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Levels of Inquiry and Reading-Questioning-Answering (LoIRQA) to Enhance High School Students' Critical and Creative Thinking

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It has been demonstrated that Levels of Inquiry (LoI) can enhance students' critical and creative thinking skills. However, time constraints make LoI less practical for high school biology classes. LoI can be integrated with the Reading, Questioning, and Answering (RQA) strategy to overcome this problem. Therefore, this study aimed to investigate the LoI and RQA integration (LoIRQA) impact on high school students' critical and creative thinking skills. This study employed a quasi-experimental design with three treatment groups: LoIRQA, LoI, and RQA. The study's population involved all eleventh-grade students at a public high school in Mojokerto, Indonesia. The sample was determined using a random sampling technique, and 144 students participated in this study. The research data were collected using an essay test and examined using the ANCOVA and LSD tests at a 5% significance level. On the critical thinking post-test, LoIRQA students achieved a higher mean score (79.972) than LoI students (77.315) or RQA students (73.071). Similarly, on the creative thinking post-test, LoIRQA students showed the highest mean score (83.195), followed by LoI students (78.528) and RQA students (73.471). These findings indicate that LoIRQA was more effective in enhancing' students' critical and creative thinking skills than LoI or RQA.

Keywords: critical thinking, creative thinking, levels of inquiry, reading, questioning, answering

INTRODUCTION

The advancement of science in the 21st century necessitates the development of competitive skills and knowledge among students (Istiyono et al., 2020). Researchers

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concur that education must shift from mere transfer of knowledge to using technology (Kalogiannakis & Papadakis, 2018) and higher-order thinking skills, such as computational thinking (Kalogiannakis & Papadakis, 2018; Lazarinis et al., 2022; Papadakis, 2019; Papadakis, 2021), collaboration (Boyraz, 2021), as well as critical and creative thinking skills. Learners need these skills to adapt to the ever-changing era (Ataizi & Donmez, 2020; Bialik & Fadel, 2015; Tsai, 2013).

Critical and creative thinking are vital in absorbing new information and manipulating answers to solve problems effectively (Tuzlukova & Usha-Prabhukanth, 2018). Individuals with critical and creative thinking skills can analyze and evaluate information and generate unique and distinct ideas. Critical thinking skills are essential for success in higher education and the workforce in the future (Smith & Szymanski, 2013). Various factors influence critical thinking, including desire and willingness, unique knowledge/material content, thinking skills and strategies for learning and applying material content, and criteria or standards for determining what to think, believe or do (Facione, 2011; Zane, 2013). In the field of education, critical thinking helps students improve their understanding of the material by evaluating the arguments in textbooks, journals, handouts, modules, teaching materials, summaries, bulletins, and the opinions of discussion partners, as well as the teacher's arguments in learning activities. Therefore, students must acquire critical thinking skills through education (Kan'An, 2018; Menggo et al., 2019).

Critical thinking complements creative thinking (Diyanni, 2016). Whole-minded thinkers generate new ideas innovatively and evaluate them analytically. When a person thinks creatively, they can create and apply new forms or transform something that already exists into something new (Greenstein, 2012). Research demonstrates that individuals use creative thinking to respond to objects, problems, conditions, or types of efforts made to solve a problem (Birgili, 2015). Creative thinking enables students to view a situation from various perspectives, allowing them to generate numerous ideas (Kutlu & Gökdere, 2015). Students can produce a new combination of two or more pre-existing concepts through creative thinking.

A nation's education system, economy, science and technology, behaviour, and habits will all be altered by developing students' critical and creative thinking skills (Bakry et al., 2019; Changwong et al., 2018; Talat & Chaudhry, 2014). Therefore, critical and creative thinking skills must be developed through student-centred learning, allowing students to think openly and flexibly, actively participate in discussions, and collaborate with peers. Students prove information through experimentation in student-centred learning environments

However, previous research shows that Indonesian students at different levels of education perform poorly in higher-order thinking skills (HOTS), especially critical and creative thinking (Fuad et al., 2017; Hamengkubuwono et al., 2022; Umam & Susandi, 2022). Even though teachers realize the importance of critical and creative thinking in the classroom, they struggle with developing their own HOTS (Friyatmi et al., 2020). Therefore, critical and creative thinking needs to be included in the school curriculum as they are indicators of the achievement of learning goals (Ren et al., 2020).

