital technology advancements have catalyzed a transformative impact on education, particularly through the provision of innovative learning media. E-Comics represent one such increasingly prevalent medium, integrating visual narratives with textual content in digital formats (Fianto et al., 2023; Furbani et al., 2025; Pugacheva et al., 2020; Sweller, 2020). Beyond

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enhancing student reading engagement, E-Comics facilitate conceptual comprehension via interactive illustrations. Concurrently, 21st-century curricular demands emphasize cultivating Higher-Order Thinking Skills (HOTS) including analysis, evaluation, and creation. Conventional pedagogical approaches, however, frequently prove inadequate in optimizing HOTS development, necessitating more effective instructional methodologies.

The theoretical underpinning for this integration is supported by the cognitive theory of multimedia learning (Mayer, 2014), which posits that students learn more deeply from words and pictures than from words alone. E-Comics, as a form of structured multimedia, effectively leverage this principle by presenting information simultaneously through visual and textual channels, thereby reducing cognitive load and facilitating the construction of mental models. This dual-coding process is essential for the complex cognitive operations inherent in HOTS, as it allows students to organize and integrate information more efficiently before applying it to novel problems. Furthermore, the narrative structure of comics provides a familiar and compelling framework that can make abstract or complex problems more concrete and accessible to young learners (Dillenbourg, 2016; Schneider et al., 2022).

Problem-Based Learning (PBL) is widely acknowledged as an efficacious approach for fostering HOTS. Within PBL frameworks, students engage with contextual problems that stimulate investigation, collaboration, and problem-solving (Funa & Prudente, 2021; Jonassen, 2024; Naslund & Filipenko, 2016). Nevertheless, PBL implementation in elementary education often encounters constraints due to the inadequate availability of media that supports the presentation of engaging, contextually relevant problems. This underscores the significance of incorporating E-Comics as a medium for presenting problems within PBL. By delivering problem scenarios through relatable visual narratives, E-Comics are posited to enhance student involvement and conceptual understanding.

Although previous studies have consistently reported the effectiveness of Problem-Based Learning in promoting higher-order thinking skills, several researchers note that its implementation at the primary school level often encounters challenges related to students' abstract reasoning abilities and limited contextual understanding. In this regard, visual and narrative-based learning media are increasingly viewed as a necessary scaffold to bridge the gap between problem complexity and learners' cognitive readiness.

The effectiveness of PBL is contingent upon the authenticity and ill-structured nature of the initial problem trigger. E-Comics offer a dynamic solution to this requirement by enabling the creation of rich, narrative-driven scenarios that embed problems within a relatable context. For instance, a comic strip can depict characters facing a real-world dilemma related to science or social studies, instantly providing the "why" and "how" that motivates student inquiry. This narrative presentation moves beyond a simple textual case study, reducing the initial abstraction of the problem and providing visual anchors—such as character expressions, environmental details, and sequential action—that scaffold the students' initial analysis and question-generation phase, which is critical for subsequent critical thinking (Barrows, 1996; Topkaya et al., 2023).

Prior research indicates the positive potential of comics in education, though investigations remain largely confined to aspects of motivation and foundational conceptual comprehension. Meanwhile, studies on PBL in elementary settings have demonstrated improvements in problem-solving abilities. However, the specific integration of E-Comics and PBL for HOTS development remains underexplored. Consequently, this study is designed to address this research void by examining the synergistic potential of E-Comics and PBL in advancing HOTS among elementary school students.

Although previous studies have demonstrated the effectiveness of Problem-Based Learning or digital comic media in improving students' learning outcomes and engagement at the elementary level, most of these studies treat e-comics as supplementary learning resources rather than as an integral instructional scaffold within the PBL process. In addition, limited attention has been given to the systematic alignment between e-comic narrative design, PBL stages, and explicit higher-order thinking skills indicators.

