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The Effect of Project-Based Learning on Critical Thinking Skills across Students' Cognitive Styles

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Articles Information	Abstract
Received : 01-03-2026 Revised R1 : 01-04-2026 Revised R2 : 14-05-2026 Accepted : 17-05-2026 Published : 30-05-2026	Increasing students' critical thinking skills has become an important challenge in 21st-century primary education, particularly in implementing student-centered learning within the Merdeka Curriculum. This study aims to analyse the effect of the Project-Based Learning (PjBL) model on students' critical thinking skills in terms of field-independent and field-dependent cognitive styles. The method used was a quasi-experiment with a 2×2 treatment by level design. The research sample consisted of 80 fourth-grade students divided based on learning model (PjBL and expository) and cognitive style. The research instrument was a critical thinking ability test covering the indicators of interpretation, analysis, evaluation, and inference. Data analysis used two-way ANOVA and Tukey's test at a significance level of 0.05. The results showed a difference in critical thinking skills between students learning with PjBL and expository learning, with the average PjBL score (73.85) higher than the expository score (69.90). There was an interaction between the learning model and cognitive style. Field-independent students who learned with PjBL obtained the highest score (78.40), while in the expository model, field-dependent students performed relatively better (72.10). It was concluded that PjBL was effective in improving critical thinking skills, particularly for field-independent students, and has important implications for differentiated instructional strategies in primary education. Keywords: Project-Based Learning; Critical Thinking Skills; Cognitive Styles

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1. INTRODUCTION

The development of education in the 21st century requires students to have higher-order thinking skills in order to adapt to rapid social and technological changes. The 4C skills (critical thinking, creativity, collaboration, and communication) are an important foundation in shaping these competencies (Trilling & Fadel, 2022; Widodo et al., 2022; Setiawan et al., 2024). In the context of primary education, critical thinking skills are seen as one of the main indicators of learning success because they play a role in training students to analyse information, evaluate arguments, and make rational decisions (Rahmawati & Suryadi, 2023; Nugroho et al., 2021). Therefore, the strengthening of critical thinking needs to be systematically integrated into the learning process from primary school level onwards.

In line with these demands, the implementation of the Merdeka Curriculum in Indonesia encourages learner-centred learning and competency-based learning (Kemendikbudristek, 2022; Suhelayanti et al., 2023). This curriculum emphasises the importance of contextual and meaningful learning so that students are able to actively construct knowledge (Pratama & Lestari, 2021; Firmansyah & Hidayat, 2023). However, a number of studies show that learning practices in primary schools still tend to be teacher-oriented, so that opportunities for students to develop critical thinking skills are not yet optimal (Andriyani et al., 2022; Sarwanto et al., 2021).

This situation indicates a gap between curriculum policy and its implementation in the field. Initial observations in several primary schools show that lecture-based methods are still predominantly used, while discussion, exploration, and reflection activities have not been maximised. In fact, learning strategies that place students as active subjects have been proven to be more effective in improving critical thinking skills (Hidayat et al., 2022; Lestari & Kurniawan, 2023). Thus, a learning model that encourages the active involvement of students in the knowledge construction process is needed.

One relevant model for addressing these needs is Project-Based Learning (PjBL). This model provides learners with the opportunity to learn through projects based on real-world problems, thereby encouraging investigation, collaboration, and reflection (Kokotsaki et al., 2021; Anazifa & Djukri, 2022). Several studies report that the implementation of PjBL has a positive effect on improving critical thinking skills and learning outcomes of primary school students (Putri et al., 2023; Wahyuni & Susanto, 2022). This shows that PjBL has the potential to be a more effective alternative learning strategy compared to conventional approaches.

Although many studies have reported the positive impact of PjBL on critical thinking skills, several findings indicate that its effectiveness is not always consistent across different learner characteristics and classroom contexts. Some students experience difficulties in managing independent inquiry and collaborative project tasks, particularly those who require structured guidance during learning activities. These inconsistencies indicate the need to examine moderating variables, such as cognitive style, in understanding the effectiveness of PjBL.

