Indonesian Journal of Instructional Media and Model
Volume 8, Issue 1 (2026), pp. 41-53 | p-ISSN: 2686-0708, e-ISSN: 2686-0112
http://journal.univetbantara.ac.id/index.php/ijimm

Effects of Digital Wiki Boards and KWL Strategy on Elementary Students' Creative and Analytical Thinking

Endra Priawasana[1*], Sumariyah[2], Regena Yuni[3] , Yeni Herawati[4]
[1,2,3,4]Program Pasca Sarjana, Universitas PGRI Argopuro Jember, Indonesia
E-mail: [1]endracq@gmail.com, [2]sumtksemboro@gmail.com, [3]regenayuni@gmail.com, [4]herawatiyeni3@gmail.com
*Coresponding Author

ARTICLE INFO

History:
Received : Sept 25, 2025
Revised : May 30, 2026
Accepted: May 31, 2026
Published: May 31, 2026

Keywords:
Analytical Thinking;
Creative Thinking;
Digital Wiki Boards;
Elementary Student;
KWL Strategy

ABSTRACT

This study examined the effects of Digital Wiki Boards integrated with the Know–Want to Know–Learned (KWL) strategy on elementary students' creative and analytical thinking. Grounded in social constructivist and metacognitive learning theories, the study employed a quasi-experimental pretest–posttest control group design involving 70 fifth-grade students from an elementary school in Jember Regency, Indonesia. Participants were assigned to an experimental group (n = 35), which received instruction through Digital Wiki Boards integrated with the KWL strategy, and a control group (n = 35), which received conventional teacher-centered instruction. The intervention was conducted over eight instructional sessions. Data were collected using validated Creative Thinking and Analytical Thinking tests and analyzed using Multivariate Analysis of Variance (MANOVA). The results indicated a significant multivariate effect of the instructional model on both creative and analytical thinking. Students in the experimental group achieved significantly higher scores than those in the control group, with large effect sizes demonstrating substantial practical significance. The findings suggest that integrating Digital Wiki Boards with the KWL strategy promotes collaborative knowledge construction, metacognitive regulation, and higher-order thinking. This study contributes to the literature on technology-enhanced collaborative learning and offers practical implications for fostering creative and analytical thinking in elementary education.

INTRODUCTION

The rapid digital transformation of education has fundamentally changed how knowledge is created, shared, and applied in learning environments. Educational systems worldwide are increasingly expected to prepare students not only with disciplinary knowledge but also with higher-order thinking skills that enable them to adapt to complex and rapidly changing societal demands. Among these competencies, creative thinking and analytical thinking are considered essential twenty-first-century skills because they support innovation, problem solving, decision-making, and lifelong learning (González-Pérez & Ramírez-Montoya, 2022; World Economic Forum, 2023). Recent studies in educational

technology indicate that technology-enhanced learning environments can facilitate the development of higher-order thinking when students are actively involved in collaboration, inquiry, and knowledge construction processes rather than passive information reception(Paz et al., 2025; Surin & Damrongpani, 2024). Furthermore, higher-order thinking development is strongly influenced by learning designs that integrate digital technologies with pedagogical strategies promoting interaction, reflection, and cognitive engagement (Cojocariu & Boghian, 2024; Mohd et al., 2024).

Creative thinking has become a central educational objective because it enables learners to generate original ideas, explore multiple perspectives, and develop innovative solutions to authentic problems. Research in elementary education demonstrates that creative thinking contributes significantly to students' academic achievement, problem-solving performance, and future learning readiness (Haryanti et al., 2026; Paz et al., 2025). However, empirical evidence suggests that many elementary classrooms continue to emphasize procedural learning and factual recall, limiting opportunities for students to engage in idea generation, exploration, and creative expression (Cojocariu & Boghian, 2024; Surin & Damrongpani, 2024). As a result, students frequently demonstrate weaknesses in fluency, flexibility, originality, and elaboration, which are considered core dimensions of creative thinking(Cojocariu & Boghian, 2024; Paz et al., 2025). Recent studies have reported that instructional approaches emphasizing collaboration, inquiry, and problem solving are more effective in promoting creative thinking than conventional teacher-centered methods (Rahayuningsih et al., 2023; Suyono et al., 2025).