Addressing this gap, the present study proposes an E-Comic–integrated Problem-Based Learning model that is intentionally designed to embed problem scenarios, guiding questions, and reflective prompts corresponding to each PBL phase and HOTS dimensions. By focusing on this integrative and cognitively oriented design at the elementary school level, this study offers a novel contribution to the intersection of PBL, digital comics, and higher-order thinking skills development.

Literatur Review

Higher-Order Thinking Skills (HOTS) encompass cognitive abilities that involve advanced mental processes, including analysis, evaluation, and creation (Anderson & Krathwohl, 2001). Within primary education contexts, cultivating HOTS plays a crucial role in equipping students to address future complex challenges. Research consistently indicates that

these skills can be fostered through challenging and contextually relevant instructional approaches (Brookhart, 2010). Problem-Based Learning (PBL), a constructivist methodology, utilizes real-world problems as the foundation for learning (Hmelo-Silver, 2004). In PBL settings, students collaborate in groups to solve authentic problems, thereby honing their analytical, synthetic, and evaluative capabilities. A meta-analysis by Walker and Leary (Walker & Leary, 2023) underscores PBL's effectiveness in enhancing higher-level cognitive learning outcomes. However, the success of PBL implementation is significantly contingent upon the quality of the problem scenarios presented.

The efficacy of PBL in primary education is further mediated by the developmental stage of the learners. Younger students often require significant scaffolding to deconstruct complex problems and direct their cognitive resources toward analysis rather than mere fact-finding (Kapur, 2016; Sari et al., 2024). This scaffolding is essential to bridge the gap between the problem's complexity and the students' emerging cognitive abilities. Without structured support, the problem-solving process may become overwhelming, potentially hindering the very HOTS development PBL aims to promote. Therefore, the design of the learning environment, particularly the instructional media used to present the problem narrative, becomes a critical variable for successful HOTS cultivation in younger demographics.

E-comics, as digital learning media, offer distinct advantages by delivering content in a visual and narrative format. Studies, such as that by Hosler and Boomer (2011), demonstrate comics' potential to improve students' understanding of scientific concepts. The dynamic and interactive nature of E-comics can further boost student motivation and engagement (Hosler & Boomer, 2011; Suri et al., 2021). Nevertheless, the specific application of E-comics for developing HOTS warrants further in-depth investigation.

Recent empirical work has begun to explore the unique attributes of E-comics that are conducive to critical thinking. The sequential art format inherently requires students to make inferences, connect narrative events, and deduce causality, which are fundamental components of analytical thinking (Wewengkang et al., 2024). Furthermore, the multimodal nature of E-comics—merging text, image, and often audio—supports cognitive load theory by distributing information across different channels, allowing working memory to process information more efficiently for deeper understanding (Kapi et al., 2017). This efficient processing is a prerequisite for engaging in the demanding tasks of evaluation and creation that define HOTS.

Integrating digital media like E-comics with the PBL approach is hypothesized to create a rich learning environment conducive to HOTS development (Clark & Mayer, 2023; Hwang et al., 2023; Mohar & Kovač, 2021). Cognitive Theory of Multimedia Learning posits that combining text and visuals enhances information processing (Mayer, 2022). Presenting problem scenarios through E-comics is expected to heighten student motivation and facilitate a deeper understanding of the problem context, potentially increasing the efficacy of the PBL process. While research by Puriasih and Trisna with junior high school students yielded positive results from integrating digital comics with PBL, comparable studies at the primary school level remain scarce (Puriasih & Trisna, 2022).

Consequently, a significant research gap exists regarding the structured integration of E-comics as a scaffolded problem-presentation tool within a PBL framework for primary education. The question remains whether the narrative and visual scaffolding provided by a well-designed E-comic can effectively prime students' analytical processes and sustain their engagement throughout a PBL cycle. Investigating this integration could provide a replicable model for educators seeking to implement HOTS-oriented pedagogy with younger learners, ultimately empowering them to become more adept and confident problem-solvers. Future research should therefore focus on empirical studies that measure specific HOTS gains when primary school students engage with PBL modules where the initial problem stimulus is delivered via a tailored E-comic narrative.

