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Effectiveness RADEC based multiliteracies approach on logical and reflective thinking skills of elementary school students

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***Abstract:**. Logical and reflective thinking are key components of higher-order thinking in 21st-century education, yet many elementary students' abilities remain underdeveloped due to teacher-centered instruction. This study investigates the effectiveness of a RADEC-based multiliteracy approach in enhancing these skills among fifth-grade students. Using a quasi-experimental pretest–posttest control group design, 45 students in Malang, Indonesia (22 experimental; 23 control) participated in the study. Data were collected through validated logical and reflective thinking tests, supported by observations and interviews. Results showed significant differences between groups. The experimental group outperformed the control group in logical thinking ($M = 75.00$ vs. 47.83; $p < .001$) and reflective thinking ($M = 81.41$ vs. 40.65; $p < .001$). The findings suggest that the structured RADEC stages integrated with multiliteracy principles effectively foster systematic reasoning and metacognitive reflection, demonstrating strong pedagogical potential for promoting higher-order thinking in elementary education.*

***Keywords**: multiliteracies, RADEC, logical thinking, reflective thinking, elementary school students*

Introduction

Entering the 21st century, the development of science and technology has grown rapidly and has impacted various aspects of human life. This condition requires the world of education to be able to prepare students with skills that are relevant to the challenges of the times. One of the main demands of 21st-century education is the mastery of higher-order thinking skills, which include critical, logical, and reflective thinking (Imran et al. 2021; Latorre-Cosculluela et al., 2021; Miterianifa et al. 2021) . With these skills, students are expected to be able to analyze, evaluate, and solve various problems creatively and responsibly. Therefore, teachers play an important role in creating learning experiences that can develop logical and reflective thinking skills from an early age, especially at the elementary school level.

Logical and reflective thinking skills are important aspects of the learning process in elementary school. Logical thinking skills help students understand cause-and-effect relationships, evaluate information rationally, and draw appropriate conclusions (Tursynkulova et al., 2023; Koray & Köksal 2009; Jawad et al., 2021). Meanwhile, reflective thinking allows students to review their learning experiences, identify mistakes, and devise better strategies for future learning (Yaacob et al. 2020; Colomer et al., 2020). These two skills serve as the foundation for lifelong learning and the mastery of 21st-century skills such as problem solving, creativity, and sound decision making.

Although important, various studies show that the logical and reflective thinking skills of elementary school students in Indonesia are still relatively low (Mudakir et al., 2020;

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Wahyuddin et al. 2021). Many students are able to understand problems, but are not yet able to interpret or design solutions independently. In reflective thinking, students are also not accustomed to evaluating their learning processes and outcomes. One of the reasons for this is that the learning model is still teacher-centered and does not provide opportunities for students to think critically and creatively (Haatainen & Aksela, 2021; Ramdani et al. 2021). This confirms the need for a more innovative and student-centered learning approach to develop these thinking skills.

Preliminary classroom observations conducted prior to this study further confirmed these findings. In several fifth-grade classrooms observed in SDN 2 Talangagung in Malang, learning activities were predominantly teacher-centered, with instruction largely focused on explanation and textbook-based exercises. Students tended to respond to closed-ended questions and relied heavily on teacher guidance when solving problems. Opportunities for students to analyze problems independently, justify their reasoning, or reflect on their learning strategies were limited. During classroom discussions, only a small number of students actively participated, while others remained passive recipients of information. Moreover, reflective activities such as evaluating errors, articulating learning difficulties, or planning improvement strategies were rarely facilitated systematically. These classroom conditions indicate that logical reasoning and reflective thinking processes have not yet been optimally developed through instructional practice. Therefore, an instructional approach that actively engages students in structured reasoning, collaborative dialogue, and reflective production is urgently needed.

One approach that is considered relevant is the multiliteracy approach. This approach emphasizes the ability to understand and use various forms of text, whether written, visual, or digital, and relate them to social and cultural contexts (Henriksen et al., 2018; Trauth-Nare 2016). Research results show that multiliteracy-based learning can improve students' higher-order thinking and reflective skills (Amil et al. 2024; Nawawi et al., 2021). However, the application of multiliteracy in Indonesian elementary schools is still rare and has not been studied in depth (Putri dan Damayanti 2024;Daulay et al., 2022).

