



SQ3R model in biology education: Linking creative thinking, problem-solving, and academic achievement

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ABSTRACT

Creative thinking is an essential competency in biology education to support students' problem-solving skills and learning outcomes in the 21st century. However, instructional strategies that effectively foster these abilities remain a pedagogical challenge. This study aimed to examine the relationship between creative thinking skills, problem-solving skills, and learning outcomes through the application of the Survey, Question, Read, Recite, Review (SQ3R) learning model in biology education. A correlational research design was employed involving 72 eleventh-grade students at Arjasa Public High School. Data were collected using creative thinking tests, problem-solving essay tests, and biology learning outcome assessments, and analyzed using Pearson product-moment correlation and simple linear regression. The results revealed a very strong positive correlation between creative thinking skills and problem-solving skills ($r = 0.911$), with creative thinking contributing 82.9% to problem-solving skills. In addition, creative thinking skills showed a strong positive correlation with learning outcomes ($r = 0.613$), contributing 37.5% to students' biology learning outcomes. These findings indicate that the SQ3R learning model supports the development of creative thinking skills that are closely associated with improved problem-solving skills and learning outcomes. Therefore, SQ3R is recommended as an alternative instructional approach in biology education to promote active learning and higher-order thinking skills.

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INTRODUCTION

In the context of 21st-century biology education, students are required not only to acquire conceptual knowledge but also to develop higher-order thinking skills, particularly creative thinking and problem-solving abilities. These skills are essential for enabling learners to analyze complex biological phenomena, generate alternative solutions, and apply knowledge flexibly in real-life contexts (Suratno et al., 2019; Simanjuntak et al., 2021). Biology, as a science that integrates conceptual understanding, inquiry, and real-world application, requires learning approaches that engage students cognitively, affectively, and psychomotorically (Hariyadi & Corebima, 2019). Consequently, the development of students' thinking skills has become a central concern in contemporary biology education.

Creative thinking has been increasingly recognized as a key competency for the 21st century, as reflected in international educational frameworks developed by the OECD, which emphasize students' capacity to generate, evaluate, and refine ideas across disciplinary contexts (OECD, 2023). Within science education, creative thinking is closely associated with students' ability to approach problems from multiple perspectives, formulate alternative explanations, and construct meaningful solutions to complex and unfamiliar situations (Fitriyah & Ramadani, 2021). Empirical studies consistently indicate that creative thinking plays a pivotal role in enhancing students' problem-solving skills and supporting meaningful learning outcomes in biology and other science domains.

Creative thinking is commonly characterized by fluency, flexibility, originality, and elaboration in generating ideas and solutions. These dimensions enable students to move beyond rote memorization and engage in divergent and reflective thinking processes when addressing biological problems (Munandar, 1999; McGregor, 2007). In biology learning, students with well-developed creative thinking skills tend to demonstrate deeper conceptual understanding and greater ability to solve open-ended and contextual problems (Sumarni et al., 2019; Siswati et al., 2023). However, many biology classrooms continue to rely on teacher-centered instruction, which limits students' opportunities to actively construct knowledge, ask questions, and participate in reflective discourse. Such instructional conditions often constrain students' creative engagement and contribute to persistent difficulties in problem-solving and suboptimal learning outcomes, particularly when dealing with abstract biological concepts (Siswati et al., 2021).

Previous research has explored a range of instructional approaches aimed at enhancing creative thinking and problem-solving skills, including problem-based learning, inquiry-based learning, and STEM-oriented approaches. While these models have demonstrated positive effects on students' higher-order thinking, their implementation often emphasizes problem contexts or experimental activities, with comparatively less attention given to students' engagement with scientific texts and reading-based cognitive processes. In biology education, reading plays a crucial role in helping students interpret complex concepts, scientific representations, and explanatory texts. Nevertheless, empirical studies examining instructional strategies that explicitly integrate reading activities with the development of creative thinking and problem-solving skills remain limited.

One instructional model that has the potential to address this gap is the Survey, Question, Read, Recite, Review (SQ3R) learning model. SQ3R is a student-centered, reading-based instructional strategy that encourages learners to actively engage with texts through questioning, self-explanation, and reflection. Through its structured stages, SQ3R supports students in organizing information, monitoring their understanding, and reconstructing knowledge in meaningful ways (Tarigan et al., 2020; Riansyah et al., 2022). These processes are closely related to metacognitive regulation and higher-order thinking skills, which are essential for effective problem-solving in biology learning.

