

## The Influence of the RADEC Model on Collaboration and Critical Thinking in Elementary School Science Learning

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### Abstract

This study aims to examine: (1) the effect of the RADEC (Read, Answer, Discuss, Explain, Create) model on student collaboration; (2) the influence of the RADEC model on students' critical thinking skills; and (3) the influence of the RADEC model on students' collaboration and critical thinking. This research method employs a quasi-experimental design, specifically a nonequivalent control group design, involving 34 students. The data analysis techniques used are the Wilcoxon test, paired sample t-test and MANOVA. The results of the study show: (1) the Wilcoxon Signed Rank Test obtained Sig.  $0.000 < 0.05$ , meaning the RADEC model has a significant effect on student collaboration; (2) the Paired sample t-test obtained Sig.  $0.000 < 0.05$ , meaning the RADEC model has a significant effect on students' critical thinking; (3) The MANOVA test obtained Sig.  $0.000 < 0.05$ , meaning that there is a significant influence of the RADEC model on students' collaboration and critical thinking abilities. These findings highlight the importance of implementing innovative learning models to support the development of collaboration and critical thinking in elementary education. This study contributes empirical evidence regarding the effectiveness of the RADEC model and provides practical insights for teachers in designing more interactive and student-centred learning experiences.

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## INTRODUCTION

The increasing complexity of knowledge in contemporary science education requires students not only to acquire factual information but also to develop higher-order competencies to interpret, evaluate, and apply knowledge in meaningful contexts. Among these competencies, collaboration and critical thinking have been widely recognized as essential skills for the 21st century. These skills enable learners to engage in collective problem-solving, exchange perspectives, and critically evaluate information to draw reasoned conclusions (Leibovitch et al., 2025). In science learning, these competencies are crucial because scientific inquiry inherently involves collaborative discussion, reasoning, and interpretation of evidence.

At the elementary school level, the development of collaboration and critical thinking plays a fundamental role in shaping students' cognitive and social development. Elementary education focuses not only on literacy and numeracy development but also on fostering social interaction skills and independent thinking. In the process, teachers encourage students to discover their own knowledge by organizing their observations (Ryanjani et al., 2024). Furthermore, meaningful classroom interactions encourage students to actively process information and construct knowledge independently (Nurishlah et al., 2024). This perspective aligns with constructivist learning theory, which states that knowledge is constructed through active engagement with learning experiences and social interactions. Furthermore, critical constructivism emphasizes reflective analysis and evaluation as key components in developing higher-order thinking skills (Permata, 2024). Therefore, an effective elementary learning environment must provide opportunities for students to engage in collaborative interactions while simultaneously developing analytical reasoning.

Although the importance of these competencies has been recognized, several studies indicate that classroom practices in elementary education continue to struggle to foster both collaboration and critical thinking. Learning activities are often dominated by teacher-centered instruction and knowledge transmission, with limited opportunities for students to engage in analytical discussions and collaborative inquiry. Classroom questions also tend to emphasize Lower-Order Thinking Skills (LOTS), which limits student engagement in deeper cognitive processes and meaningful dialogue (Suharjuddin & Nurbayti, 2025). As a result, students often become passive participants in learning activities and demonstrate limited confidence in expressing ideas or constructing logical arguments.

The phenomenon of low student collaboration and critical thinking skills was also identified through a preliminary study conducted by researchers in fifth-grade science learning. Initial observations indicated that learning activities were still dominated by the inquiry model, which was not optimally implemented to encourage collaboration and critical thinking. During group activities, student participation was uneven, with some students actively contributing while others remained passive. The questionnaire results revealed that 77.1% of students did not rely on their peers during group work, and 73.6% rarely collaborated on assignments. Furthermore, only 36.8% consistently followed group work rules, while 14% engaged in activities unrelated to the learning task.

