Studies in Elementary Education (SiEE)
https://siee.yayasancec.or.id
Vol. 1, No.2, 2025, p. 79-89

The Effect of the RADEC Learning Model on Fourth-Grade Students' Critical Thinking Skills in Learning about Customary Norms

Nisa Aulia Salsabila[1], Guntur Gunawan[2], Tika Meldina[3]
[1,2,3]Institut Agama Islam Negeri Curup, Indonesia
Corresponding Author: salsabila07122024@gmail.com

Abstract: **Introduction:** Critical thinking is a core outcome of Indonesia's Merdeka Curriculum, yet lessons in the integrated natural and social science subject (IPAS) often remain teacher-centred. This study examined the effect of the Read–Answer–Discuss–Explain–Create (RADEC) model on fourth graders' critical thinking in a social-cultural IPAS topic: customary norms. A quasi-experimental nonequivalent control group design involved 48 students from two intact classes in a public elementary school in Rejang Lebong, Indonesia (RADEC = 24; conventional instruction = 24). Critical thinking was measured with a validated ten-item essay test covering clarification, assessment, inference, and strategies, and the data were analysed with independent-samples *t*-tests and analysis of covariance (ANCOVA) with pretest scores as the covariate. Mean scores rose from 58.33 to 72.71 in the RADEC class and from 53.75 to 60.42 in the control class. Posttest scores differed significantly, $t(46) = 5.32$, $p < .001$, Hedges' $g = 1.51$, and the difference remained after pretest adjustment, $F(1, 45) = 22.35$, $p < .001$, partial $\eta^2 = .33$. RADEC strengthened critical thinking in a cultural content area, extending evidence beyond science topics; its pre-class reading and answering stages call for scaffolding for less fluent readers.

Keywords: RADEC model; critical thinking; elementary school; IPAS; customary norms

Introduction

Critical thinking, understood as reasonable reflective thinking focused on deciding what to believe or do, is widely treated as a learning outcome that schools must cultivate deliberately rather than leave to chance (Ennis, 2018; Vincent-Lancrin et al., 2019). It allows children to clarify what a problem asks, judge which information matters, draw defensible inferences, and plan reasoned courses of action. A meta-analysis of 341 effect sizes showed that critical thinking can be taught at every educational level and that instruction combining dialogue, authentic problems, and mentoring produces the largest gains (Abrami et al., 2015). A recent overview of systematic reviews reached a similar conclusion while noting that the certainty of much of this evidence remains low to moderate, which calls for more carefully designed classroom studies (Oxman et al., 2025).

In Indonesia, the Merdeka Curriculum places critical reasoning among the six dimensions of the Pancasila student profile and introduces IPAS (*Ilmu Pengetahuan Alam dan Sosial*), a subject that merges natural and social science in the elementary grades. The integration is intended to help students relate natural phenomena to social life, but it also creates demands on teachers and learners. Teachers are still adapting to new terminology, materials, and project-based expectations (Asmahasanah et al., 2023), while fourth graders often struggle to distinguish and connect the science and social content combined

Article info:
Published by Corolla Education Centre Foundation on behalf of Studies in Elementary Education. This is an open-access article under the CC BY-SA license

in IPAS (Oktaviani et al., 2025). Preliminary observation for the present study in two fourth-grade classes in Rejang Lebong, Bengkulu, found similar conditions: IPAS lessons were largely one-directional, few students asked questions, and an initial assessment placed both classes in the *fair* category of critical thinking (class means of 51.83 and 59.00 on a 0–100 scale).

One model designed for this purpose is RADEC (Read, Answer, Discuss, Explain, and Create), developed in Indonesia as a learning sequence that moves students from guided independent study to collaborative knowledge building (Sopandi, 2017). Prospective elementary teachers who experienced the model reported deeper understanding of content, stronger teamwork, and greater creativity, and expressed willingness to use it in their own teaching (Komariah et al., 2023).

