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Enhancing Elementary Students' Critical Thinking Through Role Reversal Question in Integrated Science Learning

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ABSTRACT

This classroom action research investigated the effectiveness of the Active Learning Role Reversal Question strategy in improving critical thinking skills among fourth-grade students at Madrasah Ibtidaiyah Negeri (MIN) 1 Bungo within Integrated Science and Social Studies (IPAS) learning on the topic of states of matter and their transformations. The study was grounded in constructivist and critical pedagogical theory, emphasizing dialogical inquiry, reflective interaction, and student-centered knowledge construction. The research employed the Kemmis and McTaggart spiral Classroom Action Research model involving planning, action, observation, and reflection across two instructional cycles. Data were collected through critical thinking tests, classroom observations, field documentation, and reflective analysis. Quantitative findings revealed a substantial increase in students' critical thinking achievement from 42.59% in Cycle I to 82.54% in Cycle II, indicating a 39.95% improvement. Qualitative observations additionally demonstrated significant transformation in students' analytical participation, scientific argumentation, evaluative reasoning, and intellectual confidence. The findings confirmed that the Role Reversal Question strategy effectively transformed passive teacher-centered learning into a participatory and critically oriented scientific learning environment capable of stimulating higher-order thinking and epistemological autonomy among elementary learners.

Informasi Artikel

Kata Kunci:

Active Learning; Role Reversal Question; Berpikir Kritis; Pembelajaran IPAS; Penelitian Tindakan Kelas;

ABSTRAK

Penelitian tindakan kelas ini bertujuan untuk menganalisis efektivitas strategi Active Learning tipe Role Reversal Question dalam meningkatkan kemampuan berpikir kritis siswa kelas IV Madrasah Ibtidaiyah Negeri (MIN) 1 Bungo pada pembelajaran IPAS materi wujud zat dan perubahannya. Penelitian ini berlandaskan teori konstruktivisme dan pedagogi kritis yang menekankan inkuiri dialogis, interaksi reflektif, serta konstruksi pengetahuan berbasis partisipasi aktif siswa. Metode penelitian menggunakan model spiral Classroom Action Research Kemmis dan McTaggart yang meliputi tahap perencanaan, tindakan, observasi, dan refleksi dalam dua siklus pembelajaran. Data diperoleh melalui tes kemampuan berpikir kritis, observasi kelas, dokumentasi lapangan, dan analisis reflektif. Hasil kuantitatif menunjukkan peningkatan signifikan kemampuan berpikir kritis siswa dari 42,59% pada Siklus I menjadi 82,54% pada Siklus II dengan peningkatan sebesar 39,95%. Observasi kualitatif juga menunjukkan transformasi signifikan pada partisipasi analitis, argumentasi saintifik, evaluasi logis, dan kepercayaan diri intelektual siswa.

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1. Introduction

The transformation of contemporary education in the twenty-first century has fundamentally altered the philosophical orientation of learning systems across the globe. Educational institutions are no longer expected merely to transfer factual knowledge through mechanistic memorization; instead, they are required to cultivate higher-order cognitive competencies capable of responding to technological disruption, information overload, and the increasing complexity of global society.[1] Within this framework, critical thinking emerges as one of the most indispensable competencies in modern education because it enables learners to evaluate information rationally, formulate logical arguments, identify bias, construct evidence-based conclusions, and solve multidimensional problems systematically.[2] The urgency of strengthening critical thinking skills is further reinforced by international educational assessments. Data from the Programme for International Student Assessment (PISA) consistently demonstrate that Indonesian students remain below the OECD average in scientific literacy and analytical reasoning. Such conditions indicate that Indonesian elementary education still faces structural challenges in fostering analytical and reflective learning cultures.[5]

From a theoretical perspective, critical thinking is not merely a cognitive activity but a multidimensional intellectual process involving interpretation, inference, analysis, explanation, self-regulation, and evaluation.[1] Facione conceptualizes critical thinking as reflective and reasonable thinking directed toward deciding what to believe or do.[1] Similarly, the Delphi Report emphasizes that critical thinkers possess intellectual discipline characterized by analytical rigor, evidence-based judgment, and metacognitive awareness.[39] In the context of elementary education, these competencies become increasingly important because cognitive structures developed during childhood significantly influence future academic performance, scientific reasoning, and problem-solving capacities.[32] Consequently, the cultivation of critical thinking at the primary school level should not be treated as a supplementary pedagogical objective, but rather as a foundational educational imperative.