Field observations also revealed that students' critical thinking skills had not yet developed optimally. Higher Order Thinking Skills (HOTS) test results showed that only 33.3% of students were categorized as having high critical thinking skills, while 66.7% were in the moderate category. These findings suggest that students tend to focus more on memorizing information than analyzing concepts or developing a deeper understanding. Limited participation in discussions and a lack of confidence in expressing opinions also hinder the development of students' critical thinking skills (Ulya, 2024). Furthermore, previous research shows that personal factors such as students' self-confidence play a significant role in supporting the development of critical thinking skills (Azmi et al., 2025). Therefore, improving these competencies requires a learning environment that encourages interaction, discussion, and reflective thinking.

To address these issues, researchers have explored the implementation of structured, student-centered learning models that facilitate active participation and collaborative inquiry. One learning model considered relevant is the RADEC (Read, Answer, Discuss, Explain, Create) model, which integrates reading activities, individual reasoning, collaborative discussion, explanation, and creative production. Conceptually, the RADEC model reflects the principles of constructivist and collaborative learning theories, where students actively construct knowledge through reading, reasoning, and interactions with peers throughout the learning process. Previous studies have shown that the RADEC model can improve student

learning outcomes, conceptual understanding, critical thinking skills, and social interactions (Kurniayati et al., 2025). Other studies have also reported that RADEC encourages students to engage more actively in learning and facilitates a deeper understanding of the subject matter (Lubis et al., 2024).

However, despite the growing research focus on the RADEC model, most previous studies have focused on cognitive learning outcomes or higher-order thinking skills in general. Empirical studies examining how the RADEC model simultaneously supports the development of collaboration and critical thinking are still limited, particularly in elementary school science learning. From a pedagogical perspective, examining the relationship between structured learning stages and the simultaneous development of social and cognitive competencies is important to broaden theoretical understanding of how learning models can integrate collaborative interactions with critical thinking.

Based on this gap, this study aims to examine the effect of the RADEC learning model on students' collaboration and critical thinking skills in elementary school science learning. By simultaneously investigating these two competencies, this study seeks to provide empirical evidence regarding how structured learning stages facilitate the integration of social interactions and cognitive development in science education.

## RESEARCH METHODS

This research was quantitative, using a quasi-experimental design. The group design used was a non-equivalent control group design. In this research design, the experimental and control groups were given pretests and posttests. The pretest was conducted to assess students' collaboration and critical thinking skills before the lesson, while the posttest was used to assess them after the lesson. The sample consisted of 34 students, selected using a purposive sampling technique. Sample selection was based on several criteria, including students' needs in the learning process, the school's readiness to implement the learning model, relatively similar initial student abilities, and diverse but representative student backgrounds. These considerations were intended to ensure that the sample adequately represented the student population when assessing collaboration and critical thinking skills.

In the implementation phase, the experimental group at State Elementary School 070984 Tumori is using the RADEC model, which consists of five stages: reading, answering, discussing, explaining, and creating. These stages are designed to encourage students to actively construct knowledge through reading, answering guiding questions, collaborative discussions, explaining ideas, and producing learning outcomes. Meanwhile, the control group at State Elementary School 074046 Lolomoyo was taught using the inquiry learning model, which emphasizes problem identification, investigation, and conclusion drawing. The comparison between the RADEC model and the inquiry learning model was conducted because both models emphasize active learning processes. However, the RADEC model explicitly integrates the stages of reading, discussion, and creation in a structured manner, which is expected to better facilitate the development of collaboration and critical thinking skills. Therefore, this comparison aims to test whether the stages of the RADEC model provide a more effective learning approach than the commonly used inquiry learning model in developing these competencies.

Exams and surveys were the data-gathering methods used in this investigation. Essay tests were used in this study, focusing on critical thinking indicators. The critical thinking indicators were adopted and developed from Ennis's research (Suharyani et al., 2023). The critical thinking indicator instruments are shown in [Table 1](#).

