REVISITING BIOLOGY LEARNING: THE IMPACT OF A COHORT-BASED LONGITUDINAL IMPLEMENTATION OF RQA ON STUDENTS' PROBLEM-SOLVING SKILLS

MENINJAU ULANG PEMBELAJARAN BIOLOGI: DAMPAK RQA BERBASIS KOHORT TERHADAP KETERAMPILAN PEMECAHAN MASALAH SISWA

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Abstract

Problem-solving skills are essential competencies in biology education, enabling students to analyze problems, evaluate evidence, and construct logical solutions. Although various learning models have been developed to enhance these skills, most studies have focused on short-term instructional outcomes. Limited research has examined their sustained development through cohort-based longitudinal implementation characterized by stable learning groups, continuous interaction, and shared learning experiences. This study investigated the effect of cohort-based longitudinal implementation of the Reading–Questioning–Answering (RQA) learning model on high school students' problem-solving skills in biology. A quasi-experimental design involved an experimental group (RQA) and a control group (conventional learning) at SMAN 9 Malang City, Indonesia. The same cohort participated in continuous learning from Grade 10 to Grade 11 over two consecutive semesters, enabling longitudinal examination of skill development. Problem-solving skills were measured using a standardized essay test administered as pretest and posttest. Data were analyzed using ANCOVA and effect size analysis. The results showed a significant effect of the learning model on problem-solving skills ($F = 35.711$, $p < 0.001$), with a large effect size (partial $\eta^2 = 0.217$). These findings indicate that cohort-based longitudinal RQA implementation effectively promotes sustained development of problem-solving skills in biology learning.

Keywords: Biology learning, problem-solving skills, reading–questioning–answering (RQA), cohort-based longitudinal implementation

Abstrak

Keterampilan pemecahan masalah merupakan kompetensi esensial yang harus dimiliki siswa dalam pembelajaran biologi. Meskipun berbagai model pembelajaran telah diterapkan untuk meningkatkan keterampilan pemecahan masalah siswa, sebagian besar implementasi masih berfokus pada hasil belajar jangka pendek. Belum terdapat implementasi maupun kajian yang menelaah perkembangan keterampilan pemecahan masalah melalui implementasi longitudinal berbasis kohort, dengan kelompok belajar yang tetap, interaksi berkelanjutan antar subyek, dan pengalaman belajar bersama yang berlangsung secara konsisten.Untuk memberikan telaah lebih mendalam, penelitian ini bertujuan untuk menguji pengaruh implementasi longitudinal berbasis kohort model pembelajaran Reading–Questioning–Answering (RQA) terhadap keterampilan pemecahan masalah siswa SMA secara berkelanjutan. Penelitian ini menggunakan desain kuasi-eksperimen dengan melibatkan siswa dari SMAN 9 Kota Malang sebagai subyek kelompok eksperimen (RQA) dan kelompok kontrol (konvensional) selama dua semester. Kelompok siswa yang sama mengikuti pembelajaran secara berkelanjutan dari kelas X hingga kelas XI, sehingga perkembangan keterampilan pemecahan masalah dapat ditinjau secara longitudinal lintas jenjang kelas. Data keterampilan pemecahan masalah pada siswa diukur melalui tes esai tervalidasi melalui pretest dan posttest. Analisis data dilakukan secara statistik menggunakan ANCOVA dan effect size. Hasil pengujian menunjukkan pengaruh signifikan pada model pembelajaran terhadap keterampilan pemecahan masalah ($F = 35.711$; $p < 0.001$) dengan effect size 0.217 (besar). Temuan ini menunjukkan bahwa implementasi longitudinal berbasis kohort dari RQA dapat berpotensi meningkatkan keterampilan pemecahan masalah dengan kontribusi yang besar. Implementasi model ini direkomendasikan untuk dipadukan dengan strategi pembelajaran lain guna mengoptimalkan pengembangan keterampilan siswa.

***Kata kunci**: Pembelajaran biologi, keterampilan pemecahan masalah, reading–questioning–answering (RQA), implementasi longitudinal berbasis kohort*

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Introduction

In the 21st century, biology education requires students to develop a range of higher-order thinking skills, particularly problem-solving skills (Ergazaki et al., 2021; Flavell, 2024; Korfiatis & Grace, 2022). Problem-solving skills are complex competencies that involve integrating cognitive processes, behavioral responses, and systematic strategies to identify problems, generate alternative solutions, and adaptively evaluate and select the most effective options in challenging situations (Riyadi et al., 2021; Zhang et al., 2025). These skills are essential as they enable the transformation of theoretical knowledge into practical competencies applicable across various real-life contexts (Banawi et al., 2024; Zhang et al., 2025). Moreover, the application of problem-solving skills extends beyond answering academic questions; students are expected to apply their biological knowledge to address complex, contextual issues across diverse aspects of life.

In Biology, problem-solving skills contribute to the application of scientific methodologies, including problem formulation, procedural development, and solution determination (Azzahra et al., 2025; Zhang et al., 2025). Competence in these issue-solving skills is also associated with the capacity to make evidence-based decisions, independently regulate cognitive processes, and take accountability for problem resolution (Zhang et al., 2025). Consequently, higher problem-solving competence among students correlates with an enhanced capacity to integrate biological concepts, critically assess information, and design logical, methodical, and evidence-based solutions to real-world issues. An assessment of students' problem-solving ability can be conducted using the following indicators: 1) Identifies the Problem, 2) Applies problem-solving steps, 3) Identifies a solution, 4) Evaluates solutions, 5) Defends solutions, 6) Real-world applications, 7) Inductive reasoning, 8) Deductive (Greenstein, 2012).

Despite the importance of these competencies in biology learning, previous studies have consistently shown that students' problem-solving skills remain underdeveloped. The findings revealed that students' problem-solving skills remained at the poor and very poor levels, with 67.93% (Ghofur et al., 2023). Similarly, other studies reported that students' problem-solving skills remained in the low category, with an average percentage of 51.62% (Ananda et al., 2025). These findings are further supported by OECD data indicating that approximately 30% of individuals with upper secondary or post-secondary non-tertiary attainment still demonstrate low literacy proficiency, reflecting limitations in understanding, processing, and evaluating complex information (OECD, 2025). Such conditions indicate that many students continue to experience difficulties in performing higher-order cognitive processes required for effective problem-solving, particularly in analyzing problems, organizing relevant information, and constructing evidence-based solutions.