To strengthen the implementation of multiliteracy, a learning model is needed that can activate students through activities such as reading, critical thinking, discussing, explaining, and creating. One model that meets these criteria is the RADEC (Read, Answer, Discuss, Explain, Create) model. This model guides students through structured learning stages, starting from reading and understanding information, answering questions to test understanding, discussing and explaining ideas, to creating products that apply knowledge (Pratama et al. 2019; Widodo et al., 2024; Setiawan et al. 2020). Several previous studies have also shown that the RADEC model can improve critical thinking and creative skills, as well as overall student learning outcomes (Agustin et al. 2021; Amelia et al. 2024; Sukmawati et al., 2020).

Based on the above description, it can be concluded that the RADEC-based multiliteracy approach has great potential to improve the logical and reflective thinking skills of elementary school students. However, to date, there has not been much research specifically examining the effectiveness of the RADEC-based multiliteracy approach in the context of elementary school learning in Indonesia. This indicates a research gap that needs to be addressed, as well as the scientific novelty of this study.

This study offers several distinctive contributions that differentiate it from previous research. First, while earlier studies have examined the RADEC model or multiliteracy approaches separately, this study explicitly integrates RADEC's structured instructional stages with multiliteracy principles into a unified pedagogical framework. This integration positions

RADEC not merely as a procedural learning model, but as a literacy-driven cognitive development approach that systematically guides students from multimodal text engagement to knowledge production. Second, unlike prior research that predominantly focused on general higher-order thinking skills or critical thinking, this study specifically investigates the simultaneous development of logical reasoning (e.g., controlling variables, proportional and probabilistic reasoning) and reflective thinking (e.g., reacting, elaborating, and contemplating), two cognitive dimensions that are conceptually distinct yet complementary. Third, empirical evidence regarding the implementation of such an integrated framework in Indonesian elementary school contexts remains limited. By situating the study within Indonesian primary education, this research contributes context-specific empirical validation and expands the theoretical discourse on multiliteracy-based instructional innovation in developing countries. Therefore, this study not only tests instructional effectiveness but also advances a conceptual understanding of how RADEC and multiliteracy can be synergistically designed to foster structured reasoning and metacognitive reflection in elementary learners.

Based on the above explanation, this study seeks to answer the question: Is the RADEC-based multiliteracy approach effective in improving the logical and reflective thinking skills of elementary school students? Therefore, this study aims to analyze the effectiveness of the RADEC-based multiliteracy approach on the logical and reflective thinking skills of elementary school students. The results of this study are expected to contribute to the development of innovative learning models that are relevant to the demands of 21st-century skills.

Method

This study employed a quasi-experimental pretest–posttest control group design to examine the effectiveness of the RADEC-based multiliteracy approach on students' logical and reflective thinking skills. The research was conducted in two public elementary schools in SDN 2 Talangagung in Malang, Indonesia, selected through purposive sampling to ensure comparable academic characteristics, curriculum implementation, and student demographics. A total of 45 fifth-grade students participated in the study, consisting of two intact Grade V classes: one experimental class (n = 22) and one control class (n = 23). Each school contributed one Grade V class to serve as either the experimental or control group.

The selection of Grade V students was based on both developmental and pedagogical considerations. From a cognitive development perspective, fifth-grade students (aged approximately 10–11 years) are transitioning from concrete operational to early formal operational stages, in which they begin to demonstrate the ability to engage in logical reasoning, hypothetical thinking, and structured problem-solving. These cognitive characteristics make them particularly suitable for the development of logical thinking indicators such as controlling variables, proportional reasoning, and probabilistic reasoning. Furthermore, reflective thinking, which involves metacognitive awareness and evaluation of learning processes, begins to emerge more systematically at this developmental stage. Pedagogically, the RADEC model requires students to independently read multimodal texts, formulate responses, engage in structured discussions, explain conceptual understanding, and create learning products. These activities demand a level of literacy proficiency, cognitive

readiness, and collaborative skills that are more optimally developed in upper elementary grades, particularly Grade V.

The treatment was implemented over six weeks, consisting of twelve instructional meetings (two meetings per week), with each session lasting approximately 70 minutes. The experimental group received instruction using the RADEC-based multiliteracy framework, while the control group was taught using conventional teacher-centered instruction following standard textbook-based procedures. Both groups were taught the same thematic content to ensure content equivalence, with differences only in instructional approach. Prior to the intervention, both groups completed a pretest, and a posttest was administered after the completion of the treatment period.

