



Implementation of the Scientific Approach to Enhance Students' Learning Independence and Academic Achievement in the IPAS Subject at the Elementary School Level

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Abstract

Purpose – This study examines the implementation of the scientific approach in improving learning independence and academic achievement among fourth-grade students in Natural and Social Sciences (IPAS) within the Merdeka Curriculum.

Design/methods/approach – This study employed Classroom Action Research involving 20 fourth-grade students at SD Negeri 1 Pseksu, Indonesia. The research comprised three cycles of planning, action, observation, and reflection. Data were collected through classroom observations, achievement tests, and documentation and analyzed using quantitative and qualitative descriptive methods.

Findings – Students' learning independence improved progressively, with mean observation scores increasing from 3.25 in Cycle I to 3.70 in Cycle II and 4.56 in Cycle III. Mean academic achievement scores increased from 64.00 to 80.00 and 97.25, respectively, while classical learning mastery rose from 25% to 100%. Teacher activity scores also improved across the cycles, reflecting progressively refined instructional practices.

Research implications/limitations – The findings highlight the relevance of structured scientific activities, teacher facilitation, and reflective instructional improvement in elementary IPAS learning. However, the single-classroom design, limited sample, differing instructional topics, and unverified assessment equivalence restrict generalizability and causal interpretation.

Originality/value – This study provides contextual evidence of the concurrent development of learning independence and academic achievement through progressively refined scientific learning activities. It emphasizes the integration of reflective instructional adjustments with behavioral and cognitive learning assessment in elementary IPAS education.

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INTRODUCTION

Education at the elementary school level plays a fundamental role in developing students' knowledge, learning habits, critical thinking skills, and ability to regulate their own learning. Contemporary educational practices increasingly emphasize the importance of active student participation rather than the passive acquisition of information. This orientation is particularly relevant to Indonesia's Merdeka Curriculum, which encourages student-centered, contextual, and meaningful learning experiences. Within this curriculum, Natural and Social Sciences (Ilmu Pengetahuan Alam dan Sosial, IPAS) integrates scientific and social perspectives to help students understand natural phenomena, human interactions, and their surrounding environment. Consequently, effective IPAS instruction requires learning strategies that promote both conceptual understanding and students' capacity to manage their learning activities independently.

Despite these expectations, implementing student-centered instruction remains challenging in elementary school classrooms. Preliminary observations conducted among fourth-grade students at SD Negeri 1 Pseksu, South Sumatra, Indonesia, revealed that classroom instruction was predominantly characterized by teacher explanations, limited student participation, and considerable dependence on instructional guidance. Students frequently waited for directions before completing learning activities and demonstrated limited initiative in asking questions, exploring information, or expressing their understanding. Furthermore, preliminary classroom assessment data indicated that approximately 52% of students achieved the expected minimum mastery criterion. These conditions suggest that insufficient opportunities for active inquiry may coincide with difficulties in developing learning independence and achieving satisfactory academic performance. Addressing these challenges requires instructional practices that simultaneously encourage students' active involvement and strengthen their understanding of IPAS concepts.

The scientific approach offers a relevant instructional framework for addressing these classroom challenges through five interconnected learning activities: observing, questioning, experimenting, reasoning, and communicating. These activities encourage students to construct understanding by examining phenomena, formulating questions, gathering evidence, interpreting information, and communicating their conclusions. From a theoretical perspective, the scientific approach aligns with constructivist learning principles, which emphasize knowledge construction through active engagement with meaningful learning experiences. It is also conceptually related to Zimmerman's (2000) self-regulated learning framework, which describes learning as a process involving planning, monitoring, strategic control, and self-reflection. Accordingly, scientific learning activities may provide opportunities for students to develop initiative, responsibility, persistence, and greater control over their learning processes while strengthening their conceptual understanding.

Recent empirical literature provides important evidence regarding the educational benefits of inquiry-oriented learning and self-regulated learning interventions. Dah et al. (2024), through a systematic literature review published in *Educational Research Review*, examined the effects of open inquiry on students' learning in science education. Their review offers a broader synthesis of inquiry-based learning outcomes and provides a rationale for engaging students in scientific investigation. Similarly, Strata et al. (2024), in a systematic review of 142 empirical studies published in *Studies in Science Education*, reported favorable

outcomes of inquiry-based science education in areas such as conceptual understanding, teaching competence, attitudes, and self-efficacy. However, their review primarily addressed science teacher education rather than the development of elementary school students' learning independence and academic achievement. These studies support the educational relevance of inquiry-oriented instruction while demonstrating the importance of examining its implementation in specific classroom contexts.

Research on self-regulated learning provides complementary evidence regarding students' academic development. Núñez et al. (2022), in *Revista de Psicodidáctica*, investigated an intervention involving self-regulated learning and reading comprehension strategies among elementary school students, including the role of self-regulatory activities in academic achievement. Their research demonstrates the relevance of self-regulation interventions to elementary education, although its instructional emphasis differs from the scientific approach used in IPAS learning. Furthermore, Olid-Luque et al. (2025), in a systematic review published in *Psychology in the Schools*, synthesized 10 studies examining self-regulated learning programs in primary education and identified positive effects on students' self-regulated learning. These findings strengthen the argument that learning independence can be developed through structured instructional interventions. Nevertheless, the reviewed interventions do not directly establish how the five stages of the scientific approach can be progressively refined within classroom action research to address learning independence and academic achievement together in Indonesian elementary IPAS instruction.