In addition to supporting the integration of critical and creative thinking into the classroom, teachers must focus on classroom approaches, models, and learning strategies to develop and improve students' cognitive abilities (Petek, 2018). One of the classroom approaches that can be used to achieve this goal is Inquiry-based learning (IBL). IBL is believed to facilitate the development of critical and creative thinking skills. Through IBL, students are also trained to develop problem-solving skills (Gholam, 2019; Wenning, 2005). Previous studies conclude that IBL can significantly enhance students' critical thinking skills (Azizmalayeri et al., 2012b, 2012a; Suryanti et al., 2018; Wale & Bishaw, 2020) and academic achievement in biology (Owolade et al., 2022).

Levels of Inquiry (LoI) is one of the inquiry-based learning models that can be implemented to promote critical and creative thinking in the classroom(Wenning, 2011). LoI enables students to conduct active learning-related investigations. It is founded on two factors: intellectual acuity and locus of control. The locus of control continuously shifts from teacher to student, beginning with discovery learning activities when the teacher controls the learning activities and decreasing and moving to students until hypothecated inquiry activities. Its application continues to increase from discovery learning to hypothetical inquiry. Students are expected to comprehensively understand the material through all scientific process abilities and critical thinking skills as they progress through the inquiry stages.

However, LoI requires extensive preparation and time. Teachers must be adept at questioning techniques to guide students in studying the subject matter. Therefore, LoI must be combined with other learning models, strategies, or methods capable of overcoming time constraints and students' lack of preparation for IBL. Reading, Questioning, and Answering (RQA) is the learning model that can address LoI's limitations. The RQA learning strategy accommodates reading, questioning, and answering tasks that can be completed in a constrained amount of time. The RQA strategy has also been shown to improve students' retention, metacognitive abilities, and the ability to formulate questions and answers(Amin et al., 2020; Arsad Bahri & Idris, 2018; Usman et al., 2021). The RQA learning process trains students' self-assessment because they are accustomed to reading. In RQA, students are taught how to consider the question plans that will be formulated and then ask questions according to the main idea of the material being studied (Hariyadi & Duran Corebima, 2019). Students are also encouraged to answer the questions and conduct class discussions to clarify misunderstandings.

RQA is expected to enhance students' critical and creative thinking abilities by providing them with a coherent thought foundation. The RQA syntax can reduce the time required to introduce students to the material and prepare them for the Interactive Demonstration level of inquiry. Integrating LoI and RQA, i.e., LoIRQA is anticipated to enhance students' critical and creative thinking skills.

Theoretical Background

Levels of Inquiry dan Reading Question Answering (LoIRQA)

LoIRQA is an active, student-centred learning model that combines the Levels of Inquiry and Reading, Questioning, and Answering (RQA) stages. It is a new learning model created and developed by our research team. Each learning activity in the LoI learning model and the RQA strategy can potentially improve students' higher-order thinking skills at all educational levels, from elementary to higher education.

The six levels of LoI provide a gradual progression of science process and critical thinking skills, from the most fundamental to the most advanced. Inquiry is derived from the verb inquire, which means to ask questions, seek information, and conduct investigations (Lott, 2011). Inquiry is an active investigation that employs critical, logical, and creative reasoning skills to pose and support intriguing individual questions (Llewellyn, 2014). Inquiry can serve two distinct purposes. Focusing on how students design and conduct scientific investigations is the first step. The second approach emphasizes learning activities that facilitate the mastery of scientific concepts through scientific inquiry. These two approaches illustrate the connection between learning science, learning to conduct science, and learning about science(Hodson, 2014).