Research Problem

Despite Problem-Based Learning (PBL) being widely recognized as an effective approach for cultivating Higher Order Thinking Skills (HOTS), its implementation in elementary schools frequently encounters obstacles. A primary challenge lies in designing contextually relevant problems that genuinely engage students' interest. Conventional learning materials such as textbooks or student worksheets often fail to present problems through compelling visual and narrative formats, thereby diminishing student engagement. Concurrently, the potential of visually appealing digital media like E-Comics remains underutilized in supporting PBL methodologies.

Prior research on E-Comic applications in education has predominantly concentrated on literacy development or basic conceptual understanding, with limited exploration of their impact on HOTS. Furthermore, integrative studies examining E-Comics combined with PBL to enhance HOTS at the elementary level remain scarce. Consequently, a comprehensive study is warranted to evaluate the effectiveness of this integrative model in developing students' analytical, critical, and creative thinking abilities. Within the

context of Problem-Based Learning, Multimedia Learning Theory provides a theoretical rationale for the use of E-Comics by emphasizing that learners process information more effectively when verbal and visual representations are meaningfully integrated. Meanwhile, Cognitive Load Theory explains how the structured narratives and sequential visuals in E-Comics can reduce extraneous cognitive load, allowing students to focus more on problem analysis and solution generation. The integration of these theories positions E-Comics not merely as an illustrative tool, but as a cognitive scaffold that enhances the effectiveness of PBL in fostering higher-order thinking skills at the primary school level.

By synthesizing Problem-Based Learning, Higher-Order Thinking Skills, and multimedia-based instructional design within a coherent theoretical framework, this study contributes to the growing body of research on innovative learning media for primary education. Specifically, it offers a theoretically grounded approach to integrating E-Comics into PBL as a means of addressing both cognitive and contextual challenges faced by learners.

Research Focus

This study investigates the development and testing of an integrative learning model combining E-Comics and Problem-Based Learning (PBL). The primary objective is to enhance Higher-Order Thinking Skills (HOTS) among fifth-grade elementary school students within the Natural Science subject area.

Research Aim and Question

This study aims to examine the efficacy of integrating E-Comics and Problem-Based Learning (PBL) in enhancing higher-order thinking skills (HOTS) among elementary school students. The research addresses the following questions:

1. How does the improvement in students' HOTS differ when taught using the integrated E-Comic and PBL model compared to conventional instruction?
2. How do learning activities unfold during the implementation of the E-Comic and PBL integration?
3. What are student perceptions regarding this integrated learning model?

Methodology

Design & Setting

This study employed a quasi-experimental design with a pretest-posttest control group format. The experimental group received instruction integrating E-Comics with Problem-Based Learning (PBL), while the control group experienced conventional teaching methods (lectures and limited discussions). The research was conducted at two class elementary schools in Surakarta, Central Java, Indonesia, between January and March 2025. The selection of elementary schools in Surakarta as the research location was based on the following rational considerations: Representative educational context, Active implementation of policies and curriculum, Accessibility and feasibility of research, Suitability for research objectives. To establish group equivalence, pretest scores were analyzed prior to the intervention. The results indicated no statistically significant difference between the experimental and control groups, suggesting comparable initial higher-order thinking skills before treatment.

Population & Sampling

The study population included all third-grade students in two parallel classes at the school. Purposive sampling was used to select participants based on criteria: (1) relatively homogeneous academic and social characteristics, as recommended by teachers, and (2) division into two separate classes per school. From each school, one class was assigned as the experimental group (n=30) and another as the control group (n=30), yielding a total sample of 60 students. Purposive sampling was employed to ensure that participants possessed comparable curricular backgrounds and learning characteristics relevant to the implementation of the instructional intervention. Although this sampling technique and the localized sample size limit statistical generalizability, the findings are intended to provide analytical generalization within similar educational contexts.