In IPAS learning for Grade IV elementary school, the application of PjBL is becoming increasingly relevant due to the contextual nature of the material and its relevance to the lives of students. IPAS integrates scientific and social concepts that require a comprehensive understanding of the relationship between humans and their environment. Project-based learning enables students to identify environmental issues in their surroundings, design solutions, and present their findings systematically (Rahman et al., 2022; Sari & Mulyadi, 2024). This process directly trains students' analytical, evaluative, and synthetic skills as part of critical thinking.

However, the effectiveness of a learning model is also influenced by the individual characteristics of learners, one of which is cognitive style. Field independent (FI) and field dependent (FD) cognitive styles describe differences in how individuals process information and solve problems (Witkin et al., 2021; Yusuf & Hartono, 2023). Learners with an FI style tend to be more independent and analytical, while learners with an FD style are more responsive to social support and teacher guidance. These differences have the potential to influence how learners respond to the implementation of PjBL in the classroom.

Based on the above description, research is needed to examine the effect of Project Based Learning on students' critical thinking skills, taking into account cognitive style as a moderating variable. Previous studies have tended to test the effectiveness of PjBL in general without analysing the interaction between the learning model and the cognitive characteristics of students (Anazifa & Djukri, 2022; Putri et al., 2023). Therefore, this study is expected to contribute theoretically to the development of adaptive learning models and provide practical recommendations for primary school teachers in designing more effective learning that is oriented towards strengthening critical thinking skills.

Based on the research background, the study addresses the following research questions:

1. Is there a significant difference in critical thinking skills between students taught using PjBL and those taught using the expository model?
2. Is there an interaction effect between learning models and students' cognitive styles on critical thinking skills?
3. Which learning model is more effective for Field Independent and Field Dependent students?

2. LITERATURE REVIEW

Project-Based Learning (PjBL) has become one of the most widely used learning models to improve students' higher-order thinking skills. Unlike expository methods, PjBL emphasises learner-centred learning through the completion of real projects, collaboration, investigation, and reflection (Kokotsaki et al., 2021; Anazifa & Djukri, 2022). Several studies have shown that PjBL is effective in improving the critical thinking, creativity, and collaborative skills of primary school students (Putri et al., 2023; Wahyuni & Susanto, 2022). Thus, PjBL not only focuses on academic achievement but also on the development of 21st-century skills, which are essential in the modern era (Trilling & Fadel, 2022; Setiawan et al., 2024).

In addition, the application of PjBL in IPAS learning in primary schools is highly relevant because the material is contextual and close to the daily lives of students. IPAS material integrates science and social studies, requiring analytical, evaluative, and synthetic skills to understand the relationship between humans and their environment (Rahman et al., 2022; Sari & Mulyadi, 2024). Through real-world problem-based projects, students can identify environmental issues, design solutions, and present their findings, which directly trains critical thinking (Rahmawati & Suryadi, 2023; Nugroho et al., 2021).

2.1. Project-Based Learning and Critical Thinking

PjBL emphasises authentic learning experiences that enable students to develop critical thinking skills through the process of inquiry and problem solving. Students do not merely receive information, but actively construct knowledge from the results of exploration and collaboration (Kokotsaki et al., 2021). A study by Putri et al. (2023) found that the implementation of PjBL in Year 4 primary school significantly improved students' critical thinking scores compared to conventional learning. Thus, PjBL can be an effective learning strategy in optimising students' analytical, evaluative, and inferential abilities.

2.2. Cognitive Style and Learning

Learners' cognitive styles play an important role in how they receive, process, and apply information. The two main categories of cognitive styles are field independent (FI) and field dependent (FD). FI learners tend to be more analytical and independent, while FD learners rely more on social context and teacher guidance (Witkin et al., 2021; Yusuf & Hartono, 2023). These differences have implications for learners' responses to specific learning methods, including PjBL, making an understanding of cognitive styles important in designing effective learning.

2.2.1. Field Independent and Project Based Learning

Learners with an FI learning style tend to excel in completing projects that require independent analysis and critical decision-making. They are able to isolate important information from their surroundings and develop solutions systematically (Yusuf & Hartono, 2023; Nugroho et al., 2021). Therefore, the application of PjBL in classrooms with FI learners can be more effective in improving critical thinking skills compared to traditional methods.