Empirical studies of RADEC in elementary schools are generally favourable. RADEC classes outperformed inquiry classes on higher-order thinking in an ecosystem theme (Pratama et al., 2020), improved fourth graders' critical thinking about the properties of light (Karlina et al., 2020), raised concept mastery (Ritonga et al., 2021), and produced higher normalised gains in critical thinking than conventional instruction (Latifa et al., 2025). Recent experiments have reported RADEC advantages for higher-order thinking in science (Oktadila et al., 2025), for critical thinking in IPAS classes (Fiteriani et al., 2025; Setianingrum et al., 2026), and for religious character together with critical thinking (Suryana et al., 2026). Systematic reviews conclude that RADEC supports twenty-first-century skills but that its effectiveness depends heavily on students' reading ability, because reading is its first step (Burhanudin et al., 2024; Despaliana et al., 2026; Setiawan et al., 2022). The evidence is not uniformly positive: one quasi-experiment found no significant posttest difference in concept understanding between RADEC and conventional classes (Patmawati et al., 2025), and a category analysis showed that fifth graders taught with RADEC remained weak in inference and advanced clarification (Umrotullatifah & Latif, 2025).

Two gaps follow from this literature. First, almost all RADEC experiments use science content such as respiration, light, ecosystems, energy, or colloids. The social-cultural strand of IPAS, in which students examine the norms and customs of their own communities, has rarely been tested, even though locally grounded content has been shown to offer a productive context for developing critical thinking (Sasmita et al., 2025) and RADEC-based materials for IPAS are being developed (Fatonah et al., 2023). Customary norms are a demanding topic for critical thinking because students must interpret unwritten rules, weigh reasons for them, and judge the social consequences of keeping or breaking them. Second, several RADEC studies rely on one-group designs or compare posttest scores only, without adjusting for baseline differences between intact classes or reporting effect sizes. Such reporting limits the comparability of findings across studies.

This study addresses both gaps. It tested the RADEC model in an IPAS unit on customary norms with fourth graders and analysed the results with covariate adjustment and effect sizes. Two research questions guided the study: (1) How did students' critical thinking change from pretest to posttest in the class taught with RADEC and in the class taught conventionally? (2) Did students taught with RADEC show higher critical thinking than students taught conventionally after initial differences were taken into account? It was hypothesised that the RADEC class would obtain significantly higher posttest scores than the control class, both before and after adjustment for pretest scores.

Ennis (2018) describes critical thinking as a set of dispositions and abilities that include judging the credibility of sources, identifying conclusions and reasons, inferring and judging inferences, and deciding on an action. For young learners, these abilities are best observed in how students handle the information in a concrete task. The present study therefore adopted four observable indicators originally formulated for analysing critical thinking in discussion (Perkins & Murphy, 2006). *Clarification* concerns stating what is known and what is asked in a problem. *Assessment* concerns selecting the information needed and giving reasons for the choice. *Inference* concerns relating pieces of information to draw a conclusion, for example about the consequences of an action. *Strategies* concern using the selected information to propose and explain a course of action. The indicators form a progression from understanding a situation to acting on it, which suits the elementary IPAS objectives of identifying, analysing, evaluating, and designing responses to social phenomena.

Instructional research suggests that these abilities grow when students are repeatedly asked to explain and defend their reasoning to others. Meta-analytic evidence identifies dialogue, exposure to authentic problems, and teacher mentoring as the most effective ingredients of critical thinking instruction (Abrami et al., 2015), and collaborative problem solving has shown a large overall effect on critical thinking across educational levels (Xu et al., 2023). The ICAP framework explains why: learning outcomes improve as engagement moves from passive receiving, to active manipulation, to constructive generation of new ideas, and finally to interactive co-construction with peers (Chi & Wylie, 2014). Teacher-centred lessons in which students mainly listen and answer recall questions keep most learners in the passive or active modes.

RADEC consists of five stages whose initials form its name (Sopandi, 2017). In the *Read* stage, students explore textbooks, other printed sources, or the internet, guided by pre-learning questions that range from recall to higher-order tasks. In the *Answer* stage, they answer these questions independently on a worksheet before the lesson, which lets both students and teacher identify which parts of the material are understood and which are not. In the *Discuss* stage, students compare and refine their answers in small groups, and those who have mastered the material help peers who have not. In the *Explain* stage, representatives present essential concepts to the class while the teacher checks scientific accuracy, invites questions and counterarguments, and re-explains concepts that remain unclear. In the *Create* stage, students generate and realise ideas, such as productive questions, solutions, or products, that apply what they have learned.