Within Indonesian elementary education, the Integrated Science and Social Studies subject (IPAS) occupies a strategic position in developing students' critical reasoning abilities because it integrates scientific inquiry with contextual social understanding.[8] The epistemological nature of IPAS emphasizes not only mastery of scientific facts and concepts but also the acquisition of inquiry skills, empirical observation, experimentation, and reflective reasoning.[14] Dewey argues that meaningful scientific learning emerges when students actively investigate phenomena through questioning, exploration, and reflective inquiry rather than passive reception of information.[14] Therefore, IPAS learning ideally functions as an intellectual laboratory in which students construct conceptual understanding through direct interaction with natural and social realities.[27]

Empirically, however, the implementation of IPAS learning in many Indonesian elementary schools continues to exhibit substantial pedagogical deficiencies. Research findings indicate that classroom practices remain dominated by teacher-centered instructional approaches characterized by lectures, one-way explanations, repetitive memorization, and minimal dialogical interaction.[21] Such pedagogical rigidity weakens students' cognitive engagement and significantly limits opportunities for analytical reasoning, argument construction, and reflective questioning.[20] Several studies reveal that students frequently demonstrate low participation rates during classroom discussions, reluctance to ask analytical questions, and limited ability to formulate evidence-based conclusions.[9] This phenomenon reflects a broader systemic problem within conventional educational culture, where students are socially positioned as passive recipients of authoritative knowledge rather than active constructors of meaning.[12]

The situation becomes increasingly problematic in science-related topics such as "States of Matter and Their Transformations," which intrinsically require conceptual imagination, causal reasoning, and scientific abstraction.[37] Understanding changes in matter involves comprehension of thermal energy transfer, particle movement, phase transitions, and observable physical phenomena. When such material is delivered exclusively through verbal explanation without interactive exploration, students tend to develop superficial conceptual understanding and persistent scientific misconceptions.[29] Empirical studies demonstrate that elementary students often experience difficulties distinguishing between evaporation, condensation, melting, and sublimation because learning activities fail to facilitate experiential and analytical engagement.[8] Consequently, students' cognitive performance remains confined to low-level memorization rather than analytical interpretation and scientific reasoning.[30]

The preliminary observations conducted in Class IV-A of Madrasah Ibtidaiyah Negeri (MIN) 1 Bungo further reinforce these concerns.[6] Students exhibited limited confidence in expressing opinions, weak participation in classroom discussions, and minimal initiative in generating analytical questions related to IPAS learning materials.[7] The classroom environment remained predominantly teacher-dominated, while students functioned merely as passive listeners without meaningful intellectual involvement.[6] Such pedagogical conditions ultimately produce what Freire describes as the "banking model of education," where knowledge is deposited into learners without critical negotiation or reflective engagement.[22] As a consequence, students become cognitively dependent upon teacher authority and fail to develop autonomous reasoning capacities necessary for higher-order thinking.[31]

Statistical evidence further supports the effectiveness of active learning approaches in improving critical thinking competencies.

Research conducted by Nuraini demonstrated that contextual Project-Based Learning increased elementary students' critical thinking performance significantly, with average achievement scores improving from 62.4 to 84.7 after intervention.[11] Similarly, Widodo reported that Role Reversal Question implementation increased student participation rates by more than 70% and improved conceptual understanding outcomes substantially.[28] Research by Hidayat also found that active learning strategies contributed to measurable increases in classroom engagement, analytical questioning frequency, and academic achievement.[26] Internationally, inquiry-based learning models have similarly been associated with improved scientific literacy, collaborative reasoning, and reflective thinking capacities among elementary learners.[10]

The implementation of Role Reversal Question within IPAS learning also aligns closely with the demands of twenty-first-century education, particularly the development of the "4C competencies": critical thinking, creativity, communication, and collaboration.[31] Unlike conventional lectures, which emphasize memorization and unilateral communication, active learning models foster intellectual interaction and collective problem-solving.[35] Students become cognitively responsible for defending arguments, responding to counterarguments, and justifying conclusions using empirical reasoning.[36] Such experiences are essential for preparing learners to navigate increasingly complex social, technological, and scientific realities.[5]

Accordingly, this classroom action research seeks to analyze and validate the effectiveness of the Active Learning Role Reversal Question model in improving the critical thinking abilities of fourth-grade students at MIN 1 Bungo within IPAS learning, particularly on the topic of states of matter and their transformations.[6] This research is grounded in the epistemological assumption that meaningful learning emerges not through passive knowledge transmission but through intellectual struggle, dialogical interaction, and reflective inquiry.[14] Through the reconstruction of classroom power relations and the activation of student-centered inquiry processes, Role Reversal Question is expected to transform the classroom into a dynamic cognitive ecosystem that promotes analytical reasoning, scientific literacy, and critical intellectual development.[17]

2. Methods

This study employed a Classroom Action Research (CAR) design grounded in the critical-constructivist educational paradigm, which conceptualizes learning not merely as the passive transmission of knowledge, but as a dynamic process of reflective inquiry, collaborative meaning-making, and transformative pedagogical intervention.[16] Classroom Action Research was selected because of its epistemological capacity to bridge the dichotomy between educational theory and pedagogical praxis through cyclical processes of planning, action, observation, and reflection.[23] Within this framework, the researcher simultaneously functioned as an instructional practitioner and analytical observer who continuously reconstructed pedagogical strategies based on empirical classroom realities.[24]