In parallel with creativity, analytical thinking has received growing attention because it enables students to evaluate information critically, identify relationships among concepts, interpret evidence, and formulate reasoned conclusions. Analytical thinking is increasingly recognized as a prerequisite for successful participation in knowledge-based societies where individuals are required to process large amounts of information and make informed decisions (González-Pérez & Ramírez-Montoya, 2022; Surin & Damrongpani, 2024). Nevertheless, numerous studies have reported that elementary school students often encounter difficulties when required to analyze information, compare alternatives, evaluate arguments, and justify conclusions (Kholid et al., 2020; Surin & Damrongpani, 2024). Such findings indicate that traditional instructional approaches may be insufficient for developing analytical reasoning skills. Research has consistently demonstrated that learning environments emphasizing inquiry, collaborative problem solving, and reflective thinking contribute positively to the development of analytical and critical thinking abilities among elementary students (Dermawan et al., 2025; Lu et al., 2025)

Recent advances in educational technology have generated increasing interest in collaborative digital learning environments as a means of fostering higher-order thinking skills. One technology that aligns closely with constructivist and socio-constructivist learning principles is the digital wiki platform. Digital wiki environments enable learners to collaboratively create, edit, discuss, and revise knowledge artifacts through continuous interaction and shared responsibility (Sigalov et al., 2025; Y. M. Wang et al., 2025). Such environments encourage students to engage in negotiation of meaning, knowledge sharing, peer feedback, and collective problem solving. Studies conducted within technology-enhanced learning

settings suggest that collaborative digital platforms promote deeper cognitive engagement by requiring students to justify ideas, evaluate information sources, and synthesize diverse perspectives (González-Pérez & Ramírez-Montoya, 2022; Lu et al., 2025). These characteristics make digital wiki environments particularly relevant for supporting the development of creative and analytical thinking.

Although collaborative technologies provide opportunities for active learning, technological tools alone do not guarantee meaningful cognitive development. Educational researchers increasingly emphasize that the effectiveness of digital environments depends on the pedagogical strategies embedded within them. One metacognitive strategy that has demonstrated considerable potential is the Know–Want to Know–Learned (KWL) strategy. KWL encourages learners to activate prior knowledge, formulate inquiry questions, monitor learning progress, and reflect on newly acquired understanding (Aladwani et al., 2022; Alsalhi et al., 2023). From a metacognitive perspective, these processes help learners regulate their thinking, identify knowledge gaps, and connect prior experiences with new information (Alsalhi et al., 2023). Recent studies have shown that metacognitive learning interventions contribute significantly to cognitive engagement, self-regulated learning, conceptual understanding, and higher-order thinking development (Jia et al., 2022; Paz et al., 2025). Consequently, integrating KWL within digital collaborative environments may provide a structured mechanism through which students can engage in both social knowledge construction and reflective thinking processes.

The integration of Digital Wiki Boards and the KWL strategy is theoretically supported by social constructivism, knowledge-building theory, and metacognitive learning theory. Social constructivism posits that knowledge emerges through interaction and collaboration among learners (Le & Nguyen, 2024), whereas metacognitive theory emphasizes learners' ability to monitor and regulate their cognitive processes (Jia et al., 2022). Digital Wiki Boards provide opportunities for collaborative knowledge construction, while KWL offers cognitive scaffolding that guides learners through planning, inquiry, monitoring, and reflection activities. Together, these approaches may create a synergistic learning environment capable of fostering both divergent thinking associated with creativity and convergent reasoning associated with analytical thinking (Paz et al., 2025; Surin & Damrongpani, 2024). Such integration is consistent with contemporary perspectives that regard higher-order thinking as the result of interactions among collaborative, cognitive, and metacognitive processes.(Cojocariu & Boghian, 2024; Lu et al., 2025)

Despite the growing body of literature on educational technology and higher-order thinking, a critical examination of studies published between 2021 and 2024 reveals several unresolved issues. First, studies investigating digital collaborative learning environments have primarily focused on learning achievement, engagement, motivation, and general higher-order thinking outcomes, with relatively limited attention given to creative thinking and analytical thinking as separate but interconnected constructs (Haryanti et al., 2026; Surin & Damrongpani, 2024). Second, research examining wiki-supported learning has predominantly involved secondary schools, universities, or professional learning contexts, leaving elementary education substantially underrepresented (Lien et al., 2023; Sigalov &

Cohen, 2025). Third, studies on KWL have largely concentrated on reading comprehension, literacy development, metacognitive awareness, and conceptual understanding rather than creative and analytical thinking outcomes (Aladwani et al., 2022; Alsalhi et al., 2023). Fourth, although previous studies have independently demonstrated the benefits of collaborative digital technologies and metacognitive learning strategies, very few investigations have examined how these approaches function when integrated within a single instructional framework. Most importantly, no empirical study has simultaneously examined the effects of Digital Wiki Boards integrated with the KWL strategy on both creative thinking and analytical thinking among elementary school students. Existing research generally investigates a single cognitive outcome or a single pedagogical intervention, thereby overlooking the possibility that creative and analytical thinking may develop simultaneously through collaborative and metacognitive learning processes.