Instruments & Validation

Key research instruments included: 1) HOTS Test: Essay and complex multiple-choice questions measuring analysis, evaluation, and creation abilities. Each item was assigned equal weight, and the total score was obtained by summing the scores across all items. Score interpretation was conducted based on predefined categories to ensure consistency in data analysis; 2) Learning Activity Observation Sheets: Documenting collaboration, problem-solving, and E-Comics utilization; 3) Student Response Questionnaires: Assessing perceptions of the learning model.

Instrument validation was performed by pedagogy specialists and science content experts. Prior to its use in the main study, the instrument underwent reliability testing using the Cronbach's alpha method. The results yielded a reliability coefficient of $\alpha = 0.85$, indicating [good/very good] internal consistency. Therefore, the instrument was considered reliable and appropriate for data collection. Intervention fidelity was ensured through the use of standardized lesson plans, consistent instructional duration across groups, and

regular monitoring during classroom implementation. The same instructor delivered the intervention to minimize instructional variability, and adherence to the planned procedures was documented throughout the study

Data Collection

The data collection procedure involved: 1) Pretest: Administered to both groups before intervention; 2) Intervention: The experimental group received E-Comics integrated PBL instruction across 8 sessions (Science topic: reproduction of living organisms). Each session included: (a) problem presentation via E-Comics, (b) group discussion, (c) investigation, and (d) solution presentation; 3) Posttest: Conducted following the intervention; 4) Observations and Questionnaires: Completed during and after the intervention period.

To address the second research question concerning students' learning activities during the E-Comic–PBL implementation, an observational analysis was conducted using a structured activity rubric aligned with the phases of Problem-Based Learning. Each learning session was analyzed across indicators of engagement, collaboration, problem analysis, and solution development. The collected data were quantified and further interpreted to identify patterns of active learning behaviors that reflect Higher-Order Thinking Skills (HOTS) development.

The third research question, which focuses on students' perceptions of the E-Comic–PBL learning model, was analyzed using descriptive statistics and thematic analysis. Questionnaire responses were grouped into three main aspects: perceived usefulness, learning motivation, and cognitive support. Open-ended responses were coded thematically to capture students' subjective experiences and attitudes toward the learning process.

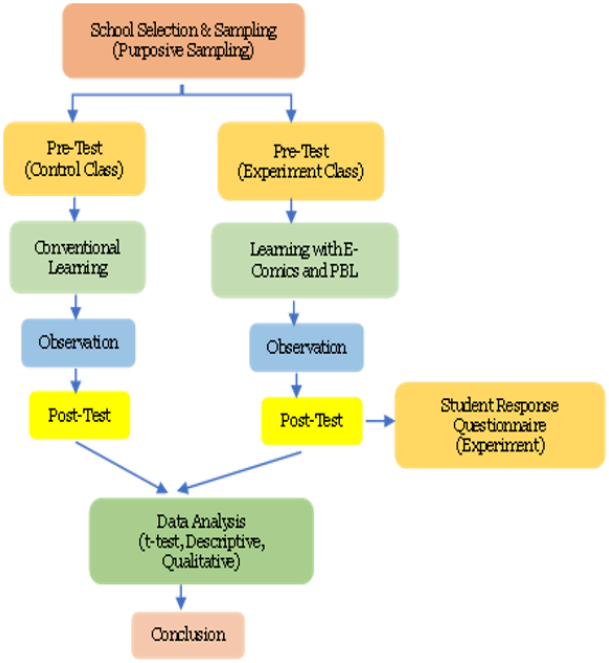
Analytical Approach

Data analysis combined quantitative and qualitative methods: 1) Normality (Shapiro-Wilk) and homogeneity (Levene's test) assessments preceded hypothesis testing; 2) Independent samples t-tests compared HOTS improvement (N-gain scores) between experimental and control groups; 3) Descriptive statistics analyzed observation and questionnaire data; 4) Qualitative analysis interpreted learning activities from observation records.