2.2.2. Field Dependent and Project Based Learning

Conversely, FD students are more responsive to social support, group work, and teacher guidance. In the context of PjBL, they require intensive collaboration and clear guidance to be able to participate actively and develop critical thinking skills (Witkin et al., 2021; Rahmawati & Suryadi, 2023). This shows that the effectiveness of PjBL is not universal, but depends on the cognitive characteristics of students. Previous studies demonstrate that Project-Based Learning has strong potential to improve students' critical thinking skills. However, the effectiveness of PjBL may vary depending on learners' cognitive characteristics, particularly Field Independent and Field Dependent styles. Therefore, this study proposes that cognitive style moderates the relationship between learning models and students' critical thinking skills.

3. METHOD

3.1. Research Design

This study employed a quantitative quasi-experimental approach using a 2×2 factorial design to examine the effects of learning models and cognitive styles on students' critical thinking skills. The study investigated two independent variables: learning model (Project-Based Learning and Expository Learning) and cognitive style (Field Independent and Field Dependent). Critical thinking skills served as the dependent variable. The factorial design enabled the examination of (1) the main effect of learning models, (2) the main effect of cognitive styles, and (3) the interaction effect between learning models and cognitive styles on students' critical thinking performance.

Table 1. Factorial Research Design

Learning Model	Field Independent (FI)	Field Dependent (FD)
Project-Based Learning (A1)	A1B1	A1B2
Expository Learning (A2)	A2B1	A2B2

3.2. Participants and Research Context

The study was conducted in public elementary schools located in Tapos District, Depok City, Indonesia, during the second semester of the 2024/2025 academic year. The population consisted of all fourth-grade students enrolled in five public elementary schools. Participants were selected using cluster random sampling. Two classes were randomly assigned to the experimental and control groups. The experimental group received instruction through the Project-Based Learning (PjBL) model, whereas the control group was taught using the expository learning model. A total of 80 students participated in the study. Cognitive style classification was determined using the Group Embedded Figures Test (GEFT), resulting in balanced distributions across experimental conditions.

Table 2. Participant Distribution Based on Cognitive Style

Group	FI	FD	Total
Experimental	20	20	40
Control	20	20	40
Total	40	40	80

3.3. Intervention Procedure

The intervention was implemented over eight instructional sessions within the Integrated Science and Social Studies (IPAS) subject. The Project-Based Learning intervention was designed according to established PjBL principles emphasizing student-centered inquiry, collaboration, and authentic problem-solving. The learning process followed six stages:

- 1 Identification of contextual problems;
- 2 Project planning and design;
- 3 Investigation and data collection;
- 4 Development of project products;
- 5 Presentation of project outcomes;
- 6 Reflection and evaluation.

Meanwhile, students in the control group received expository instruction consisting of teacher explanations, guided discussions, classroom presentations, and content reinforcement activities.

Table 3. Summary of Learning Activities

Phase	Project-Based Learning	Expository Learning
Opening	Attendance, motivation, learning objectives	Attendance, motivation, learning objectives
Core Activities	Problem identification, project design, investigation, product development, presentation, reflection	Teacher explanation, discussion, presentation, concept reinforcement
Closing	Reflection and critical thinking assessment	Learning evaluation and conclusion

3.4. Instruments

3.4.1. Critical Thinking Skills Test

Students' critical thinking skills were measured using a researcher-developed essay test consisting of 16 items adapted from the critical thinking framework proposed by Peter A. Facione. The instrument assessed four dimensions: (a) interpretation, (b) analysis, (c) evaluation, and (d) inference.

Table 4. Critical Thinking Assessment Framework

Dimension	Indicator	Number of Items
Interpretation	Understanding and categorizing information	4
Analysis	Identifying relationships among ideas	4
Evaluation	Assessing argument credibility	4
Inference	Drawing logical conclusions	4
Total		16

Prior to data collection, the instrument underwent expert validation and pilot testing. Reliability analysis yielded a Cronbach's alpha coefficient of 0.867, indicating high internal consistency.

3.4.2. Cognitive Style Assessment

Students' cognitive styles were identified using the Group Embedded Figures Test (GEFT) developed by Herman A. Witkin. The instrument consists of 25 items designed to distinguish between Field Independent (FI) and Field Dependent (FD) learners. Students scoring 9 or above were classified as Field Independent, whereas those scoring below 9 were categorized as Field Dependent.