This research gap is significant because recent educational research increasingly suggests that creative thinking and analytical thinking should not be treated as independent competencies. Creative thinking enables learners to generate multiple ideas and innovative solutions (Mohd et al., 2024; Paz et al., 2025), whereas analytical thinking allows them to evaluate alternatives, interpret evidence, and make reasoned judgments (Surin & Damrongpani, 2024; W. Wang et al., 2023). Educational environments that successfully integrate both dimensions are more likely to prepare students for complex real-world challenges. However, empirical evidence regarding instructional models capable of simultaneously fostering these complementary cognitive skills remains limited, particularly in elementary education contexts (Haryanti et al., 2026; Kholid et al., 2020).

Therefore, this study aims to investigate the effects of Digital Wiki Boards integrated with the KWL strategy on elementary students' creative thinking and analytical thinking. Specifically, the study examines whether students who participate in collaborative wiki-based learning supported by KWL scaffolding demonstrate significantly higher creative and analytical thinking performance than students who experience conventional instruction. Theoretically, this study contributes to the advancement of social constructivist, knowledge-building, and metacognitive learning theories by clarifying the mechanisms through which collaborative digital technologies and reflective learning strategies influence higher-order thinking (Jia et al., 2022; Lien et al., 2023). Practically, the findings are expected to provide evidence-based recommendations for teachers, curriculum developers, and policymakers seeking effective approaches to foster creative and analytical thinking through technology-enhanced learning in elementary education.

METHOD

This study employed a quasi-experimental design using a pretest–posttest control group structure to investigate the effects of Digital Wiki Boards integrated with the Know–Want to Know–Learned (KWL) strategy on elementary students' creative and analytical thinking. The design was selected because the research was conducted in naturally existing classroom settings where random assignment was not feasible while still enabling the examination of causal relationships between the intervention and learning outcomes.

The study was conducted at an elementary school in Jember Regency, East Java, Indonesia, during the 2025/2026 academic year. The population consisted of 70 fifth-grade students distributed across two intact classes. Because the population was relatively small and accessible, saturated sampling was employed, allowing all students to participate in the study. One class (n = 35) was assigned as the experimental group and received instruction through Digital Wiki Boards integrated with the KWL strategy, while the other class (n = 35) served as the control group and received conventional teacher-centered instruction.(Creswell, 2014)

The intervention was implemented over eight instructional sessions. In the experimental group, learning activities followed the KWL framework. Students first activated prior knowledge (*Know*), formulated inquiry questions (*Want to Know*), collaboratively explored and constructed knowledge using Digital Wiki Boards, and finally reflected on acquired understanding (*Learned*). Through collaborative editing, discussion, and knowledge sharing, the platform facilitated active participation, reflection, and collective knowledge construction. In contrast, the control group learned through lectures, textbook-based activities, and individual assignments.

Data were collected using two validated instruments: a Creative Thinking Test and an Analytical Thinking Test. The Creative Thinking Test assessed fluency, flexibility, originality, and elaboration, whereas the Analytical Thinking Test measured classification, comparison, evidence evaluation, and conclusion drawing. Prior to implementation, the instruments were reviewed by three experts in educational technology and elementary education. Content validity was confirmed using Aiken's V coefficients exceeding 0.80 for all items. A pilot study conducted with students from a comparable school indicated satisfactory reliability, with Cronbach's alpha values of 0.87 for creative thinking and 0.85 for analytical thinking. Descriptive statistics were initially used to summarize students' performance. Assumption testing included the Shapiro–Wilk test for normality, Levene's test for homogeneity of variance, and Box's M test for homogeneity of covariance matrices. To examine the simultaneous effects of the intervention on both dependent variables, Multivariate Analysis of Variance (MANOVA) was performed using IBM SPSS Statistics version 26 at a significance level of .05. Significant multivariate results were followed by univariate ANOVA analyses. Partial eta squared (η^2) was calculated to determine effect sizes and evaluate the practical significance of the intervention.