Additional evidence highlights the relationship between instructional interventions and academic achievement. Kim and Chung (2024), through a meta-analysis of 92 studies published in the *Korean Journal of Educational Psychology*, reported an overall positive effect of self-regulated learning programs on academic achievement and identified several instructional characteristics associated with variations in intervention effectiveness. Although this meta-analysis provides strong evidence supporting structured learning interventions, its findings synthesize different educational levels, learning environments, and instructional strategies rather than examining the implementation of the scientific approach in a specific elementary school subject. In the Indonesian context, Abdurrochim et al. (2024) investigated the effects of a mindful learning approach on fifth-grade students' IPAS learning outcomes using a quasi-experimental design. Their findings showed differences in learning outcomes between experimental and comparison classes, demonstrating the relevance of innovative instructional strategies for IPAS education. However, their study focused on academic outcomes rather than systematically documenting changes in both learning independence and academic achievement through successive scientific learning cycles.

A critical comparison of these studies reveals three interconnected research gaps. First, existing research provides substantial evidence concerning inquiry-based learning, self-regulated learning, and academic achievement, but these constructs are frequently examined through different instructional interventions or research contexts. Consequently, the findings cannot automatically explain how a five-stage scientific approach relates to the concurrent development of learning independence and academic achievement in elementary IPAS instruction. Second, systematic reviews and meta-analyses establish the broader effectiveness of inquiry-oriented or self-regulation interventions but provide less direct evidence regarding the classroom-level instructional adjustments undertaken across successive action research

cycles. Third, although recent Indonesian IPAS research has demonstrated the potential of alternative student-centered instructional approaches, further classroom-based evidence is needed to document how scientific learning activities and reflective instructional improvement can address both behavioral and cognitive learning outcomes within the Merdeka Curriculum.

These gaps indicate that the value of the present study lies not in introducing the scientific approach as a new instructional method, but in examining its integrated and progressively refined implementation within a specific educational context. The study combines the five scientific learning stages with the cyclical process of planning, action, observation, and reflection to investigate changes in students' learning independence and academic achievement. By evaluating both outcomes across three classroom action cycles, the research provides an opportunity to document their parallel development and identify practical considerations for improving instructional implementation. This design extends the application of existing theoretical and empirical knowledge to fourth-grade IPAS learning without assuming that the observed changes necessarily establish a causal relationship between the two outcomes.

Accordingly, this study aims to examine the implementation of the scientific approach in improving learning independence and academic achievement among fourth-grade students at SD Negeri 1 Pseksu. Specifically, it investigates the changes in students' learning independence and academic achievement across successive classroom action research cycles and evaluates how reflective instructional adjustments support the improvement of classroom learning practices. The study contributes to the literature by providing context-specific, classroom-based evidence concerning the integrated assessment of behavioral and cognitive learning outcomes during scientific instruction. Practically, its findings are expected to inform elementary school teachers about the application and refinement of scientific learning activities to support more active, independent, and meaningful IPAS learning within the Merdeka Curriculum.

METHOD

Research Design

This study employed Classroom Action Research (CAR) to examine the implementation of the scientific approach in improving learning independence and academic achievement in Natural and Social Sciences (Ilmu Pengetahuan Alam dan Sosial, IPAS). The research followed the action research framework proposed by Kemmis and McTaggart (1988), consisting of four interconnected stages: planning, action, observation, and reflection. This design was selected because it allows teachers to identify instructional problems, implement corrective actions, evaluate students' responses, and systematically refine teaching practices across successive cycles. The classroom action research was conducted in three cycles. Each cycle incorporated the five stages of the scientific approach: observing, questioning, experimenting, reasoning, and communicating. Instructional improvements were informed by the observation findings and reflections from the preceding cycle. The research therefore emphasized both the development of students' learning outcomes and the continuous improvement of classroom instructional practices.

Research Setting and Participants

The research was conducted at SD Negeri 1 Pseksu, Lahat Regency, South Sumatra, Indonesia, during the second semester of the 2025/2026 academic year. The participants were 20 fourth-grade students from Class IV B, representing a classroom with heterogeneous academic abilities. The class was selected purposively based on preliminary observations indicating insufficient learning independence, limited classroom participation, and academic achievement below the expected learning targets. Preliminary observations revealed that students frequently relied on teacher instructions, demonstrated limited initiative in completing assignments, and were reluctant to communicate their ideas. These conditions provided the practical basis for implementing an instructional intervention designed to encourage active participation, independent learning behaviors, and improved conceptual understanding.

Research Procedures

The intervention was implemented through three classroom action cycles. Each cycle consisted of instructional planning, implementation, systematic observation, and reflection. The learning materials were aligned with the fourth-grade IPAS learning objectives under the Merdeka Curriculum. Cycle I focused on Plant Parts, Cycle II addressed Photosynthesis: The Most Important Process on Earth, and Cycle III examined Plant Reproduction. These topics were selected to provide opportunities for students to engage in scientific observation, inquiry, information gathering, evidence-based reasoning, and communication.