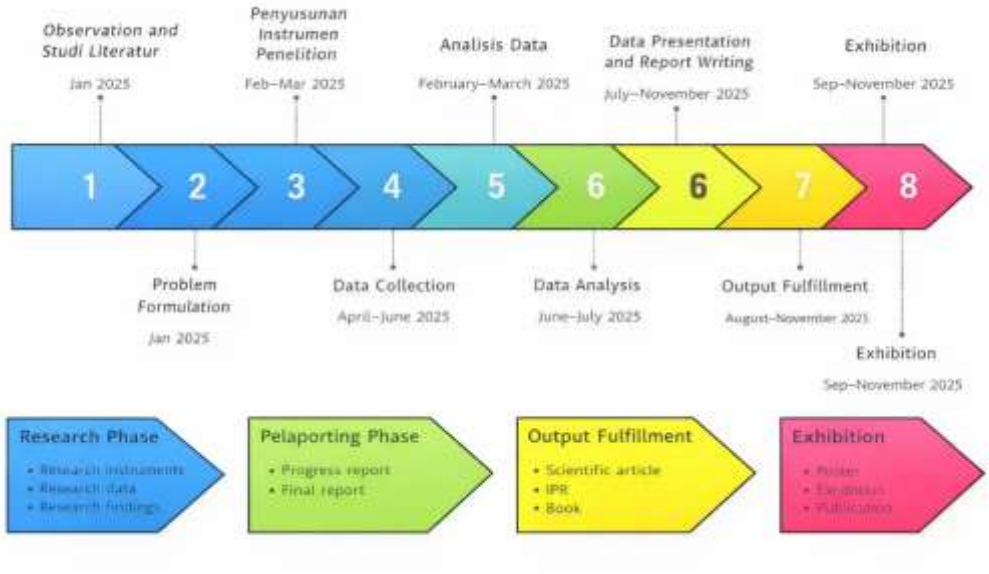

Figure 1. Stages, Timeline Outputs

The data collection techniques used in this study were tests, observations, and interviews. Tests were conducted before and after treatment, consisting of two types, namely multiple choice and multiliteracy-based essays, each of which aimed to measure students' logical and reflective thinking skills. The questions used integrated indicators of logical thinking, namely controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, and combinatorial reasoning, as well as indicators of reflective thinking, namely reacting, elaborating, and contemplating. There were two classes used in accordance with the research design, namely the control class and the experimental class, which can be described in the following table:

Table 1. Quasi-Experimental Research Design

Group	*Pretest*	Treatment	*Posttest*
Experimental	O_1	X_E	O_2
Control	O_3	Xc	O_4

Description :
O_1 : Measurement of the initial abilities of the experimental group
X_E : Treatment in the form of a RADEC-based multiliteracy approach
O_2 : Measurement of the final abilities of the experimental group
O_3 : Measurement of the initial abilities of the control group
X_C : Treatment in the form of a conventional approach
O_4 : Measurement of the final abilities of the control group

Observations were conducted to determine the implementation of the RADEC-based multiliteracy approach in fifth grade classrooms. Interviews were used to explore the opinions of students and teachers regarding the application of the RADEC-based multiliteracy approach.

Classroom observations were conducted using a structured observation sheet developed to assess the fidelity of the RADEC-based multiliteracy implementation. The instrument employed a four-point rating scale (1 = not implemented, 2 = partially implemented, 3 = adequately implemented, 4 = fully implemented) to evaluate each stage of the RADEC model (Read, Answer, Discuss, Explain, Create). The observation indicators included teacher facilitation strategies, student engagement in multimodal literacy activities, collaborative discussion quality, clarity of explanation processes, and evidence of creative knowledge production. To ensure objectivity, two trained observers independently recorded classroom activities, and inter-rater agreement was calculated to confirm consistency of scoring.

Semi-structured interviews were conducted to enrich and triangulate the quantitative findings. A total of two Grade V teachers (one from the experimental class and one from the control class) participated in the interviews. In addition, twelve students from the experimental class were selected using purposive sampling representing high, medium, and low achievement levels (four students from each category) to obtain diverse perspectives. The interviews explored participants' experiences during the learning process, perceptions of the RADEC stages, challenges encountered, and reflections on how the instructional approach influenced their reasoning and reflective processes. All interviews were audio-recorded and transcribed verbatim prior to thematic analysis.