**Table 1.** Critical Thinking Ability Test Grid

No.	Critical Thinking Ability Indicators	Cognitive Level	Question Form	Question Number
1.	Analytical skills	C4	Essay	1
2.	Combination skills	C6	Essay	6,7
3.	Problem recognition and solution skills	C5	Essay	4,5
4.	Conclusion skills	C6	Essay	3
5.	Evaluation skills	C5	Essay	2

The critical thinking ability test instrument in this study had previously undergone internal and external validity tests, and data processing was then conducted to yield valid conclusions (Elangovan & Sundaravel, 2021). The validity test results showed that all statement items had a calculated  $r$  value greater than the table  $r$  (0.329), indicating that all items were valid. The reliability test results using Cronbach's Alpha yielded a value of 0.989, which falls within the very high range, indicating that the instrument is suitable for use in the study. Furthermore, a questionnaire was used to assess students' collaboration skills using collaboration indicators. The collaboration indicator instruments are shown in Table 2.

**Table 2.** Collaboration Skills Instrument Grid

No.	Indicator	Question Number
1.	Positive interdependence	1,2,3,18
2.	Face-to-face interactions	4,5,6,19
3.	Personal accountability and responsibility	7,8,9
4.	Communication skills	10,11,12,13
5.	Ability to work in a group	14,15,16,17,20

Collaboration ability was measured using a Likert scale with four response options: always, often, sometimes, rarely, and never. The instrument used was first tested for validity and reliability to ensure its suitability as a data-collection tool. Based on the test results for 20 statement items, the calculated  $r$  values for 12 statement items were greater than the table  $r$  (0.329), whereas the other 8 statement items had calculated  $r$  values less than the table  $r$ . With the criteria that an item is declared valid if the calculated  $r >$  table  $r$ , the analysis results showed that 12 statement items were declared valid, while the other 8 statement items did not meet the validity criteria and were therefore not used in the study. The results of the reliability test using the Cronbach's Alpha coefficient showed a value of 0.82, indicating that the instrument is reliable and suitable for measuring students' collaboration skills.

Furthermore, the researcher conducted research prerequisite tests using normality tests and homogeneity tests. The data were analyzed using the Wilcoxon test, paired-sample  $t$ -test, and MANOVA. The Wilcoxon test was used to assess the effect of the RADEC model on student collaboration because the collaboration data did not meet the assumption of a normal distribution; a nonparametric test was deemed more appropriate. Meanwhile, a paired-samples  $t$ -test was used to assess the effect of the RADEC model on students' critical thinking skills, as the data met the assumption of normality, allowing a parametric analysis to compare pretest and posttest scores. Furthermore, a MANOVA test was conducted to examine the simultaneous effect of the RADEC model on students' collaboration and critical thinking skills. The use of MANOVA allows for the simultaneous analysis of multiple dependent variables, thereby providing insight into how the learning model affects competencies in science learning among fifth-grade elementary school students.

## RESULTS AND DISCUSSION

This experimental research was conducted in two public elementary schools. The control group at State Elementary School 074046 Lolomoyo implemented the inquiry learning model, while the experimental group at State Elementary School 070984 Tumori implemented the RADEC model. The implementation of the RADEC model in the experimental group followed five stages. In the Reading stage, students were assigned to read science learning materials related to the topic before class to build initial understanding. In the Answering stage, students individually answered guiding questions prepared by the teacher to assess their understanding of the reading material. During the Discussing stage, students worked in small groups to compare their answers, exchange ideas, and solve problems collaboratively. In the Explaining stage, each group presented the results of their discussion and explained their reasoning to the class, while other groups provided feedback or alternative perspectives.

Finally, in the Creating stage, students were encouraged to produce a simple product or solution related to the topic. These stages not only supported conceptual understanding but also facilitated the development of critical thinking, collaboration, and communication skills. This aligns with the opinion of Pratama et al. (2020), who stated that the RADEC model encourages students' critical thinking through discussion, explanation, and creation activities that involve analysis, evaluation, and idea generation. The research data obtained were first analyzed using the Wilcoxon test to determine the effect of the RADEC model on student collaboration in fifth-grade elementary school science learning. The results of the Wilcoxon test are presented in the following table.

