Model Ricorse with QFT (Question Formulation Technique): Enhancing Students' Higher-Order Thinking Skills (HOTS) and Science Literacy

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Model Ricorse with QFT (Question Formulation Technique): Enhancing Students' Higher-Order Thinking Skills (HOTS) and Science Literacy

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Abstract

21st-century learning has undergone a paradigm shift in education from teacher-centered to student-centered. It recently emphasises students' critical and creative thinking abilities, effective communication, innovation, problem-solving, and collaboration. This study examined the Ricorse model's effectiveness with the Question Formulation Technique (QFT) in enhancing students' higher-order thinking skills (HOTS) and science literacy. It involved 296 fifth-grade students from three selected state elementary schools, chosen through cluster random sampling. Each group consisted of 148 students divided into control and experimental groups. Data were collected through multiple-choice and essay instruments and subsequently analysed using multivariate analysis of variance (MANOVA). The research variables were students' higher-order thinking skills (HOTS) and science literacy. The results indicated that the Ricorse model with QFT effectively improves students' higher-order thinking skills (HOTS) and science literacy, as it encouraged active participation during the learning process, trained students to develop questioning skills, find answers, analyse, share ideas, and draw conclusions. Thus, it can foster curiosity and metacognitive abilities among students.

Keywords: *Ricorse Model, QFT (Question Formulation Technique), higher-order thinking skills (HOTS), science literacy*

Introduction

In the field of education, there is an increasing emphasis on teachers' multifaceted roles, extending beyond technical expertise. Besides possessing subject knowledge, they are expected to exhibit effective pedagogical skills, integrate technology awareness, and implement appropriate teaching strategies (Irdalisa et al., 2020). Teachers hold a pivotal position as influential agents in students' learning experiences, shaping their understanding of subject matter and nurturing their intrinsic motivation to learn (Ambusaydi et al., 2021). Students' thinking abilities will be more directed when they can express themselves, voice their opinions, solve problems independently and in groups, thus fostering social interaction among students (Prihatmojo et al., 2019).

High-order thinking skills (HOTS) entail students engaging in mental activities that critically and creatively connect, manipulate, and transform their existing knowledge and experiences. Through these cognitive processes, students can make informed decisions (Dinni, 2018). Furthermore, HOTS empower students to analyse, evaluate, and innovate when addressing challenges within their environment (Ichsan et al., 2019). However, field observations reveal a limited range of strategies teachers employ to cultivate students' thinking abilities (Indriyana & Kuswandono, 2019). Students are often directed to comprehend and memorize the subject matter, resulting in a deficiency in their higher-order thinking skills. This challenge poses an issue that educators must address in the teaching process. Another contributing factor is teachers'

insufficient knowledge of HOTS; not all educators possess a comprehensive understanding of it, and they may struggle to select appropriate methods and instructional models to enhance it (Afifah & Retnawati, 2018). Thus, addressing these issues requires a concerted effort from teachers and the education community to bolster students' HOTS and promote effective learning strategies.

HOTS is influenced by individual literacy capabilities (Indriyana & Kuswandono, 2019). There are five steps to enhance HOTS through literacy: setting learning objectives for reading in the classroom, engaging students in interactive questioning, instructing them to practice reviewing and improving comprehension, providing feedback, and assessing their learning progress (Indriyana, 2019). However, Indonesia consistently ranks at the lowest level regarding science literacy (Chasanah et al., 2022). According to the Programme for International Student Assessment (PISA), science literacy among Indonesian students remains below the international average (Winarni et al., 2020). In 2012, Indonesia ranked 64th out of 65 countries with a score of 382. Subsequently 2015, it ranked 64th from 72 participating countries, scoring 403. These survey results indicate that science literacy among Indonesian students falls significantly below the international standard set by the organization (OECD, 2015). PISA's assessment places Indonesia's science literacy at the lowest rank among 64 countries (Rusilowati et al.). This finding highlights Indonesian students' low science literacy level (Azrai et al., 2020).

Science literacy plays a crucial role in applying knowledge and skills among students, as it encourages active participation in constructing knowledge, reflecting on experiences, analyzing the real world, enhancing social negotiation, learning effective communication, and integrating learning experiences (Setyowati et al., 2022). Science literacy directs how science can serve as a solution for decision-making in addressing various issues. With science literacy capabilities, students can analyze, reason, and communicate effectively when confronted with problems, thus enabling them to solve and interpret challenges in diverse situations. Proficiency in science literacy equips students with the necessary skills to navigate real-life situations in the era of globalization (Winarni et al., 2020).