The methodological architecture of this research adopted the Kemmis and McTaggart spiral model of Classroom Action Research, which emphasizes recursive cycles of intervention designed to improve instructional quality systematically and sustainably.[6] This model was considered particularly relevant because it enables pedagogical innovation to be implemented in iterative stages while simultaneously facilitating continuous evaluation of students' cognitive development.[25] The research was conducted in Class IV-A of Madrasah Ibtidaiyah Negeri (MIN) 1 Bungo during the 2025/2026 academic year and involved 28 elementary students consisting of male and female learners with heterogeneous academic abilities and socio-cognitive characteristics.[7]

Data collection within this research employed both qualitative and quantitative approaches in order to achieve methodological triangulation and analytical comprehensiveness.[6] Quantitative data were obtained through critical thinking tests administered at the end of each action cycle. The assessment instruments were designed based on higher-order thinking indicators encompassing analytical reasoning, interpretation, evaluation, inference, and problem-solving capacities.[39] Student achievement scores were subsequently analyzed using descriptive statistical techniques to identify patterns of cognitive improvement across instructional cycles.[30] The percentage formula utilized in this study was formulated as follows:

$$P = F: N \times 100\%$$

where PPP represents the percentage of achievement, fff denotes the frequency of observed indicators, and NNN refers to the total number of participants.[6]

Qualitative data, meanwhile, were derived from classroom observations, reflective journals, field documentation, and participatory interactions occurring throughout the instructional process.[24] These data were analyzed using interactive analytical procedures involving data reduction, data display, interpretative categorization, and conclusion verification.[16] Through this multidimensional analytical approach, the study sought not only to measure statistical improvement in critical thinking performance but also to understand the transformative dynamics underlying students' cognitive and behavioral changes during the learning process.[12]

3. Discussion

The contemporary crisis of elementary education cannot merely be interpreted as a technical failure in curriculum implementation or instructional delivery. More fundamentally, it reflects a deeper epistemological crisis within the architecture of classroom pedagogy itself. Conventional educational systems continue to reproduce hierarchical models of knowledge transmission in which teachers occupy the exclusive position of epistemic authority while students remain subordinated as passive recipients of information.[12] Such pedagogical structures ultimately create what Paulo Freire critically conceptualized as the "banking model of education," namely an educational mechanism in which knowledge is symbolically "deposited" into learners without dialogical participation, reflective negotiation, or intellectual autonomy.[22] Within this rigid instructional ecosystem, students gradually lose their capacity for analytical reasoning, argumentative resistance, and epistemic independence because the classroom no longer functions as a democratic intellectual space but rather as an instrument of cognitive conformity.[31]

This pedagogical stagnation becomes increasingly problematic in the context of twenty-first-century education, where learners are expected to possess higher-order thinking competencies capable of navigating informational complexity, technological acceleration, and multidimensional social realities.[5] Critical thinking, therefore, cannot be developed through passive memorization or repetitive lecture-based instruction because analytical reasoning fundamentally requires active intellectual engagement, cognitive conflict, dialogical interaction, and reflective inquiry.[1] Facione argues that critical thinking involves a multidimensional constellation of cognitive operations encompassing interpretation, analysis, inference, evaluation, explanation, and self-regulation.[39] These dimensions are not mechanically acquired through information exposure alone; rather, they emerge through sustained participation in intellectually demanding activities that compel learners to question assumptions, construct arguments, evaluate evidence, and negotiate meaning collaboratively.[1]

Within this theoretical landscape, the Active Learning paradigm emerges as one of the most influential pedagogical responses to the structural limitations of conventional teacher-centered education.[12] Active Learning fundamentally rejects the assumption that learning is an automatic consequence of listening to explanations or receiving information from instructional authorities.[31] Instead, learning is conceptualized as a participatory cognitive process in which students become active agents responsible for constructing, testing, and reconstructing knowledge through intellectual engagement.[17] Silberman explicitly emphasizes that meaningful learning only occurs when students are cognitively activated through questioning, discussion, problem-solving, conceptual experimentation, and reflective analysis.[17] Consequently, Active Learning does not merely represent a collection of classroom techniques but constitutes a broader epistemological transformation concerning how knowledge is produced, legitimized, and internalized within educational spaces.[18]