Mapped onto the ICAP framework, *Read* and *Answer* demand constructive engagement because students must generate answers from texts, whereas *Discuss* and *Explain* demand interactive engagement because ideas are tested against those of peers. *Create* extends the sequence to application. The stages also correspond to the four critical thinking indicators: answering pre-learning questions requires clarification, comparing answers requires assessment of relevant information, explaining and responding to challenges requires inference, and designing products requires strategies. On this basis, RADEC was expected to improve students' critical thinking more than conventional instruction, in which most reasoning is carried out by the teacher.

Method Research Design

The study used a quasi-experimental nonequivalent control group design with a pretest and a posttest. Two intact classes were assigned to conditions without

randomisation: one class received instruction using the RADEC model, and the other received conventional instruction on the same content (Table 1).

Table 1
Research Design

Class	Pretest	Treatment	Posttest
Experimental (4A)	O_1	X (RADEC model)	O_2
Control (4B)	O_3	– (conventional instruction)	O_4

Note. O_1 and O_3 = pretest; O_2 and O_4 = posttest; X = RADEC treatment.

Participants and Setting

The study took place at SD Negeri 12 Rejang Lebong, an A-accredited public elementary school in an urban area of Curup Timur District, Rejang Lebong Regency, Bengkulu Province, Indonesia, with 262 students. Data were collected between May and July 2025. The population consisted of all fourth-grade students (N = 48) in two classes of 24 students each, and both classes were included. Class 4A was designated as the experimental class because its preliminary critical thinking mean was lower (51.83) than that of class 4B (59.00), which served as the control class. The study was conducted with formal research permission and the approval of the school principal, and students are reported anonymously.

Instructional Procedures

Both classes studied the same IPAS unit from the grade 4 textbook, Chapter 8 "Building a Civilised Society", Topic A "Norms in the Customs of My Region". The learning objectives were identical: to distinguish customary norms related to speech, greetings, and everyday rules; to apply local norms in real situations; to analyse customary rules such as ceremonies, traditional dress, and gift-giving; to evaluate the social and cultural consequences of violating norms; and to design strategies for preserving norms among young people. Each class received eight lesson hours of 35 minutes.

In the experimental class, the RADEC stages were implemented as follows. *Read*: at the end of the preceding meeting, students received pre-learning questions and explored the textbook, other printed sources, and internet sources at home. *Answer*: students answered the pre-learning questions independently on a worksheet before the lesson, and the teacher monitored their progress. *Discuss*: in class, students compared their answers in small groups; those who had completed the worksheet helped peers who had not, and the teacher observed which concepts were still unclear. *Explain*: group representatives presented essential concepts to the class, other groups asked questions, challenged, or added information, and the teacher confirmed the accuracy of the explanations and re-explained concepts that many students had not mastered. *Create*: groups generated ideas and produced an illustration or poster depicting norms in their own surroundings, then reported it to the class. In the control class, conventional instruction consisted of apperception questions, a teacher-led lecture linking norms to students' daily experience, question-and-answer sessions to check understanding, clarification of misunderstood points, and a teacher-guided summary.

Instrument

Critical thinking was measured with an essay test developed for the unit. Items were mapped onto the four indicators described above (clarification, assessment, inference, and strategies; Perkins & Murphy, 2006). The items targeted cognitive levels from understanding (C2) to creating (C6). Each response was scored from 0 to 4 with an analytic rubric for the relevant indicator, and the total was converted to a 0–100 scale. The same test was used as pretest and posttest. Table 2 summarises the final instrument.

Table 2
Blueprint of the Final Critical Thinking Test

Indicator	Content focus	Cognitive level	Items
Clarification	Norms of speech toward elders and peers; local norms in daily life; customary greetings	C2–C3	3
Assessment	Turn-taking rules in customary ceremonies; customary gift-giving	C4	2
Inference	Social impact of violating norms at customary events; neglect of norms by young people	C5	2
Strategies	Preserving norms through customary leaders; compliance during ceremonies; educating young people	C6	3
Total			10

Content validity was judged by two experts, an elementary education lecturer and a fourth-grade teacher, who rated each of the 12 draft items on a five-point scale. Aiken's *V* (Aiken, 1985) ranged from 0.50 to 0.88 across items, with an overall value of 0.79, indicating moderate-to-high agreement that the items represented the intended content. The draft test was then tried out with 20 students outside the study sample. Pearson item–total correlations exceeded the critical value ($r = .444$, $\alpha = .05$) for 10 items; two items ($r = .339$ and .262) were discarded. Corrected item–total correlations of the remaining items ranged from .44 to .79, internal consistency was high (Cronbach's $\alpha = .883$), and item difficulty placed seven items in the easy range, two in the moderate range, and one in the difficult range.