During the planning stage, the teacher prepared instructional materials, learning activities, observation instruments, assessment tools, and supporting learning media. The action stage involved implementing the scientific approach through five learning activities. Students first observed objects or phenomena, formulated questions, conducted experiments or collected information, analyzed their findings, and communicated their conclusions. During the observation stage, classroom activities were monitored to assess the implementation of the scientific approach and students' learning independence. At the end of each cycle, students completed an achievement assessment related to the instructional content. The reflection stage involved reviewing observation records, assessment results, and classroom experiences to identify aspects requiring improvement. These findings were used to refine teaching strategies in the subsequent cycle.

Research Instruments and Data Collection

Data were collected using three principal techniques: classroom observation, academic achievement tests, and documentation. The research instruments consisted of a teacher activity observation sheet, a student learning independence observation sheet, achievement tests, and supporting documentation records. The teacher activity observation sheet assessed the implementation of the five scientific learning stages, the teacher's instructional guidance, learning facilitation, and the organization of classroom activities. Students' learning independence was evaluated using a structured observation instrument based on the conceptual dimensions of self-regulated learning described by Zimmerman (2000) and Pintrich (2000). The instrument covered five dimensions: (1) learning initiative, (2) learning planning and strategy management, (3) self-monitoring and regulation, (4) persistence and responsibility, and (5) self-reflection. Academic achievement was assessed using curriculum-aligned tests administered at the end of each cycle. The assessments focused on students'

understanding of concepts addressed during the respective IPAS lessons. Supporting documentation included classroom activity records, student assignments, attendance records, and observational field notes.

Learning Independence Observation Rubric

Learning independence was assessed using a five-point observation scale. The rubric was developed from observable learning behaviors corresponding to the five dimensions of self-regulated learning. Learning initiative referred to students' willingness to begin learning activities, ask questions, and seek information without continuous teacher prompting. Planning and strategy management concerned students' ability to organize learning activities, select appropriate resources, and determine suitable approaches to completing tasks. Self-monitoring and regulation assessed students' ability to monitor their progress, recognize difficulties, and adjust their learning strategies. Persistence and responsibility reflected students' commitment to completing assigned activities and overcoming learning difficulties. Self-reflection concerned students' ability to evaluate their learning experiences, identify areas for improvement, and respond constructively to feedback. Each observed dimension was assessed using a rating scale ranging from 1 (very poor) to 5 (very good). The mean observation score was interpreted using the following classification: 1.00–1.80 (very poor), 1.81–2.60 (poor), 2.61–3.40 (fair), 3.41–4.20 (good), and 4.21–5.00 (very good). The interval width was determined by dividing the difference between the maximum and minimum scale values by the number of classification categories: Interval width = $(5 - 1) / 5 = 0.80$.

The classification provided a consistent descriptive basis for interpreting observed learning independence across research cycles. When expressed as a percentage, the proportion of the observed score relative to the maximum possible score was calculated separately from the mean-score classification.

Observation Procedures

Classroom observations were conducted during the implementation of the scientific approach in each action cycle. Two observers contributed to the assessment of students' learning independence and the implementation of classroom activities. Observations focused on students' behaviors during scientific learning activities, including their initiative in asking questions, independence in completing tasks, participation in scientific investigation, ability to monitor learning progress, persistence when encountering difficulties, and reflection on learning outcomes. Observers used structured observation sheets containing predetermined indicators and rating categories. Observation results were documented and summarized at the end of each cycle. Scores from the two observers were combined to obtain descriptive measures of students' learning independence. The results were subsequently discussed during the reflection stage to identify areas requiring instructional improvement.

Instrument Validity and Reliability

The observation instruments and achievement tests were developed based on the research objectives, relevant theoretical constructs, and fourth-grade IPAS learning outcomes. The learning independence instrument was conceptually aligned with self-regulated learning theory, while the teacher observation instrument was aligned with the five stages of the scientific approach. The thesis documentation describes instrument review by academic supervisors and collaborating teachers to examine the relevance, clarity, readability, and appropriateness of the assessment items. The achievement tests were also described as

undergoing content validation and item evaluation concerning difficulty levels and discriminatory power. To support observation consistency, the study involved two observers whose assessments were summarized for each research cycle. However, numerical evidence of inter-rater agreement and internal consistency reliability was not provided in the available methodological documentation. Therefore, the use of two observers should be interpreted as a procedural measure supporting observation consistency rather than evidence of statistically established inter-rater reliability. Similarly, although the achievement tests were developed and reviewed in accordance with the instructional objectives, numerical reliability coefficients were not available in the reviewed documentation. The reliability and measurement precision of these instruments should consequently be considered methodological limitations unless the corresponding validation and reliability results can be provided from the original research records.

Data Analysis

The collected data were analyzed using quantitative and qualitative descriptive techniques. Quantitative analysis was applied to students' learning independence scores, achievement test results, and classical learning mastery. Qualitative analysis was used to interpret classroom observation records, instructional implementation, and reflection findings.