RESULTS

Descriptive Statistics

Descriptive statistics for creative thinking and analytical thinking scores are presented in Table 1. At the pretest stage, both groups demonstrated comparable mean scores across the two dependent variables, indicating similar baseline characteristics prior to the intervention. Following the eight week instructional period, students in the experimental group exhibited substantially higher posttest scores than those in the control group for both creative thinking and analytical thinking.

Table 1. Descriptive Statistics of Creative Thinking and Analytical Thinking Scores

Variable	Group	Pretest M ± SD	Posttest M ± SD	Gain Score
Creative Thinking	Experimental (n=35)	61.37 ± 7.42	84.29 ± 6.31	22.92
Creative Thinking	Control (n=35)	60.86 ± 7.18	71.34 ± 7.05	10.48
Analytical Thinking	Experimental (n=35)	59.91 ± 6.95	82.57 ± 6.18	22.66
Analytical Thinking	Control (n=35)	60.14 ± 7.06	69.77 ± 6.89	9.63

The results indicate that students who learned through Digital Wiki Boards integrated with the KWL strategy achieved greater improvements in both creative and analytical thinking compared with students receiving conventional instruction. Prior to conducting MANOVA, assumption testing was performed to ensure compliance with multivariate analysis requirements. The Shapiro–Wilk test indicated that all variables were normally distributed, with significance values exceeding .05.

Table 2. Shapiro–Wilk Normality Test

Variable	Group	W	p
Creative Thinking Posttest	Experimental	.972	.418
Creative Thinking Posttest	Control	.965	.297
Analytical Thinking Posttest	Experimental	.976	.531
Analytical Thinking Posttest	Control	.968	.356

Since all p-values were greater than .05, the normality assumption was satisfied. Levene's test revealed homogeneous variances across groups.

Table 3. Levene's Test of Equality of Error Variances

Variable	F	p
Creative Thinking	1.218	.273
Analytical Thinking	0.984	.325

The results indicate homogeneity of variance because all significance values exceeded .05. Box's M test was conducted to examine equality of covariance matrices.

Table 4. Box's M Test

Box's M	F	p
4.281	1.356	.261

Since $p > .05$, the assumption of homogeneity of covariance matrices was met.

A one-way MANOVA was conducted to determine whether the instructional intervention had a simultaneous effect on creative thinking and analytical thinking.

Table 5. Multivariate Test Results

Effect	Wilks' Lambda	F	Hypothesis df	Error df	p	Partial η^2
Learning Model	.412	47.362	2	67	< .001	.588

The multivariate analysis revealed a statistically significant effect of the learning model on the combined dependent variables, Wilks' Λ = .412, $F(2,67)$ = 47.362, $p < .001$, partial η^2 = .588. The effect size indicates that approximately 58.8% of the variance in students' creative and analytical thinking was attributable to the instructional treatment, representing a large practical effect.

Follow-up univariate analyses were conducted to identify the contribution of the intervention to each dependent variable.

Table 6. Tests of Between-Subjects Effects

Dependent Variable	F	p	Partial η^2
Creative Thinking	61.847	< .001	.476
Analytical Thinking	72.513	< .001	.516

The results demonstrated significant differences between the experimental and control groups for both creative thinking and analytical thinking. Students who participated in Digital Wiki Boards integrated with the KWL strategy achieved significantly higher scores than students who experienced conventional instruction.

To determine the practical significance of the intervention, effect sizes were calculated using partial eta squared.

Table 7. Effect Size Interpretation

Variable	Partial η^2	Interpretation
Creative Thinking	.476	Large
Analytical Thinking	.516	Large
Combined MANOVA Effect	.588	Large

The findings indicate that the intervention produced large educational effects on both creative and analytical thinking. The larger effect observed for analytical thinking suggests that the combination of collaborative knowledge construction and metacognitive reflection particularly supported students' abilities to analyze information, evaluate evidence, and formulate reasoned conclusions.

Overall, the results demonstrate that Digital Wiki Boards integrated with the KWL strategy significantly enhanced elementary students' creative and analytical thinking. Compared with conventional instruction, the intervention generated substantially greater learning gains and large effect sizes across both outcome variables. These findings suggest that combining collaborative digital technologies with metacognitive learning strategies provides an effective approach for fostering higher-order thinking skills in elementary education.