However, understanding science education that develops students' science literacy has not been entirely effective (Adnan et al., 2021). Not all teachers can create effective learning environments that foster science literacy among students (Winarni et al., 2020). The challenges in education stem from the weaknesses in implementing the teaching and learning process by teachers in schools (Wahyu et al., 2020). Students are not accustomed to working on science problems using discourse, and the learning process remains conventional, primarily focused on conceptual mastery (Windiyariani et al., 2017). The resolution of these issues is hoped to be addressed by teachers. As the key figures in achieving learning objectives, teachers should adopt appropriate instructional models to ensure students can learn effectively and efficiently (Muspawi et al., 2019).

The conventional teaching models need to be replaced with creative and innovative approaches (Irdalisa et al., 2023). The Ricorse instructional model has been extensively studied by researchers and proven effective in fostering critical thinking for students of diverse academic abilities (Mahanal et al., 2019), analytical thinking skills (Diah et al., 2023), literacy skills (Fadhilah et al., 2023), problem-solving abilities (Putri et al., 2023), and enhancing students' critical thinking skills (Hardianto et al., 2023). Built on the principles of constructivism, the Ricorse model promotes a more active and student-centered classroom environment, leading to increased interest and motivation in

learning (Ahmad, 2016). The Ricorse instructional model follows a syntactical structure comprising the following steps: (1) Reading, (2) Identifying the problem, (3) Constructing the solution, (4) Solving the problem, (5) Reviewing the problem-solving process, and (6) Extending the problem-solving to related contexts (Mahanal and Zubaidah, 2017).

However, combining Ricorse research with the Question Formulation Technique (QFT) is still relatively uncommon. QFT is a technique developed by the Right Question Institute, and several studies have reported its potential implementation as a learning strategy to enhance students' curiosity, engagement, problem-solving skills, and independent thinking (Leblact et al., 2017; Minigan, 2017; Garibay et al., 2020). The QFT consists of six stages: (1) A Question Focus (Qfocus), (2) The rules for producing questions and Producing questions, (3) Categorizing questions, (4) Prioritizing questions, (5) Next steps, and (6) Reflection (Agustini and Sopandi, 2017). Each stage of the QFT is designed to facilitate students in generating numerous questions (Garibay, 2020), encouraging them to think more deeply about the questions they create, thereby promoting critical thinking and enhancing students' long-term comprehension (Nurhasanah, 2021).

Therefore, integrating Ricorse principles and the QFT technique can be an innovative instructional model. This model provides a framework for inquiry-based learning guided by students' questions. It is designed to facilitate students in problem-solving through the generation of questions, promoting divergent, convergent, and metacognitive thinking, thus empowering and developing students' higher-order thinking skills (HOTS) and scientific literacy. This study examines the Ricorse model's effectiveness with QFT in enhancing students' higher-order thinking skills (HOTS) and scientific literacy.

Literature Review

Ricorse Model

The Ricorse model is a problem-solving-based instructional approach that facilitates students' thinking skills in the 21st century. Developed by Mahanal and Zubaidah in 2017, the Ricorse model comprises six stages: 1) Reading, 2) Identifying the problem, 3) Constructing the solution, 4) Solving the problem, 5) Reviewing the solution, and 6) Extending the solution (Mahanal et al., 2019). Each stage of the Ricorse model encourages students to apply higher-order thinking. Through systematic and guided problem-solving exercises, the Ricorse instructional model actively engages students (Mahanal et al., 2022). The syntax of the Ricorse model is an extension of John Dewey's learning syntax and can be outlined as follows: 1) Reading, 2) Identifying the problem, 3) Constructing the solution, 4) Solving the problem, 5) Reviewing the problem solving, and 6) Extending the problem solving (Manahal and Zubaidah, 2017). Additionally, the Ricorse syntax includes grouping students into heterogeneous teams to reduce the academic achievement gap between students with low and high academic abilities (Putri et al., 2020). Numerous researchers have reported on the potential of the Ricorse model to enhance various skills. The Ricorse instructional model can be implemented in education to improve creative thinking skills (Mahanal and Zubaidah, 2017). Furthermore, it holds promise in enhancing students' scientific reasoning abilities

across different academic levels (Putri et al., 2020). Ricorse is a model that fosters the development of creative and critical thinking skills, encouraging students to engage in complex problem-solving (Sari et al., 2018). The Ricorse instructional model has the potential to enhance creative thinking skills among students with low academic abilities (Sumiati et al., 2018). Additionally, it effectively bridges the gap in critical thinking skills between high- and low-achieving students (Maharal et al., 2019). Compared to inquiry-based approaches, Ricorse has demonstrated greater success in improving high school students' science literacy (Mawaddah et al., 2021). Furthermore, Ricorse has been reported to significantly enhance students' problem-solving skills compared to conventional instructional models (Manisa et al., 2020).