The theoretical foundation of SQ3R is consistent with the ICAP framework, which posits that learning outcomes improve as students move from passive reception of information toward increasingly constructive and interactive cognitive engagement (Chi & Wylie, 2014). Empirical evidence further supports the effectiveness of instructional strategies that involve retrieval practice, self-explanation, and active engagement in improving long-term retention, conceptual understanding, and problem-solving performance (Dunlosky et al., 2013; Prince, 2004). However, despite its strong theoretical alignment with higher-order thinking frameworks, research examining how SQ3R supports creative thinking and how this, in turn, relates to students' problem-solving skills and learning outcomes in biology education remains scarce, particularly at the senior high school level.

Most existing studies tend to focus primarily on learning outcomes as end products, without

explicitly examining the cognitive mechanisms through which creative thinking contributes to students' problem-solving abilities within structured reading-based instructional contexts. This lack of empirical evidence highlights a critical gap in the literature and underscores the need for studies that integrate creative thinking, problem-solving, and reading-based instructional strategies within biology education.

Therefore, this study aims to investigate the relationship between creative thinking skills and problem-solving skills, as well as the relationship between creative thinking skills and biology learning outcomes through the implementation of the SQ3R learning model among senior high school students. By examining these relationships, the present study seeks to contribute empirical evidence to the development of instructional strategies that promote creative thinking, active learning, and higher-order cognitive engagement in biology education.

METHODS

Research Design

This study employed a correlational research design, which aims to examine the degree of relationship between two or more variables without manipulating them (Creswell & Creswell, 2018). In this study, creative thinking skills functioned as the predictor variable, while problem-solving skills and biology learning outcomes served as the criterion variables.

The SQ3R (Survey, Question, Read, Recite, Review) learning model was implemented as an instructional framework during the learning process to ensure consistency in classroom instruction. Correlational design was selected because it allows researchers to identify the strength and direction of relationships among variables as they naturally occur in educational settings (Fraenkel et al., 2019).

Population and Sample

The population of this study consisted of all eleventh-grade science students at Arjasa Public High School during the 2024/2025 academic year, comprising four science classes with a total of 144 students.

Prior to sample selection, an equivalence test consisting of 15 multiple-choice questions based on the Grade X biology curriculum was administered to all four classes. Normality testing was conducted to ensure comparability among classes. Based on the equivalence test results, one class was selected as the research sample using purposive sampling. The final sample consisted of 72 students from one eleventh-grade science class who met the equivalence criteria (Table 1).

Table 1.
Demographic Characteristics of Population and Sample.

Category	Description
School	Arjasa Public High School
Academic Year	2024/2025
Population	144 students (4 science classes)
Sample Size	72 students
Grade Level	Grade XI (Science)
Sampling Technique	Purposive sampling based on equivalence test

Research Instrument

The research instruments consisted of three types of assessment tools, namely: (1) a creative thinking skills test, (2) a problem-solving essay test, and (3) a biology learning outcomes test. The creative thinking skills test was developed based on the theoretical framework of creative thinking proposed by Torrance, which conceptualizes creative thinking through four core indicators: fluency, flexibility, originality, and elaboration. These indicators have been widely used in science education research and were operationalized in this study by adapting the indicators described by Simanjuntak et al. (2021). The instrument was constructed in the form of open-ended biology questions that allowed students to generate multiple ideas, apply different solution strategies, and elaborate their responses using relevant biological concepts.

Several contextual modifications were applied to ensure the suitability of the instrument for senior high school biology learning. Specifically, the test items were designed using biology topics aligned with the curriculum and presented in problem situations that required students to interpret

information, generate alternative responses, and provide explanatory reasoning. This adaptation was intended to capture students' creative thinking performance within the context of biology learning rather than as a generic creativity measure.

Content validity of the instruments was established through expert judgment involving biology education lecturers and experienced biology teachers to ensure alignment with learning objectives and assessment indicators. Reliability testing was conducted using Cronbach's Alpha coefficient. The results indicated that all instruments demonstrated acceptable reliability, with alpha values exceeding the minimum threshold of 0.70, indicating that the instruments were reliable for data collection (Fraenkel et al., 2019).