Learning independence was summarized using the mean scores of the observation dimensions and the overall proportion of the obtained score relative to the maximum possible score. The observation percentage was calculated as follows:

$$P = (S / S_{\max}) \times 100\% \quad (1)$$

Where P represents the learning independence percentage, S represents the obtained observation score, and $S_{\max}$ represents the maximum possible observation score. Students' mean academic achievement was calculated using:

$$\bar{X} = \Sigma X / N \quad (2)$$

Where $\bar{X}$ represents the mean academic achievement score, ΣX represents the sum of students' achievement scores, and N represents the total number of students assessed. Classical learning mastery was determined by calculating the percentage of students who achieved the predetermined minimum learning criterion:

$$CM = (n / N) \times 100\% \quad (3)$$

Where CM represents classical mastery, n represents the number of students meeting or exceeding the minimum learning criterion, and N represents the total number of students completing the assessment. The quantitative findings were compared across the three action cycles to describe changes in learning independence and academic achievement. Qualitative observation data were interpreted alongside these numerical results to identify instructional difficulties and improvements in classroom participation. Since the classroom action research design did not independently isolate the effects of the intervention from other potential

influences, changes across cycles were interpreted descriptively rather than as definitive evidence of causality.

Criteria for Research Success

The success criteria were based on the classroom action research indicators established in the original research methodology. Instructional implementation and students' learning independence were expected to demonstrate progressive improvement, with a minimum achievement target of 75% for the designated activity indicators. For academic achievement, the original thesis specified a minimum learning achievement criterion (KKTP) of 75 and a classical mastery target of at least 80% of participating students. These criteria provided the basis for evaluating whether the instructional actions had achieved the predetermined classroom learning targets.

Ethical Considerations

Because the research involved elementary school students, ethical considerations included institutional authorization, parental or guardian consent, age-appropriate student participation, confidentiality, and the responsible handling of educational records. The original thesis identifies the school's involvement and institutional support for the research. However, the available documentation does not establish whether written parental consent, student assent, or formal ethics committee approval was obtained. Therefore, these procedures should not be represented as completed without confirmation from the original research records. For transparent reporting, the final manuscript should specify the actual permission and consent procedures implemented during data collection, including how student identities were protected and how classroom documentation was managed. Any unavailable ethical documentation should be acknowledged rather than retrospectively assumed.

RESULTS AND DISCUSSION

Preliminary Classroom Conditions

The preliminary classroom assessment identified several instructional challenges in fourth-grade IPAS learning at SD Negeri 1 Pseksu. Classroom observations indicated that teaching activities were predominantly teacher-centered, while students demonstrated limited initiative, insufficient confidence in asking questions, and considerable dependence on teacher guidance when completing learning tasks.

The preliminary records reported a mean academic achievement score of 66.40, with 16 of 30 students (53.33%) meeting the minimum mastery criterion. The initial assessment of learning independence also indicated relatively limited self-regulatory learning behaviors, particularly in planning learning activities, independently seeking information, and evaluating learning outcomes.

However, these preliminary findings were based on 30 students, whereas the classroom action research involved 20 students from Class IV B. Consequently, the preliminary results are presented as contextual evidence of the instructional problem rather than as a directly comparable baseline for calculating learning gains among the 20 intervention participants.

Improvement in Students' Learning Independence

The classroom observation records indicated progressive improvement in students' learning independence during the implementation of the scientific approach across three

action research cycles. To maintain consistency with the original observation instruments, the results are reported using the mean ratings obtained from two observers on a five-point scale rather than percentages interpreted as proportions of students.

Table 1. Students' Learning Independence Across Three Action Cycles

Research Stage	Observer I	Observer II	Mean Score	Category
Cycle I	3.30	3.20	3.25	Fair
Cycle II	3.60	3.80	3.70	Good
Cycle III	4.63	4.50	4.56	Very Good

Source: Classroom observation records, Tables 4.3, 4.8, and 4.14. Categories are based on the five-point rubric described in the Methods section.

In Cycle I, the mean learning independence score was 3.25, indicating a fair level of independent learning behavior. Classroom observations revealed that several students remained dependent on teacher instructions, especially when formulating questions, organizing learning activities, and interpreting information obtained through observation. Students were still becoming familiar with the scientific learning stages and often required additional guidance to complete their assignments.

Reflection on Cycle I identified the need to improve student participation, provide more engaging instructional media, and organize learning activities according to students' differing levels of understanding. These findings informed the instructional adjustments planned for Cycle II.

In Cycle II, the mean observation score increased to 3.70, corresponding to the good category. The instructional activities incorporated more opportunities for group discussion, scientific experimentation, and independent information gathering. Students demonstrated greater willingness to ask questions, express opinions, and participate in the exploration of scientific concepts.

Nevertheless, the Cycle II reflection indicated that participation remained uneven. Some students continued to require assistance in managing their learning time and choosing appropriate learning strategies. Therefore, additional recommendations included the use of more concrete and contextual instructional media, individualized support for students experiencing difficulties, and better time allocation across the five scientific learning stages.

In Cycle III, the mean learning independence score reached 4.56, corresponding to the very good category. Students demonstrated stronger initiative in completing activities, greater persistence when facing learning difficulties, and increased confidence in communicating their findings. The teacher increasingly emphasized facilitation, feedback, and opportunities for students to reflect on their learning experiences.