To ensure methodological rigor, the validity and reliability of the research instruments were established prior to data collection. Content validity was examined through expert judgment involving three experts in elementary education, educational psychology, and multiliteracy pedagogy. The experts evaluated the alignment between test items and the predefined indicators of logical thinking (controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, and combinatorial reasoning) as well as reflective thinking (reacting, elaborating, and contemplating). Revisions were made based on feedback regarding clarity, cognitive demand, and contextual relevance of the items.

Construct validity was further examined through pilot testing conducted with 30 students from a comparable elementary school not involved in the main study. Item discrimination and difficulty indices were calculated to ensure appropriate differentiation

between high- and low-performing students. Items that did not meet acceptable psychometric criteria were revised or removed.

Instrument reliability was calculated using Cronbach's Alpha coefficient for the essay-based reflective thinking test and KR-20 for the multiple-choice logical thinking test. The reliability coefficient for the logical thinking instrument was $\alpha = 0.82$, while the reflective thinking instrument showed a reliability coefficient of $\alpha = 0.86$, both indicating high internal consistency. These results confirm that the instruments were sufficiently reliable for measuring students' logical and reflective thinking skills.

The assessment format was designed based on multiliteracy principles by integrating verbal texts, visual representations, and contextual problem situations. For example, one logical thinking item presented students with a short informational text accompanied by a table showing plant growth under different sunlight conditions. Students were required to identify the controlled variables and determine the causal relationship between sunlight exposure and plant height. This item assessed students' ability to apply controlling-variable reasoning within a contextual and multimodal format.

For reflective thinking, one essay item presented students with a real-life environmental scenario supported by an infographic. Students were asked to explain their reasoning in solving the problem, evaluate the strengths and weaknesses of their chosen strategy, and describe what they would improve if given another opportunity. This format was designed to measure reacting (initial response), elaborating (expansion of reasoning), and contemplating (metacognitive evaluation) dimensions of reflective thinking.

The data analysis techniques used in this study were quantitative and qualitative. Data analysis in this study began with a prerequisite test to determine the appropriate type of statistical test. The Shapiro-Wilk normality test was chosen because the number of samples per group was less than 50. The test results showed that the reflective thinking skills data in the experimental and control classes were normally distributed. In contrast, the logical thinking skills data in the experimental class showed that the data distribution was not normal, even though the control class was in the normal category.

Based on these results, the selection of statistical test techniques was carried out differently for each variable. The logical thinking skills variable was analysed using the Mann-Whitney U Test non-parametric test. Meanwhile, because the reflective thinking skills data was normally distributed, the analysis was carried out using the Independent Samples t-Test parametric test. These tests were conducted to prove the hypotheses in this study, namely H0: there is no effect of the RADEC-based multiliteracy approach on logical and reflective thinking skills simultaneously, and Ha: there is an effect of the RADEC-based multiliteracy approach on logical and reflective thinking skills simultaneously.

The observation and interview data were analysed using a qualitative descriptive approach, aiming to understand the learning process using the RADEC-based multiliteracy approach and the responses of students and teachers to this approach.

Results and Discussion

After the RADEC-based multiliteracy approach was applied to the experimental class and the conventional method to the control class, the research data was presented to provide a quantitative description of the students' logical and reflective thinking skills. The following table serves as the basis for comparative analysis between the groups. Furthermore, the results were analysed and discussed scientifically to evaluate the effectiveness of the RADEC approach in improving the higher-order thinking skills of primary school students.

Table 2. Group Statistics for Logical Thinking Variables

	Class	N	Mean	Std. Deviation	Std. Error Mean
Logical	Experiment Class	22	75,00	11,019	2,349
	Controll Class	23	47,83	17,309	3,609

For the logical thinking variable, the average score for the experimental class was 75.00 with a standard deviation of 11.019 (N = 22), while the control class only obtained an average of 47.83 with a standard deviation of 17.309 (N = 23). The smaller variation in scores in the experimental class indicates better consistency in learning outcomes, which is in line with the character of RADEC in organizing learning activities systematically and focusing on strengthening reasoning. These findings confirm that the structured RADEC stages are able to facilitate a systematic thinking process so that students find it easier to draw logical conclusions and understand cause-and-effect relationships rationally.