Data Analysis

Descriptive statistics were computed for each class and occasion, and scores were classified as *very good* (80–100), *good* (61–79), *fair* (41–60), *poor* (21–40), or *very poor* (0–20). Normality was examined with the Shapiro–Wilk test and homogeneity of variance with Levene's test. The hypothesis was tested with an independent-samples *t*-test on posttest scores using SPSS 23. Because the classes were intact and not randomised, supplementary analyses were computed from the raw scores in Python (SciPy and statsmodels): an independent-samples *t*-test on pretest scores, paired-samples *t*-tests within each class, normalised gain, $\langle g \rangle = (\text{posttest} - \text{pretest})/(100 - \text{pretest})$ (Hake, 1998), and an analysis of covariance (ANCOVA) with pretest scores as the covariate after the homogeneity of regression slopes had been checked. Effect sizes are reported as Hedges' *g* and partial η^2 and interpreted with conventional benchmarks (Cohen, 1988). The significance level was set at .05.

Results and Discussion

Pretest and Posttest Critical Thinking

Table 3 presents the descriptive statistics. The experimental class began slightly higher than the control class ($M = 58.33$ vs. 53.75). After instruction, the experimental class mean rose by 14.38 points to 72.71, whereas the control class mean rose by 6.67 points to 60.42. Both within-class changes were statistically significant: experimental, $t(23) = 6.80$, $p < .001$; control, $t(23) = 3.66$, $p = .001$. Every student in the experimental class gained at least 5 points, while four students in the control class showed no gain or a decline. Measured as normalised gain, the class-level improvement was 0.35 (moderate) in the experimental class and 0.14 (low) in the control class.

Table 3
Descriptive Statistics of Critical Thinking Scores

Statistic	Experimental pretest	Experimental posttest	Control pretest	Control posttest
n	24	24	24	24
Mean	58.33	72.71	53.75	60.42
SD	8.17	8.72	8.11	7.21
Median	60.00	72.50	52.50	60.00
Minimum	45	55	40	50
Maximum	75	90	70	75
Mean gain		14.38		6.67
Normalised gain <g>		0.35		0.14

Note. Scores are on a 0–100 scale. Normalised gain is computed from class means.

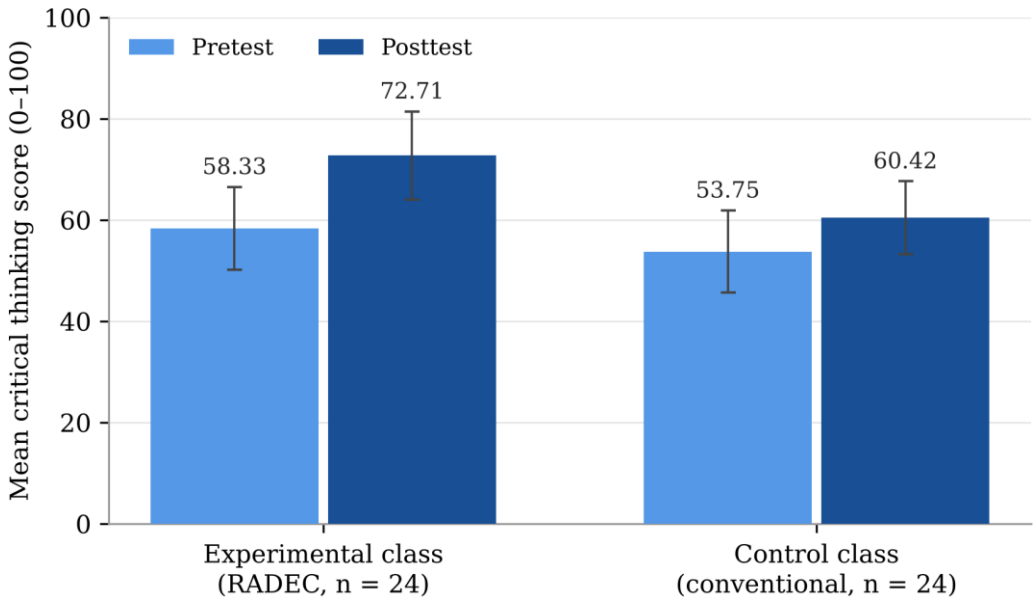

Figure 1. Mean pretest and posttest critical thinking scores by class (error bars show ±1 SD)