Overall, the mean observation score increased by 1.31 points between Cycle I and Cycle III. This pattern indicates improvement in observed learning independence during the intervention period. However, because the measurements were obtained through descriptive classroom observations, the findings should not be interpreted as independently establishing a causal effect of the scientific approach.

Improvement in Students' Learning Achievement

Students' academic achievement was examined using the learning assessments administered during each action research cycle. For consistency, the results reported below prioritize the post-test scores and mastery counts presented in the original cycle-specific achievement tables.

Table 2. Students' Academic Achievement Across Three Action Cycles

Research Stage	Students Assessed	Mean Post-Test Score	Students Achieving Mastery	Classical Mastery
Cycle I	20	64.00	5	25.00%
Cycle II	20	80.00	11	55.00%
Cycle III	20	97.25	20	100.00%

Source: Achievement summary tables for Cycles I, II, and III. Classical mastery was recalculated using the number of students achieving mastery divided by the 20 participating students.

In Cycle I, the mean post-test score was 64.00, with 5 of 20 students (25.00%) meeting the learning mastery criterion. Although the mean score increased from the Cycle I pre-test value of 53.50, most students had not yet achieved the expected learning standard. Classroom reflection suggested that students needed more opportunities to participate in scientific activities and that instructional time and learning media required improvement.

Following these findings, the Cycle II instructional plan placed greater emphasis on scientific investigation, collaborative discussion, and the use of instructional resources to support conceptual understanding. The mean post-test score increased to 80.00, while 11 of 20 students (55.00%) achieved mastery. Although these results indicated improvement compared with Cycle I, the proportion of students achieving mastery remained below the predetermined classical mastery target.

The Cycle II reflection identified several continuing challenges, including differences in students' participation, insufficient time for some learning activities, and the need for additional support for students experiencing conceptual difficulties. The instructional recommendations for Cycle III consequently emphasized more contextual learning media, differentiated assistance, and improved management of scientific learning activities.

In Cycle III, the original achievement summary reported a mean post-test score of 97.25, with all 20 students achieving the mastery criterion. The recorded classical mastery percentage therefore reached 100.00%. Classroom observations suggested that students had become more familiar with the scientific learning procedures and more confident in participating in learning activities.

However, the interpretation of achievement changes requires methodological caution. Each cycle addressed a different IPAS topic: plant parts in Cycle I, photosynthesis in Cycle II, and plant reproduction in Cycle III. Therefore, increases in mean scores across cycles may reflect a combination of instructional improvements, topic characteristics, differences in assessment difficulty, and students' growing familiarity with the learning procedures.

Although the achievement tests were prepared using curriculum-related learning indicators, the available documentation does not provide sufficient empirical evidence demonstrating equivalent test difficulty across the three cycles. Accordingly, the observed score differences should be interpreted as descriptive changes in cycle-specific achievement

rather than definitive evidence of equivalent learning gains across identical assessment conditions.

Teacher Activity Observation Results

Teacher activity was assessed throughout the three action cycles to examine the implementation and progressive refinement of the scientific approach. The original observation records included ratings from two observers, which were summarized using a five-point assessment scale.

Table 3. Teacher Activity Observation Results

Research Stage	Observer I	Observer II	Mean Score	Category
Cycle I	3.38	3.50	3.44	Good
Cycle II	3.63	3.88	3.75	Good
Cycle III	4.50	4.75	4.63	Very Good

Source: Teacher activity observation records, Tables 4.2, 4.7, and 4.13. Categories are interpreted using the scale intervals specified in the Methods section.

In Cycle I, the mean teacher activity score was 3.44. The teacher implemented the principal stages of the scientific approach, although the observation and reflection records indicated that classroom organization, learning media, student engagement, and instructional time management still required improvement.

In response to these findings, instructional recommendations for Cycle II emphasized more interactive learning activities, the use of varied instructional materials, and increased opportunities for student participation. The mean teacher activity score subsequently increased to 3.75. These observations suggest that the implementation of scientific learning activities became more structured, although further adjustments were still needed.

In Cycle III, the mean teacher activity score increased to 4.63. Classroom observations indicated stronger implementation of learning facilitation, more effective management of scientific activities, and greater emphasis on student participation and feedback.

Across the three cycles, the mean teacher activity score increased by 1.19 points. This descriptive improvement coincided with higher observed learning independence and academic achievement scores. Nevertheless, the parallel development of these indicators does not establish that improvements in teacher performance were the sole cause of the changes in student outcomes.

Reflection-Based Instructional Improvements

The classroom action research design enabled instructional adjustments to be made after evaluating the results of each cycle. The cycle-specific reflection records identified difficulties in participation, instructional media, time management, and students' ability to complete scientific learning activities independently.

These reflection findings show that the intervention involved more than repeating the same instructional activities across three cycles. The process included identifying classroom difficulties and making pedagogical adjustments intended to improve subsequent teaching practices. The progression of instructional improvements provides the principal contribution of the classroom action research. Rather than attributing the outcomes exclusively to the

scientific approach, the findings illustrate how its implementation was refined through observation, reflection, and instructional adjustment in an authentic elementary classroom.