QFT (Question Formulation Technique)

Question Formulation Technique (QFT) is an approach that teaches individuals how to formulate their questions, thus shifting the role of the questioner to the students themselves. QFT is a process that instructs students to generate their questions, improve upon them, determine how to use their questions to guide their learning and reflect on what and how they have learned (Mannion, 2019). Developed by Luz Santana and Dan Rothstein of the Right Question Institute in Lawrence, MA, QFT is an instructional strategy that was first widely introduced in the field of education through the book "Make Just One Change: Teach Students to Ask Their Own Questions" (Rothstein and Santana, 2011). The Question Formulation Technique (QFT) comprises several essential elements: 1) learners are presented with a Question Focus (QFocus), which serves as a cue to elicit questions; 2) learners work on improving their questions; 3) learners devise strategies for using the questions (prioritizing questions according to the QFocus); 4) learners reflect on what they have learned, how they learned it, and what they think differently after going through the process (Garibay et al., 2020).

Many researchers have reported the potential of implementing QFT as a learning strategy to enhance various skills. Leblanc et al. (2017) found that the implementation of QFT in engineering undergraduate programs stimulates students' curiosity and engagement. Similarly, Clark et al. (2019) observed that applying QFT encourages divergent thinking among high school students. Therefore, the formulation of questions is an essential skill that learners in the 21st century must develop to cultivate curiosity, problem-solving ability, and independent thinking (Minigan 2017; Garibay et al. 2020).

Several studies have been conducted on Ricorse and QFT separately. However, no reports have yet explored the integration of Ricorse and QFT. Thus, the researchers aim to investigate the implementation of the Ricorse model with QFT in enhancing high-order thinking skills (HOTS) and scientific literacy among students.

The collaboration between the Ricorse model and the Question Formulation Technique (QFT) is still relatively rare in research. QFT is a technique developed by the Right Question Institute. Some studies have reported on the potential implementation of QFT as a learning strategy, showing its effectiveness in enhancing curiosity, student engagement, problem-solving skills, and independent thinking (Leblanc et al. 2017; Minigan 2017; Garibay et al. 2020). QFT consists of six stages: (1) A Question Focus (QFocus), (2) The rules for producing question and Producing question, (3) Categorizing Question, (4) Prioritizing Question, (5) Next steps, and (6) Reflection (Agustini and Sopandi 2017). Each stage of QFT is designed to facilitate students in

generating multiple questions (Garibay 2020), which helps them think more deeply about the questions they create, enhances critical thinking, and improves students' long-term understanding (Nurhasanah 2021).

Hence, the integration of Ricorse principles and QFT technique can be seen as an innovative instructional model. This model provides a framework for inquiry-based learning guided by students' questions. It is designed to facilitate students in problem-solving through question formulation and trains them to think divergently, convergently, and metacognitively, thus empowering and developing their higher-order thinking skills (HOTS) and scientific literacy. The objective of this research is to examine the effectiveness of the Ricorse model with QFT (Question Formulation Technique) in enhancing students' higher-order thinking skills (HOTS) and scientific literacy. Therefore, the research question is focused on investigating the effectiveness of the Ricorse model with QFT in improving students' higher-order thinking skills and scientific literacy.

Methodology

This research belongs to a quasi-experiment using a pretest-posttest control group design. The researcher implemented the Ricorse model with the Question Formulation Technique (QFT) in the experimental group, while the control group received the Direct Instruction model. The sampling technique used was cluster random sampling, resulting in a sample size of 296 students, with 148 students in each control and experimental group. The assessment indicators for higher-order thinking skills (HOTS) and science literacy can be seen in Figure 1.