Table 3. Group Statistics for Reflective Thinking Variables

	Class	N	Mean	Std. Deviation	Std. Error Mean
Reflective	Experiment Class	22	81,41	11,541	2,461
	Controll Class	23	40,65	26,620	5,551

Based on Table 3, descriptive statistics show that reflective thinking skills in the experimental class (N = 22) learning with the RADEC-based multiliteracy approach had a mean of 81.41 with a standard deviation of 11.541, while the control class (N = 23) that learned conventionally had a mean of 40.65 with a standard deviation of 26.620, so that descriptively there was a clear advantage in the experimental group. This difference in mean of approximately 40.76 points indicates the strong impact of RADEC learning on strengthening the cognitive reflection of primary school students, which will be confirmed through inferential statistical hypothesis testing in the next stage.

Table 4. Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Logical	Experiment Class	0,873	22	0,009
	Control Class	0,956	23	0,379
Reflective	Experiment Class	0,954	22	0,373
	Control Class	0,956	23	0,388

Based on the results of the normality test, for the logical thinking variable, the experimental class showed abnormal results according to S–W (p=0.009), so the conclusion used was abnormal for the experimental class. The control class in the logical variable was normally distributed because the S–W value was above the threshold (p=0.379), so only one group (experimental) violated the normality assumption in this variable. For the reflective thinking variable, both groups met the normality assumption = S–W, for example, S–W for the experimental class was p=0.373 and for the control class was p=0.388, both of which were greater than (0.05).

Because the reflective data are normal in both groups, testing the difference in means between groups for this variable is appropriate using the Independent Samples t-Test according to the distribution prerequisite. Conversely, because the logical data in the experimental class are not normal, the comparison between groups for the logical thinking variable uses the nonparametric Mann–Whitney U test.

Table 5. Mann-Whitney U Test (Logical)

	Logical
Mann-Whitney U	45,500
Wilcoxon W	321,500
Z	-4,768
Assymp. Sig. (2-tailed)	0,000

Table 5 shows the results of the Mann–Whitney U test to compare logical thinking skills between the experimental class and the control class in conditions where the assumption of normality is not met in one of the groups. The statistical values obtained are Mann–Whitney U=45.500, Wilcoxon W=321.500, and Z=-4.768 with Asymp. Sig. (2-tailed) p=0.000, thus meeting the significance criterion of ‘p<0.05’. Based on these criteria, the test decision rejects H_0 and accepts H_1, which means that there is a significant difference in logical thinking skills between the two groups. The direction of the difference is parallel to the previous descriptive findings, namely that the scores in the experimental class are higher than those in the control class, so that RADEC-based multiliteracy learning is associated with better logical thinking achievements in this research sample.

Table 6. T Independent Samples Test (Reflective)

	Reflective
t	6,609
df	43
Sig. (2-tailed)	0,000

Table 6 shows a significant difference in the mean reflective thinking skills between the experimental and control classes, with the experimental class scoring much higher than the control class. Levene's test for equality of variances was significant (F=16.165; p=0.000), so the assumption of equal variances was not met and the main interpretation refers to the row ‘Equal variances not assumed’. In this row, the t-test shows a significant difference with

t(30.27)=6.713 and p<0.001, confirming that the two groups are statistically different in reflective thinking skills. The mean difference reached 40.757 points with a standard error of approximately 6.071 and a 95% confidence interval of approximately 26.36 to 53.15, indicating a strong and consistent effect size across the sample. Substantively, these results are consistent with the role of the RADEC-based multiliteracy approach, which encourages the Explain and Create stages to deepen the reflection process, resulting in higher and more consistent reflective achievements in the experimental class compared to conventional learning. Thus, from both an inferential and pedagogical perspective, the application of RADEC has been proven to significantly improve reflective thinking skills in the context of this study.