It is precisely within this critical pedagogical context that the Role Reversal Question strategy acquires substantial theoretical significance.[17] Among Silberman's numerous Active Learning strategies, Role Reversal Question stands out not merely as an instructional technique but as a radical pedagogical intervention aimed at deconstructing traditional cognitive power relations within the classroom.[18] Unlike conventional questioning methods, which preserve the teacher's monopoly over inquiry and evaluation, Role Reversal Question intentionally transfers epistemic authority to students through structured role exchange.[19] This pedagogical inversion fundamentally disrupts the traditional asymmetry of classroom discourse by positioning students as active interrogators while temporarily transforming teachers into respondents subjected to analytical scrutiny.[17]

The operational structure of the Role Reversal Question strategy reflects a highly systematic pedagogical design.[17] Initially, teachers construct strategic conceptual questions aligned with the essential learning objectives of the subject matter.[17] This preparatory phase is pedagogically crucial because it ensures that instructional discourse remains intellectually structured rather than improvisational.[7] Subsequently, students are organized into collaborative heterogeneous groups and tasked with generating analytical questions related to the learning material independently.[18] The process of question construction itself constitutes a sophisticated cognitive activity because students must first comprehend conceptual relationships, identify potential misconceptions, and anticipate argumentative responses before formulating valid inquiries.[10]

From a critical thinking perspective, the act of constructing questions activates multiple higher-order cognitive dimensions simultaneously.[1] Students must engage in interpretation to understand conceptual meanings, analysis to identify logical relationships, inference to predict responses, and evaluation to determine the intellectual validity of their own questions.[39] This process can be conceptually illustrated as follows:

1. CT=I+A+E+Ex+SR

where CT represents Critical Thinking, I denotes Interpretation, A refers to Analysis, E signifies Evaluation, Ex represents Explanation, and SR indicates Self-Regulation.[1] The intellectual climax of the strategy emerges during the role exchange session itself,

Despite these limitations, the Role Reversal Question strategy nevertheless represents a highly significant pedagogical innovation because it redefines the classroom as a participatory intellectual community rather than a unilateral instructional hierarchy.[17] Through the reconstruction of questioning authority, the strategy cultivates analytical courage, argumentative reasoning, reflective judgment, and epistemic

autonomy among learners.[1] More importantly, it transforms learning from a passive process of information reception into an active process of intellectual struggle, collaborative inquiry, and critical consciousness formation.[22] Within this transformative pedagogical framework, students are no longer positioned merely as objects of instruction but emerge as active subjects capable of interrogating, reconstructing, and producing knowledge independently.[14]

Table 1. Linearity Test Results

Pedagogical Component	Sum of squares	df	Mean Square	F	Sig.
Cognitive Activation	0.25	5	84.70	21.17	0,372
Dialogical Participation	0.20	1	89.00	17.80	0,046
Student Inquiry Engagement	0.15	4	87.50	13.12	0,880
Scientific Argumentation	0.20		79.60	15.92	
Psychological Safety Climate	0.20		81.60	16.32	0,880
Total Effectiveness Index	1.00	2	84.33	16.3	0,6

Source: analyzed by the author.

The statistical construction presented in Table 1 demonstrates that the implementation of the Active Learning Role Reversal Question model generated a substantially high pedagogical effectiveness index, reaching a cumulative weighted score of 84.33. From an analytical perspective, the highest empirical achievement was identified within the dimension of dialogical participation (89.00), indicating that the instructional intervention successfully transformed classroom interaction from a monologic instructional structure into a participatory discourse ecosystem characterized by reciprocal questioning, collaborative reasoning, and argumentative engagement.[17] This finding reinforces constructivist assumptions asserting that meaningful learning emerges through dialogical interaction and collective negotiation of meaning rather than unilateral knowledge transmission.[14]

Furthermore, the cognitive activation dimension obtained a weighted contribution of 21.17, representing the strongest proportional influence within the effectiveness index due to its higher weighting coefficient (0.25). This outcome suggests that the Role Reversal Question strategy effectively stimulated higher-order cognitive processes involving analytical reasoning, conceptual interpretation, inference construction, and evaluative judgment.[1] The relatively high inquiry engagement score (87.50) additionally confirms that students became increasingly capable of generating independent analytical questions, which constitutes one of the primary indicators of critical consciousness and epistemic autonomy within contemporary educational theory.[39]

Nevertheless, the comparatively lower empirical score observed in the scientific argumentation dimension (79.60) reveals that although students demonstrated increased participation and questioning intensity, their ability to formulate scientifically rigorous and logically coherent arguments remained partially underdeveloped.[10] This phenomenon indicates that dialogical participation alone does not automatically guarantee argumentative sophistication. Effective scientific reasoning additionally requires sustained conceptual reinforcement, evidentiary literacy, and repeated exposure to analytical discourse practices.[35]

Similarly, the psychological safety dimension achieved a moderately high score (81.60), suggesting that the instructional environment successfully reduced students' anxiety, fear of failure, and reluctance to participate in intellectual discussion.[33] This finding is particularly significant because psychological safety constitutes a foundational prerequisite for critical inquiry and reflective participation within collaborative learning environments.[11] Students are more likely to challenge assumptions, express dissenting opinions, and engage in analytical debate when classroom interaction is perceived as intellectually supportive rather than punitive.[22]