Research Procedure

The research procedure consisted of four main stages: (1) preparation, (2) sampling, (3) implementation, and (4) data collection (Figure 1). The preparation stage involved the development of research instruments, including tests of creative thinking skills, problem-solving skills, and biology learning outcomes, followed by content validation through expert judgment to ensure alignment with learning objectives and assessment indicators.

During the sampling stage, an equivalence test was administered to examine the similarity of students' initial abilities across available classes. The results of the equivalence test were used as the basis for selecting the research sample through purposive sampling, ensuring that the selected class met the criteria of comparable initial competence. The implementation stage involved the application of the Survey, Question, Read, Recite, and Review (SQ3R) learning model in biology instruction on the digestive system topic. The SQ3R learning stages were conducted systematically to engage students in active reading, questioning, self-explanation, and reflection throughout the learning process.

Finally, data collection was conducted by administering the validated creative thinking skills test, problem-solving essay test, and biology learning outcomes test to obtain data on students' higher-order thinking skills and learning achievement following the implementation of the SQ3R learning model.

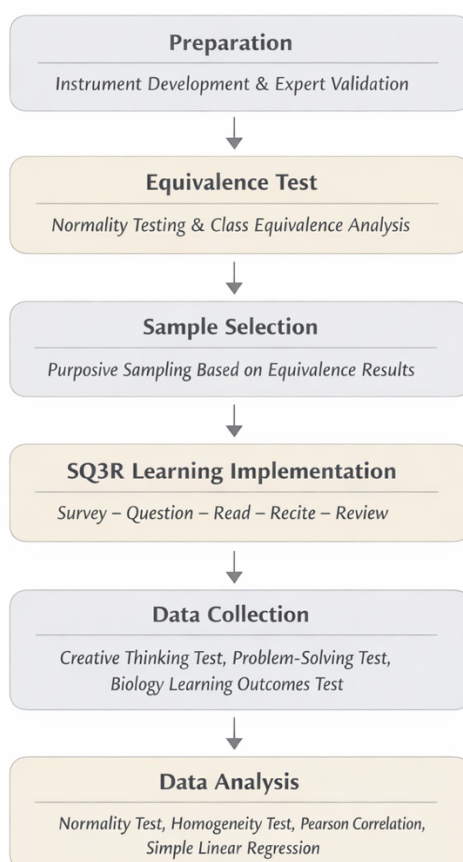


Figure 1. Research Procedure Flowchart

Data Analysis Techniques

Data analysis was performed using SPSS version 26. Preliminary analyses included the Kolmogorov–Smirnov test for normality and Levene’s test for homogeneity. Analysis of variance (ANOVA) was used to examine sample equivalence. Hypothesis testing was conducted using Pearson product-moment correlation and simple linear regression to analyze the relationships among creative thinking skills, problem-solving skills, and learning outcomes.

RESULTS AND DISCUSSION

This study examined the relationships between creative thinking skills, problem-solving skills, and biology learning outcomes within the implementation of the SQ3R learning model. The analysis emphasizes key empirical findings and their theoretical implications in the context of biology education.

Creative Thinking Skills and Problem-Solving Skills

The results indicate a very strong positive relationship between students’ creative thinking skills and problem-solving skills. As shown in [Table 2](#), the Pearson correlation coefficient reached $r = 0.911$ ($p < 0.01$), indicating that higher levels of creative thinking are consistently associated with better problem-solving performance in biology learning.

Table 2.

Correlation between Creative Thinking Skills and Problem-Solving Skills

Variable	r	Sig. (2-tailed)	N
Creative Thinking Skills – Problem-Solving Skills	0.911**	0.000	72

Note. $p < 0.01$

This strong correlation suggests that creative thinking plays a central cognitive role in students’ ability to analyze biological problems, generate alternative solutions, and evaluate outcomes. To further examine this relationship, a simple linear regression analysis was conducted.

Table 3.

Simple Linear Regression of Creative Thinking Skills on Problem-Solving Skills

Predictor	B	Std. Error	Beta	t
Constant	13.093	3.920	–	3.340
Creative Thinking Skills	0.871	0.047	0.911	18.437

Dependent Variable: Problem-Solving Skills

The regression results indicate that creative thinking skills significantly predict problem-solving skills. Each one-unit increase in creative thinking score is associated with an increase of 0.871 units in problem-solving performance ([Table 3](#)). The contribution analysis further confirms this strong effect.