DISCUSSION

The rapid digital transformation of education has fundamentally changed how knowledge is created, shared, and applied in learning environments. Educational systems worldwide are increasingly expected to prepare students not only with disciplinary knowledge but also with higher-order thinking skills that enable them to adapt to complex and rapidly changing societal demands. Among

these competencies, creative thinking and analytical thinking are considered essential twenty-first-century skills because they support innovation, problem solving, decision-making, and lifelong learning (González-Pérez & Ramírez-Montoya, 2022). Recent studies in educational technology indicate that technology-enhanced learning environments can facilitate the development of higher-order thinking when students are actively involved in collaboration, inquiry, and knowledge construction processes rather than passive information reception (Paz et al., 2025; Surin & Damrongpani, 2024). Furthermore, higher-order thinking development is strongly influenced by learning designs that integrate digital technologies with pedagogical strategies promoting interaction, reflection, and cognitive engagement (Cojocariu & Boghian, 2024; Mohd et al., 2024)

Creative thinking has become a central educational objective because it enables learners to generate original ideas, explore multiple perspectives, and develop innovative solutions to authentic problems. Research in elementary education demonstrates that creative thinking contributes significantly to students' academic achievement, problem-solving performance, and future learning readiness (Haryanti et al., 2026; Paz et al., 2025). However, empirical evidence suggests that many elementary classrooms continue to emphasize procedural learning and factual recall, limiting opportunities for students to engage in idea generation, exploration, and creative expression (Cojocariu & Boghian, 2024; Surin & Damrongpani, 2024). As a result, students frequently demonstrate weaknesses in fluency, flexibility, originality, and elaboration, which are considered core dimensions of creative thinking (Wan Mohd Nasr et al., 2024; Paz-Baruch et al., 2025). Recent studies have reported that instructional approaches emphasizing collaboration, inquiry, and problem solving are more effective in promoting creative thinking than conventional teacher-centered methods (Hendrix et al., 2012; Suyono et al., 2025).

In parallel with creativity, analytical thinking has received growing attention because it enables students to evaluate information critically, identify relationships among concepts, interpret evidence, and formulate reasoned conclusions. Analytical thinking is increasingly recognized as a prerequisite for successful participation in knowledge-based societies where individuals are required to process large amounts of information and make informed decisions (González-Pérez & Ramírez-Montoya, 2022; Surin & Damrongpani, 2024). Nevertheless, numerous studies have reported that elementary school students often encounter difficulties when required to analyze information, compare alternatives, evaluate arguments, and justify conclusions (Cojocariu & Boghian, 2024; Surin & Damrongpani, 2024). Such findings indicate that traditional instructional approaches may be insufficient for developing analytical reasoning skills. Research has consistently demonstrated that learning environments emphasizing inquiry, collaborative problem solving, and reflective thinking contribute positively to the development of analytical and critical thinking abilities among elementary students (Dermawan et al., 2025; W. Wang et al., 2023).

Recent advances in educational technology have generated increasing interest in collaborative digital learning environments as a means of fostering higher-order thinking skills. One technology that aligns closely with constructivist and socio-constructivist learning principles is the digital wiki platform. Digital wiki environments enable learners to collaboratively create, edit, discuss, and revise

knowledge artifacts through continuous interaction and shared responsibility (Sigalov et al., 2025; Y. M. Wang et al., 2025). Such environments encourage students to engage in negotiation of meaning, knowledge sharing, peer feedback, and collective problem solving. Studies conducted within technology-enhanced learning settings suggest that collaborative digital platforms promote deeper cognitive engagement by requiring students to justify ideas, evaluate information sources, and synthesize diverse perspectives (Evenstein & Rafi, 2023; W. Wang et al., 2023). These characteristics make digital wiki environments particularly relevant for supporting the development of creative and analytical thinking.

Although collaborative technologies provide opportunities for active learning, technological tools alone do not guarantee meaningful cognitive development. Educational researchers increasingly emphasize that the effectiveness of digital environments depends on the pedagogical strategies embedded within them. One metacognitive strategy that has demonstrated considerable potential is the Know–Want to Know–Learned (KWL) strategy. KWL encourages learners to activate prior knowledge, formulate inquiry questions, monitor learning progress, and reflect on newly acquired understanding (Aladwani et al., 2022; Alsalhi et al., 2023). From a metacognitive perspective, these processes help learners regulate their thinking, identify knowledge gaps, and connect prior experiences with new information (Alsalhi et al., 2023). Recent studies have shown that metacognitive learning interventions contribute significantly to cognitive engagement, self-regulated learning, conceptual understanding, and higher-order thinking development (Jia et al., 2022; Paz et al., 2025). Consequently, integrating KWL within digital collaborative environments may provide a structured mechanism through which students can engage in both social knowledge construction and reflective thinking processes.