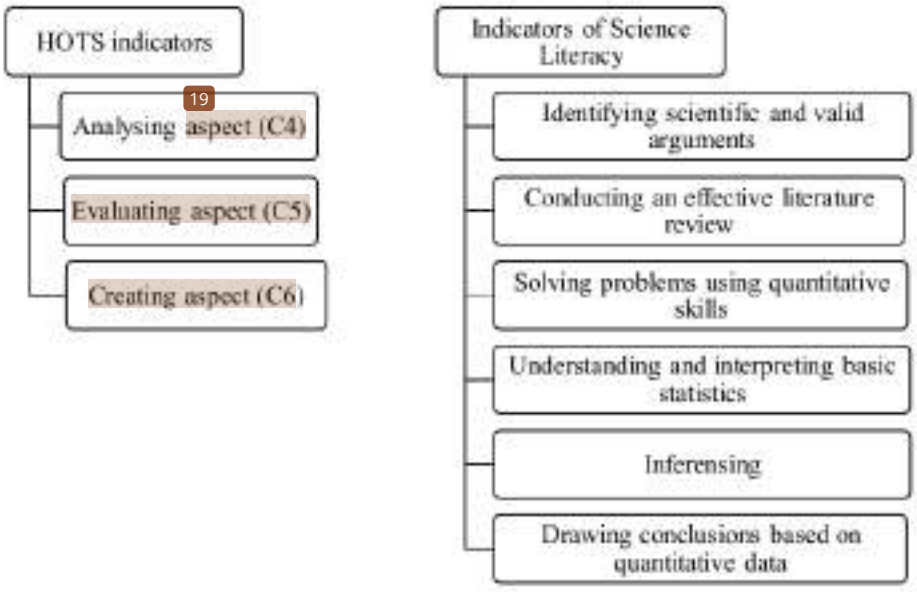

Figure 1. Indicators of HOTS and Science Literacy Assessment

Multiple-choice questions were used to collect data on high-order thinking skills (HOTS), while essay questions were used to gather data on students' science literacy. Experts validated both the HOTS multiple-choice questions and the essay questions. The data on high-order thinking skills (HOTS) and science literacy from the students were used to test the proposed hypothesis that the implementation of the Ricorse model with QFT (Question Formulation Technique) was effective in enhancing high-order thinking skills (HOTS) and science literacy among the students. Multivariate analysis of variance (MANOVA) was utilized to test this hypothesis.

Results

The normality test results using the Kolmogorov-Smirnov test with a significance level of 5% indicated that the data followed a normal distribution (Sculinggan 2013). Similarly, the results of the homogeneity test using the Barlett test showed that the samples used came from populations with equal variances. Based on the calculation of the Manova test with Wilk Lambda analysis, an F value of 933.976 was obtained with a significance value of 0.000 < 0.05. Furthermore, the tests of between-subject effects revealed that the relationship between Ricorse and QFT (Question Formulation Technique) used with HOTS resulted in an F value of 1452.109 with a significance value of 0.000, and the relationship between Ricorse and QFT (Question Formulation Technique) used with science literacy yielded an F value of 1775.217 with a significance value of 0.000. These findings indicate significant differences in students' HOTS and science literacy due to the variations of the instructional models.

The experimental class employed the Ricorse model with QFT, while the control class utilized the Direct Instruction teaching model. To determine the more effective instructional model, the marginal and cell means for each dependent variable were examined as presented in Table 1.

Table 1. Marginal and cell Means

Class	Learning Model	Dependent Variable	Low	Moderate	High	Marginal Mean
Experiment	Ricorse Model with QFT (Question Formulation Technique)	High-Order Thinking Skills (HOTS)	81,40	85,00	90,51	85,64
		Science literacy	77,40	84,49	85,00	83,20
Control	Direct Instruction	High-Order Thinking Skills (HOTS)	62,60	65,00	71,63	66,41

	Model	Science literacy	64,10	65,00	68,88	65,99
Marginal means		High-Order Thinking Skills (HOTS)	72,00	75,00	81,07	
		Science literacy	70,75	74,75	76,94	

Discussion

The marginal means of the variables "Higher Order Thinking Skills (HOTS)" and "Science Literacy" for the experimental class were higher compared to the control class. For the variable "Higher Order Thinking Skills (HOTS)," the mean score for students using the Ricorse model with QFT was 85.64, while for those using the Direct Instruction teaching model, it was 66.41. Thus, the average HOTS score with the Ricorse model and QFT was better than that with the Direct Instruction teaching model (Table 1). Similarly, for the variable "Science Literacy," the mean score for students using the Ricorse model with QFT was 83.20, while for those using the Direct Instruction teaching model, it was 65.99. Hence, the average Science Literacy score with the Ricorse model and QFT was superior to that with the Direct Instruction teaching model. Based on these findings, it can be concluded that students' Higher Order Thinking Skills (HOTS) and Science Literacy were better when using the Ricorse model with QFT than the Direct Instruction teaching model.