This analysis is used to analyze differences between groups, as this method is suitable for achieving research objectives and provides accurate and relevant analysis results.

The following presents the research flow chart.

Figure 1:
research flow chart



Findings

Table 1 below shows the Average Pretest, Posttest, and N-Gain HOTS Scores between the experimental and control groups.

Table 1.
Average Pretest, Posttest, and N-Gain HOTS Scores

Group	Pretest (Mean)	Posttest (Mean)	N-Gain	p-value (t-test)
Experiment	45.23	82.67	0.68	0.000
control	44.87	65.45	0.38	

Note: N-Gain is calculated using the formula (Posttest-Pretest)/(100-Pretest).
A p-value <0.05 indicates a significant difference.

As shown in the table, students in the experimental group achieved higher average scores than those in the control group, indicating a positive effect of the implemented intervention. The initial pretest scores for both groups were remarkably similar (Experiment: 45.23; Control: 44.87), indicating a comparable baseline level of HOTS proficiency prior to the instructional intervention.

Following the treatment, a marked disparity in posttest performance was observed. The experimental group achieved a substantially higher mean score of 82.67, compared to the control group's mean of 65.45. This differential improvement is most accurately captured by the N-Gain score, which normalizes for the initial starting point. The experimental group's N-Gain of 0.68 falls into the "moderate" to "high" effectiveness range, according to standard interpretive frameworks

(e.g., Hake, 1998). In stark contrast, the control group's N-Gain of 0.38 is indicative of only "low" to "moderate" effectiveness. This substantial difference in gain scores suggests that the instructional intervention applied to the experimental group was significantly more efficacious in fostering HOTS.

The independent samples t-test results confirm the statistical significance of this finding. The p-value of 0.000, which is well below the standard alpha level of 0.05, allows for the rejection of the null hypothesis. Therefore, it can be conclusively stated that there is a statistically significant difference in the mean HOTS posttest scores between the group that received the experimental treatment and the group that underwent conventional instruction. This result provides robust empirical evidence that the intervention implemented in the experimental group was successful in enhancing students' higher-order cognitive abilities.

Figure 2.
Comparison Diagram of N-Gain HOTS per Indicator

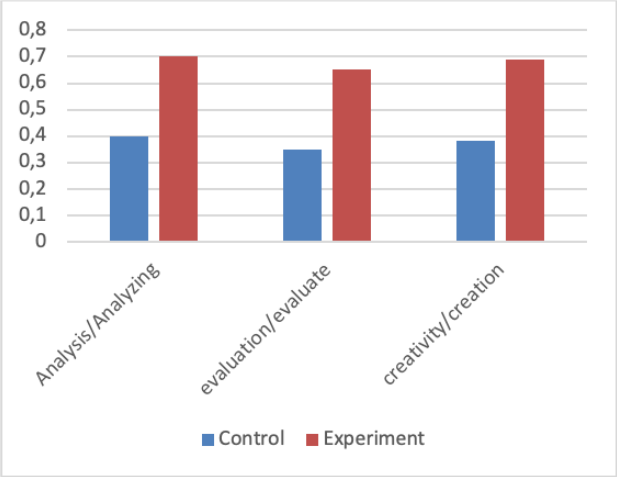


Figure 2 delineates the normalized gain (N-Gain) for each Higher-Order Thinking Skills (HOTS) indicator, providing a granular view of the experimental intervention's efficacy. The data reveals a consistent and superior performance by the experimental cohort across all measured cognitive domains compared to the control group. The most substantial improvement was recorded for the analysis indicator (N-Gain = 0.70), followed closely by creation, with the evaluation indicator showing a marginally lower, yet still robust, gain of 0.66. Crucially, all three indicators for the experimental group reside within the moderate-to-high effectiveness range. This stands in stark contrast to the control group, which demonstrated uniformly moderate gains (N-Gain 0.35–0.40) across the same indicators. This differential performance strongly suggests that the pedagogical approach employed in the experimental condition was particularly effective in fostering advanced cognitive processes, with a pronounced impact on analytical abilities.