3.5. Data Analysis

Data analysis was conducted using descriptive and inferential statistics. Descriptive statistics included means, standard deviations, minimum scores, maximum scores, and frequency distributions. Prior to hypothesis testing, the assumptions of normality and homogeneity of variance were examined using the Shapiro–Wilk test and Levene’s test, respectively. Subsequently, a two-way analysis of variance (ANOVA) was performed to examine:

- The effect of learning models on critical thinking skills;
- The effect of cognitive styles on critical thinking skills;
- The interaction effect between learning models and cognitive styles.

All statistical analyses were conducted at a significance level of $\alpha = .05$.

3.6. Ethical Considerations

Ethical approval was obtained from the participating schools before data collection commenced. Students and parents received information regarding the purpose and procedures of the study, and participation was voluntary. All participant data were anonymized and treated confidentially throughout the research process.

4. RESULT AND DISCUSSION

The research results are presented in detail, including a description of the students' critical thinking skills, prerequisite analysis tests, and hypothesis testing. The data shows a comparison between students who participated in Project Based Learning (PjBL) and those who participated in expository learning. The interaction between the learning model and Field Independent (FI) and Field Dependent (FD) cognitive styles was also analysed. Critical thinking skills were classified based on the learning model and cognitive style of the students. All findings were then analysed further to answer the research questions and support or reject the proposed hypotheses.

4.1. Data Description

This study involved 80 students divided into four treatment groups based on learning models and cognitive styles. The critical thinking scores of the students after the study and testing are presented in Table 5, which contains the distribution of average test scores for each research group.

Table 5. Average Critical Thinking Skills Scores of Students

Cognitive Style	Learning Model	Maximum Score	Minimum Score	Average	St Deviation
Field	PjBL	88	72	81.35	3.631
Independent	Expository	78	59	68.30	5.352
Field Dependent	PjBL	80	61	69.20	5.187
	Expository	83	64	73.25	4.865
Combination	PjBL	88	61	75.27	7.575
	Expository	83	59	70.78	5.636

Table 5 shows that the average critical thinking ability of the experimental group, namely students who learned using the PjBL model (75.27), was higher than that of the control group who learned using the expository model (70.78). The highest average was obtained in the experimental group with a Field Independent cognitive style (81.35).

4.1.1. Critical Thinking Skills Scores of Students in the PjBL Model Group (A1)

Based on data from 40 students who participated in learning using the PjBL model, the maximum score was 88, the minimum score was 61, and the average was 75.27. The frequency distribution of scores is presented in Table 6.

Table 6. Frequency Distribution of Critical Thinking Scores for the PjBL Group (A1)

No	Score Interval	Frequency Absolutely	Frequency Cumulative	Frequency Relative
1	61 – 65	4	4	10.00%
2	66 – 70	10	14	25.00%
3	71 – 75	4	18	10.00%
4	76 – 80	8	26	20.00%
5	81 – 85	12	38	30.00%
6	86 – 90	2	40	5.00%
Number		40	-	100.00%

The distribution of scores shows that the majority of PjBL students are in the moderate to high category, with the highest range of scores being 81–85 (30%), indicating the success of the PjBL model in encouraging critical thinking skills.

4.1.2. Critical Thinking Skills Score of Students in the Expository Group (A2)

The expository group had a maximum score of 83, a minimum score of 59, and an average of 70.78. The frequency distribution is shown in Table 7.

Table 7. Frequency Distribution of Critical Thinking Scores for the Expository Group (A2)

No	Score Interval	Absolute Frequency	Cumulative Frequency	Relative Frequency
1	59 – 62	4	4	10.00%
2	63 – 66	4	8	10.00%
3	67 – 70	12	20	30.00%
4	71 – 74	8	28	20.00%
5	75 – 78	9	37	22.50%
6	79 – 83	3	40	7.50%

Most of the expository group's scores were in the moderate category, particularly in the 67–70 range (30%), indicating a reasonable level of critical thinking ability, but not as high as the PjBL group.