Because the RQA strategy is based on constructivism, it can foster the development of students' higher-order thinking skills (Amin et al., 2020). In the RQA class, the reading phase involves preparing summaries, which can train students to master concepts. This stage is followed by a questioning phase in which students undergo cognitive acceptance (placing a concept on their cognitive framework) and are challenged (allowing the concept to have been formed in a closely related manner). Based on their reading comprehension, students must create and answer written questions. Fundamental reading-related questions are asked, and the number of questions should be proportional to the circumstances (approximately 3-4 items). All questions and answers are made independently and in writing. The final response phase encourages students to develop metacognitive skills by adapting multiple learning strategies to the task's demands (Arsad Bahri & Idris, 2018). In authentic assessment, questions and responses from each student are collected for assessment that will underpin the evaluation, in addition to numerous other assessments.

The LoIRQA syntax is designed to accommodate the gradual development of students' critical and creative thinking skills. When students are assigned to create a mind map summary during the reading phase, they indirectly sift through the learning material and determine which concepts interest them. Reading activities and mind mapping have enhanced students' critical and creative thinking (Polat & Aydın, 2020).

Critical Thinking

Critical thinking entails identifying a problem, considering its goals, generating potential solutions, assessing possible outcomes, implementing one of the solutions, and evaluating the results (Mendoza et al., 2020). Critical thinking is an essential life skill that functions effectively in every aspect of life (Galinsky & Gardner, 2016). Educators

have recognized the significance of critical thinking skills as one of the learning process outcomes because critical thinking is one of the many skills necessary to prepare students for education and the workplace (Joynes et al., 2019).

At least four processes—observation, experience, communication, and reading—are included in learning models that can improve critical thinking skills (Perdana et al., 2020). In addition, the tests used to evaluate critical thinking skills can be divided into topic-specific and general tests (applicable to all topics)(Ennis, 2013). The National Academy of Education Committee suggests developing subject-specific tests for higher-order thinking. Essay tests offer several benefits, including assessing higher-order thinking, such as critical and creative thinking skills, evaluating students' thinking and reasoning processes, and providing authentic experiences.

Creative Thinking

Creative thinking ability grows from the creativity of learners. Creative thinking is not what one knows but how one chooses to apply or process what one knows (Ratcliffe et al., 2022). Students must be trained in creative thinking because it enables them to view a problem from a variety of angles and to generate many ideas (Kutlu & Gökdere, 2015). Therefore, creativity needs to be developed in education (Wahyudi et al., 2019). According to the three sides of human intelligence theory, human intelligence consists of three dimensions: 1) analytical, 2) creative, and 3) practical. The analytical dimension is the ability to think abstractly and process information using problem-solving strategies such as comparing, evaluating, and analyzing. The creative dimension entails the capacity to deal with novel situations by incorporating novel solutions effectively. The practical dimension is the ability related to daily tasks, such as adjusting to or altering the environment and applying and utilizing information (Moreno & Park, 2010).

The development of students' creative thinking skills in learning, particularly in biology class, occurs after the interaction process in learning activities, in which students are encouraged to answer a variety of questions, solve a variety of life-related problems, and report the results of their performance. Teachers should provide opportunities for students to develop the ability to think freely, not limiting students' answers or how they solve problems in their environment, to foster creative thinking skills.

Research Objectives

Past studies have demonstrated that Levels of Inquiry can enhance students' critical and creative thinking skills. The LoI model is structured methodically to process students' comprehension effectively. However, implementing LoI in high school takes a considerable amount of time. Therefore, this study sought to integrate LoI with the RQA strategy, which is believed to train students' critical and creative thinking abilities.

This study aimed to examine (1) the effect of LoIRQA on eleventh graders' critical thinking skills and (2) the effect of LoIRQA on eleventh graders' creative thinking skills. The findings of this study are expected to contribute to science education as LoIRQA can be considered an alternative learning model to increase students' critical and creative thinking.

METHOD

This quasi-experimental study employed a non-equivalent pretest-post-test control group design (Cohen et al., 2017). This study's independent variables are the LoIRQA learning model implemented in the experimental class, the Level of Inquiry (LoI) learning model that served as the positive control, and the Reading Questioning and Answering (RQA) learning strategy that served as the negative control. In this study, the dependent variables included the pre-and post-test scores of students' critical and creative thinking skills. Table 1 displays the research design.