Table 4. Summary of Reflection Findings and Instructional Adjustments

Cycle	Main Reflection Findings	Instructional Adjustments or Recommendations
Cycle I	Limited student independence, low mastery, insufficient participation, and a need for improved time management.	Increase interactive activities, experiments, group discussions, differentiated support, and the use of engaging learning media.
Cycle II	Improved participation and achievement, but uneven student involvement, persistent conceptual difficulties, and inefficient use of discussion time.	Strengthen contextual media, provide individualized guidance, and improve the allocation of time for scientific activities.
Cycle III	Higher observed independence, improved learning achievement, and stronger implementation of scientific learning activities.	Maintain the instructional improvements while providing continued support to students who still experience learning difficulties.

Source: Reflection and recommendation sections for Cycles I–III.

Interpretation of the Findings and Assessment Comparability

The findings indicate progressive improvements in students' learning independence, academic achievement, and teacher instructional performance across three classroom action research cycles. Learning independence increased from a mean observation score of 3.25 in Cycle I to 3.70 in Cycle II and 4.56 in Cycle III, while mean academic achievement scores increased from 64.00 to 80.00 and 97.25, respectively. Teacher activity scores also improved from 3.44 to 3.75 and 4.63. These parallel developments suggest that the progressive refinement of scientific learning activities was accompanied by increasingly favorable classroom conditions for active participation, independent learning, and conceptual understanding. However, the observed trends should be interpreted as descriptive changes within the classroom action research process rather than definitive evidence of causal relationships.

From a constructivist perspective, the scientific approach provides opportunities for students to develop understanding through active engagement with learning materials and their surrounding environment. Its five stages—observing, questioning, experimenting, reasoning, and communicating—encourage students to move beyond memorizing information toward investigating phenomena, evaluating evidence, and constructing explanations. During observation, students identify characteristics of natural phenomena, while questioning encourages curiosity and awareness of knowledge gaps. Experimentation and information gathering enable students to explore evidence, whereas reasoning and communication support the organization, interpretation, and presentation of findings. These interconnected activities provide opportunities for developing conceptual understanding through meaningful learning experiences rather than relying exclusively on teacher explanations.

This interpretation is consistent with Dah et al. (2024), whose systematic review examined the contributions of open inquiry to science learning, including conceptual

understanding, motivation, scientific thinking, and scientific literacy. Their findings support the educational relevance of inquiry-oriented activities while emphasizing the importance of appropriate teacher guidance and classroom support. In the present study, improvements across the three cycles were accompanied by instructional adjustments involving learning media, classroom participation, time allocation, and teacher facilitation. Therefore, the observed development should not be attributed simply to increased opportunities for student inquiry but understood within the broader process of progressively refined instructional practices.

The relationship between the scientific approach and learning independence can be further interpreted through Self-Regulated Learning Theory. Zimmerman (2000) conceptualized self-regulated learning as an active process through which students establish goals, monitor their activities, regulate learning strategies, and evaluate their performance. The scientific approach provides opportunities corresponding to these processes. Questioning and planning investigations may encourage students to identify learning objectives and information needs. Experimentation and reasoning require students to monitor their activities, examine evidence, and reconsider their understanding. Communicating findings and participating in reflection provide opportunities for evaluating learning outcomes and identifying areas requiring improvement. Through repeated participation in these activities, students may gradually develop greater initiative, persistence, responsibility, and control over their learning processes.

Núñez et al. (2022) provide relevant empirical support through their investigation of self-regulated learning interventions among elementary school students. Their study examined the relationship between self-regulatory activities and academic achievement, highlighting the importance of learning strategies and students' active regulation of learning processes. Although their intervention focused on reading comprehension rather than scientific inquiry, it provides a useful comparative perspective for interpreting the development of learning independence. The present study extends this discussion to elementary IPAS learning by documenting how scientific learning activities were implemented and refined across successive classroom action cycles. Nevertheless, the relationship between learning independence and academic achievement was not statistically tested in this study; therefore, learning independence should be interpreted as a theoretically plausible supporting process rather than an empirically established mediator.

Further support is provided by Olid-Luque et al. (2025), who systematically reviewed self-regulated learning interventions in primary education. Their findings indicated that structured interventions could support students' self-regulated learning, with teacher guidance, explicit learning strategies, and motivational support contributing to implementation. These findings help explain the continuing importance of teacher facilitation throughout the present study. Elementary school students may require structured guidance before independently managing complex learning activities. Consequently, instructional support, repeated practice, constructive feedback, and opportunities for reflection remain important elements in developing learning autonomy. The improvement in teacher activity scores observed across the three cycles is consistent with this interpretation, although it does not independently establish the contribution of teacher performance to student outcomes.

The parallel development of learning independence and academic achievement may also be interpreted through the complementary roles of cognitive engagement and learning regulation. Students who actively seek information, monitor their understanding, persist when encountering difficulties, and evaluate their learning strategies may have greater opportunities to develop conceptual knowledge. Conversely, successful learning experiences may strengthen students' confidence and willingness to participate in subsequent activities. Kim and Chung (2024), through a meta-analysis of self-regulated learning interventions, identified positive effects on academic achievement across educational contexts. Their findings support the broader relevance of structured learning regulation to academic performance. However, the present study did not test the direction or strength of the relationship between learning independence and achievement. Accordingly, the simultaneous improvement of these indicators should not be interpreted as evidence that one directly caused the other.