The distribution of students across categories shifted accordingly (Table 4). At pretest, most students in both classes were in the *fair* category. At posttest, 22 of 24 experimental students (91.7%) reached the *good* or *very good* category, including seven students (29.2%) at *very good*. In the control class, 10 students (41.7%) reached *good*, none reached *very good*, and the majority (58.3%) remained *fair*.

Table 4
Distribution of Students across Critical Thinking Categories

Category (score)	Experimental pretest	Experimental posttest	Control pretest	Control posttest
Very good (80–100)	0 (0.0)	7 (29.2)	0 (0.0)	0 (0.0)
Good (61–79)	7 (29.2)	15 (62.5)	4 (16.7)	10 (41.7)
Fair (41–60)	17 (70.8)	2 (8.3)	18 (75.0)	14 (58.3)
Poor (21–40)	0 (0.0)	0 (0.0)	2 (8.3)	0 (0.0)
Very poor (0–20)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Note. Values are frequencies with percentages in parentheses (n = 24 per class).

Comparison between Classes

Shapiro–Wilk tests indicated that pretest and posttest scores were normally distributed in both classes (experimental pretest $p = .303$, posttest $p = .418$; control pretest $p = .314$, posttest $p = .122$). Variances were homogeneous at pretest, $F(1, 46) = 0.01$, $p = .916$, and at posttest, $F(1, 46) = 0.54$, $p = .468$. The interaction between class and pretest score was not significant, $F(1, 44) = 0.01$, $p = .936$, so the assumption of homogeneous regression slopes for ANCOVA was met.

Table 5 summarises the between-class comparisons. The pretest difference of 4.58 points favoured the experimental class and approached significance ($p = .057$), confirming that the intact classes were not fully equivalent at baseline. At posttest, the experimental class scored 12.29 points higher than the control class, $t(46) = 5.32$, $p < .001$, 95% CI [7.64, 16.94], Hedges' $g = 1.51$. The advantage was also significant for raw gain scores ($g = 0.78$) and normalised gain ($g = 1.00$). After adjustment for pretest scores, the adjusted posttest means were 72.07 for the experimental class and 61.05 for the control class, a difference of 11.02 points, $F(1, 45) = 22.35$, $p < .001$, partial $\eta^2 = .33$. The hypothesis was therefore supported.

Table 5
Between-Class Comparisons of Critical Thinking

Outcome	Difference (E − C)	Test statistic	*p*	Effect size
Pretest score	4.58	$t(46) = 1.95$	.057	$g = 0.55$
Posttest score	12.29	$t(46) = 5.32$	< .001	$g = 1.51$
Raw gain	7.71	$t(46) = 2.76$	.008	$g = 0.78$
Normalised gain	0.20	$t(46) = 3.56$	< .001	$g = 1.00$
Posttest adjusted for pretest (ANCOVA)	11.02	$F(1, 45) = 22.35$	< .001	partial $\eta^2 = .33$

Note. E = experimental (RADEC) class; C = control class. Normalised gain differences are based on individual gains.

Discussion

The central finding is that fourth graders taught customary norms through the RADEC model achieved substantially higher critical thinking than peers taught conventionally, and that this advantage was not an artefact of the experimental class's slightly higher starting point. The adjusted difference of about 11 points and the large effect sizes are consistent with earlier RADEC studies: Pratama et al. (2020) reported a posttest difference of 13.6 points over inquiry learning, Setianingrum et al. (2026) a difference of 11.6 points in IPAS, and Latifa et al. (2025) a normalised gain of 0.62 against 0.33 for conventional teaching. The normalised gain in the present study (0.35) was lower than that of Latifa et al. (2025) but close to the 0.40 reported by Karlina et al. (2020), which suggests that one short unit moves students' critical thinking a moderate distance rather than to mastery. The present effect is also considerably larger than the average effect in Abrami et al.'s (2015) meta-analysis. This contrast should be read with caution, because the test was developed for the unit and closely aligned with its activities, and because small samples of intact classes tend to produce inflated estimates.