Table 2.
Results of Observation of Learning Activities in the Experimental Group

Aspect	Average Score (1-4)	Category
Engagement	3.75	High
Collaboration	3.60	High
Problem Solving	3.45	Moderate
Use of E-Comics	3.80	High

The observational data from the experimental group, as detailed in Table 2, indicate a generally successful implementation of the instructional intervention. Student performance was particularly strong in the domains of Engagement (Average Score = 3.75) and Use of E-Comics (Average Score = 3.80), both categorized as 'High'. This suggests that the integration of the digital comic media was highly effective in capturing student interest and facilitating interaction with the learning material. Furthermore, the Collaboration aspect scored highly (Average Score = 3.60), implying that the learning environment successfully promoted productive group dynamics and cooperative tasks.

A more nuanced finding emerges in the Problem-Solving category, which received a 'Moderate' classification with an average score of 3.45. While this indicates a positive trajectory and demonstrates that students were actively engaged in solution-oriented activities, it also reveals a perceptible gap compared to the other metrics. This discrepancy suggests that while the learning design was successful in fostering engagement and collaboration, the translation of these activities into fully developed, independent problem-solving competencies may require further reinforcement or a longer intervention period to mature. The analysis of students' learning activities indicates that the integration of E-Comic within the PBL framework facilitated higher levels of student engagement and cognitive involvement, particularly during problem identification and solution formulation stages. These activities correspond to the HOTS dimensions of analysis, evaluation, and creation, thereby directly addressing the second research question

This pattern of results implies that the use of E-comics served as a powerful catalyst for motivation and collaborative work. However, the moderate score in problem-solving highlights a critical area for pedagogical refinement. It may be necessary to incorporate more explicit scaffolding techniques—such as structured brainstorming protocols, guided reflection on the problem-solving process, or direct instruction on specific heuristic strategies—within the E-comic narrative framework to more directly bridge

the gap between engagement and the advanced cognitive processes required for sophisticated problem-solving.

Figure 3.
Student Responses to Learning

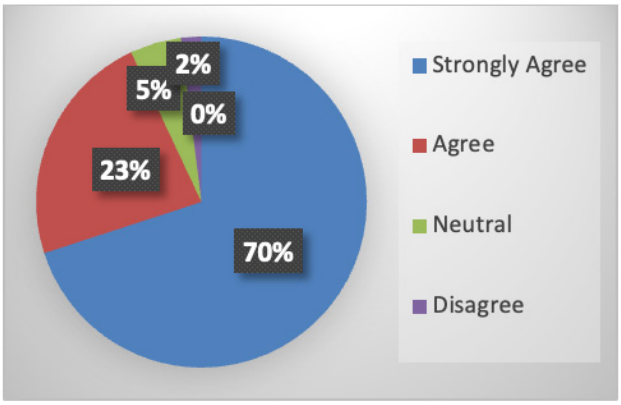


Figure 3 shows the results of a survey of student responses. The survey data reveals an overwhelmingly favorable reception of the integrative learning model among the student cohort. A commanding 93% of respondents expressed a positive stance, selecting either 'Agree' (70%) or 'Strongly Agree' (23%). This notable consensus indicates that the pedagogical approach successfully resonated with the vast majority of participants.

Qualitative feedback elucidates the reasons behind this strong endorsement. Students reported that the utilization of E-Comics significantly enhanced their engagement by presenting subject matter in a more captivating and accessible format, thereby facilitating improved comprehension of complex issues. Furthermore, the Problem-Based Learning (PBL) component was perceived as instrumental in developing their capacity for critical thinking, suggesting the model's efficacy in promoting higher-order cognitive skills. The findings related to student perceptions demonstrate a positive response toward the E-Comic–PBL integration, particularly in terms of learning motivation and conceptual understanding. These results provide analytical evidence that directly addresses the third research question, indicating that students perceive the learning model as supportive of HOTS-oriented learning.