The implementation of Cycle I represented the initial operationalization of the Role Reversal Question strategy as a deliberate pedagogical intervention designed to disrupt the deeply entrenched teacher-centered instructional culture prevailing within the classroom.[17] At the beginning of the intervention, students were systematically organized into heterogeneous collaborative groups and instructed to analyze conceptual dimensions related to states of matter and thermal energy transformation processes.[37] In accordance with Silberman's procedural syntax, the teacher subsequently declared the formal reversal of classroom authority structures by assigning students the symbolic and functional role of "instructional examiners" responsible for questioning and evaluating the teacher publicly.[17]

From a theoretical standpoint, this pedagogical inversion was expected to stimulate analytical participation, dialogical interaction, and higher-order cognitive engagement.[18] However, empirical observations during Cycle I revealed that the abrupt redistribution of epistemic authority generated substantial psychological resistance among students.[6] Quantitative evaluation conducted at the end of the first cycle demonstrated that the average classical critical thinking achievement rate reached only 42.59%, remaining substantially below the predetermined Minimum Mastery Criterion (KKM).[6] Although statistically disappointing, this initial outcome possesses profound analytical significance because it reveals the structural depth of students' cognitive dependency upon conventional pedagogical hierarchies.[22]

The low achievement rate observed during Cycle I cannot merely be interpreted as an indicator of instructional failure. More fundamentally, it reflects the existence of what may be conceptualized as "academic culture shock," namely a psychological condition emerging when students accustomed to passive learning environments are suddenly confronted with intellectual autonomy and dialogical responsibility.[9] For years, students had been socially conditioned to occupy subordinate cognitive positions as listeners rather than interrogators.[12] Consequently, the abrupt transfer of questioning authority generated emotional discomfort, self-doubt, hesitation, and mild cognitive panic.[6] Students demonstrated uncertainty regarding their legitimacy and competence to challenge teacher authority publicly, indicating that traditional pedagogical structures had internalized epistemic inferiority within student consciousness.[22]

Furthermore, analytical examination of student-generated questions during Cycle I demonstrated that the majority remained confined within Lower Order Thinking Skills (LOTS) categories.[1] Rather than constructing causal, analytical, or hypothetical inquiries, students predominantly formulated definitional questions such as "What is melting?" or "What is evaporation?"[6] This phenomenon reveals that although classroom participation increased procedurally, the underlying structure of students' analytical reasoning remained underdeveloped. From Facione's critical thinking framework, such tendencies indicate weaknesses within the dimensions of analysis, inference, and evaluation.[39] Students had not yet developed sufficient cognitive sophistication to transform conceptual understanding into investigative inquiry capable of stimulating scientific argumentation.[10]

The most significant deficiency emerged during the evaluative debate phase of the instructional process.[17] Consistent with Silberman's strategy, the teacher intentionally responded to student questions using scientifically incorrect yet humorously provocative explanations designed to stimulate critical rebuttal.[17] For instance, the teacher claimed that "ice melts because it cries from overheating outside the refrigerator."[6] Surprisingly, rather than critically challenging the flawed scientific premise, students merely laughed and treated the response as entertainment without constructing analytical counterarguments.[6] This reaction demonstrates a critical epistemological weakness: students remained unable to distinguish between humorous discourse and scientific validity through logical evaluation.[35]

The instructional refinements implemented during Cycle II generated an extraordinary quantitative and qualitative transformation.[6] Statistical evaluation at the conclusion of the cycle demonstrated that students' collective critical thinking achievement increased dramatically from 42.59% to 82.54%.[6] This substantial increase indicates not merely incremental academic improvement but a fundamental transformation in students' epistemological participation within classroom discourse.[17]

The statistical escalation can be mathematically illustrated as follows:

2. $\Delta CT = CTC2 - CTC1 = 82.54\% - 42.59\% = 39.95\%$

More importantly, qualitative observations revealed profound improvements across all six dimensions of Facione's critical thinking framework.[39] Students no longer formulated simplistic definitional questions; instead, they began constructing sophisticated investigatory inquiries involving causal reasoning, environmental analysis, and hypothetical projection.[6] One student group, for instance, formulated the following analytical question: "If polar ice continues melting due to global temperature increases, what specific effects would occur regarding sea-level volume, and which sequential phase transformations are involved within this process?"[6] Such questioning demonstrates substantial advancement in analytical reasoning, inferential logic, and conceptual abstraction.[10]]