In response to these challenges, numerous studies and implementations of innovative learning models have been conducted across various educational settings to enhance students' problem-solving skills (Agustina et al., 2024; Koehler et al., 2020; Mahanal et al., 2022; Tóthová & Rusek, 2021). Technically, learning models function as systematic frameworks that guide teachers in facilitating students' achievement of learning objectives. One learning model identified as effective for improving problem-solving skills is the Reading–Questioning–Answering (RQA) model (Aisya et al., 2023; Azzahra et al., 2025). The RQA model integrates several learning activities, including reading, question formulation, and answer construction, in order to promote active cognitive engagement among students during the learning process (Corebima et al., 2023).

Numerous studies indicate that the RQA model has been extensively implemented in classroom learning (Aisya et al., 2023; Choirunisa’ et al., 2024; Corebima et al., 2023; Hariyadi et al., 2018). Nevertheless, the duration of RQA implementation in these studies is generally limited to a relatively short period, typically ranging from two to three months. This limited timeframe restricts the ability of previous studies to capture the longitudinal development, stability, and sustainability of students’ problem-solving skills, thereby leaving a critical gap in understanding the long-term effectiveness of the RQA model.

When employing a cohort-based longitudinal implementation, it becomes possible to adopt a more comprehensive, systematic, and long-term perspective in evaluating the development of students' problem-solving skills. In educational research, a cohort-based longitudinal design does not merely refer to repeated measurements over time, but also to the sustained observation of the same group of learners as they progress through shared learning experiences as a relatively stable learning community. Such an approach enables researchers to examine not only short-term instructional effects but also the developmental trajectory, consistency, and sustainability of students' skills across instructional periods. Through continuous participation in similar pedagogical experiences, cohort-based learning may foster stronger academic engagement, cognitive continuity, and cumulative skill development.

This cohort-based longitudinal implementation aligns with the developmental nature of problem-solving skills, which evolve progressively through sustained cognitive engagement over time (Banawi et al., 2024; Zhang et al., 2025). The implementation of the RQA model, which emphasizes reading, question formulation, and answer construction, has the potential to support this developmental process, as each phase encourages students to identify problems, analyze information, and construct rational solutions. Furthermore, integrating a cohort-based longitudinal implementation with the RQA model enables a more comprehensive evaluation of students’ problem-solving development by examining not only changes in learning outcomes at a single point in time, but also the consistency and trajectory of skill development across instructional periods. Therefore, this study addresses the research problem of whether the cohort-based longitudinal implementation of the RQA learning model significantly influences students’ problem-solving skills in biology learning. This study also provides novel insights into the sustainability and developmental trajectory of problem-solving skills in biology education.

Research Methods

Research design and participants

This study employed a quasi-experimental pretest-posttest design with a control group (Capili & Anastasi, 2024). The design was chosen to assess the long-term effects of the RQA learning model on high school students' biology problem-solving skills. In this context, consistency refers to the stability and persistence of the model's effects across different measurement points and instructional periods. The implementation of the RQA learning model was conducted across two consecutive semesters, namely the even semester of the 2019/2020 academic year and the odd semester of the 2020/2021 academic year. This longitudinal implementation was intended to capture the developmental trajectory of students' problem-solving skills under sustained exposure to the RQA model.

In this study, the cohort-based longitudinal implementation referred to the continuous tracking of the same group of students who progressed together from Grade X to Grade XI while consistently experiencing the same instructional model. Students who received the RQA model during the second semester of Grade X continued to receive the same instructional model in the first semester of Grade XI, ensuring continuity of treatment across the study period. Beyond repeated measurement, this approach emphasized continuity of shared learning experiences and allowed the researchers to examine students' problem-solving development as a learning trajectory within a stable instructional group. Data collection was carried out at SMAN 9 in Malang City.

The research design is presented in Table 1. Two groups were involved in this study: an experimental group and a control group. The control group consisted of students from Grade X MIPA 6, who subsequently progressed to Grade XI MIPA 6. In the control group, instruction was conducted using teacher-centered, conventional classroom practices commonly implemented at the school, including lectures, textbook explanations, question–answer sessions, and assignment-based activities, without the structured stages of the RQA model. In contrast, the experimental group consisted of students from Grade X MIPA 2, who similarly advanced to Grade XI MIPA 2 and participated in learning activities using the RQA model.

Table 1. Quasi-Experimental Research Design Pretest and Posttest Design with a Control Group

Pre test	**Type of Lear ning**	**Class**	**Number of Students**	***Post test***
O1	RQA	X MIPA 2	33	O2
O3		XI MIPA 2	33	O4
O5	Convent ional	X MIPA 6	34	O6
O7		XI MIPA 6	34	O8

Description:
O1: Pretest in experimental class X
O2: Posttest in experimental class X
O3: Pretest in experimental class XI
O4: Posttest in experimental class XI
O5: Pretest in control class X
O6: Posttest in control class X
O7: Pretest in control class XI
O8: Posttest in control class XI

Data collection procedure

An equivalency test was conducted using analysis of variance (ANCOVA) to determine the initial comparability between the experimental and control groups prior to the implementation of the RQA model. The results of the equivalency test indicated a p-value greater than 0.05, suggesting that there was no statistically significant difference between the groups and that they were therefore equivalent at baseline.

During the implementation phase of the study, a pretest was administered at the beginning of the learning process, followed by instructional activities using the RQA model, and concluded with a posttest to evaluate students' problem-solving skills. Data were collected by scoring students' pretest and posttest responses using a problem-solving skills rubric adapted from Greenstein (2012). To ensure analytical rigor, the resulting scores were subsequently analyzed using analysis of covariance (ANCOVA) to examine the significance of the RQA model's effect on students' problem-solving skills, while effect size analysis was employed to determine the practical significance of the observed effects.

Learning environment and intervention

The intervention in Grade X (Phase E) was conducted once a week in a single instructional meeting lasting 90 minutes, in accordance with the Kurikulum Merdeka. In the experimental group, students participated in learning activities using the RQA model, which consists of three stages: (1) Reading, in which students engaged with relevant materials, information, and news related to the assigned topic and produced summaries; (2) Questioning, during which students formulated questions based on concepts or content that remained unclear; and (3) Answering, in which students constructed responses to the questions they had previously generated. These learning activities were implemented continuously within the same cohort of students across instructional periods to support sustained cognitive engagement and longitudinal observation of problem-solving skill development.

In the control class, the learning process was conducted using conventional classroom instruction commonly implemented at the school, including teacher explanations, textbook-oriented learning activities, question-and-answer interactions, and assignment-based tasks. The instructional process in this group was carried out without applying the specific syntax or structured stages of a particular learning model. The intervention in both the experimental and control groups was implemented over one semester, focusing on topics including biodiversity, ecosystems, and environmental change.