For the logical thinking variable, the average score for the experimental class was 75.00 with a standard deviation of 11.019 (N = 22), while the control class only obtained an average of 47.83 with a standard deviation of 17.309 (N = 23). The smaller variation in scores in the experimental class indicates better consistency in learning outcomes, which is in line with the character of RADEC in organizing learning activities systematically and focusing on strengthening reasoning. These findings confirm that the structured RADEC stages are able to facilitate a systematic thinking process so that students find it easier to draw logical conclusions and understand cause-and-effect relationships rationally.

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This study shows that the RADEC-based multiliteracy approach is associated with a significant improvement in the logical and reflective thinking skills of primary school students, as confirmed by quantitative analysis using the Mann–Whitney U test and Independent Samples t-Test. These findings are reinforced by qualitative data from observations of learning implementation and interviews with teachers and students, which provide an in-depth understanding of the learning mechanisms and participants' perceptions of the effectiveness of RADEC in the context of multiliteracy.

The effectiveness of RADEC on logical thinking skills

The Mann–Whitney U test results showed a significant difference in logical thinking skills between the experimental class (M=75.00; SD=11.019) and the control class (M=47.83; SD=17.309) with a p-value <0.001, indicating the superiority of the RADEC approach in facilitating structured reasoning. Observational data confirmed that the Read–Answer–Discuss stages contributed to systematic information processing, in which students did not merely receive material passively but actively constructed understanding through pre-learning literacy activities, deductive–analytical reasoning exercises in the Answer phase, and concept clarification through collaborative discussion.

Interviews with teachers revealed that the Discuss phase is a crucial moment in the formation of logical thinking, as students are encouraged to compare answers, evaluate their peers' arguments, and strengthen their reasoning structures through social interaction. Furthermore, observations show that the integration of multimodal texts (verbal, visual,

audiovisual) in the Read phase enriches the context of understanding and stimulates richer mental representations, thereby facilitating the processes of abstraction and generalisation that are at the core of logical reasoning. This pattern is consistent with the multiliteracy framework, which emphasises the importance of multimodal representation in deepening meaning and supporting higher-order thinking skills.

The Mann–Whitney U test results showed a significant difference in logical thinking skills between the experimental class and the control class, indicating the superiority of the RADEC approach in facilitating structured reasoning. This quantitative finding is supported by qualitative evidence from classroom observations and interviews. During the Discuss stage, students were observed actively comparing answers and defending their reasoning. One teacher stated, *"During the discussion phase, students began to question each other's answers and provide logical arguments. They were no longer just waiting for confirmation from me."* This indicates a shift from passive reception to analytical engagement.

Similarly, a student from the experimental class explained, *"When we read the material first and answered the questions ourselves, I tried to understand why the answer was correct, not just guess. Then in discussion, my friends sometimes had different answers, and we had to explain our reasons."* This statement illustrates how the Read–Answer–Discuss sequence encouraged students to practice controlling variables and causal reasoning through structured peer interaction. These qualitative insights reinforce the statistical results by demonstrating how the RADEC stages systematically scaffold logical thinking processes.

The effectiveness of RADEC on reflective thinking skills

In reflective thinking skills, the results of the Independent Samples t-Test showed a significant difference with an average difference of 40.757 points between the experimental class (M=81.41) and the control class (M=40.65), reinforced by a p-value of <0.001. Qualitative data from student interviews indicated that the Explain and Create stages were the main catalysts in developing metacognitive awareness, as students not only explained their understanding but also evaluated the cognitive strategies used and identified weaknesses in their learning process.

Observations in the experimental class showed that in the Explain phase, students actively articulated their understanding in their own words, linked new knowledge to existing cognitive schemas, and formulated improvement strategies when encountering misunderstandings. Interviews with teachers reinforced these findings by revealing that the Create phase provided space for students to produce work based on their learning experiences, which implicitly required in-depth evaluation of conceptual understanding and reflection on the cognitive processes they had undergone. Students stated that the activity of creating products (posters, videos, mind maps) forced them to think more deeply about the essence of the material, integrate various perspectives gained from discussions, and express their understanding in a personally meaningful format. Observation data also showed that the multiliteracy approach in RADEC enriched the learning experience through the use of various forms of text and information media that stimulated self-reflection.

In terms of reflective thinking, the significant difference between groups is further strengthened by students' and teachers' testimonies regarding the Explain and Create stages. Observations revealed that students were encouraged not only to present answers but also to articulate the reasoning behind them and evaluate their understanding. One teacher commented, *"In the Explain phase, students had to clarify how they arrived at their answers. Some realized they misunderstood the concept and corrected themselves after explaining it aloud."* This indicates the emergence of metacognitive awareness during instruction.