Table 4.

Contribution of Creative Thinking Skills to Problem-Solving Skills

R	R ²	Adjusted R ²	Std. Error
0.911	0.829	0.827	2.936

As presented in [Table 4](#), creative thinking skills explain 82.9% of the variance in problem-solving skills. This exceptionally high contribution highlights creative thinking as a dominant factor in students’ problem-solving performance. Theoretically, this finding aligns with the view that problem-solving requires both divergent thinking (idea generation) and convergent thinking (evaluation and selection), which are core components of creative cognition (Munandar, 1999; Treffinger in Hasanah & Putra, 2017).

From a cognitive perspective, creative thinking encompasses fluency, flexibility, originality, and elaboration, which collectively enable learners to generate multiple representations of a problem and explore alternative solution pathways (Munandar, 1999; 2002). Biology learning frequently presents complex and abstract concepts—such as physiological processes or systemic interactions—that cannot be solved through memorization alone. Students must interpret information, connect prior knowledge,

and adapt reasoning strategies, all of which are facilitated by creative cognitive processes.

The SQ3R learning model appears to intensify this relationship by systematically activating creative cognition at multiple stages of learning. During the survey stage, students are encouraged to identify key structures and patterns in the learning material, which activates prior knowledge and supports cognitive flexibility. This aligns with the notion that creative thinking begins with recognizing relationships among concepts rather than isolated facts (McGregor, 2007). The question stage further stimulates divergent thinking by prompting students to formulate their own questions, shifting them from passive recipients of information to active constructors of meaning.

These stages are crucial because problem-solving fundamentally depends on how problems are framed. Students who can generate meaningful questions are better equipped to define problems accurately, a prerequisite for successful problem-solving (Treffinger in Hasanah & Putra, 2017). The strong contribution of creative thinking to problem-solving skills found in this study (82.9%) suggests that SQ3R not only supports comprehension but also restructures students' cognitive approach to problem situations.

The read and recite stages further deepen this process by requiring students to analyze information selectively and reconstruct knowledge in their own words. This reconstruction process strengthens elaboration and originality, two essential dimensions of creative thinking that enable learners to adapt knowledge to novel contexts (Simanjuntak et al., 2021). As Jensen et al. (2014) noted, students with well-developed creative thinking skills demonstrate superior self-regulation during problem-solving, allowing them to evaluate alternative strategies and refine solutions more effectively.

Empirically, the findings of this study extend previous research reporting strong relationships between creative thinking and problem-solving abilities (Sigit et al., 2019; Latif et al., 2022). However, the magnitude of the relationship observed here suggests that reading-based, metacognitively structured instruction such as SQ3R may offer a more direct pathway for cultivating creative problem-solving skills than models that focus primarily on task completion or discussion alone. Meta-analytic evidence indicates that instructional approaches emphasizing active engagement and metacognitive regulation have substantial effects on student achievement (Hattie, 2009).

Creative Thinking Skills and Biology Learning Outcomes

A strong positive relationship was also found between creative thinking skills and biology learning outcomes. As shown in Table 5, the Pearson correlation coefficient was $r = 0.613$ ($p < 0.01$), indicating that students with higher creative thinking skills tend to achieve better academic results in biology.

Table 5.
Correlation between Creative Thinking Skills and Learning Outcomes

Variable	r	Sig. (2-tailed)	N
Creative Thinking Skills – Learning Outcomes	0.613**	0.000	72

Note. $p < 0.01$

To further examine this relationship, regression analysis was conducted to determine the predictive contribution of creative thinking skills to learning outcomes.

Table 6.
Simple Linear Regression of Creative Thinking Skills on Learning Outcomes

Predictor	B	Std. Error	Beta	t
Constant	51.494	5.985	–	8.604
Creative Thinking Skills	0.468	0.072	0.613	6.487

Dependent Variable: Learning Outcomes

The regression results show that each one-unit increase in creative thinking skills is associated with a 0.468-unit increase in biology learning outcomes (Table 6). The contribution analysis is presented in Table 7.

