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The Effect of the RADEC Learning Model on Students' Critical Thinking Skills

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Abstract
This quasii-experimentale study with prettest-posttest control group design examined the effect of the RADEC learning model on eighth-grade students' mathematical critical thinking skills in Two-Variable Linear Equation Systems (SPLDV) at SMPN 2 Nanga Pinoh. Seventy-one students participated in RADEC experimental and conventional control classes. Paired t-test analysis revealed significant improvements in critical thinking skills in the experimental group ($p < 0.05$), with very large effect size (Cohen's $d = 4.41$), demonstrating both statistical and practical effectiveness of RADEC in promoting active student engagement through reading, answering, discussing, explaining, and creating activities.

Keywords: RADEC, critical thinking skills, mathematics learning

1. Introduction

Critical thinking skillss represent essential cognitive abilities that enable students to analyzee information logically, evaluate arguments critically, and make informed decisions based on available evidence (Ennis, 1993;Wijayanti1 et al., 2020). In mathematics education, mathematical critical thinking is fundamental for developing deep understanding of complex concepts such as Two-Variable Linear Equation Systems (SPLDV) and connecting them to real- life applications (Tri Nurjanah et al., 2025).

Unfortunately, numerous studies indicate that Indonesian junior high school students exhibit low mathematical critical thinking abilities. This deficiency primarily stems from the dominance of conventional teacher-centered learning models that encourage passive learning and rote memorization (Vitriasari et al., 2023). Such approaches emphasize formula memorization and algorithmic procedures without fostering conceptual understanding.

Preliminary observations conducted by researchers at SMPN 2 Nanga Pinoh confirmed this issue. Eighth-grade students displayed low learning motivation, struggled to identify relationships between variables in SPLDV problems, and demonstrated limitations in evaluating the correctness of problem-solving steps. Furthermore, students failed to connect SPLDV concepts to practical everyday applications, such as budgeting or simple data analysis.

As an alternative, the RADEC (*Read-Answer-Discuss-Explain-Create*) learning model, developed by (Sopandi, 2019), offers an innovative approach contextualized for Indonesian classroom conditions. RADEC consistss of five systematic stages: independent reading of material, answering evaluative questions, group discussions, oral explanations, and creating creative products. Various studies at the elementary school level have proven RADEC's effectiveness in enhancing critical thinking skills in science subjects (Setiawan et al., 2020; Salsabila, 2025), Indonesian language (Pratama et al., 2019), and energy concepts (Sopandi, 2017). RADEC's success is supported by its student - centered approach that promotes active engaggement and collaboration among students (Sukmawati et al., 2020).

However, a crucial research gap exists: no studies have specifically investigated the effectiveness of the RADEC model in developing mathematical critical thinking skills among junior high school students,particularly targeting the interpretation, analysis, evaluation, and inference indicators according (Facione, 2015) in SPLDV instruction. This gap becomes increasingly significant considering the distinct characteristics of junior high mathematics compared to elementary level. While elementary mathematics emphasizes basic concept introduction, junior high mathematics requires higher-order abstract thinking to understand functional relationships and complex equation systems. Moreover, the SPLDV context is highly relevant to everyday problem-solving needs that demand systematic and evaluative thinking.

Therefore, this study aims to examine the effect of the RADEC learning model compared to conventional methods on eighth-grade students' mathematical critical thinking skills in SPLDV at SMPN 2 Nanga Pinoh. This research is expected to fill this literature gap while providing practical recommendations for mathematics educators at the junior high school level.

2. Methods

This study adopted a quasi-experimental framework using preetest-posttest control group design at SMPN 2 Nanga Pinoh during the 2025/2026 school year. Through purposive sampling, 71 eighth-grade students were divided into an experimental group implementing the RADEC model *(Read-Answer-Discuss-Explain-Create*) or a control group using conventional methods.