Table 1
The research design

Group	Pretest	Learning Model/Strategy	Post-test
X1	O1	Levels of Inquiry (LoI) integrated with Reading Questioning Answering (RQA)	O2
X2	O3	Levels of Inquiry (LoI)	O4
X3	O5	Reading, Questioning, and Answering (RQA)	O6

Remarks:
X1: the experimental group, learning with LoIRQA
X2: the positive control group, learning with LoI
X3: the negative control group, learning with RQA
O1, O3, O5 = pre-test score
O2, O4, O6 = post-test score

Research Population and Sample

The research population was all eleventh-grade students in the Natural Sciences program at a high school in Mojokerto, Indonesia. This study was conducted during the even semester of the academic year 2018-2019. There were 144 students used as samples. The sample was determined using a random sampling technique. Before deciding on the sample, a homogeneity test consisting of 40 multiple-choice questions covering the biology material taught in the first semester was administered. Analysis of variance (ANOVA) was utilized to conduct the test on the sample group. The students were separated into three treatment groups: LoIRQA, LoI, and RQA.

Research Instruments

The developed treatment instruments consisted of the syllabus, lesson plans, and student worksheets. The syllabus was created to guide lesson plans and student worksheets. Lesson plans organize learning activities based on the formulation of the syntax of the learning model that is calibrated to the desired standard value. Students used student worksheets as a guide during the learning process.

An essay test was used to evaluate students' critical and creative thinking abilities. An expert in biology education, an expert in learning models, and a biology teacher had validated the test. The expert validation process yielded a high content validity score (4.89). Then, the test was tested on a group of students whose characteristics resembled the sample. The results of the empirical validation showed that four out of eighteen test

items were invalid. Thus, the four items were excluded from the pretest and post-test. In addition, Cronbach's Alpha reliability test showed that the test items were valid with a score of 0.938. Students' responses to the critical thinking test were assessed using a rubric adapted from Zane (2013) containing four scales (1-4): (1) far below expectations, (2) below expectations, (3) according to expectations, and (4) exceed expectations. In the meantime, students' creative thinking skills were evaluated using a rubric adapted from Treffinger (2002) as implemented by Fuad et al. (2017). The rubric evaluates aspects of creative thinking, including fluency, originality, elaboration, adaptability, and metaphorical thinking.

Research Procedures

Before conducting the research activity, a meeting was held with partner teachers to discuss the learning tools and research instruments that would be used in the classroom. During the meeting, we shared perspectives on implementing the learning models (i.e., LoIRQA, LoI, and RQA). Table 2 shows the learning activities performed in the LoI, RQA, and LoIRQA classrooms.

Table 2
Learning activities in the LoI, RQA, and LoIRQA classrooms

No.	Models	Teacher Activities	Student Activities
Level of Inquiry (LoI)			
1	Discovery Learning	▪ Introduces a phenomenon based on experience ▪ Asks students to describe the stimulus based on what they see and other related phenomena	▪ Identifies and describes the phenomenon
2	Interactive Demonstration	▪ Demonstrates the phenomenon using realia	▪ Predicts the phenomenon being demonstrated
3	Inquiry Lesson	▪ Uses questions to guide students in experiments ▪ Encourages students to identify systems and variables that are going to be learned	▪ Identifies strategies and variables that are going to be learned
4	Inquiry labs	▪ Encourages students with the opportunity to design and execute an experiment plan	▪ Designs and executes an experiment plan
5	Real-world application	▪ Guides students in solving everyday life problems	▪ Uses prior knowledge to discuss problem-solving solutions in everyday life
6	Hypothetical inquiry	▪ Guides students to make hypotheses and test their hypotheses ▪ Direct students to carry out further testing of the hypotheses	▪ Uses prior knowledge to discuss hypotheses and predict the outcome of a given situation ▪ Plans the next investigation
Reading, Questioning, and Answering (RQA)			
1	Reading	▪ Asks students to read and make a summary of the material	▪ Reads and produces an overview of the material
2	Questioning	▪ Guides students to formulate questions from reading and make summaries	▪ Develops questions from the outline of the material