Another important finding concerns the progressive improvement of instructional implementation through reflection-based adjustments. The Cycle I reflection identified limited student participation, difficulties in managing learning activities independently, and the need for improved instructional media and time allocation. Subsequent adjustments introduced more interactive activities, group discussions, scientific investigations, contextual learning materials, and differentiated assistance. By Cycle III, teacher activity observations indicated stronger implementation of scientific learning stages and more consistent facilitation of student participation. These findings demonstrate that the classroom action research involved continuous pedagogical refinement rather than the repetition of an unchanged instructional procedure.

Strata et al. (2024), through their systematic review of inquiry-based science education in teacher education, highlighted the importance of instructional competence in implementing inquiry-oriented learning. Although their review focused on science teacher education rather than elementary school students, its findings provide a relevant perspective on the challenges of translating inquiry-based principles into classroom practice. In the present study, improvements in teacher activity observations suggest that greater familiarity with scientific learning procedures and reflection-based instructional adjustments coincided with more structured classroom implementation. Teacher guidance and student independence should therefore not be regarded as opposing instructional conditions; appropriately structured guidance may provide opportunities for students to develop greater learning autonomy.

These findings also have practical implications for implementing the Merdeka Curriculum in elementary IPAS education. The curriculum emphasizes contextual learning, active student participation, and competencies that extend beyond factual knowledge acquisition. Scientific learning activities are relevant to these objectives because they encourage students to investigate phenomena, collect and interpret information, formulate explanations, and communicate their understanding. However, the findings suggest that the successful organization of such activities requires teachers to consider students' developmental characteristics, prior knowledge, available learning resources, and individual learning needs. The scientific approach should therefore be implemented as a flexible

pedagogical process supported by continuous observation and reflection rather than as a rigid sequence of instructional activities applied identically across different learning topics.

The observed improvements must nevertheless be interpreted in relation to the methodological limitations of the study, particularly assessment comparability. First, the classroom action research involved only 20 fourth-grade students from one elementary school, limiting the transferability of the findings to other educational contexts. Second, preliminary classroom assessment records involved 30 students, whereas the intervention was conducted with 20 students. Consequently, the preliminary findings cannot be treated as a directly comparable baseline for calculating learning gains among the intervention participants. Third, the learning topics differed across cycles, with Cycle I addressing plant parts, Cycle II focusing on photosynthesis, and Cycle III examining plant reproduction. These topics may involve different levels of conceptual complexity, prior familiarity, and assessment difficulty.

Although the achievement tests were developed according to curriculum-related learning objectives, the available methodological documentation did not establish equivalent test difficulty across the three cycles. Therefore, the increases in academic achievement scores cannot be attributed exclusively to the scientific approach or its instructional refinement. They may also reflect differences in learning content, assessment difficulty, and students' increasing familiarity with classroom procedures. Furthermore, the available documentation did not provide numerical evidence of inter-rater reliability for observational assessments or reliability coefficients for achievement tests. These limitations require the recorded improvements to be interpreted as descriptive changes in cycle-specific classroom indicators rather than standardized estimates of instructional effectiveness.

The principal contribution of this study lies in its integrated examination of learning independence and academic achievement during the progressive refinement of scientific learning activities in an elementary IPAS classroom. Previous studies have established the broader relevance of inquiry-based learning and self-regulated learning interventions, but the present study provides context-specific evidence of how behavioral and cognitive learning outcomes can be monitored simultaneously through observation, assessment, reflection, and instructional adjustment. Its contribution is therefore primarily pedagogical and contextual rather than the identification of a new causal mechanism. The findings illustrate how teachers may use reflective classroom action research to improve the organization of scientific learning activities while monitoring students' independence and academic performance.

Overall, the study suggests that structured scientific learning activities, when accompanied by appropriate teacher guidance and continuous reflection, may provide classroom conditions that support students' learning independence and academic achievement. Nevertheless, the findings do not establish the independent effectiveness of the scientific approach because of the absence of equivalent assessments across cycles, the limited sample size, and the lack of statistical testing of the relationship between the two outcomes. Future research should employ comparable assessment instruments, larger samples, and comparative or longitudinal designs to examine more rigorously how scientific learning practices contribute to students' self-regulated learning and academic development.

CONCLUSION

This study demonstrates that the implementation of the scientific approach was accompanied by progressive improvements in students' learning independence and academic achievement across three classroom action research cycles in elementary IPAS education. Students' mean learning independence scores increased from 3.25 in Cycle I to 3.70 in Cycle II and 4.56 in Cycle III. Similarly, mean academic achievement scores increased from 64.00 to 80.00 and 97.25, while classical learning mastery improved from 25% to 100%. These findings indicate that structured scientific learning activities, supported by continuous reflection and instructional adjustments, can provide favorable conditions for developing students' independent learning behaviors and conceptual understanding.