Similarly, significant progress emerged within the dimensions of evaluation and explanation.[1] When the teacher once again intentionally presented scientifically flawed arguments, students no longer responded passively or humorously.[6] Instead, they actively constructed evidence-based rebuttals using references derived from textbooks, classroom experiments, and prior observational activities.[6] Students demonstrated the ability to formulate coherent deductive explanations capable of dismantling false scientific claims systematically.[35] Consequently, classroom discourse evolved into a genuinely dialogical scientific debate characterized by argumentative equality between students and teacher.[17]

The most transformative outcome, however, appeared within the domain of self-regulation.[39] As students successfully challenged adult authority through scientific reasoning, their intrinsic intellectual confidence increased dramatically.[6] This psychological empowerment subsequently activated metacognitive awareness, enabling students to revise arguments independently, acknowledge conceptual weaknesses openly, and reconstruct reasoning dynamically during discussion processes.[1] Such developments indicate the emergence of authentic reflective consciousness rather than mere performative participation.[22]

At the culmination of the instructional process, students collectively demonstrated the ability to formulate holistic scientific conclusions concerning the role of thermal energy in transforming matter between solid, liquid, and gaseous states without sacrificing conceptual validity or scientific coherence.[6] This outcome confirms that the Role Reversal Question strategy successfully transformed classroom learning from rote memorization into a process of collaborative scientific inquiry and critical intellectual engagement.[17]

Tabel 2 .Quantitative Transformation of Critical Thinking Dimensions Following the Implementation of the Role Reversal Question Model

Critical Thinking Dimension	C 1	C2	Improvement (%)	Analytical Interpretation
Interpretation	45.2	84.10	+38.90	Students became capable of identifying conceptual relationships and contextual scientific meanings more comprehensively.
Analysis	41.8	86.30	+44.50	Significant improvement in constructing causal and investigatory scientific questions.
Evaluation	39.5	81.40	+41.90	Students demonstrated stronger ability to challenge invalid arguments critically and scientifically.
Explanation	43.1	82.70	+39.60	Learners developed more coherent, evidence-based, and deductive scientific explanations.
Inference	44.0	80.90	+36.90	Students showed greater capability in drawing logical conclusions from empirical phenomena.
Self-Regulation	41.9	79.80	+37.90	Increased metacognitive awareness and willingness to revise arguments independently.
Classical Critical Thinking Achievement	42.5	82.54	+39.95	The instructional intervention generated substantial cognitive and epistemological transformation.

Source: analyzed by the author.

Collectively, these findings confirm that the Active Learning Role Reversal Question strategy functions not merely as a participatory instructional technique but as a transformative pedagogical mechanism capable of reconstructing classroom epistemology itself.[17] Through systematic disruption of traditional authority structures, dialogical interaction, reflective scaffolding, and collaborative inquiry, students gradually evolved from passive listeners into active scientific reasoners capable of analytical evaluation, argumentative resistance, and autonomous intellectual judgment.[22]

Table 3. Comparative Classroom Ecosystem Transformation and Critical Thinking Development Across Research Cycles

Phase	Qualitative Observation of Classroom Ecosystem and Psychological Climate	Critical Thinking Achievement Percentage	Analysis of Manifested Facione Critical Thinking Indicators
Pre-Cycle	Classroom interaction was highly passive and entirely teacher-centered. Students experienced demotivation and intellectual anxiety when attempting to ask questions. Learning activities were predominantly dominated by rote memorization practices.	**< 30%** *(Very Low)*	The Interpretation dimension remained extremely weak. There was an almost complete absence of activities representing Evaluation, Explanation, and Self-Regulation capacities.
Cycle I	Classroom structure began transitioning into collaborative active-group interaction; however, students experienced role-confusion syndrome during the role reversal process. Learners remained hesitant to engage in debate, and most questions were still limited to fundamental conceptual definitions.	**42.59%**	Analytical reasoning skills began to emerge, although they remained insufficiently directed toward scientific inquiry. Self-Regulation failed to develop optimally due to students' psychological insecurity and lack of confidence when confronting teacher authority.
Cycle II	The classroom atmosphere transformed into an interactive, dynamic, enjoyable, and intellectually competitive learning environment. Cross-role scientific debates emerged organically, and students demonstrated strong confidence in challenging the "student" (teacher)	**82.54%**	A highly substantial and evenly distributed cognitive improvement was identified across all critical thinking dimensions, including comprehensive Interpretation, sharp Evaluation, logical Explanation, and empirically groundd

Source: analyzed by the author.

The substantial quantitative escalation from 42.59% in Cycle I to 82.54% in Cycle II provides an exceptionally strong empirical justification for the pedagogical validity and instructional effectiveness of the selected intervention model. From both administrative and academic evaluation perspectives, the achievement of a classical mastery level exceeding the fundamental institutional threshold of 80% demonstrates that the classroom action intervention successfully generated a statistically and pedagogically significant transformation in students' critical thinking performance.[6] Consequently, the research process did not require continuation into a third instructional cycle because the predetermined indicators of success had already been comprehensively achieved.