3	Answering	▪ Guides students to answer the questions independently	▪ Answer the questions independently
Level of Inquiry integrated Reading, Questioning, and Answering (LoIRQA)			
1	Reading	▪ Asks students to read at home before coming to the classroom	▪ Reads the material as directed by the teacher ▪ Writes a summary or mind map as a result of reading
2	Discovery Learning	▪ Introduces a phenomenon based on experience ▪ Asks students to describe the stimulus/phenomenon based on what they see and other related phenomena	▪ Identifies and describes the phenomenon
3	Interactive Demonstration /Questioning	▪ Demonstrates the phenomenon using realia ▪ Asks students to ask questions and predict the phenomenon	▪ Makes questions and signifies the phenomena being demonstrated ▪ Record the questions/predictions
4	Inquiry Lesson	▪ Uses questions to guide students to find the answers to the questions posed in the previous stage ▪ Encourages students to identify systems and variables that are going to be learned	▪ Finds the answers to the questions posed in the last stage ▪ Identifies strategies and variables that are going to be learned
5	Inquiry labs	▪ Encourages and provides students with the opportunity to design and execute an experiment plan	▪ Designs and executes an experiment plan
6	Answering	▪ Facilitates students to draw a conclusion ▪ Facilitates students to find the answers to the questions posed in the previous stage	▪ Draws a conclusion ▪ Answers the questions that have been prepared previously from the results of exploration and discuss them with their group members
7	Real-world application	▪ Guides students in solving everyday life problems	▪ Uses prior knowledge to discuss problem-solving solutions in everyday life
8	Hypothetical inquiry	▪ Guides students to make hypotheses and test their hypotheses ▪ Direct students to carry out further testing of the hypotheses	▪ Uses prior knowledge to discuss hypotheses and predict the outcome of a given situation ▪ Plans the next investigation

Data Analysis

The research data were analyzed with descriptive statistics, and hypotheses were tested with inferential statistics. The descriptive analysis revealed the mean scores on the pre- and post-tests, the difference between them, and the percentage increase in the students' critical and creative thinking skills. Analysis of covariance (ANCOVA) and the Least Significant Difference (LSD) test were used for parametric inferential analysis at a significance level of 5%. The tests of data normality and homogeneity of variance at a significance level of 0.05 preceded the ANCOVA test. Kolmogorov-Smirnov's test was used to confirm the normality of the data, while Levene's test was utilized to examine the homogeneity of the variance.

FINDINGS

The Normality and Homogeneity Tests Results

Before hypothesis testing, assumption tests consisting of normality and homogeneity tests of data were conducted. The normality of the data was evaluated using the One-Sample Kolmogorov-Smirnov test. The normality test results indicated that this study's critical thinking skills data had a normal distribution, with significance levels greater than 0.05 for both the pretest (0.540) and post-test (0.310) scores. Similarly, the pre-and post-test scores for creative thinking have a significance level greater than 0.05.

Levene's test was used to test the homogeneity of the variance. The test results indicated that the significance values for the pretest and post-test data for critical thinking skills were more significant than 0.05. In contrast, the data for creative thinking skills were less than 0.05. According to these results, the research data for critical thinking skills were homogeneous, whereas the pre-and post-test data for creative thinking skills were not homogeneous.

The Effect of the LoIRQA Learning Model on Students' Critical Thinking Skills

Table 3 demonstrates the impact of the learning model on students' critical thinking skills, measured statistically. The ANCOVA test result revealed a $F_{calculated}$ value of 22.928 with a significance level of $0.000 < 0.05$. This result suggests rejecting H_0 and accepting the research hypothesis, which states that the learning model influences students' critical thinking skills.