The principal contribution of this study lies in documenting the integrated development of learning independence and academic achievement through progressively refined scientific learning practices within the Merdeka Curriculum. The findings emphasize the importance of teacher facilitation, contextual learning materials, active student participation, and reflective instructional improvement rather than the mechanical application of scientific learning stages.

However, this study was limited to 20 students in a single classroom, while the instructional topics and assessment instruments differed across cycles. Consequently, the findings cannot establish causal relationships or fully comparable learning gains. Future research should employ equivalent assessments, larger samples, and comparative or longitudinal designs to examine the effectiveness of scientific approaches in promoting sustained learning independence and academic achievement.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

In the preparation of this manuscript, the authors utilized ChatGPT by OpenAI to assist with language editing, English translation, improving academic clarity, refining sentence structure, and aligning the manuscript with journal writing conventions. All AI-assisted outputs were subsequently reviewed, revised, and verified by the authors to ensure accuracy, consistency, and conformity with the research findings. The authors assume full responsibility for the final content of the publication.

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REFERENCES

- Abdurrochim, P. L., Hanifah, N., & Syahid, A. A. (2024). The effect of a mindful learning approach on science and social studies (IPAS) learning outcomes among fifth-grade elementary school students. *ELSE (Elementary School Education Journal)*, 8(2). <https://doi.org/10.30651/else.v8i2.22704>
- Arends, R. I. (2012). *Learning to teach* (9th ed.). McGraw-Hill Education.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman and Company.

- Bloom, B. S. (Ed.). (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. David McKay.
- Dah, N. M., Noor, M. S. A. M., Kamarudin, M. Z., & Azziz, S. S. S. A. (2024). The impacts of open inquiry on students' learning in science: A systematic literature review. *Educational Research Review*, 43, 100601. <https://doi.org/10.1016/j.edurev.2024.100601>
- Dewey, J. (1938). *Experience and education*. Collier Books.
- Fadillah, R. (2022). Faktor-faktor yang memengaruhi prestasi belajar siswa di pendidikan dasar. *Jurnal Pendidikan Dasar*, 5(1), 33–42.
- Fitriani, N., & Darmana, A. (2021). Hubungan antara self-regulated learning dengan prestasi belajar siswa sekolah dasar. *Jurnal Pendidikan Dasar*, 12(1), 1–10.
- Handayani, S., & Sari, D. K. (2023). Pengaruh pendekatan saintifik terhadap hasil belajar IPA di SD Kurikulum Merdeka. *Jurnal Pendidikan dan Pembelajaran Dasar*, 10(2), 115–126.
- Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.
- Hidayat, R., & Wibowo, S. (2020). Efektivitas scientific approach dalam mengembangkan keterampilan proses sains dan higher order thinking skills (HOTS). *Jurnal Penelitian Pendidikan*, 20(1), 45–56.
- Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia. (2022). Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia Nomor 262/M/2022 tentang perubahan atas Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 56/M/2022 tentang pedoman penerapan kurikulum dalam rangka pemulihan pembelajaran.
- Kim, S., & Chung, Y. (2024). Meta-analysis on the effect of intervention in academic achievement of self-regulated learning program. *Korean Journal of Educational Psychology*, 38(2), 253–284. <https://doi.org/10.17286/KJEP.2024.38.2.06>
- Mulyani, N., Suardana, P., & Dewi, P. N. A. (2022). Peningkatan kemandirian belajar mahasiswa melalui model pembelajaran berbasis proyek. *Jurnal Ilmiah Pendidikan dan Pembelajaran*, 6(2), 201–210.
- Núñez, J. C., Tuero, E., Fernández, E., Añón, F. J., Manalo, E., & Rosário, P. (2022). Effect of an intervention in self-regulation strategies on academic achievement in elementary school: A study of the mediating effect of self-regulatory activity. *Revista de Psicodidáctica*, 27(1), 9–20. <https://doi.org/10.1016/j.psicod.2021.09.001>
- Olid-Luque, M., Ayllón-Salas, P., Arco-Tirado, J. L., & Fernández-Martín, F. D. (2025). Impact of self-regulated learning programs in primary education: A systematic review. *Psychology in the Schools*, 62(3), 734–755. <https://doi.org/10.1002/pits.23352>
- Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451–502). Academic Press.
- Putri, A. D., et al. (2023). Implementasi Kurikulum Merdeka dan peran guru dalam merancang pembelajaran kontekstual. *Jurnal Pendidikan Aktual*, 15(1), 15–26.
- Ramadhani, D., & Kusumah, Y. S. (2021). Pengaruh faktor lingkungan dan dukungan sosial terhadap prestasi belajar siswa. *Jurnal Pendidikan dan Sosial*, 7(2), 145–158.
- Sari, N. M., & Dewi, I. A. (2020). Pengaruh pendekatan saintifik terhadap prestasi belajar siswa pada mata pelajaran IPA. *Jurnal Pedagogi dan Pembelajaran*, 3(2), 241–250.

- Strata, T. T. S., Henriksen, E. K., & Jegstad, K. M. (2024). Inquiry-based science education in science teacher education: A systematic review. *Studies in Science Education*, 60(2), 191–249. <https://doi.org/10.1080/03057267.2023.2207148>
- Winkel, W. S. (2009). *Psikologi pengajaran* (6th ed.). Rineka Cipta.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.