Analytically, this dramatic increase cannot merely be interpreted as a numerical improvement in academic performance; rather, it reflects a deeper epistemological transformation within the classroom learning ecosystem itself.[17] The transition from passive instructional dependency toward active analytical participation indicates that students successfully reconstructed their cognitive identity from recipients of information into autonomous participants capable of interpretation, evaluation, scientific explanation, and evidence-based inference.[39] Such findings reinforce constructivist educational assumptions asserting that meaningful learning outcomes emerge when learners are directly involved in dialogical inquiry, intellectual confrontation, and reflective argumentation rather than mechanistic memorization practices.[14]

Furthermore, the successful attainment of the 80% mastery benchmark signifies that the Role Reversal Question strategy was not only effective in improving isolated cognitive indicators but also capable of producing holistic behavioral and psychological transformation.[11] Students demonstrated significantly increased confidence in articulating arguments, challenging flawed reasoning, and revising conceptual assumptions independently during scientific discussion processes.[35] This phenomenon confirms that critical thinking development fundamentally depends upon the creation of psychologically safe and intellectually participatory learning environments.[33]

From the perspective of Classroom Action Research methodology, the termination of the intervention at Cycle II additionally reflects the successful realization of reflective pedagogical reconstruction as conceptualized within the Kemmis and McTaggart cyclical model.[23] The reflective refinement conducted after Cycle I effectively resolved the structural weaknesses identified during the initial implementation phase, particularly those related to psychological resistance, analytical questioning quality, and unequal participation dynamics.[25] As a result, the second cycle succeeded in transforming the classroom into a dynamic dialogical ecosystem characterized by collaborative inquiry, argumentative interaction, and autonomous scientific reasoning.[17]

The quantitative improvement trajectory can be mathematically represented as follows:

3. $PI = 42.59\ 82.54 - 42.59 \times 100\% = 93.80\%$

where PI represents the percentage of pedagogical improvement achieved across instructional cycles. The calculation demonstrates that the intervention produced an approximate 93.80% relative increase in students' critical thinking achievement, thereby confirming the highly transformative impact of the Active Learning Role Reversal Question model on elementary-level IPAS instruction.[6]

Ultimately, the findings of this research affirm that pedagogical innovation rooted in active learning, dialogical inquiry, and epistemological role reconstruction possesses substantial capacity to overcome cognitive passivity and stimulate higher-order thinking development among elementary students.[1] Therefore, the success of this intervention should not merely be interpreted as an isolated classroom achievement, but rather as empirical evidence supporting the broader necessity of transitioning from authoritarian instructional paradigms toward participatory and critically oriented educational models within contemporary elementary education systems.[22]

The dramatic transformation observed in the cognitive landscape of fourth-grade students at MIN 1 Bungo should not be interpreted as an accidental pedagogical phenomenon emerging in isolation. Rather, it constitutes a measurable manifestation of the Role Reversal Question intervention's capacity to activate previously dormant analytical structures within students' cognition.[1] The substantial increase in critical thinking achievement from 42.59% in Cycle I to 82.54% in Cycle II empirically demonstrates that the effectiveness of the intervention was rooted not merely in procedural classroom modification, but in its ability to reconstruct the psychological and epistemological foundations of classroom interaction itself.[6]

From an affective-psychological perspective, the success of the intervention primarily stemmed from its ability to dismantle students' emotional barriers toward intellectual participation.[2] In conventional pedagogical environments, low critical thinking performance at the elementary level is frequently caused not by students' biological inability to process complex information, but by the existence of structural academic anxiety generated through rigid teacher-centered authority systems.[22] Fear of producing incorrect answers, fear of public embarrassment, and fear of being negatively evaluated by teachers often function as the primary suppressors of analytical courage and dialogical participation.[33] The Role Reversal Question strategy disrupted this oppressive atmosphere by integrating theatrical role exchange, dialogical humor, pedagogical provocation, and gamified interaction into the learning process.[9] When the teacher intentionally positioned himself as a vulnerable participant capable of making mistakes and being corrected

publicly by students, the rigid hierarchy of classroom authority gradually dissolved.[17] Consequently, students began to experience a stronger sense of intellectual legitimacy, emotional safety, and ownership over classroom discourse.[11]

This psychological liberation became the essential precondition for the emergence of authentic critical thinking.[1] Without the removal of emotional inhibition, analytical cognition cannot operate optimally because students remain cognitively defensive rather than intellectually exploratory.[33] The dramatic improvement identified during Cycle II confirms that once emotional barriers were reduced, students became significantly more willing to articulate arguments, challenge assumptions, and engage in scientific debate assertively.[6]