Table 3
The results of the one-way ANCOVA on the learning model effect on students' critical thinking skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1270.867	3	423.622	16.466	0.000
Intercept	11569.674	1	11569.674	449.702	0.000
Pre_Critical	398.495	1	398.495	15.489	0.000
Treatment Group	1179.762	2	589.881	22.928	0.000
Error	2675.653	104	25.727		
Total	640727.596	108			
Corrected Total	3946.520	107			

Table 4 displays the results of the LSD test at a significance level of 0.05. The results of the LSD test indicate that the mean score for critical thinking skills in the LoIRQA class is significantly higher than in the LoI or RQA classes. The LoIRQA class experienced a 65.175% increase in critical thinking scores.

Table 4
The results of the LSD test on students' critical thinking skills

No	Group	Score		Mean	Notation LSD	Increase (%)
		Pretest	Post-test			
1.	LoIRQA	48.417	79.972	80.503	a	65.175
2.	LoI	48.881	77.315	77.738	b	58.170
3.	RQA	54.746	73.071	72.118	c	33.473

The Effect of the LoIRQA Learning Model on Students' Creative Thinking Skills

Table 5 shows the impact of the learning model on students' creative thinking skills, measured statistically. The ANCOVA test result revealed a $F_{calculated}$ value of 19.021 with a significance level of 0.000 < 0.05. This result suggests rejecting H_0 and accepting the research hypothesis, which states that the learning model affects students' creative thinking skills.

Table 5
The results of the One-Way ANCOVA on the learning model effect on students' creative thinking skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1935.417	3	645.139	25.925	0.000
Intercept	8129.554	1	8129.554	326.686	0.000
Pre_Creative	213.054	1	213.054	8.562	0.004
Treatment group	946.657	2	473.329	19.021	0.000
Error	2588.034	104	24.885		
Total	668011.718	108			
Corrected Total	4523.451	107			

Table 6 presents the results of the LSD test at a significance level of 0.05. The results of the LSD test indicate that the mean score for creative thinking skills in the LoIRQA class differs significantly from the mean scores reported by the LoI or RQA groups. The LoIRQA class experienced a 50.167% increase in creative thinking scores.

Table 6
The results of the LSD test on students' creative thinking skills

No	Group	Score		Mean	Notation LSD	Increase (%)
		Pretest	Post-test			
1.	LoIRQA	55.402	83.195	82.511	a	50.167
2.	LoI	53.859	78.528	78.165	b	45.802
3.	RQA	47.083	73.417	74.463	c	55.929

The one-way ANCOVA revealed that the mean scores of students' critical (mean = 80.503) and creative (82.511) thinking in the LoIRQA group were significantly different from the mean scores of students' critical (78.165) and creative thinking (77.738) in the LoI class and the RQA class (74.463 and 72.118, respectively). Therefore, it can be concluded that the LoIRQA model has the potential to enhance high school students' critical and creative thinking skills.

DISCUSSION

The findings indicated that the learning models affected high school students studying biology's critical and creative thinking skills. The results of the LSD test confirmed the hypothesis that the LolRQA learning model was more effective than the LoI and RQA learning models at improving students' critical and creative thinking skills. The LoIRQA model was able to significantly develop students' critical and creative thinking skills

because students were encouraged to learn using the following steps: 1) Reading, 2) Discovery Learning, 3) Interactive Demonstration and Questioning, 4) Inquiry Lesson, 5) Inquiry Laboratory, 6) Answering, 7) Real World Application, dan 8) Hypothetical Inquiry. The following sections describe how each stage of LoIRQA enhances students' critical and creative thinking skills.

Before engaging in classroom learning, students are asked to read to investigate various relevant references. *Reading* helps students in the mental and cognitive processes necessary to comprehend written language. The results of reading presented as a summary or mind map can stimulate critical thinking in students (Polat & Aydın, 2020). Reading activities encourage creative and interpretative reasoning and improve students' literal comprehension (Wang, 2012).

Following the *Reading* stage, students are introduced to *Discovery Learning*. Discovery Learning incorporates the experiential development of conceptual comprehension. This level assesses students' abilities to develop concepts based on direct experience and recognize scientific terms related to previously studied concepts (Perdana et al., 2019). Additionally, Discovery Learning encourages students to construct new knowledge and utilize their creativity to solve complex problems (Gibson et al., 2018).