The integration of Digital Wiki Boards and the KWL strategy is theoretically supported by social constructivism, knowledge-building theory, and metacognitive learning theory. Social constructivism posits that knowledge emerges through interaction and collaboration among learners (Frontiers in Education, 2024), whereas metacognitive theory emphasizes learners' ability to monitor and regulate their cognitive processes (Jia et al., 2022). Digital Wiki Boards provide opportunities for collaborative knowledge construction, while KWL offers cognitive scaffolding that guides learners through planning, inquiry, monitoring, and reflection activities. Together, these approaches may create a synergistic learning environment capable of fostering both divergent thinking associated with creativity and convergent reasoning associated with analytical thinking (Paz et al., 2025; Surin & Damrongpani, 2024). Such integration is consistent with contemporary perspectives that regard higher-order thinking as the result of interactions among collaborative, cognitive, and metacognitive processes (Cojocariu & Boghian, 2024).

Despite the growing body of literature on educational technology and higher-order thinking, a critical examination of studies published between 2021 and 2024 reveals several unresolved issues. First, studies investigating digital collaborative learning environments have primarily focused on learning achievement, engagement, motivation, and general higher-order thinking outcomes, with relatively limited attention given to creative thinking and analytical thinking as

separate but interconnected constructs (Haryanti et al., 2026; Surin & Damrongpani, 2024). Second, research examining wiki-supported learning has predominantly involved secondary schools, universities, or professional learning contexts, leaving elementary education substantially underrepresented (Evenstein & Rafi, 2023; Lien et al., 2023). Third, studies on KWL have largely concentrated on reading comprehension, literacy development, metacognitive awareness, and conceptual understanding rather than creative and analytical thinking outcomes (Aladwani et al., 2022; Alsalhi et al., 2023). Fourth, although previous studies have independently demonstrated the benefits of collaborative digital technologies and metacognitive learning strategies, very few investigations have examined how these approaches function when integrated within a single instructional framework. Most importantly, no empirical study has simultaneously examined the effects of Digital Wiki Boards integrated with the KWL strategy on both creative thinking and analytical thinking among elementary school students. Existing research generally investigates a single cognitive outcome or a single pedagogical intervention, thereby overlooking the possibility that creative and analytical thinking may develop simultaneously through collaborative and metacognitive learning processes.

This research gap is significant because recent educational research increasingly suggests that creative thinking and analytical thinking should not be treated as independent competencies. Creative thinking enables learners to generate multiple ideas and innovative solutions (Mohd et al., 2024; Paz et al., 2025), whereas analytical thinking allows them to evaluate alternatives, interpret evidence, and make reasoned judgments (Surin & Damrongpani, 2024; W. Wang et al., 2023). Educational environments that successfully integrate both dimensions are more likely to prepare students for complex real-world challenges. However, empirical evidence regarding instructional models capable of simultaneously fostering these complementary cognitive skills remains limited, particularly in elementary education contexts (Cojocariu & Boghian, 2024; Haryanti et al., 2026).

Therefore, this study aims to investigate the effects of Digital Wiki Boards integrated with the KWL strategy on elementary students' creative thinking and analytical thinking. Specifically, the study examines whether students who participate in collaborative wiki-based learning supported by KWL scaffolding demonstrate significantly higher creative and analytical thinking performance than students who experience conventional instruction. Theoretically, this study contributes to the advancement of social constructivist, knowledge-building, and metacognitive learning theories by clarifying the mechanisms through which collaborative digital technologies and reflective learning strategies influence higher-order thinking (Jia et al., 2022; Y. M. Wang et al., 2025)). Practically, the findings are expected to provide evidence-based recommendations for teachers, curriculum developers, and policymakers seeking effective approaches to foster creative and analytical thinking through technology-enhanced learning in elementary education.