The intervention in Grade XI (Phase F) consisted of two instructional meetings per week. The first meeting lasted 90 minutes, while the second meeting lasted 135 minutes. In the experimental group, students were instructed using the RQA learning model, whereas the control group received conventional instruction from subject teachers. The intervention in both groups was implemented over one semester, covering topics including animal tissues, the locomotor system, and the circulatory system.

Instruments for Data Collection

The research instruments comprised both treatment and measurement tools developed by the researchers. The treatment instruments included the syllabus and instructional modules. The measurement instrument is an essay test consisting of contextual biology problems designed to assess students' skills in identifies the problem, applies problem-solving steps, identifies a solution, evaluates solutions, defends solutions, real-world applications, inductive reasoning, deductive, according to the problem-solving indicators adapted from Greenstein (2012).

All instruments underwent prior review and validation by experts in learning and subject matter before implementation. The reliability of the essay test was evaluated using Cronbach's Alpha, yielding coefficients of 0.895 for the Grade X test and 0.823 for the Grade XI test, both indicating a good level of reliability. The assessment of students' problem-solving skills was conducted using a scoring rubric adapted from Greenstein (2012).

Data Analysis

This study involved data analysis conducted in several stages: (1) testing the normality of data distribution, (2) examining the homogeneity of variance, (3) performing an analysis of covariance (ANCOVA), and (4) determining the magnitude of the effect (effect size). The normality test was conducted to evaluate whether the collected data were normally distributed. If the data met the assumption of normality, parametric statistical tests were applied; otherwise, nonparametric alternatives were considered. In this study, the Kolmogorov–Smirnov test was employed to assess the normality of the data distribution.

The homogeneity of variance test was conducted to determine whether the data distributions exhibited equal variances. This study employed Levene's test to assess homogeneity at the 5% significance level ($\alpha = 0.05$). Once the data satisfied the assumptions of normality and homogeneity, they were further analyzed using ANCOVA to examine the effect of the RQA model on students' problem-solving skills.

In the ANCOVA analysis, students' pretest scores on problem-solving skills were treated as the covariate variable. The inclusion of the covariate aimed to statistically control for students' initial differences in problem-solving ability prior to the intervention, thereby enabling a more accurate estimation of the effect of the RQA learning model on posttest performance. Subsequently, effect size analysis was conducted to evaluate the practical significance of the findings by determining the magnitude of the treatment effect.

Results and Discussion

Normality Test for Data Distribution

The normality test of data distribution is a prerequisite for covariance analysis, as it determines whether the data for each study variable are normally distributed. The results of the normality test showed significance values of 0.092 for the pretest data on problem-solving skills and 0.193 for the posttest data. Since both values exceed the 0.05 significance level, it can be concluded that the distributions of the pretest and posttest scores for problem-solving skills meet the assumption of normality.

Meeting the normality assumption indicates that the data exhibit a balanced and unbiased distribution, thereby supporting the validity of subsequent parametric analyses. The assumption of normality is particularly important in parametric techniques such as ANCOVA, as it directly influences the accuracy of parameter estimation and the validity of hypothesis testing. Methodological studies suggest that violations of distributional assumptions, particularly normality, may affect the Type I error rate and reduce model efficiency; therefore, testing this assumption prior to the main analysis is essential (Kaymaz et al., 2020). Furthermore, recent studies emphasize that the normality assumption is critical to various statistical models, as it closely relates to the reliability and robustness of the conclusions drawn (Iheaka, 2025; Kim et al., 2024).

Test for Homogeneity of Variance

The homogeneity of variance test is a statistical procedure used to assess whether the variances across data groups are equal. The results of the study showed that the significance values for problem-solving skills in the pretest and posttest were 0.245 and 0.310, respectively. Since both values exceed the alpha level of 0.05, it can be concluded that the pretest and posttest data for problem-solving skills meet the assumption of homogeneity of variance.

Meeting the assumption of homogeneity of variance indicates that variability across groups is relatively balanced, thereby enabling unbiased comparisons between groups without distortion caused by unequal dispersion (Kim et al., 2024). This condition is a fundamental requirement for parametric analyses such as ANCOVA, as violations of this assumption may compromise parameter estimation accuracy and increase the risk of errors in statistical decision-making (Iheaka, 2025). Methodological studies further emphasize that the assumption of homogeneity of variance is essential for ensuring model stability and the validity of statistical inferences, particularly in group comparisons within experimental or quasi-experimental designs (Kaymaz et al., 2020). Therefore, meeting this assumption strengthens the credibility of subsequent analyses, as observed differences are more likely to reflect treatment effects rather than random variation among groups.

ANCOVA Test Results: The Impact of RQA on Problem-Solving Skills in Biology Education

The ANCOVA results in Table 2 indicate that the effect of the learning model on students' problem-solving skills is significant (p = 0.000), which is lower than the 0.05 significance level. This result indicates that the learning model has a statistically significant effect on students' problem-solving skills. Specifically, this finding confirms that implementing the RQA model significantly improves students' problem-solving skills compared to conventional learning. For a more detailed examination of the effect of the learning model on students' problem-solving skills, refer to the results presented in Table 2.

Table 2. Summary of ANCOVA Analyses Regarding the Impact of Learning Type on Students' Problem-Solving Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1232.424[a]	4	308.106	32.681	.000	.503
Intercept	1439.959	1	1439.959	152.736	.000	.542
X Problem	370.054	1	370.054	39.252	.000	.233
Type of Learning	336.678	1	336.678	35.711	.000	.217
Error	1216.182	129	9,428			
Total	1166930.473	134				
Corrected Total	2448.605	133				

The ANCOVA analysis also revealed that the covariate variable, pretest problem-solving score (XProblem) significantly influenced students' posttest performance (F = 39.252; p < 0.05). This finding indicates that students' initial problem-solving ability contributed substantially to their final achievement. Therefore, controlling the covariate was necessary to ensure that the observed differences in posttest scores more accurately reflected the effect of the RQA intervention rather than pre-existing differences between groups.

According to Figure 1, the adjusted mean score for conventional learning is 91.658, while the adjusted mean score for learning using the RQA model is 94.831. The difference between these adjusted means is 3.46%, indicating that students in the RQA group achieved higher problem-solving scores than those in the conventional group. This indicates that students' prior competence influenced their final achievement in problem-solving skills. However, after statistically controlling for these initial differences, the RQA model continued to demonstrate a significant effect on students' problem-solving performance. This suggests that the improvement observed in the experimental group was not solely determined by students’ initial skills, but was also associated with the structured reading activities embedded within the RQA learning process, which supported deeper conceptual understanding and more systematic cognitive engagement. This difference suggests not only statistical significance but also a meaningful improvement in learning outcomes, supporting the effectiveness of the RQA model in enhancing students' problem-solving skills in biology.