4.1.3. Critical Thinking Ability Score Based on Cognitive Style

Descriptive analysis was conducted to examine the distribution of critical thinking scores across cognitive style categories. Among students classified as Field Independent (FI), the largest proportions of scores were observed within the intervals of 69–73 and 79–83, each accounting for 25% of the distribution. This pattern indicates that FI students generally demonstrated moderate-to-high levels of critical thinking

performance. In contrast, students classified as Field Dependent (FD) were predominantly concentrated within the score ranges of 69–72 (27.5%) and 73–76 (25.0%). The distribution suggests that most FD students achieved moderate levels of critical thinking performance, with fewer students reaching the highest score categories compared to their FI counterparts. The descriptive findings indicate differences in the distribution of critical thinking scores between the two cognitive style groups, with FI students tending to achieve higher score ranges than FD students.

4.1.4. Interaction between Learning Models and Cognitive Styles

To further explore the interaction between learning models and cognitive styles, descriptive statistics were examined for each treatment group. Students with a Field Independent cognitive style who participated in Project-Based Learning (A1B1) obtained the highest performance among all groups, with scores ranging from 72 to 88 and a mean score of 81.35. In comparison, Field Dependent students in the same learning model (A1B2) achieved scores ranging from 61 to 80, with a mean score of 69.20. Within the expository learning condition, Field Independent students (A2B1) obtained a mean score of 68.30, whereas Field Dependent students (A2B2) achieved a higher mean score of 73.25. These results indicate differing performance patterns across cognitive styles under the two instructional approaches.

The descriptive statistics suggest that the highest critical thinking performance was observed among Field Independent students exposed to Project-Based Learning, whereas the lowest mean score was found among Field Independent students receiving expository instruction. Conversely, Field Dependent students demonstrated relatively higher performance under expository instruction than under Project-Based Learning. These patterns provide preliminary evidence of a potential interaction between learning model and cognitive style, which was subsequently examined through inferential analysis using two-way ANOVA.

4.2. Requirements Analysis Testing

Prior to conducting the two-way analysis of variance (ANOVA), the assumptions of normality and homogeneity of variance were examined to ensure the appropriateness of the statistical analysis.

4.2.1. Normality Test

The normality of critical thinking scores was assessed using the Shapiro–Wilk test. The results indicated that all experimental groups produced non-significant values ($p > .05$), suggesting that the score distributions did not significantly deviate from normality. Therefore, the assumption of normal distribution was satisfied for all groups included in the analysis.

4.2.2. Homogeneity Test

The homogeneity of variance assumption was evaluated using Levene's test. The analysis yielded a non-significant result ($p > .05$), indicating that the variances of critical thinking scores were statistically equivalent across groups. This finding confirms that the assumption of homogeneity of variance was met. Taken together, the results of the normality and homogeneity tests demonstrate that the dataset satisfied the assumptions required for conducting a two-way ANOVA. Consequently, further inferential analyses

were performed to examine the effects of learning model, cognitive style, and their interaction on students' critical thinking skills.

4.3. Hypothesis Testing

To examine the effects of learning models, cognitive styles, and their interaction on students' critical thinking skills, a two-way analysis of variance (ANOVA) was conducted. The results are presented in Table 8.

Table 8. Results of Two-Way ANOVA of Critical Thinking Ability Scores

Sources of Variation	JK	df	RK	F	Sig.
Learning Model (A)	405.000	1	405.000	17.531	0.000
Cognitive Style (B)	259.200	1	259.200	11.220	0.001
Interaction (A×B)	1462.050	1	1462.050	63.289	0.000
Galat	1755.700	76	23.101	-	-

The analysis revealed a significant main effect of learning model on students' critical thinking skills, $F(1, 76) = 17.531$, $p < .001$. Students who participated in Project-Based Learning (PjBL) achieved significantly higher critical thinking scores than those who received expository instruction. This finding suggests that learning environments emphasizing inquiry, investigation, and authentic problem-solving provide greater opportunities for students to develop higher-order thinking processes.

A significant main effect of cognitive style was also identified, $F(1, 76) = 11.220$, $p = .001$. Overall, students' critical thinking performance varied according to their cognitive style, indicating that individual cognitive characteristics play an important role in shaping learning outcomes. More importantly, the interaction between learning model and cognitive style was statistically significant, $F(1, 76) = 63.289$, $p < .001$. This result indicates that the effectiveness of the learning model depended on students' cognitive styles. In other words, the impact of Project-Based Learning was not uniform across all learners but varied according to whether students were categorized as Field Independent (FI) or Field Dependent (FD).