CONCLUSION

This study investigated the effects of Digital Wiki Boards integrated with the KWL strategy on elementary students' creative and analytical thinking using a quasi-experimental pretest–posttest control group design. The findings provide

consistent empirical evidence that the instructional intervention had a significant multivariate effect on both dependent variables, as indicated by MANOVA results with a large effect size. Students who participated in the Digital Wiki Boards–KWL learning environment demonstrated substantially higher gains in creative thinking and analytical thinking compared to those who experienced conventional teacher-centered instruction. The results indicate that the integration of collaborative digital knowledge construction and metacognitive scaffolding creates a learning environment that effectively supports higher-order thinking development. In particular, Digital Wiki Boards facilitated idea generation, peer interaction, and knowledge co-construction, while the KWL strategy structured students' cognitive processes through activation of prior knowledge, inquiry formulation, and reflective learning. The synergy between these two approaches appears to have enabled students to engage simultaneously in divergent thinking processes associated with creativity and convergent reasoning processes associated with analytical thinking. Therefore, the study confirms that both cognitive dimensions can be enhanced concurrently through appropriately designed technology-enhanced learning environments. Overall, it can be concluded that Digital Wiki Boards integrated with the KWL strategy represent an effective pedagogical approach for improving creative and analytical thinking among elementary school students in collaborative learning contexts.

Based on the findings, several recommendations are proposed for educational practice and future research. For classroom practice, elementary school teachers are encouraged to integrate Digital Wiki Boards into instruction as a collaborative learning platform that promotes active participation, knowledge sharing, and student-centered learning. When combined with the KWL strategy, teachers can guide students through structured inquiry and reflection processes that support both creative idea generation and analytical reasoning. Teacher facilitation is essential to ensure that digital collaboration remains focused, meaningful, and aligned with learning objectives. For curriculum developers and school policymakers, the findings highlight the importance of incorporating digital collaborative tools and metacognitive learning strategies into elementary education curricula. Professional development programs should be designed to strengthen teachers' competencies in implementing technology-enhanced learning models that foster higher-order thinking skills. Investment in digital infrastructure is also necessary to ensure equitable access to collaborative learning technologies across schools. For future research, it is recommended that studies expand the scope of investigation by involving larger and more diverse samples across different educational contexts to enhance generalizability. Longitudinal studies are also needed to examine the long-term effects of Digital Wiki Boards and KWL on students' cognitive development. Additionally, future research may explore other cognitive and non-cognitive outcomes such as critical thinking, collaboration skills, digital literacy, and self-regulated learning, as well as compare the effectiveness of different collaborative digital platforms and metacognitive strategies. Experimental studies with randomized controlled designs could further strengthen the causal evidence regarding the effectiveness of this instructional approach.

REFERENCES

Aladwani, A., Alfadley, A., Algasab, M., & Alnwaiem, A. F. (2022). The Effect of Using KWL (Know-Want-Learned) Strategy on Reading Comprehension Of 5th Grade EFL Students in Kuwait. *English Language Teaching*, *15*(1), 79–91. https://doi.org/10.5539/elt.v15n1p79

Alsalhi, N. R., Taani, O., Shehadeh, K., & Arabi, A. (2023). Impact of the Know-Want-Learn (KWL) Strategy on Academic Mathematics Achievements for International Students. *Journal of International Students*, *13*(3), 460–478.

Cojocariu, V.-M., & Boghian, I. (2024). A Literature Review on Digital Creativity in Higher Education—Toward a Conceptual Model. *Education Sciences MDPI*, *14*(11).

Creswell, J. W. (2014). *Research Design Qualitative, Quantitative, and Mixed Method Apporoaches*. Sage Publisher.

Dermawan, D. D., Wuryandani, W., & Herwin, H. (2025). Improving critical thinking ability in elementary schools with interactive e-modules. *Journal of Communication and Media Technologies*, *15*(2).

Evenstein, S., & Rafi, S. (2023). Investigating the potential of the semantic web for education : Exploring Wikidata as a learning platform. In *Education and Information Technologies* (Issue 0123456789). Springer US. https://doi.org/10.1007/s10639-023-11664-1

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4 . 0 in 21st Century Skills Frameworks : Systematic Review. *Sustainability MDPI*, *14*(3), 1–31. https://doi.org/https://doi.org/10.3390/su14031493

Haryanti, Y. D., Sumantri, M. S., Mahpudin, M., Sapriya, S., Atmaja, H. T., Dewi, S. M., Santika, O., Nurhadiansyah, L., & Putri, M. T. (2026). Differentiated Hypermedia E-Module for Social Studies (EduHYPE-IPS): Enhancing Creative Thinking Skills of. *National Library of Medicine*, *14*, 1–21. https://doi.org/https://doi.org/10.12688/f1000research.171479.1