The structure of RADEC offers a plausible explanation for the result. The *Read* and *Answer* stages require students to identify what a question asks and what a text says before any whole-class explanation, which corresponds to the clarification indicator. The *Discuss* stage requires them to compare answers and decide which information is relevant and why, which exercises assessment. In the *Explain* stage, students articulate their reasoning publicly and respond to challenges from other groups, a form of interactive engagement that the ICAP framework links to deeper understanding (Chi & Wylie, 2014).

The *Create* stage, in which groups designed posters about norms in their surroundings, parallels the strategy items that asked students to plan how norms could be preserved. Taken together, these stages provide the combination of dialogue, authentic problems, and teacher guidance that Abrami et al. (2015) identified as most effective, and they embed the collaborative problem solving that Xu et al. (2023) found to foster critical thinking. In contrast, the conventional lessons gave students few occasions to justify or defend their own reasoning, which is consistent with the modest gain and with the four control students who did not improve.

The content area also appears to matter. Customary norms are familiar to children from home and community life, yet they are rarely examined explicitly. Questions about why a younger person waits for an elder to speak at a ceremony, or what happens socially when young people ignore customary rules, require students to infer reasons and consequences from their own cultural experience. This finding supports the view that locally grounded content can be a productive vehicle for critical thinking (Sasmita et al., 2025) and extends RADEC evidence, which has been concentrated on science topics (Burhanudin et al., 2024; Despaliana et al., 2026; Setiawan et al., 2022), to the social-cultural strand of IPAS. It also complements studies showing that RADEC can support character-related outcomes alongside critical thinking (Suryana et al., 2026). Because IPAS asks teachers to connect natural and social phenomena, a learning model that functions in both strands is of practical value for curriculum implementation (Fatonah et al., 2023; Oktaviani et al., 2025).

The results also show that RADEC did not benefit all students equally. Individual gains in the experimental class ranged from 5 to 40 points, and two students remained in the *fair* category. This variation agrees with reviews that identify reading ability as the main condition for RADEC's success, because students who cannot extract information from texts during the *Read* stage arrive at the *Discuss* stage with incomplete answers (Burhanudin et al., 2024; Hervianti et al., 2024). It also echoes findings that inference and advanced clarification remain difficult for many students even after RADEC lessons (Umrotullatifah & Latif, 2025), and it may help explain why some RADEC studies have found no significant advantage (Patmawati et al., 2025). Simplified texts, guiding questions at several cognitive levels, and short in-class reading support for less fluent readers are therefore advisable when RADEC is used with young learners.

The baseline comparison deserves comment. The experimental class was chosen because its preliminary score was lower, yet at pretest it scored higher than the control class. Such reversals are common when intact classes are compared on single measurements and illustrate why posttest-only comparisons can overstate or understate treatment effects. Adjusting for pretest scores reduced the estimated difference from 12.29 to 11.02 points but did not change the conclusion. Reporting covariate-adjusted estimates and effect sizes, as done here, would make future RADEC studies easier to compare and to synthesise.

Several limitations qualify these conclusions. The study involved two intact classes in one school, so school-level and teacher-level influences cannot be separated from the treatment, and the findings cannot be generalised beyond similar settings. Implementation fidelity was not measured systematically. The instrument was developed for this unit, its content validity rested on two raters, and its psychometric properties were estimated from a small try-out group. The intervention was short, and no delayed posttest was administered, so the durability of the gains is unknown. Analyses were conducted on total scores rather than on separate indicators. Future research should use multiple schools with

cluster randomisation where possible, monitor fidelity, analyse each critical thinking indicator, test reading ability as a moderator, and examine whether gains persist over a semester.