From an epistemological and cognitive-load perspective, the effectiveness of the Role Reversal Question strategy can additionally be explained through the inversion of conventional learning demands.[10] In traditional classrooms, students are generally required only to receive and reproduce information through low-level memorization activities.[12] However, acting as the initiator of analytical questioning requires substantially higher cognitive operations because students must first synthesize conceptual understanding before constructing investigatory scenarios capable of challenging others intellectually.[39] In order to formulate analytical questions regarding evaporation, condensation, or thermal transformation mechanisms, students were required to engage simultaneously in interpretation, analysis, inference, and evaluation.[1]

Moreover, the implementation of this strategy within the IPAS subject possesses substantial ontological relevance because science learning fundamentally requires students to understand natural mechanisms through analytical inquiry rather than deductive memorization.[37] Scientific concepts related to states of matter and thermal transformation involve causal reasoning, hypothetical thinking, and empirical evaluation.[29] When students were able to formulate investigatory questions such as whether melted and refrozen candle wax would regain identical mass, volume, and structural properties, they were unconsciously engaging in sophisticated inferential reasoning, metacognitive reflection, and scientific hypothesis construction.[1] Such dialogical inquiry represents the essential core of authentic science education.[14]

Nevertheless, one of the most significant findings of this study lies in the recognition that innovative instructional models alone do not automatically guarantee pedagogical success.[6] The relatively low achievement during Cycle I (42.59%) demonstrates that even theoretically sophisticated pedagogical interventions may fail if they are not accompanied by adequate psychological facilitation and adaptive instructional scaffolding.[25] Importantly, this early-stage difficulty should not be interpreted as evidence of theoretical weakness within the Role Reversal Question model itself.[17] Rather, it reflects the magnitude of the cultural and cognitive shock experienced by students who had long been institutionalized within passive and indoctrinative educational traditions.[22]

The exponential improvement achieved during Cycle II therefore articulates a critical pedagogical message regarding the importance of instructional patience, emotional sensitivity, and adaptive facilitation within transformative learning environments.[6] Teachers are required not only to master scientific content but also to function as psychological facilitators capable of guiding analytical confidence, modeling investigatory reasoning, and strategically provoking intellectual debate without damaging students' emotional security.[33] In this sense, the success of Role Reversal Question ultimately depended not merely upon the procedural mechanics of role exchange, but upon the teacher's ability to orchestrate a psychologically safe yet cognitively challenging intellectual ecosystem capable of stimulating students' analytical potential to its fullest extent.[11]

4. Closing

The findings of this classroom action research conclusively demonstrate that the implementation of the Active Learning Role Reversal Question strategy generated a profound pedagogical, cognitive, and epistemological transformation within the IPAS learning process of fourth-grade students at MIN 1 Bungo. The intervention successfully reconstructed the traditional teacher-centered classroom paradigm into a dialogical and participatory intellectual ecosystem characterized by analytical interaction, collaborative inquiry, reflective reasoning, and argumentative engagement. Through the systematic deconstruction of conventional authority structures, students gradually evolved from passive recipients of information into active constructors of scientific knowledge capable of interpretation, evaluation, explanation, inference, and self-regulation.

Empirically, the dramatic quantitative escalation of students' critical thinking achievement from 42.59% in Cycle I to 82.54% in Cycle II confirms the substantial effectiveness of the pedagogical intervention. This improvement not only reflects increased academic performance but also signifies the emergence of higher-order cognitive consciousness among learners. Students demonstrated stronger analytical confidence, improved scientific argumentation, greater willingness to challenge flawed reasoning, and enhanced capacity to construct evidence-based conclusions independently. The findings additionally reveal that meaningful critical thinking development is inseparable from psychologically safe, dialogical, and intellectually democratic learning environments capable of encouraging reflective participation and collaborative problem-solving.

Theoretically, this study reinforces constructivist and critical pedagogical assumptions asserting that authentic learning emerges through active inquiry, cognitive conflict, reflective interaction, and negotiated meaning-making rather than mechanistic memorization practices. The Role Reversal Question strategy proved highly effective because it repositioned students as epistemic subjects possessing legitimate authority to question, evaluate, and reconstruct knowledge critically.

Consequently, the classroom ceased functioning merely as a space of instructional transmission and instead transformed into a dynamic arena of scientific discourse and intellectual emancipation.

From a practical educational perspective, the results of this research imply that elementary education institutions must progressively transition away from authoritarian and monologic instructional orientations toward more participatory and inquiry-based pedagogical models. The successful implementation of the Role Reversal Question strategy indicates that even elementary-level learners possess substantial capacity for sophisticated analytical reasoning when provided with appropriate scaffolding, dialogical opportunities, and psychologically supportive classroom conditions. Therefore, the integration of active learning paradigms within IPAS instruction should be regarded not merely as a methodological alternative but as an essential educational necessity for cultivating critical, reflective, and scientifically literate learners capable of responding to the increasingly complex demands of twenty-first-century society.

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