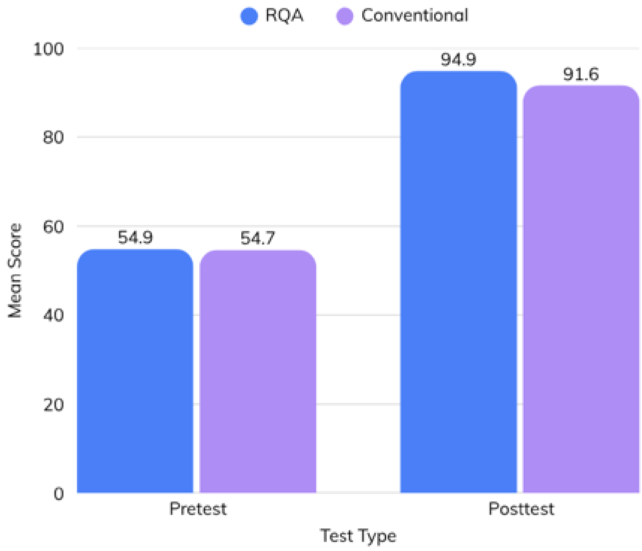


Figure 1. Comparison of Students’ Problem-Solving Skills Between Learning Groups

The effectiveness of the RQA learning model in enhancing problem-solving skills is closely associated with its instructional syntax. The initial phase of the RQA model, namely reading, serves as the foundational stage of learning, requiring students to engage with materials relevant to a given topic actively. Through this process, students develop a deeper understanding of the content, as reflected in the quality of their summaries. Previous studies have consistently reported improvements in students' comprehension as a result of reading and summarization activities (Aisya et al., 2023; Corebima et al., 2023; Turker et al., 2025) even up to 100% level (Kusuma & Baskara, 2023). This finding is consistent with the present study, which found that students exposed to the RQA model demonstrated higher problem-solving performance than those in conventional learning settings. Furthermore, the significant covariate effect in the ANCOVA analysis indicates that students’ initial problem-solving ability contributed to their final performance; however, the RQA model remained effective after controlling for these initial differences.

Engagement in reading activities combined with summarization further enhances students' comprehension through structured cognitive processes supported by specific neural mechanisms (Juhkam et al., 2023; Pastera & Gaitano, 2024; Turker et al., 2025; Zhu et al., 2025). During reading, students are required to identify key ideas, organize information, and monitor their understanding of the material, leading to more coherent and systematically structured knowledge (Pastera & Gaitano, 2024). Neuroscientific evidence indicates that reading activities activate cognitive and language-processing networks associated with comprehension, information organization, and meaning construction (Turker et al., 2025). When summarizing complex information, students are trained to focus on essential content while filtering out irrelevant details, aligning with hierarchical information processing at the letter, word, and text levels in the left hemisphere. This process not only strengthens comprehension but also facilitates cognitive organization, a critical factor in effective problem-solving. Furthermore, paraphrasing content reinforces students' conceptual understanding and supports the activation of higher-order cognitive processes necessary for deeper learning (Turker et al., 2025).

With consistent practice, students can enhance their understanding of text structure by identifying patterns of information and integrating essential components into a coherent whole (Juhkam et al., 2023). This development is further supported by the synchronization of cognitive processes with the cerebellum, which enhances cognitive efficiency (Turker et al., 2025). Active engagement before, during, and after reading activities enables students to focus on critical information and enhances overall comprehension. Previous research indicates that reading, both explicitly and implicitly, consistently activates cognitive networks that support deeper understanding (Pastera & Gaitano, 2024).

The integration of information processing, memory consolidation, and active engagement makes reading and summarization effective strategies for improving students' understanding, while simultaneously strengthening the cognitive and neural foundations required for a more systematic approach to problem-solving. The concepts that students acquire and summarize during the reading phase subsequently serve as the basis for more active and meaningful learning experiences. As students' conceptual understanding improves, they are better able to demonstrate optimal problem-solving performance during the learning process. Given the critical role of student understanding in enhancing problem-solving skills, numerous studies emphasize the importance of strengthening conceptual understanding as a foundation for effective problem-solving (Aisya et al., 2023; Azzahra et al., 2025; Corebima et al., 2023; Kayman & Aydın, 2026; Mafarja et al., 2023).

The second syntax of the RQA learning model, questioning, is a learning activity in which students are required to generate at least two questions related to content that remains unclear or requires further verification. Questioning plays a critical role in strengthening scientific problem-solving skills, as the quality of the questions determines the direction and depth of problem analysis. The ability to formulate, analyze, and evaluate questions enables students to better understand the underlying problem before identifying alternative solutions (Hong et al., 2023). Questions generated by students are a direct manifestation of higher-order thinking skills. Well-structured and focused questions assist students in identifying the essence of a problem and narrowing its scope, thereby enhancing analytical precision and clarity (Minarik & Bulgren, 2024).

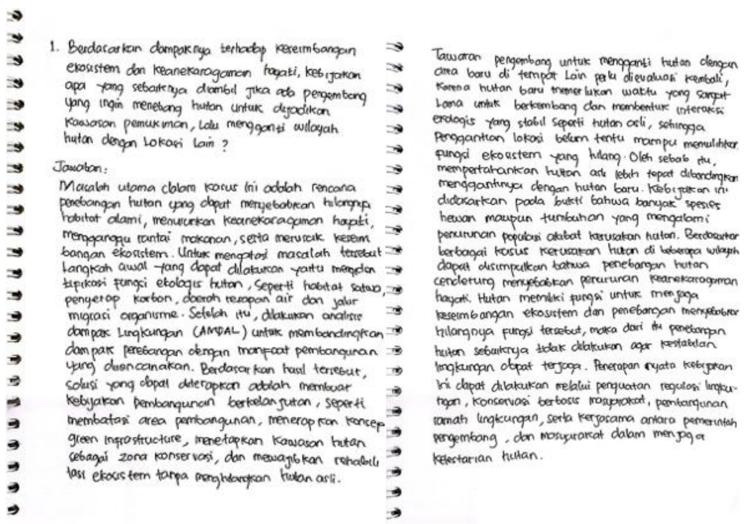
Furthermore, questioning influences how students engage with problems through specific cognitive processes, particularly in constructing more accurate problem representations (Hong et al., 2023). This process encourages students to reframe or reformulate problems, clarify goals and constraints, and consequently reduce the likelihood of errors in subsequent solution stages. High-quality questions also facilitate the generation of alternative ideas and promote preliminary evaluations of the feasibility of proposed solutions (English, 2023). Moreover, questions that require evidence-based explanations and justifications can further enhance students' reasoning skills and deepen their conceptual understanding (Priemer et al., 2020). To thoroughly explore problems, students need to engage in systematic investigation, gather relevant evidence, critically examine underlying assumptions, and understand the conceptual implications of the problem (Chomsriharat & Polyiem, 2024; Choudhar et al., 2022). As students become more familiar with these cognitive processes, they are better able to articulate assumptions, avoid misinterpretations, and identify relationships among relevant variables during problem-solving. This is consistent with the present study's findings, which showed that students in the RQA group demonstrated superior problem-solving performance, particularly in identifying and structuring problems effectively. Ultimately, integrating summarizing and questioning activities enables students to develop more focused and effective problem-solving skills, as they cannot only understand knowledge but also analyze, evaluate, and apply it to generate questions.