**Table 3.** Collaborative Wilcoxon Test Output

Variable	N	Mean Rank	Sum of Ranks
Posttest_ Experiment - Pretest_ Experiment			
• Negative Ranks	0	0,00	0,00
• Positive Ranks	19	10,00	190,00
Total	19		
Posttest_ Control - Pretest_ Control			
• Negative Ranks	0	0,00	0,00
• Positive Ranks	15	8,00	120,00
Total	15		

Table 3 shows that in the experimental group that implemented the RADEC model, no students experienced a decline in learning outcomes (Negative Rating = 0), while all 19 students (Positive Rating = 19) experienced a significant difference in scores from pretest to posttest, with an Average Rating of 10.00 and a Total Rating of 190.00. Meanwhile, in the control group, an Average Rating of 8.00 and a Total Rating of 120.00 were obtained. These findings indicate that the RADEC model significantly influences students' collaboration skills.

Furthermore, to determine the extent to which the application of the RADEC learning model influences students' collaboration abilities, the following descriptive analysis results table shows this.

**Table 4.** Collaboration Value Description Analysis Results

	N	Mean	Minimum	Maximum
Collaboration Pretest	19	34,11	25	43
Collaboration Posttest	19	87,84	80	97

Based on the descriptive analysis results in Table 4, the average score for student collaboration in the pretest was 34.11, while in the posttest it increased to 87.84. This difference

in average scores indicates a significant improvement in students' collaboration skills after implementing the RADEC learning model. The minimum and maximum scores also showed significant differences, with the lowest score increasing from 25 to 80 and the highest from 43 to 97. This indicates an increase in students' collaboration skills after implementing learning using the RADEC model.

The improvement in students' collaboration skills in this study indicates that the RADEC model is capable of creating a learning environment that emphasizes meaningful social interactions among students. This improvement lies in the structured stages of the RADEC model, particularly the Discussion and Creation stages. During the Discussion stage, students are required to exchange ideas, compare answers, and negotiate solutions to given problems. This interaction encourages previously passive students to become more involved in group activities. Furthermore, the Creation stage requires students to work collaboratively, strengthening collective responsibility and encouraging more balanced participation among group members. These learning conditions may explain the substantial improvement in collaboration skills compared to the initial conditions, where student participation tended to be uneven.

These results support previous research showing that the RADEC model can improve the quality of student collaboration through structured group discussions and task-based collaborative activities (Ramadhan et al. 2025). Similarly, Pratiwi & Helsa (2025) found that the RADEC model is designed to support the development of 21st-century skills, including collaboration, through learning activities that encourage positive interdependence among students. Furthermore, Kurniyati et al. (2025) also reported that RADEC was more effective in managing group interactions because its structured learning stages provided clearer guidance for students during collaborative activities.

Furthermore, a paired samples t-test was conducted to examine the effect of the RADEC model on students' critical thinking skills in the fifth-grade science learning. This analysis compared the pretest and posttest mean scores to identify changes in students' critical thinking skills after implementing the RADEC learning model. The use of the paired samples t-test is appropriate because the analysis focuses on comparing two related measurements obtained from the same group of students before and after the learning intervention. The results of the paired samples t-test analysis are presented in Table 5.

**Table 5.** Critical Thinking Paired Sample T-Test Output

	Mean	Sig. (2-tailed)
Pretest - Posttest	-43,211	,000

Table 5 shows that the Sig. (2-tailed) value is 0.000, which is lower than the 0.05 significance level, indicating a significant difference between students' pretest and posttest scores. The mean difference of -43.211 indicates that the posttest scores are higher than the pretest scores. The negative value occurs because the analysis calculates the difference as pretest minus posttest, resulting in a negative mean when the posttest scores exceed the pretest scores. This result indicates a significant improvement in students' critical thinking skills after the implementation of the RADEC model.