This highly positive quantitative result, substantiated by student testimony, strongly suggests that the fusion of visual narrative media (E-Comics) with a constructivist pedagogical framework (PBL) creates a potent and effective learning environment. The data underscores the model's success not only in conveying information but also in actively training essential analytical competencies, marking it as a promising strategy for contemporary education. Future research could investigate the longitudinal effects of this model on specific cognitive gains and knowledge retention.

Overall, the findings consistently indicate that the proposed approach offers advantages over the traditional method, both in terms of measurable learning outcomes and the quality of the learning process.

Discussion

While the findings of this study corroborate previous research indicating that Problem-Based Learning (PBL) supported by digital learning materials enhances students' problem-solving skills and learning engagement, our results also reveal nuanced differences. Specifically, unlike prior studies that reported uniform improvements across cognitive domains, the present study found that the impact of PBL-based digital materials was more pronounced in higher-order thinking skills than in basic conceptual understanding. This divergence may be attributed to the contextual design of the digital materials, which emphasized authentic problem scenarios rather than content repetition.

Moreover, this study offers a new perspective by demonstrating that the effectiveness of digital PBL materials is influenced by students' prior experience with self-directed learning. This finding extends earlier research by suggesting that digital PBL environments may require differentiated scaffolding strategies to accommodate learners with varying levels of autonomy.

In addition to confirming the effectiveness of PBL in a digital context, this study contributes to the literature by highlighting how instructional design characteristics such as problem complexity and interactivity influence learning outcomes. These findings provide a deeper understanding of how digital learning materials can be optimized within the PBL framework.

The results of this study prove that the integration of E-Comics and PBL significantly improves students HOTS compared to conventional learning. These findings are in line with the research by Wu et al (2021), which shows that interactive visual media can improve the effectiveness of PBL. In this context, E-Comics act as scaffolding that helps students understand the context of the problem visually and narratively, thereby facilitating the process of analysis and problem solving (Þahan & AtlÝ, 2025) .

The highest increase in the analysis indicator (N-Gain=0.70) shows that presenting problems through E-Comics triggers students to identify the components of the problem systematically. This aligns with Mayer's theory that combining text and visuals facilitates deeper information processing. Additionally, the story

format in E-Comics makes problems more contextual, enabling students to connect them more easily with prior knowledge (Rasmet et al., 2025).

The observed learning activities also showed high levels of student engagement and collaboration. This indicates that this integrative model not only enhances cognitive skills but also social skills. These findings support (Hmelo-Silver, 2004) research that PBL is effective in creating a collaborative learning environment. E-Comics as a problem-presentation medium successfully served as a catalyst for productive discussions among students.

Students' positive responses to this learning model reinforce Hosler & Boomer's findings that comics can increase learning motivation. In this study, the interactive aspects of E-Comics, such as simple animations and easy navigation, made students more enthusiastic. This high motivation is suspected to be one of the driving factors behind the improvement in HOTS (Bijuklič, 2024; Hosler & Boomer, 2011).

However, the problem-solving aspect still has a slightly lower observation score (3.45) compared to other aspects. This may be due to the complexity of the problems, which require repeated practice. Therefore, it is recommended to implement this model continuously so that students become more skilled in developing innovative solutions (Farias et al., 2023).

Furthermore, the findings suggest that the narrative structure of E-Comics may serve as a metacognitive scaffold, guiding students to monitor and evaluate their problem-solving strategies more effectively. This is consistent with recent work, who demonstrated that digitally narrated scenarios prompt learners to engage in self-questioning and strategic planning, which are core components of metacognitive regulation essential for HOTS development (Berenji, 2021; Šterman Ivančič, 2024; Yuliani & Setiawan, 2024). The sequential panels in E-Comics inherently model a procedural approach to deconstructing complex issues, thereby making the abstract stages of problem-solving more tangible and accessible to students.