The third syntax of the RQA learning model, namely answering, requires students to respond to previously formulated questions. This activity encourages students to identify relevant information, analyze problems critically, and construct systematic solutions based on logical reasoning (Eticha et al., 2026; Pee, 2020). Through the process of generating and answering their own questions, students develop more accurate problem representations and strengthen their ability to evaluate alternative solutions. In addition, this stage promotes deeper conceptual understanding, evidence-based reasoning, and independent problem-solving performance (Aropiq et al., 2025; Nugroho et al., 2025).

From a problem-solving perspective, the answering phase incorporates various strategic approaches, such as identifying patterns, organizing information systematically, applying logical reasoning, evaluating alternative perspectives, and testing possible solutions (Blanc et al., 2025; Kedrick et al., 2023; Kuzle, 2019; Posamentier & Krulik, 2008; Rohati et al., 2024; Weng & Lin, 2024). This phase also involves collecting relevant evidence, identifying feasible solutions, and evaluating the strengths and limitations of each alternative solution (Karamustafaoğlu & Pektaş, 2023).

The quality of students' answers further reflects their competence in concrete problem-solving skills. Comprehensive, well-organized, and logically structured answers demonstrate students' ability to understand problems, apply relevant concepts, and evaluate the validity of their solutions. A systematic structure of answers indicates that students possess a thorough understanding of the problem-solving process, from problem identification to solution evaluation (Hong et al., 2023). Clear argumentation and the precise use of evidence significantly enhance problem-solving competence, as these elements reflect students' ability to critically analyze and justify their solutions (Rodil, 2024).

In contrast, responses that focus solely on final answers without adequate explanation suggest a superficial problem-solving approach and fail to demonstrate deep conceptual understanding. Empirical studies across diverse learning contexts indicate that improving the quality of students' answers not only reflects conceptual understanding but also signifies the development of systematic and adaptive problem-solving skills (Chomsriharat & Polyiem, 2024; English, 2023; Kuzle, 2019; McCormick et al., 2015; Weng & Lin, 2024).



1. Berdasarkan dampaknya terhadap keseimbangan ekosistem dan keanekaragaman hayati, kebijakan apa yang sebaiknya diambil jika ada pengembang yang ingin menebang hutan untuk dijadikan kawasan pemukiman, lalu mengganti wilayah hutan dengan lokasi lain?

Jawaban:

Masalah utama dalam kasus ini adalah rencana penebangan hutan yang dapat menyebabkan hilangnya habitat alami, menurunkan keanekaragaman hayati, mengganggu rantai makanan, serta merusak keseimbangan ekosistem. Untuk mengatasi masalah tersebut langkah awal yang dapat dilakukan yaitu mengidentifikasi fungsi ekologis hutan, seperti habitat satwa, penyerap karbon, daerah resapan air dan jalur migrasi organisme. Setelah itu, dilakukan analisis dampak lingkungan (AMDAL) untuk membandingkan dampak penebangan dengan manfaat pembangunan yang direncanakan. Berdasarkan hasil tersebut, solusi yang dapat diterapkan adalah membuat kebijakan pembangunan berkelanjutan, seperti membatasi area pembangunan, menerapkan konsep green infrastructure, menetapkan kawasan hutan sebagai zona konservasi, dan mewajibkan rehabilitasi ekosistem tanpa menghilangkan hutan asli.

Tawaran pengembang untuk mengganti hutan dengan area baru di tempat lain perlu dievaluasi kembali, karena hutan baru memerlukan waktu yang sangat lama untuk berkembang dan membentuk interaksi ekologis yang stabil seperti hutan asli, sehingga penggantian lokasi belum tentu mampu memulihkan fungsi ekosistem yang hilang. Oleh sebab itu, mempertahankan hutan asli lebih tepat dibandingkan menggantinya dengan hutan baru. Kebijakan ini didasarkan pada bukti bahwa banyak spesies hewan maupun tumbuhan yang mengalami penurunan populasi akibat kerusakan hutan. Berdasarkan berbagai kasus kerusakan hutan di beberapa wilayah dapat disimpulkan bahwa penebangan hutan cenderung menyebabkan penurunan keanekaragaman hayati. Hutan memiliki fungsi untuk menjaga keseimbangan ekosistem dan penebangan menyebabkan hilangnya fungsi tersebut, maka dari itu penebangan hutan sebaiknya tidak dilakukan agar kestabilan lingkungan dapat terjaga. Penerapan nyata kebijakan ini dapat dilakukan melalui penguatan regulasi lingkungan, konservasi berbasis masyarakat, pembangunan ramah lingkungan, serta kerjasama antara pemerintah, pengembang, dan masyarakat dalam menjaga kelestarian hutan.

Figure 2. Examples of students’ questions and answers generated during the implementation of the RQA learning model.

An example of students’ questioning and answering activities during the RQA implementation is presented in Figure 2. The figure demonstrates how students generated problem-oriented questions and constructed explanations based on relevant biological concepts. Through this process, students were encouraged to analyze problems critically, connect conceptual understanding with evidence, and formulate logical solutions, thereby supporting the development of systematic problem-solving skills. Overall, integrating the answering stage into the RQA learning syntax substantially enhances students' systematic and adaptive problem-solving skills. This interpretation is consistent with the findings of the present study, which demonstrated that students who participated in the RQA model exhibited higher problem-solving performance, particularly in selecting, organizing, and evaluating appropriate solution strategies.