Data collection employed a five-item essay test administered as both pretest and posttest to assess critical thinking abilities on Two-Variable Linear Equation Systems (SPLDV) material. This study defines critical thinking through four core indicators: interpretation, analysis, evaluation, and inference (Facione, 2020). Test items were validated by three experts using a 5- point Likert scale, analyzed with Aiken's V Index yielding V = 0.725 (critical thinking test), V = 1.119658 (teaching module), and V = 0.820513 (LKPD), with criteria V < 0.4 (low), 0.4-0.8 (moderate), V > 0.8 (high) indicating moderate to high content validity (Aiken, 1985;Utami et al., 2024). Instrument reliability was verified through Cronbach's alpha on pretest data from 36 students, yielding α = 0.624 (N of Items = 5); if Cronbach's Alpha ≥ 0.60, the instrument is declared reliable (Darma, 2021;Azizah, 2025).

The study began by administering a pretest to all students to determine initial abilities. The experimental class learning process was conducted in two sessions, with the first session covering Read, Answer, and Discuss stages, and the second session continuing with systematically designed Explain and Create stages. In contrast, the control group followed traditional teaching approaches delivered in one session. Following intervention completion, participants completed a posttest to evaluate critical thinking proficiency gains. Pretest and posttest results were analyzed to assess RADEC's inflluence on students' critical thinking abillities relative to the control group.

Data analysis utilized descriptive statistics and paired t-tests to measure RADEC's effect on students' mathematical critical thinking abilities. Descriptive measures-including means, standard deviations, minimums, maximums, and score ranges-summarized pretest-posttest performance across both groups (Waruwu et al., 2025). Prior to t-testing, normality (Kolmogorov-Smirnov) and homogeneity (Levene) assumptions were verified using SPSS version 25. Paired t-test was selected for repeated measures design in quasi-experimental research requiring within-group pre-post comparisons. Effect size was calculated using Cohen's d to evaluate the practical magnitude of RADEC's impact, complementing statistical significance (Cohen, 1988 ; Iii & Penelitian, 2018).

3. Result and Discussion

This research examines RADEC's (*Read-Answer-Discuss-Explain-Create*) influence on mathematical critical thinking abilities, focusing on Two-Variable Linear Equations (SPLDV) among SMPN 2 Nanga Pinoh students. Two classes participated: RADEC experimental versus conventional control groups.

The researchers conducted descriptive analysis, normality tests, homogeneity tests, and hypothesis testing using SPSS version 25, complemented by manual effect size analysis with Cohen's d. Descriptive statistics summarized means, standard deviations, minimums, maximums, and ranges of *preetest-posttest* scores for both experimental and control classes. Hypothesis testing involved Paired Samples T-Test for statistical significance, while Cohen's d effect size was calculated manually from mean differences and standard deviation of differences to measure the practical magnitude of RADEC's impact beyond statistical significance alone (Cohen, 1988; Rohaeni et al., 2023)

3.1. Descriptive Analysis

The resultss of descriptive data analysis regarding the mathematical critical thinking abilities of students from both classes can be seen in Table 1.

Table 1.
Descriptive Data Analysis Results

Class	N	Range	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Experiment	36	30	5	35	19.36	7.867
Post-Experimental Test	36	32	68	100	86.56	8.083
Pre-Test Control	35	20	5	25	13.17	5.250
Post-Test Control	35	36	31	67	48.20	9.270
Valid N (listwise)	35					

Table 1 displays the descriptive analysis outcomes for mathematical critical thinking performance across both experimentale and control classes. The averagee *preetest* score of the experimentale class students reached 19.36 (SD = 7.867), while the *posttest* score increased significantly to 86.56 (SD = 8.083). The test assessment consisted of 5 essay items, each with a maximum score of 16 (4 indicators × 4 scores), totaling 80 scores converted to a 0-100 scale.

This research operationalizes critical thinking based on (Facione, 2015) indicators, consisting of four main aspects: interpretation, analysis, evaluation, and inference. In the *pretest*, only the interpretation indicator met the criteria for students' criticall thinking skillss, evident in their ability to understand and express the meaning or significance of mathematical problems accurately (Rani & Napitupulu, 2015). The analysis, evaluation, and inference indicators were not met due to students' difficulties in identifying relationships between information pieces, assessing the correctness of problem-solving steps, and drawing logical conclusions, stemming from a lack of in-depth conceptual understanding and limited reasoning skills (Zebua et al., 2024).