Table 7.
Contribution of Creative Thinking Skills to Learning Outcomes

R	R ²	Adjusted R ²	Std. Error
0.614	0.375	0.367	4.482

As shown in [Table 7](#), creative thinking skills account for 37.5% of the variance in learning outcomes. Although this contribution is lower than that observed for problem-solving skills, it remains substantial within educational research, where learning outcomes are influenced by multiple cognitive and contextual factors. Learning outcomes in biology are influenced by a constellation of factors, including prior knowledge, motivation, instructional quality, and learning environment (Siswono, [2005](#); Yusnaeni et al., [2016](#)). Within this complex system, creative thinking functions as a cognitive catalyst that enhances the depth and durability of learning rather than acting as a sole determinant.

Students with strong creative thinking skills are more likely to engage in meaningful learning processes, such as connecting new information with existing cognitive structures and evaluating understanding critically. This aligns with constructivist perspectives, which emphasize that learning occurs most effectively when students actively construct knowledge rather than passively absorb information (Sumarni et al., [2019](#)). The SQ3R model supports this process by embedding reflection and self-evaluation into the learning cycle, particularly during the review stage.

The contribution of creative thinking to learning outcomes (37.5%) suggests that creativity enhances learning quality, not merely test performance. Students trained to think creatively tend to develop conceptual understanding that is transferable across contexts, a key objective of biology education in the 21st century (Suratno et al., [2019](#)). This finding supports Safitri et al. ([2023](#)), who reported that creative thinking skills significantly predicts biology achievement when learning environments encourage exploration and intellectual engagement.

Importantly, the recite and review stages of SQ3R function as metacognitive checkpoints that reinforce learning. By articulating understanding in their own words and revisiting key ideas, students strengthen memory consolidation and conceptual coherence (Hariyadi & Corebima, [2019](#)). These processes explain why creative thinking contributes meaningfully to learning outcomes, even though achievement is shaped by multiple interacting variables. The recite and review stages of SQ3R align with self-regulated learning theory, which emphasizes learners' ability to monitor, evaluate, and regulate their own cognitive processes during learning (Zimmerman, [2002](#)).

The findings of this study suggest that the effectiveness of SQ3R lies not merely in its structure as a reading strategy, but in its ability to train core cognitive processes underlying creativity, problem-solving, and learning. Unlike traditional instructional approaches that emphasize content coverage, SQ3R orchestrates a sequence of cognitive activities surveying, questioning, analyzing, reconstructing, and reviewing that collectively cultivate higher-order cognitive processes. This finding is consistent with Breti ([2024](#)), who highlighted that instructional environments play a critical role in shaping students' creative capacities. Empirical studies further demonstrate that structured instructional strategies such as SQ3R enhance students' engagement with scientific texts and promote deeper cognitive processing, which in turn supports the development of higher-order thinking skills, including creativity and problem-solving (Ratni, [2023](#); Ratni, [2020](#)). By positioning students as active meaning-makers rather than passive recipients of information, SQ3R transforms learning into an iterative cycle of inquiry, reflection, and self-regulation. Evidence from biology and science education contexts indicates that students exposed to SQ3R show greater understanding of complex subject matter and improved learning outcomes compared to those taught using traditional instructional approaches (Ratni, [2023](#); Ratni, [2020](#)). Consequently, sustained engagement in SQ3R-based learning fosters productive habits of mind that support both creative thinking and academic success.

Overall, this study provides empirical evidence that integrating SQ3R into biology education strengthens the cognitive foundations necessary for problem-solving and meaningful learning. The strong relationships observed between creative thinking, problem-solving skills, and learning outcomes highlight the importance of instructional models that explicitly engage students' creative and metacognitive processes.

CONCLUSION

This study demonstrates that creative thinking skills are strongly associated with both problem-solving skills and biology learning outcomes within the implementation of the SQ3R learning model. The findings reveal a very strong positive relationship between creative thinking and problem-solving skills ($r = 0.911$), indicating that creative thinking accounts for 82.9% of the variance in students' problem-solving abilities. In addition, a strong positive relationship was found between creative thinking skills

and learning outcomes ($r = 0.613$), with creative thinking contributing 37.5% to students' academic achievement in biology. These results indicate that the SQ3R learning model provides a structured learning environment that supports the development of creative thinking, which in turn plays a crucial role in enhancing students' capacity to solve biological problems and achieve meaningful learning outcomes through active, reflective, and cognitively engaging learning processes.

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