The cohort-based longitudinal implementation in this study further enabled students to engage continuously in repeated cycles of reading, questioning, and answering activities across instructional periods. This sustained engagement supported the gradual development of problem-solving skills within a stable learning community, allowing students to progressively refine their conceptual understanding, analytical reasoning, and solution strategies over time. Consequently, problem-solving development can be interpreted not merely as an immediate instructional outcome, but as a continuous cognitive trajectory facilitated through sustained RQA learning experiences.

The findings of this study are also consistent with constructivist learning theory, which emphasizes that knowledge is actively constructed through cognitive engagement, questioning, reflection, and meaning-making processes during learning activities. Through the reading, questioning, and answering stages, students actively organize information, connect prior knowledge with new concepts, and construct deeper conceptual understanding, thereby supporting the development of problem-solving skills in biology learning.

The significant covariate effect identified in the ANCOVA analysis indicates that students’ initial problem-solving ability contributed to variations in posttest performance. Nevertheless, after statistically controlling for these initial differences, students who participated in the RQA learning model continued to demonstrate higher problem-solving outcomes compared to those in conventional learning settings. This finding suggests that the cognitive processes facilitated through the RQA model played an important role in strengthening students' conceptual understanding and promoting the development of more systematic problem-solving skills beyond the influence of prior ability alone.

Results of the Effect Size Test of Students' Problem-Solving Skills in Biology

The effect size estimates presented in Table 2 indicate that the significance value for the effect of the learning model on students' problem-solving skills in biology is 0.000, accompanied by a partial eta squared (η^2) value of 0.217, which is categorized as large scale (Kraft, 2020). These findings suggest that variations in instructional approaches exert a substantial influence on students' problem-solving outcomes. The significant result further indicates that a substantial proportion of the variance in students' problem-solving skills can be attributed to the learning model implemented. In educational research, effect size serves as a measure of practical significance that complements statistical significance testing, reflecting the magnitude of an intervention's impact regardless of sample size (Kraft, 2020; Laura & Christopher, 2020; Wheatley et al., 2020). The interpretation of effect size values should be contextualized within the field under investigation (Brydges, 2019; Hedges, 2025; Laura & Christopher, 2020; Simpson, 2023), particularly in education.

These findings underscore the importance of evaluating research outcomes not only in terms of statistical significance but also in relation to their practical implications for educational practice. The substantial effect observed indicates that the implemented learning model effectively promotes students' cognitive engagement and enhances higher-order thinking processes. The inclusion of pretest scores as a covariate in the ANCOVA analysis strengthened the interpretation of the effect size findings by ensuring that the observed differences in students' problem-solving performance were not solely influenced by initial ability differences between groups. After adjustment, the substantial effect size of the RQA model indicates that the learning process contributed meaningfully to the improvement of students' cognitive engagement and problem-solving development across the implementation period. This suggests that the RQA learning model can facilitate meaningful learning experiences that sustainably develop students' problem-solving skills.

Furthermore, the implications of these findings highlight the need to expand and sustain the implementation of adaptive and context-based learning models specifically designed to foster problem-solving skills as a core competency in biology education. In this context, integrating a structured learning model such as RQA can serve as a strategic pedagogical intervention to improve both the quality of learning processes and students' cognitive outcomes.

Conclusion

This study demonstrates that the cohort-based longitudinal implementation of the Reading–Questioning–Answering (RQA) learning model significantly improves students' problem-solving skills in biology, as indicated by a significance value of 0.000 ($p < 0.05$) and a large effect size (partial eta squared = 0.217). The observed improvement compared to conventional learning indicates that the RQA model contributes meaningfully to students' problem-solving performance. After controlling for differences in students' initial problem-solving ability through ANCOVA, the findings further suggest that the improvement was associated with the contribution of the RQA learning process rather than baseline differences between groups. The effectiveness of the RQA model is closely related to its structured learning syntax, which actively engages students in reading, question formulation, and answer construction, thereby promoting deeper conceptual understanding and more systematic problem-solving processes. Furthermore, the cohort-based longitudinal implementation enabled the observation of students' problem-solving development as a continuous trajectory within a stable learning group, providing insights into the sustainability of the RQA model across instructional periods.

These findings highlight the importance of implementing the RQA model consistently in biology learning to support students' cognitive development and problem-solving skills. Future studies are recommended to apply the RQA model across broader biological topics and integrate it with other instructional approaches to strengthen its adaptability and long-term educational impact.

AI Use Statement in the Writing Process

During the preparation of this manuscript, the authors used Grammarly Pro to review and improve the quality of the translated text. Following the use of this tool, the authors carefully reviewed and edited the manuscript as necessary and retain full responsibility for the accuracy, integrity, and final content of the article.

Conflict of Interest Statement

The authors declare that they have no financial interests or personal relationships that could have influenced, or could reasonably be perceived to have influenced, the research reported in this article.

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References

Agustina, R. S., Zubaidah, S., & Susanto, H. (2024). Using Remap-STAD Learning Assisted by The GitMind Application to Improve Students' Problem-Solving Skills in Biology Education. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *8*(1), 17–39. https://doi.org/10.36312/esaintika.v8i1.1662

Aisya, N., Ibrohim, I., Mahanal, S., & Maghfiroh, H. (2023). The effect of reading questioning answering integrated with creative problem solving on critical thinking. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2), 198–205. https://doi.org/10.22219/jpbi.v9i2.25718

Ananda, O. T., Mahanal, S., & Susanto, H. (2025). Students' Problem-Solving Skills: A Descriptive Study in High School Biology Education. *Jurnal Pro-Life*, *12*(3). https://doi.org/10.33541/pro-life.v12i3.7389

Aropiq, P. R., Nasrullah, A., & Yendra, N. (2025). Enhancing Problem-

Solving and Self-Directed Learning in 8th-Grade Students through a Problem-Based Learning Approach. *Progressive of Cognitive and Ability*, *4*(1), 30–38. https://doi.org/10.56855/jpr.v4i1.1325

Azzahra, W., Surtikanti, H. K., & Riandi, R. (2025). Biology Learning Research Trends Based on Quantitative Literacy to Improve Higher Order Thinking Skills: A Literature Review. *Journal of Science and Technological Education*, *4*(1), 50-61. Retrieved from https://meta.amiin.or.id/index.php/meta/article/view/142

Banawi, A., Rumasoreng, M. I., Hasanah, N., Rahawarin, D. A., & Basta, I. (2024). The Relationship between Problem-Solving Skills and Student Academic Achievement: A Meta-Analysis in Education. *Journal of Ecohumanism*, *3*(3), 1287–1299. https://doi.org/10.62754/joe.v3i3.3413