Conclusion

This study shows that the RADEC model improved fourth graders' critical thinking in an IPAS unit on customary norms. Students taught with RADEC progressed from mostly *fair* to mostly *good* or *very good* performance, whereas most students taught conventionally remained *fair*. The posttest advantage was large and remained significant after adjustment for initial differences between the classes. These findings extend evidence on RADEC from science topics to the social-cultural strand of IPAS and suggest that the model's sequence of guided reading, independent answering, peer discussion, public explanation, and creation offers a practical way to put the Merdeka Curriculum's emphasis on critical reasoning into practice. Teachers who adopt RADEC should prepare pre-learning questions at several cognitive levels and provide reading support so that the model benefits students with weaker literacy. Further studies with larger and randomised samples, fidelity monitoring, and indicator-level analysis are needed to confirm the size and durability of the effect.

References

[1] Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research, 85*(2), 275–314. https://doi.org/10.3102/0034654314551063

[2] Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

[3] Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. *Journal of Integrated Elementary Education, 3*(2), 137–149. https://doi.org/10.21580/jieed.v3i2.17592

[4] Burhanudin, Maftuh, B., Sujana, A., Sopandi, W., Sapriya, & Nanola, N. (2024). The RADEC learning model in primary schools: A systematic literature review. *Mimbar Sekolah Dasar, 11*(2), 487–511. https://doi.org/10.53400/mimbar-sd.v11i2.65596

[5] Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

[6] Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

[7] Despaliana, I., Hidayah, N., & Firmansah, D. (2026). Effects of the RADEC learning model on elementary school students' critical thinking skills: A systematic literature review. *Jurnal Gentala Pendidikan Dasar, 11*(2), 587–600. https://doi.org/10.22437/gentala.v11i2.56291

[8] Ennis, R. H. (2018). Critical thinking across the curriculum: A vision. *Topoi, 37*(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4

[9] Fatonah, N., Sopandi, W., Handayani, H., Maulana, Y., Gunawan, I., & Suhendra, I. (2023). Development and validation of student worker worksheets based on the RADEC learning model for natural and social sciences (IPAS) subjects in elementary

schools. *Current Issues on Elementary Education Journal, 2*(2), 59–64. https://doi.org/10.17509/ciee.v2i2.64099

[10] Fiteriani, I., Sopandi, W., Wahyudin, & Hernawan, A. H. (2025). The effectiveness of the RADEC (Read, Answer, Discuss, Explain, Create) learning model on students' critical thinking skills in the IPAS subject. *Jurnal Penelitian Pendidikan IPA, 11*(10). https://doi.org/10.29303/jppipa.v11i10.12763

[11] Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

[12] Hervianti, W., Cahyani, I., & Sopandi, W. (2024). The RADEC: Improving reading comprehension and self-regulated learning in elementary school. *International Conference on Elementary Education, 6*(1), 547–554. https://proceedings2.upi.edu/index.php/icee/article/view/3657

[13] Karlina, D., Sopandi, W., & Sujana, A. (2020). Critical thinking skills of fourth grade in light properties materials through the RADEC model. *International Conference on Elementary Education, 2*(1), 1743–1753. https://proceedings2.upi.edu/index.php/icee/article/view/802

[14] Komariah, M., Sa'ud, U. S., Sopandi, W., & Sujana, A. (2023). RADEC learning model: Perception and implementation in prospective primary school teachers. *Perspektif Ilmu Pendidikan, 37*(1), 45–52. https://doi.org/10.21009/PIP.371.6

[15] Latifa, D. A., Ali, E. Y., & Sujana, A. (2025). Efektifitas model pembelajaran RADEC terhadap peningkatan kemampuan berfikir kritis peserta didik kelas IV sekolah dasar [The effectiveness of the RADEC learning model in improving fourth-grade students' critical thinking]. *COLLASE (Creative of Learning Students Elementary Education), 8*(1), 55–61. https://doi.org/10.22460/collase.v8i1.23566

[16] Oktadila, S. S., Nasbey, H., & Jaya, I. (2025). Enhancing higher-order thinking skills in elementary science learning using the RADEC model. *Jurnal Penelitian Pendidikan IPA, 11*(3). https://doi.org/10.29303/jppipa.v11i3.10398

[17] Oktaviani, A. N. N., Toharudin, M., & Muamar. (2025). Analisis kendala peserta didik dalam memahami konsep integrasi pembelajaran IPAS kelas IV SD Negeri Klampok 01 [Analysis of fourth graders' difficulties in understanding integrated IPAS concepts]. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(2), 393–403. https://doi.org/10.23969/jp.v10i02.28390