Improvements in students' critical thinking can be seen in the structured stages of the RADEC learning model. The "Read and Answer" stage requires students to engage with the learning material before class discussions, helping them build an initial conceptual understanding and prepare responses to the guiding questions. This preparation phase can reduce students' reliance on memorization and encourage them to process information more analytically. Furthermore, the "Discuss, Explain, and Create" stage requires students to

compare ideas, justify their reasoning, and develop solutions collaboratively. These activities require students to analyze information, evaluate multiple viewpoints, and formulate conclusions, which are key components of the critical thinking process.

These results align with previous research showing that RADEC-based learning activities can support higher-order thinking processes through structured stages of reading, discussion, and knowledge construction (Noerharyono et al., 2025). Similarly, learning frameworks that actively engage students in questioning, discussing, and explaining have been shown to strengthen the development of critical thinking in science learning (Tillah & Subekti, 2024). In addition, the use of HOTS-based questions in the RADEC stage can further stimulate students' cognitive engagement and reduce the dominance of memorization in science lessons (Afiyah & Ginanjar, 2025).

Next, a MANOVA test was conducted to determine the effect of the RADEC model on student collaboration and critical thinking in fifth-grade science lessons. The following are the results of the MANOVA test in this study.

**Table 6.** MANOVA Test Output

Effect	Multivariate Tests <sup>a</sup>				
		Value	F	Sig.	Partial Eta Squared
Model	Pillai's Trace	,901	141,043	,000	,901
	Wilks' Lambda	,099	141,043	,000	,901
	Hotelling's Trace	9,100	141,043	,000	,901
	Roy's Largest Root	9,100	141,043	,000	,901

Table 6 shows that the Sig. values for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root are  $0.000 < 0.05$ . These results indicate that students who participated in the RADEC model showed simultaneous differences in collaboration and critical thinking compared to students who did not receive this treatment. Thus, the RADEC model significantly influenced students' collaboration and critical thinking in science learning. Furthermore, the Partial Eta Squared value was 0.901, indicating that the learning model had a highly significant influence, amounting to 90.1%, on these variables simultaneously. Therefore, it can be concluded that the RADEC learning model used was effective in influencing students' collaboration and critical thinking skills.

The very high multivariate effect also indicates that the RADEC model can create learning conditions that encourage more active participation and deeper engagement with learning tasks. When students are required to discuss ideas, defend arguments, and produce outputs together, they are more likely to engage in reasoning processes when interacting with peers. Such conditions can facilitate collaborative behavior and higher-order cognitive processing during science learning.

The improvements observed in this study may be partly influenced by increased student motivation when experiencing a new learning model or by the structured nature of group activities, which encourage more balanced participation among students. Regardless of these possibilities, the results of this study align with previous research showing that RADEC learning activities can support the development of analytical thinking and collaborative learning processes (Agustin et al., 2023; Magfirah et al., 2024). Through engagement in this process, students are also required to independently analyze and draw conclusions from scientific concepts (Septian et al., 2025). The findings of this study indicate that collaboration and critical thinking develop simultaneously through the implementation of RADEC. RADEC allows students to develop critical thinking through structured social interactions, not just through individual activities. Thus, RADEC can be seen as a relevant learning model to meet

the demands of 21st-century learning, particularly in integrating social and cognitive skills in a balanced manner (Salsabila et al., 2025; Sukmawati et al., 2024).

## CONCLUSION

Based on the research results, the RADEC model has a positive and significant influence on the collaboration and critical thinking skills of fifth-grade elementary school students in science learning. This finding confirms that the RADEC syntax can create a learning process that encourages active student engagement and meaningful social interactions. The novelty of this research lies in the empirical testing of the RADEC model on two 21st-century learning process competencies simultaneously at the elementary school level, especially in science learning, which has so far been more researched in terms of learning outcomes or at higher levels of education. The practical implication is that RADEC can be used as an effective alternative learning model for elementary school teachers to shift LOTS-oriented learning towards collaborative learning and higher-order thinking. Theoretically, this finding strengthens the relevance of the social constructivist approach in developing elementary school students' collaboration and critical thinking skills.

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