Blanc, S., Conchado, A., Benlloch-Dualde, J. V., Monteiro, A., & Grindei, L. (2025). Digital competence development in schools: a study on the association of problem-solving with autonomy and digital attitudes. *International Journal of STEM Education*, *12*(1). https://doi.org/10.1186/s40594-025-00534-6

Brydges, C. R. (2019). Effect Size Guidelines, Sample Size Calculations, and Statistical Power in Gerontology. *Innovation in Aging*, *3*(4). https://doi.org/10.1093/geroni/igz036

Choirunisa', N., Biruni, I. B., Ruslina, E., Fahruli, M. T. A., Jasman, Muh. W., Karomika, D., Abdillah, R. R., Hardyanto, Y. S. P., Wulanningsih, U. A., Rahmana, A. Y., & Sofyan, M. A. (2024). Reading questioning answering (RQA) for the empowerment of students' creative thinking skills. *AIP Conference Proceedings*, *3106*(1), 070017. https://doi.org/10.1063/5.0215239

Chomsriharat, S., & Polyiem, T. (2024). The development of problem-solving of grade 11 students using problem-based learning integrated with questioning strategies. *Journal of Green Learning*, *4*(2), 57–67. https://doi.org/10.53889/jgl.v4i2.414

Choudhar, S., Bi, N., Singh, P. N., & Talwar, P. (2022). Study on Problem Solving Skills and Its Importance. *World Journal of English Language*, *12*(3), 47–54. https://doi.org/10.5430/wjel.v12n3p47

Corebima, A. D., Sulisetijono, S., Siswati, B. H., & Choirunisa, N. (2023). The Comparative Study of The Effects of Inquiry Learning Model, RQA Learning Model, Mixed-Learning Model (Inquiry, RQA, TPA), and Conventional Learning on The Retention of Biology Concept Gaining at Senior High Schools in Indonesia. *INTED Proceedings*, *1*, 1487–1493. https://doi.org/10.21125/inted.2023.0429

English, L. D. (2023). Ways of thinking in STEM-based problem solving. *ZDM - Mathematics Education*, *55*(7), 1219–1230. https://doi.org/10.1007/s11858-023-01474-7

Ergazaki, M., Knippels, M. C., Zabel, J., Pilar, M., Aleixandre, J., & Passmore, C. (2021). *Contributions from Biology Education Research Series Editors*. Springer. https://doi.org/10.1007/978-3-030-86051-6

Eticha, M. D., Hunde, A. B., & Ketema, T. (2026). The role of a designed problem-solving method with metacognitive scaffolding on students' conceptual change learning and teachers' instructional practices in Biology. *Thinking Skills and Creativity*, *59*, 102033. https://doi.org/10.1016/j.tsc.2025.102033

Flavell, J. H. (2024). Metacognitive aspects of problem solving. In *Routledge eBooks*. https://doi.org/10.4324/9781032646527-16

Ghofur, A., Jatmiko, B., & Sanjaya, I. G. M. (2023). Profile of High School Students' Problem-Solving Skills and the Application of Problem-Based Learning: A Preliminary Study. *Studies in Learning and Teaching*, *4*(3), 522–536. https://doi.org/10.46627/silet.v4i3.317

Greenstein, L. M. (2012). *Assessing 21st century skills: A guide to evaluating mastery and authentic learning*. Corwin Press.

Hariyadi, S., Corebima, A. D., Zubaidah, S., & Ibrohim. (2018). Contribution of mind mapping, summarizing, and Questioning in the RQA learning model to genetic learning outcomes. *Journal of Turkish Science Education*, *15*(1), 80–88. https://doi.org/10.12973/tused.10222a

Hedges, L. V. (2025). Interpretation of the Standardized Mean Difference Effect Size When Distributions Are Not Normal or Homoscedastic. *Educational and Psychological Measurement*, *85*(2), 245–257. https://doi.org/10.1177/00131644241278928

Hong, J. L., Liao, C.-Y., Chan, T.-W., & Chang, J.-F. (2023). The Impact of Development-questioning Activities on Students' Pre-writing Ideas. *Proceedings of the 31st International Conference on Computers in Education*. https://doi.org/10.58459/icce.2023.1388

Iheaka, V. C. (2025). Diagnosing and correcting violations of normality and constant variance assumptions in multiple linear regression analysis. *International Journal of Advanced Statistics and Probability*, *12*(1), 17–27. https://doi.org/10.14419/8bnsc148

Juhkam, M., Jõgi, A. L., Soodla, P., & Aro, M. (2023). Development of reading fluency and metacognitive knowledge of reading strategies during reciprocal teaching: do these changes actually contribute to reading comprehension? *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1191103

Karamustafaoğlu, O., & Pektaş, H. M. (2023). Developing students' creative problem solving skills with inquiry-based STEM activity in an out-of-school learning environment. *Education and Information Technologies*, *28*(6), 7651–7669. https://doi.org/10.1007/s10639-022-11496-5

Kayman, F., & Aydın, E. (2026). The role of thinking and problem-solving dispositions on the academic achievement of Turkish language teacher candidates. *European Journal of Psychology of Education*, *41*(1). https://doi.org/10.1007/s10212-026-01064-7

Kaymaz, Ö., Tekindal, M. A., Doğanay Erdoğan, B., & Ateş, C. (2020). Robustness of analysis of covariance (ANCOVA) under the distributions assumptions and variance homogeneity. *Eurasian Journal of Veterinary Sciences*, *36*(1), 58–65.

https://doi.org/10.15312/eurasianjvetsci.2020.260

Kedrick, K., Schrater, P., & Koutstaal, W. (2023). The Multifaceted Role of Self-Generated Question Asking in Curiosity-Driven Learning. *Cognitive Science*, *47*(4). https://doi.org/10.1111/cogs.13253

Kim, J., Kim, D. H., & Kwak, S. G. (2024). Comprehensive guidelines for appropriate statistical analysis methods in research. *Korean Journal of Anesthesiology*, *77*(5), 503–517. https://doi.org/10.4097/kja.24016

Koehler, A. A., Fiock, H., Janakiraman, S., Cheng, Z., & Wang, H. (2020). Asynchronous online discussions during case-based learning: A problem-solving process. *Online Learning Journal*, *24*(4), 64–92. https://doi.org/10.24059/olj.v24i4.2332

Korfiatis, K., & Grace, M. (2022). *Current Research in Biology Education*. Springer Nature. Retrieved from https://link.springer.com/bookseries/16350