A student also reflected, *"When we made posters and videos, we had to rethink the lesson and decide what was most important. I noticed which parts I didn't really understand, so I asked my friends before finishing the task."* This statement demonstrates the contemplative dimension of reflective thinking, where students evaluate their comprehension and adjust their strategies. The Create stage, therefore, functioned not only as a product-oriented activity but also as a reflective mechanism that deepened cognitive processing. These qualitative findings triangulate the quantitative data, confirming that the RADEC-based multiliteracy approach fosters metacognitive reflection alongside structured reasoning.

The relationship between the findings and the multiliteracy and RADEC frameworks

The integration of multiliteracy and RADEC creates a learning environment that not only focuses on cognitive understanding, but also explores the social, reflective, and creative dimensions of students. The results of observations show that the use of various modes of representation (verbal, visual, audiovisual) in the Read phase enriches the way students understand information, so that information processing becomes more meaningful and supports higher-order thinking skills.

Interviews with teachers confirm that the RADEC approach facilitates active, collaborative, and reflective learning in each phase, in line with the principles of multiliteracy that emphasise contextual, participatory, and transformative learning. Teachers also stated that the RADEC model is easy to implement because of its simple and easy-to-remember syntax, yet it remains effective in developing 21st-century competencies, including critical, logical, and reflective thinking skills.

Students said that learning with RADEC was more interesting and meaningful than conventional learning because they were given the opportunity to actively explore the material, discuss with peers, explain their own understanding, and create creative products that reflected their learning outcomes. These findings are consistent with previous research stating that the multiliteracy approach and the RADEC learning model can improve critical, logical, and reflective thinking skills because they require students to think actively, collaboratively, and reflectively in every phase of the learning process.

Pedagogical implications and implementation

From a qualitative perspective, the results of observations and interviews show that the success of the RADEC-based multiliteracy approach lies not only in its systematic syntactic structure, but also in the quality of social interaction that occurs in the classroom, the

teacher's skills in facilitating discussion and reflection, and the relevance of the learning material to the real-life context of the students. Teachers emphasise the importance of preparing high-quality pre-learning materials and using relevant multimodal media to ensure the effectiveness of the Read stage in sparking students' interest and initial understanding.

Overall, the triangulation of quantitative and qualitative data reinforces the conclusion that the RADEC-based multiliteracy approach is effective in developing primary school students' logical and reflective thinking skills and is highly relevant for application in learning that emphasises the formation of higher-order thinking skills as part of 21st-century competencies. This approach has the potential to be adopted more widely in the context of primary school learning in Indonesia, particularly to strengthen multilevel literacy and critical thinking skills in the era of globalisation and the digital revolution.

Conclusion

This study concludes that the RADEC-based multiliteracy approach is effective in improving primary students' logical and reflective thinking, as evidenced by both quantitative and qualitative findings. Quantitatively, logical thinking scores were higher in the RADEC class than in the control class (75.00 vs. 47.83), with significance confirmed through the Mann–Whitney U test due to the non-normal distribution of the experimental group's logical data, while reflective thinking was also substantially higher in the RADEC class (81.41 vs. 40.65), with significance confirmed using the Independent Samples t-Test with unequal variances ($p < 0.001$ in both analyses). Qualitative data from observations and interviews converged with these statistical results, indicating that the Read–Answer–Discuss–Explain–Create sequence fosters structured reasoning, metacognitive awareness, and meaningful engagement with multimodal texts, thereby explaining the higher and more consistent outcomes in the experimental group. Pedagogically, these findings suggest that RADEC's structured literacy-to-production pathway effectively scaffolds students from preparatory reading and independent response to dialogic clarification, explanation, and artifact creation, cultivating logical inference, causal analysis, and self-evaluative reflection aligned with 21st-century competencies. Nevertheless, several limitations should be acknowledged, including the relatively small sample drawn from only two elementary schools in one city, the six-week intervention period that may not fully capture long-term impacts, the limited qualitative informants that may not represent the full range of classroom experiences, and the focus solely on logical and reflective thinking without examining other potential outcomes such as creativity, collaboration, or long-term academic achievement.

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