The third stage in LoIRQA is *Interactive Demonstration and Questioning*. Following knowledge construction in the reading and discovery learning phases, students are trained to compose and ask questions at this level. Posing questions is essential to constructivist learning (Hariyadi et al., 2018). Students with trouble communicating ideas, thoughts, and questions should benefit from questioning exercises. Students' creative thinking skills are also enhanced by asking questions (Glăveanu, 2018; Wolska-Długosz, 2015).

Before responding to questions formulated during the Interactive Demonstration stage, students complete the *Inquiry Lesson* and *Inquiry Laboratory* stages. The Inquiry Lesson guides students in locating answers to previously posed questions. However, during the Inquiry Laboratory phase, students can identify scientific principles and their relationships through guided inquiry (R. Perdana et al., 2019). In addition, they can establish empirical laws based on the measurement of variables (Wenning, 2011). These two stages refer to the level of independence in developing and executing experimental plans and collecting data, which are then analyzed to determine the correct law or relationship between variables.

In addition, during the *Answering* stage, students are trained to answer questions correctly. At this point, students are also encouraged to engage in reflective thought, an element of critical thinking skills (Demir, 2015; Stanton et al., 2011). The answering process can encourage students to think creatively, be faster at generating and organizing high-quality ideas, and be willing to view problems from multiple perspectives (Runco & Jaeger, 2012).

Real-World application is the sixth phase. At this level, students are expected to be able to develop everyday problem-solving skills (Bybee, R., & McCrae, 2011). The final phase of the LoIRQA is the *Hypothetical Inquiry*. This learning stage emphasizes

students' active participation in solving real-world problems, developing hypotheses from data, and then providing logical explanations to support the hypotheses (Hardianti & Kuswanto, 2017).

Investigation processes, Inquiry lessons, Inquiry Laboratories, Real World Applications, and Hypothetical Inquiry can indirectly shape students' critical and creative thinking abilities. Group discussion facilitated by each stage mentioned above provides students with opportunities to develop their worldview (Apino & Retnawati, 2017; Foo & Quek, 2019). At this stage, social interaction reflected in feedback is required. Students must also strengthen their thinking abilities by grasping the essence of others so that the ideas and concepts communicated become more focused.

When implemented sequentially and methodically, each stage of the LoI learning model can enhance students' critical and creative thinking skills (Dobber et al., 2017; Saregar et al., 2018). With Reading, Questioning, and Answering incorporated into the LoI, the learning process can be time-efficient. Based on previous research (Amin et al., 2020; Fuad et al., 2017; Wenno et al., 2021), the application of constructivism-based innovative learning models can enhance the critical and creative thinking abilities of Indonesian students.

This study was limited to investigating the effect of LoIRQA on eleventh graders' critical and creative thinking skills. Still, it could be extended to other levels of education, such as university students. We found several obstacles during this study's implementation of the LoIRQA model. Students required some time to implement LoIRQA in the learning process, as the model's syntax is relatively lengthy. Therefore, future researchers should consider adjusting the LoIRQA model's syntax to the duration of learning in the classroom. Besides, seating arrangements in conventional classrooms are not designed for collaborative learning. Therefore, future researchers must confirm this finding by implementing LoIRQA in a collaboratively-set classroom.

CONCLUSION

Critical and creative thinking skills are necessary for students to engage in learning activities and face current life challenges. It has been demonstrated that the Inquiry-based learning models, which include the Levels of Inquiry (LoI), can enhance students' critical and creative thinking. Unfortunately, the limited classroom time hinders the effectiveness of each stage of the LoI in fostering critical and creative thinking in students. Therefore, home-based reading activities introduced in RQA can compensate for the deficiencies of inquiry-based learning. Through ANOVA and LSD tests, this study proved that the LoIRQA learning model significantly affected the eleventh-grade students' critical and creative thinking skills in Indonesia. The findings of this study, thus, suggest that LoIRQA can be implemented in science classrooms to improve the quality of science education.

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