From a socio-constructivist perspective, the synergy between E-Comics and PBL effectively creates a shared referential framework for group discourse. The visual narrative provides a common ground for discussion, reducing ambiguities and aligning team members' understanding of the problem space. This aligns with contemporary studies on collaborative learning, which indicate that shared visual artifacts significantly improve the quality of group reasoning and co-construction of knowledge (Fitria et al., 2023; Tracey & Hutchinson, 2019). The E-Comic, therefore, is not merely a presentation tool but a boundary object that mediates social interaction and collective cognitive effort.

Regarding the slightly lower performance in problem-solving, this could be attributed to the cognitive load associated with transferring analytical insights into actionable, novel solutions. While E-Comics excel at framing problems and facilitating analysis, the act of synthesis and creation demands a distinct cognitive effort that may require more prolonged exposure. This observation finds support in a study, which noted that students often need multiple cycles of feedback and iteration within digital learning environments to transition comfortably from analysis to innovative solution generation (Bogataj, 2024; Lee & Hannafin, 2016; Ismiyanto et al., 2024) Future implementations could thus incorporate more iterative prototyping phases following the initial problem analysis facilitated by the E-Comics.

Although the findings indicate that the integration of E-Comics within PBL is associated with improved cognitive outcomes and learner motivation, it is important to consider alternative explanations. For instance, the observed effects may partly stem from a novelty effect or from increased instructional guidance provided during the implementation of PBL, rather than from the E-Comics alone. Empirically, the results demonstrate a statistically significant improvement in students' problem-solving performance and learning motivation. From an interpretative perspective, these outcomes suggest that E-Comics may function as cognitive and motivational scaffolds by externalizing problem representations and sustaining learner engagement during the PBL process.

Conclusion

Based on the research results, it can be concluded that the integration of E-Comics and PBL is effective in improving the higher-order thinking skills (HOTS) of elementary school students. This learning model not only significantly improves analytical, evaluative, and creative abilities but also encourages active engagement, collaboration, and motivation among students. E-Comics have proven to be an effective medium for presenting problems in PBL due to their visual, narrative, and interactive nature. Thus, this integration can be recommended as a pedagogical innovation for developing HOTS at the elementary education level. Despite the contributions of this study, several methodological limitations should be acknowledged. First, the sample was drawn from a single educational institution, which may limit the generalizability of the findings to other educational contexts or student populations. Second, the study employed a quasi-experimental design without random assignment, which may have introduced selection bias. Third, data collection relied partly on self-reported measures, which are subject to social desirability and response bias. Future studies are encouraged to employ longitudinal designs, multi-

institutional samples, and mixed-method approaches to further validate and extend the present findings.

These conclusions should be interpreted in light of several limitations, including the relatively small sample size and the short duration of the intervention. Consequently, while the findings support the potential of E-Comics as supportive scaffolding tools in PBL, further studies with broader contexts and longer implementation periods are required before making broader generalizations

Implications

Theoretically, this study reinforces the model of integrating digital media and the constructivist approach in developing HOTS. Practically, this study provides an alternative innovative learning model for elementary school teachers. Teachers can develop E-Comics with local content to increase the relevance of the problems. Schools are advised to provide supporting infrastructure such as digital devices and teacher training.

Research Limitations

This study has several limitations: 1) The sample is limited to two schools in one district, so generalization should be done with caution; 2) The research material is limited to the topic of science (reproduction of living things); 3) The development of E-Comics in this study still needs the use of augmented reality or advanced interactive features.

Further Research Recommendations

Based on these limitations, the following are recommended: 1) Further research with a broader and more diverse sample; 2) Experiments in other subjects such as Mathematics or Social Studies; 3) Development of E-Comics using more advanced technology (e.g., augmented reality-based) and testing its impact; 4) Longitudinal research to observe the long-term effects of this integrative model; 5) Studies on the factors mediating the effectiveness of the model, such as the role of teachers and parental support.

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