The posttest showed significant improvements across all four indicators. Analysis improvement was evident in students' ability to organize and connect information systematically (Martyanti, 2025). Evaluation enhancement appeared in their capacity to assess and select appropriate problem-solving steps (Fristadi & Bharata, 2015).

Inference progress was demonstrated through abilities to draw accurate conclusions, make predictions, and provide supporting reasons for decisions in mathematical contexts (Zebua et al., 2024). The extreme increase from pretest (5-35) to posttest (68-100) is reasonable given the very low baseline (19.36/100 = 24% initial proficiency) combined with RADEC's systematic and effective learning structure, not due to an overly easy posttest—this evidences intervention success without significant ceiling effects (Hake, 1999;Ulfa., 2024).

These findings indicate substantial critical thinking gains following RADEC implementation. In the control group, the pretest mean was 13.17 (SD = 5.250), rising to a posttest mean of 48.20 (SD = 9.270), showing notable but smaller improvement compared to the experimental group. Score range variations and min-max values across classes confirm RADEC's superior effectiveness in elevating critical thinking abilities (Raharjo, 2018).

3.2. Normality Test

The researchers obtained *preetest* and *posttest* data from the control class and the experimental class. The analysis continued with a normality test using the *Kolmogorov-Smirnov* formula through SPSS 25 *for Windows* software. The researchers also conducted a homogeneity test and hypothesis test after the normality test was completed. Table 2 presents the normality test outcomes.

Table 2.
Normality Test Results

		Kolmogorov-Smirnov[a]		
	Class	Statistic	df	Sig.
Results	Pre-Test Eksperimen	.099	36	.200*
	Post-Test Eksperimen	.102	36	.200*
	Pre-Test Kontrol	.122	35	.200*
	Post-Test Kontrol	.096	35	.200*

Normality testing confirmed normal distribution for all *pretest* and *posttest* scores across experimental and control groups. All four datasets (experimental *pretest/posttest*, control *pretest/posttest*) showed Sig. values of 0.200, surpassing the 0.05 threshold and satisfying normality assumptions (Raharjo, 2018).

3.3. Homogeneity Test

The results of the homogeneity test are presented in Table 3.

Table 3.
Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Results	Based on Mean	2.473	3	138	.064
	Based on Median	2.369	3	138	.073
	Based on Median and with Adjusted df	2.369	3	120.219	.074
	Based on trimmed mean	2.478	3	138	.064

The Levene's test of homogeneity yielded a Sig. value of 0.064, as seen by the researcher *based on the Mean*. According to the established criteria, the data was declared to have homogeneous variance because the Sig. value obtained (0.064) was greater than 0.05 (Raharjo, 2018).

Table 4.
Results of the Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	preEks-postEks	-67.19444	4.64647	.77441	-68.76658	-65.62231	-86.768	35	.000
Pair 2	preKont-postKont	-35.02857	4.88988	.82654	-36.70830	-33.34884	-42.380	34	.000

Table 4 reveals a paired samples t-test two-tailed significance of 0.000. Per standard criteria, the null hypothesiss (H0) is rejected and alternative hypothesiss (Ha) accepted since this p-value falls below the 0.05 threshold (Raharjo, 2018). With a $p < 0.05$, findings confirm RADEC significantly impacts students' critical thinking abilities.

3.4. Effect Size Cohen's D Test

To determine the effectiveness level of the RADEC (*Read-Answer-Discuss-Explain-Create*) learnning model in enhancing students' mathematical critical thinking skillss, further analysis was conducted using Cohen's d effect sizee calculation. Cohen's d serves as a widely used effect size measure to compare mean differences between two independent groups, specifically the posttest results of the experimental class (RADEC) and the control class (conventional method). This Cohen's d effect size was calculated manually based on the posttest mean difference and pooled standard deviation, with the test results presented in Table 5 below (Keilmuan et al., n.d. 2024).