[18] Oxman, A. D., Nsangi, A., Martínez García, L., Kaseje, M., Samsó Jofra, L., Semakula, D., Munthe-Kaas, H., & Rosenbaum, S. E. (2025). The effects of teaching strategies on learning to think critically in primary and secondary schools: An overview of systematic reviews [version 2; peer review: 2 approved]. *F1000Research, 13*, 1426. https://doi.org/10.12688/f1000research.158087.2

[19] Patmawati, P., Sujana, A., & Sunaengsih, C. (2025). Pengaruh model pembelajaran RADEC terhadap pemahaman konsep peserta didik di sekolah dasar [The effect of the RADEC learning model on elementary students' conceptual understanding]. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(3), 367–379. https://doi.org/10.23969/jp.v10i03.29985

[20] Perkins, C., & Murphy, E. (2006). Identifying and measuring individual engagement in critical thinking in online discussions: An exploratory case study. *Educational Technology & Society, 9*(1), 298–307.

[21] Pratama, Y. A., Sopandi, W., Hidayah, Y., & Trihastuti, M. (2020). Pengaruh model pembelajaran RADEC terhadap keterampilan berpikir tingkat tinggi siswa sekolah

dasar [The effect of the RADEC learning model on elementary students' higher-order thinking skills]. *JINoP (Jurnal Inovasi Pembelajaran), 6*(2), 191–203. https://doi.org/10.22219/jinop.v6i2.12653

[22] Ritonga, R. A., Sopandi, W., & Rosbiono, M. (2021). Student concept mastery on colloid material through RADEC learning. *Journal of Educational Sciences, 5*(3), 520–532. https://doi.org/10.31258/jes.5.3.p.520-532

[23] Sasmita, R. N., Maryani, E., Sapriya, S., & Anisah, A. S. (2025). Development of a local potential-based learning model to enhance critical thinking skills. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda), 8*(1), 20–32. https://doi.org/10.55215/jppguseda.v8i1.11301

[24] Setianingrum, F. J., Wicaksono, A. G., & Jumanto. (2026). Pengaruh model pembelajaran RADEC terhadap kemampuan berpikir kritis peserta didik pada mata pelajaran IPAS kelas IV sekolah dasar [The effect of the RADEC learning model on fourth graders' critical thinking in IPAS]. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(3), 337–348. https://doi.org/10.23969/jp.v11i03.62412

[25] Setiawan, T. Y., Destrinelli, D., & Wulandari, B. A. (2022). Keterampilan berfikir kritis pada pembelajaran IPA menggunakan model pembelajaran RADEC di sekolah dasar: Systematic literature review [Critical thinking skills in science learning using the RADEC model in elementary schools: A systematic literature review]. *Justek: Jurnal Sains dan Teknologi, 5*(2), 133–141. https://doi.org/10.31764/justek.v5i2.11421

[26] Sopandi, W. (2017). The quality improvement of learning processes and achievements through the read-answer-discuss-explain-and create learning model implementation. In *Proceeding of the 8th Pedagogy International Seminar 2017: Enhancement of Pedagogy in Cultural Diversity toward Excellence in Education* (Vol. 8, pp. 132–139).

[27] Suryana, N., Sopandi, W., & Ruyadi, Y. (2026). The effectiveness of the RADEC learning model in strengthening religious character and critical thinking among elementary school students. *Jurnal Penelitian Pendidikan IPA, 12*(1). https://doi.org/10.29303/jppipa.v12i1.14251

[28] Umrotullatifah, N., & Latif, A. (2025). Category analysis of fifth graders' critical thinking ability on respiration using the RADEC learning model. *Current Issues on Elementary Education Journal, 4*(2), 64–85. https://doi.org/10.17509/ciee.v4i2.92175

[29] Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). *Fostering students' creativity and critical thinking: What it means in school*. OECD Publishing. https://doi.org/10.1787/62212c37-en

[30] Xu, E., Wang, W., & Wang, Q. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. *Humanities and Social Sciences Communications, 10*(1), 1–11. https://doi.org/10.1057/s41599-023-01508-1