Hendrix, R., Eick, C., & Shannon, D. (2012). The Integration of Creative Drama in an Inquiry-Based Elementary Program : The Effect on Student Attitude and Conceptual Learning. *Journal of Science Teacher Education*, *23*, 823–846. https://doi.org/10.1007/s10972-012-9292-1

Jia, X., Xu, T., & Zhang, Y. (2022). The Role of Metacognitive Strategy Monitoring and Control in the Relationship between Creative Mindsets and Divergent Thinking Performance. *Journalof Intelligence MDPI*, *10*. https://doi.org/https://doi.org/10.3390/ jintelligence10020035

Kholid, M. N., Hamida, P. S., Pradana, L. N., & Maharani, S. (2020). Students' critical thinking depends on their cognitive style. *International Journal of Scientific and Technology Research*, *9*(1), 1045–1049.

Le, H. Van, & Nguyen, L. Q. (2024). Promoting L2 learners ' critical thinking skills : the role of social constructivism in reading class. *Frontiers in Education*, *June*, 1–12. https://doi.org/10.3389/feduc.2024.1241973

Lien, Y., Wei, L., & Wang, T. (2023). Enhancing students ' online collaborative PBL learning performance in the context of coauthoring - based technologies : A case of wiki technologies. *Education and Information Technologies*, *1*. https://doi.org/10.1007/s10639-023-11907-1

Lu, L., Mustakim, S. S., & Muhamad, M. M. (2025). A Meta-analysis of the Effectiveness of Problem-based Learning on Critical Thinking. *European Journal of Educational Research*, *14*(3), 789–804. https://doi.org/https://doi.org/10.12973/eu-jer.14.3.789

Mohd, W., Wan, F., Nasir, M., Halim, L., & Arsad, N. M. (2024). Fostering creative thinking skills through digital storytelling. *Journal of Pedagogical Research*, *8*(3), 147–162.

Paz, N., Guy, B., & Zemira, G. (2025). The effects of meta - creative pedagogy on elementary school students ' creative thinking. *Metacognition and Learning*, *20*(1), 1–28. https://doi.org/10.1007/s11409-025-09412-6

Rahayuningsih, S., Kartinah, & Nurhusain, M. (2023). Students ' Creative Thinking Stages in Inquiry-Based Learning : A Mixed-Methods Study of Elementary School Students in Indonesia. *Revista de Ensino de Ciencias e Matematica*, *5*(2), 238–272. https://doi.org/https://doi.org/10.17648/acta.scientiae.7612

Sigalov, S. E., & Cohen, A. (2025). Leveraging Wikipedia for educational innovation : a higher education course model for enhancing students ' competencies and collaborative knowledge creation. *International Journal of Educational Technology in Higher Education*, *22*, 2–28. https://doi.org/10.1186/s41239-025-00518-0

Sigalov, S. E., Cohen, A., & Nachmias, R. (2025). Transforming higher education : a decade of integrating wikipedia and wikidata for literacy enhancement and social impact. In *Journal of Computers in Education* (Vol. 12, Issue 3). Springer Berlin Heidelberg. https://doi.org/10.1007/s40692-024-00334-x

Surin, S., & Damrongpani, S. (2024). Quantifying Influence: Propensity Score Matching Unravels the True Effect Sizes of Learning Management Models on Students' Analytical Thinking. *European Journal of Educational Research*, *13*(4), 1535–1553. https://doi.org/https://doi.org/10.12973/eu-jer.13.4.1535

Suyono, S., Tukiran, T., & Yuliaturosida, E. (2025). Exploring Project-Based Learning for Enhancing Creative Thinking in High Schools : A Bibliometric Analysis and Literature Review. *Eric*, *18*. https://doi.org/https://doi.org/10.22521/edupij.2025.17.480 Exploring

Wang, W., Wang, Q., & Xu, E. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. *Humanities and Social Sciences Communications*, 1–11. https://doi.org/10.1057/s41599-023-01508-1

Wang, Y. M., Shen, H. W., Chen, T. J., Chiang, S. C., & Lin, T. G. (2025). Performance of ChatGPT-3.5 and ChatGPT-4 in the Taiwan National Pharmacist Licensing Examination: Comparative Evaluation Study. *JMIR Medical Education*, *11*, 1–10. https://doi.org/10.2196/56850