Table 5.
Effect Size Test Results

Group	Mean	Std. Dev	Sample Size (n)	Conclusion Results
Eksperiment	86.5556	8.08330	36	4.410305
Control	48.2000	9.26981	35	

The effect size test using Cohen's d was performed to measure the magnitude of the practical impact of the RADEC model on students' mathematical critical thinking skillss by comparing posttest results between the experimental group (M = 86.56, SD = 8.08, n = 36) and the control group (M = 48.20, SD = 9.27, n = 35). The calculation yielded a Cohen's d value of 4.41, which falls into the category of very large effect (> 0.8), confirming that RADEC provides substantial and superior influence compared to conventional methods in improving students' criticall thinking skillss on Two-Variable Linear Equation Systems (SPLDV) material. This analysis complements the paired t-test findings ($p < 0.05$) with practical evidence that inter-group differences are not only statistically significant but also educationally meaningful (Rohaeni et al., 2023).

RADEC was applied in the experimental group across three instructional sessions. The RADEC model systematically links each learning process with critical thinking indicators. In the Read stage, students develop interpretation skills by reading and understanding the material independently. The *Answer* stage requires the application of analytical skills by working on problems that require problem solving and information organization. The *Discuss* stage encourages students to evaluate through group discussions, assessing the correctness and accuracy of answers and reasons. The *Explain* stage trains students' inference as they explain the results of discussions and solutions logically in front of the class. The *Create* stage challenges students to create questions or models in SPLDV material that require creativity and contain critical thinking indicators. Each stage specifically supports different aspects of critical thinking, making learning more structured and effective (Pratiwi & Helsa, 2025).

The implementation of learning in the control class used conventional learning methods that were generally lecture-based and involved practice questions. In the study, learning activities took place over two meetings. The conventional learning model in the control class emphasized lecture methods and individual practice questions. Teachers delivered material directly, so students' interpretation skills were not developed independently. Limited practice questions prioritized memorization and the application of facts without honing in-depth analytical and evaluative skills. Minimal interaction between students also hinders the development of inference skills, which require discussion and logical reasoning. The conventional model is less effective in developing all indicators of critical thinking comprehensively compared to the RADEC model, which is more interactive and systematic in building students' critical thinking skills (Nurseptiani & Maryani, 2020).

Findings reveal RADEC significantly enhances critical thinking in Two-Variable Linear Equations at SMPN 2 Nanga Pinoh by fostering dynamic, interactive, and innovative classroom dynamics that build deeper comprehension. Conversely, control group conventional methods—dominated by teacher-led lectures and solo tasks—restrict peer collaboration and creative engagement, proving less impactful. These outcomes align with statistical evidence of marked differences, underscoring RADEC's superior efficacy for critical thinking development (Rohaeni et al., 2023).

4. Conclusion

Findings affirm RADEC effectively elevates students' critical thinking across all dimensions via interactive sessions focused on concept mastery, problem-solving, and creative mathematical tasks, fostering diverse cognitive development opportunities. This approach fosters a participatory and collaborative learning atmosphere, providing space for students to effectively develop important cognitive abilities. In contrast, conventional learning approaches tend to be more dominant in one-way material delivery and independent practice. RADEC offers a suitable innovative framework for mathematics instruction, enhancing both learning quality and junior high students' critical thinking development.

Despite the significant findings, this study has several limitations. First, the quasi-experimental design with purposive sampling from a single school (SMPN 2 Nanga Pinoh) limits generalizability to broader populations or diverse regions in Indonesia. Second, the short intervention period (two sessions) and reliance on a five-item essay test may not fully capture long-term retention of critical thinking skills. Third, the study did not control for confounding variables such as prior teacher experience or student motivation levels.

For future research, longitudinal studies tracking RADEC's effects over multiple months across multiple schools and regions are recommended to enhance generalizability. Additionally, comparative studies integrating RADEC with digital tools (e.g., GeoGebra for SPLDV visualization) or mixed-method approaches incorporating qualitative data on student perceptions could provide deeper insights. Finally, expanding to other mathematical topics or grade levels would test RADEC's versatility.

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