The Ricorse model with QFT proves effective in enhancing higher-order thinking skills as it actively engages students in the learning process. This approach encourages students to think critically about problems, conduct experiments to find answers, analyse and interpret data, and discuss their findings to draw conclusions (Mairoza and Fitriza, 2021). The Ricorse model actively involves students, allowing them to contribute their ideas (Azizah et al. 2020). The integration of QFT (Question Formulation Technique) within the Ricorse model is particularly effective in fostering students' higher-order thinking skills and science literacy. The learning phases are designed to develop questioning skills through idea generation, categorisation, prioritisation, and group discussions. By employing this model, teachers can support students in developing their questioning, metacognitive, and interpersonal skills, enabling them to ask relevant questions and developing their curiosity and motivation to learn.

Combining the Ricorse model's learning syntax with QFT empowers students' higher-order thinking skills (HOTS) and science literacy. The "reading" phase in the Ricorse model enables students to comprehend a passage, activating prior knowledge and stimulating them to identify the problems presented by rearticulating the text. During this phase, students focus on formulating questions, categorising them, and prioritising them based on the reading material, thereby improving their reading concentration. Reading is a key strategy in empowering higher-order thinking skills as it assists students in acquiring new information and establishing connections between ideas (Duke and Pearson 2002). Developing strong reading skills helps students progress academically and enhances their professionalism (Velásquez 2020).

In the "Identifying the problem" phase, students can recognise issues and deepen their knowledge about a particular problem. Problem identification involves students to clarify unclear and unstructured problems and allow them to search for the required solution criteria (Maluanl and Zubaidah 2017). In the "Constructing the solution" phase, students identify and explore the problem to determine the strategies for forming the solution. During the "Solving the problem" phase, students implement strategies to resolve the problem. The selected solutions are based on considerations from previously chosen solutions. In the "Reviewing the problem-solving" phase, students reflect and reevaluate to ensure the selected information is accurate. Lastly, in the "Extending the problem solution" phase, students communicate the results of their discussions. Thus, the learning syntax of the Ricorse model with QFT is designed to activate higher-order thinking skills through problem-solving activities. Consequently, using the Ricorse model with QFT stimulates students to enhance their thinking abilities at higher levels, involving critical thinking skills in digesting various types of information and solving problems. It enables students to construct explanations and connect acquired information to make decisions.

The Ricorse and QFT models also help students to develop important metacognitive skills in HOTS. It refers to the ability to reflect on one's own thinking processes as well as monitor and regulate on learning. It indicates that Ricorse and QFT models are very suitable to help improve students' higher-order thinking skills.

High-order thinking skills refer to students' cognitive process at a higher level of thinking, extending beyond memorization and restating known information (Mairoza and Fitriza 2021). These skills are crucial for students to master as they enable them to make decisions, present strong arguments, think broadly from various perspectives to respond to problems effectively, generate problem-solving ideas, and encourage active participation in discussions (Lestari 2017; Heong et al. 2012). In the domain of analysing, which is a part of HOTS, students are presented with a case or phenomenon to classify information, determine relationships, distinguish causes and effects, and identify and connect elements within the information. In the evaluation domain, students can assess ideas and solutions and can accept or reject statements. In creating domain, students can draw general conclusions from a given concept or perspective on a particular matter.

Scientific literacy is the ability to understand scientific concepts and principles and think scientifically to solve daily problems (Chasanah et al. 2022). Measured scientific literacy consists of identifying valid scientific opinions, conducting effective literature searches, solving problems using quantitative skills, understanding and interpreting basic statistics, making predictive inferences, and drawing conclusions based on quantitative data. Scientific literacy is essential to instill among students in 21st-century learning (Nisa et al. 2021). The existence of scientific literacy can prevent someone from making mistakes in understanding some information (Sharon and Tsabari 2020).

Conclusion

Based on the research findings, it can be concluded that the Ricorse model with QFT (Question Formulation Technique) is effective in enhancing students' high-order thinking skills (HOTS) and scientific literacy.

Acknowledgment

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