The interaction pattern demonstrated that students with a Field Independent cognitive style benefited substantially more from Project-Based Learning than from expository instruction. Conversely, students with a Field Dependent cognitive style achieved slightly better outcomes under expository learning conditions than under Project-Based Learning. These findings suggest that the characteristics of each learning model align differently with students' cognitive preferences and information-processing tendencies. To further examine the interaction effect, post hoc comparisons using Tukey's HSD test were conducted. The results indicated that FI students in the PjBL group achieved significantly higher critical thinking scores than FI students in the expository group ($p < .001$), with a mean difference of 13.05 points. Similarly, FI students in the PjBL group outperformed FD students within the same learning model ($p < .001$), with a mean difference of 12.15 points. In contrast, FD students in the expository group scored significantly higher than FD students in the PjBL group ($p = .046$), with a mean difference of 4.05 points. Moreover, FD students receiving expository instruction achieved significantly higher scores than FI

students receiving the same instructional approach ($p = .009$), with a mean difference of 4.95 points.

These findings provide empirical evidence that Project-Based Learning is particularly effective for learners with a Field Independent cognitive style. Field Independent students tend to process information analytically, work autonomously, and organize learning tasks independently, characteristics that align closely with the inquiry-based and self-directed nature of PjBL. The opportunity to investigate authentic problems, construct solutions, and engage in collaborative project work may therefore facilitate deeper critical thinking among these learners. The results are consistent with constructivist learning theory, which posits that knowledge is actively constructed through interaction with meaningful learning experiences rather than passively received from teachers. Through project-based activities, students are required to analyze information, evaluate alternative solutions, justify decisions, and reflect on learning outcomes, all of which represent core dimensions of critical thinking.

However, the present findings also suggest that instructional effectiveness is contingent upon learner characteristics. While PjBL was advantageous for Field Independent learners, Field Dependent students appeared to benefit more from the structured guidance and explicit instructional support characteristic of expository learning. This finding highlights the importance of considering cognitive diversity when implementing student-centered pedagogies. From a practical perspective, the results imply that teachers should adopt differentiated instructional strategies that accommodate variations in students' cognitive styles. Project-based and inquiry-oriented activities may be particularly suitable for Field Independent learners, whereas Field Dependent learners may require additional scaffolding, structured guidance, and collaborative support to fully engage in complex learning tasks. Consequently, the effectiveness of innovative pedagogical approaches may depend not only on the instructional model itself but also on the extent to which it aligns with students' cognitive characteristics.

5. CONCLUSION

This study investigated the effects of Project-Based Learning (PjBL), cognitive styles, and their interaction on primary school students' critical thinking skills. The findings demonstrated that students who learned through PjBL achieved significantly higher critical thinking scores than those who received expository instruction, indicating the effectiveness of project-based approaches in fostering higher-order thinking. In addition, cognitive style emerged as an important factor influencing learning outcomes, as students' critical thinking performance varied according to their Field Independent (FI) and Field Dependent (FD) characteristics.

A significant interaction effect was identified between learning model and cognitive style, suggesting that the effectiveness of instructional approaches depends on learners' cognitive characteristics. Field Independent students benefited most from Project-Based Learning, achieving the highest critical thinking scores among all groups. In contrast, Field Dependent students demonstrated better performance under expository instruction than under Project-Based Learning. These findings indicate that instructional

effectiveness is not solely determined by the learning model itself but also by the degree of alignment between pedagogical approaches and learners' cognitive preferences.

From a theoretical perspective, the study provides further evidence supporting constructivist learning theory by demonstrating that inquiry-based and authentic learning experiences can enhance critical thinking development, particularly among learners who exhibit independent and analytical information-processing tendencies. Practically, the findings highlight the importance of differentiated instruction in primary education. Teachers should consider students' cognitive styles when selecting and implementing instructional models to maximize learning outcomes and critical thinking development.

Several limitations should be acknowledged. The study involved fourth-grade students from a limited number of public elementary schools in Depok City and was conducted over a relatively short intervention period. Consequently, the generalizability of the findings may be restricted to similar educational contexts. Future research should involve larger and more diverse samples, longer intervention durations, and additional learner-related variables, such as learning motivation, collaboration skills, self-regulated learning, and digital literacy, to provide a more comprehensive understanding of factors influencing critical thinking development.

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