Kraft, M. A. (2020). Interpreting Effect Sizes of Education Interventions. *Educational Researcher*, *49*(4), 241–253. https://doi.org/10.3102/0013189X20912798

Kusuma, A. S., & Baskara, Z. W. (2023). Pengaruh Strategi Pembelajaran Reading Questioning and Answering (RQA) Terintegrasi Mind Mapping Terhadap Kterampilan Metakognitif dan Retensi Mahasiswa. *Jurnal Ilmiah Profesi Pendidikan*, *8*(1b), 929–938. https://doi.org/10.29303/jipp.v8i1b.1312

Kuzle, A. (2019). Design and evaluation of practice-oriented materials fostering students' development of problem-solving competence: The case of working backward strategy. *LUMAT*, *7*(3), 28–54. https://doi.org/10.31129/LUMAT.7.3.401

Laura, G., & Christopher, R. B. (2020). An Examination of Effect Sizes and Statistical Power in Speech, Language, and Hearing Research. *Journal of Speech, Language, and Hearing Research*, *63*(5), 1572–1580. https://doi.org/10.1044/2020_JSLHR-19-00299

Mafarja, N., Mohamad, M. M., Zulnaidi, H., & Fadzil, H. M. (2023). Using of reciprocal teaching to enhance academic achievement: A systematic literature review. In *Heliyon* (Vol. 9, Number 7). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2023.e18269

Mahanal, S., Zubaidah, S., Setiawan, D., Maghfiroh, H., & Muhaimin, F. G. (2022). Empowering College Students' Problem-Solving Skills through RICOSRE. *Education Sciences*, *12*(3). https://doi.org/10.3390/educsci12030196

McCormick, N. J., Clark, L. M., & Raines, J. M. (2015). Engaging Students in Critical Thinking and Problem Solving: A Brief Review of the Literature. *Journal of Studies in Education*, *5*(4), 100. https://doi.org/10.5296/jse.v5i4.8249

Minarik, D., & Bulgren, J. A. (2024). Addressing the Learning Needs of Students with Disabilities Through Effective Questioning. In *Creating an Inclusive Social Studies Classroom for Exceptional Learners* (pp. 123–134). Emerald Group Publishing Ltd. https://doi.org/10.1108/979-8-88730-647-620251010

Nugroho, A. A., Sajidan, Suranto, & Masykuri, M. (2025). The Effects Of Socio-Scientific Inquiry Based Learning on Students' Problem-Solving Skills. *Journal of Baltic Science Education*, *24*(1), 149–168. https://doi.org/10.33225/jbse/25.24.149

OECD. (2025). *Education at a Glance 2025: OECD Indicators*. OECD Publishing. https://doi.org/10.1787/1c0d9c79-en

Pastera, J. M. R., & Gaitano, J. H. (2024). Learners' Reading Strategies and Comprehension Skills. *International Journal of Science and Management Studies (IJSMS)*, *7*(5), 54–70. https://doi.org/10.51386/25815946/ijsms-v7i5p104

Pee, L. G. (2020). Enhancing the learning effectiveness of ill-structured problem solving with online co-creation. *Studies in Higher Education*, *45*(11), 2341–2355. https://doi.org/10.1080/03075079.2019.1609924

Posamentier, A. S., & Krulik, S. (2008). *Problem-Solving Strategies for Efficient and Elegant Solutions, Grades 6-12: A Resource for the Mathematics Teacher*. Corwin Press. Retrieved from https://books.google.co.id/books?id=x6jpLJttbJ8C

Priemer, B., Eilerts, K., Filler, A., Pinkwart, N., Rösken-Winter, B., Tiemann, R., & Zu Belzen, A. U. (2020). A framework to foster problem-solving in STEM and computing education. *Research in Science and Technological Education*, *38*(1), 105–130. https://doi.org/10.1080/02635143.2019.1600490

Riyadi, Syarifah, T. J., & Nikmaturrohmah, P. (2021). Profile of students' problem-solving skills viewed from Polya's four-steps approach and elementary school students. In *European Journal of Educational Research*, *10*(4), 1625–1638). https://doi.org/10.12973/EU-JER.10.4.1625

Rodil, M. S. P. (2024). Gearing towards Efficient Problem Solving: Exploring the Determinants That Influence Success. *Journal of Interdisciplinary Studies in Education*, *13*(2), 120-151. Retrieved from https://eric.ed.gov/?id=EJ1446994

Rohati, R., Marlina, M., Kumalasari, A., & Winarni, S. (2024). Exploring students' strategies in the problem-solving process on number pattern material. *AIP Conference Proceedings*, *3024*, 50002. https://doi.org/10.1063/5.0204412

Simpson, A. (2023). Benchmarking a Misnomer: A Note on "Interpreting Effect Sizes in Education Interventions." *Educational Researcher*, *52*(3), 180–182. https://doi.org/10.3102/0013189X20985448

Tóthová, M., & Rusek, M. (2021). Developing Students' Problem-Solving Skills Using Learning Tasks: An Action Research Project in Secondary School. *Acta Chimica Slovenica*, *68*(4), 1016–1026. https://doi.org/10.17344/acsi.2021.7082

Turker, S., Fumagalli, B., Kuhnke, P., & Hartwigsen, G. (2025). The 'reading' brain: Meta-analytic insight into functional activation during reading in adults. *Neuroscience & Biobehavioral Reviews*, *173*. https://doi.org/10.1016/j.neubiorev.2025.106166

Weng, T. S., & Lin, T. H. (2024). Improving students' problem-solving abilities through answering questions in metaverse games: taking GOXR software as an example. *Smart Learning Environments*, *11*(1). https://doi.org/10.1186/s40561-024-00321-w

Wheatley, C., Beale, N., Wassenaar, T., Graham, M., Eldridge, E., Dawes, H., & Johansen-Berg, H. (2020). Fit to Study: Reflections on designing and implementing a large-scale randomized controlled trial in secondary schools. *Trends in Neuroscience and Education*, *20*. https://doi.org/10.1016/j.tine.2020.100134

Zhang, C., Wang, P., Zeng, X., & Wang, X. (2025). A case study on developing students' problem-solving skills through interdisciplinary thematic learning. *Frontiers in Psychology*, *16*. https://doi.org/10.3389/fpsyg.2025.1447089

Zhu, X., Sun, Y., Liu, Y., Xu, W., & Cheong, C. M. (2025). Towards a better understanding of integrated writing performance: The influence of literacy strategy use and independent language skills. *Assessing Writing*, *64*. https://doi.org/10.1016/j.asw.2025.100922