Enhancing Students' Biology-Critical Thinking Skill through CIRC-Based Scientific Approach (Cirsa)

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Abstract Critical thinking skills are referred to as one of the 21st-century skills. These skills should be empowered through Biology learning. This study aims to analyze the improvement of biology-critical thinking skills in students who are taught through the CIRC learning model based on the scientific approach (Cirsa). Critical thinking skills are measured by tests developed by researchers and validated by theoretical biologists. The instrument includes indicators of critical thinking skills such as formulating problems, giving arguments, making deductions, conducting inductions, conducting evaluations, and deciding and implementing. This study used a quasi-experimental method with a pretest-posttest non-equivalent control group design. This study involved 160 students (M = 95, F = 65) of 8th grade of a Madrasah Tsanawiyah School in Bogor. The findings of this study show that students who are taught by Cirsa have higher Biology-critical thinking skills than those by conventional learning. In conclusion, Cirsa learning was recommended to develop or enhance students' critical thinking skills related to biological concepts.

Keywords Biology, Circ, Cirsa, Critical Thinking, Scientific Approach

1. Introduction

Biology education, especially in anatomy and physiology learning, is essential in developing scientific knowledge among students [1,2]. Anatomy and physiology are knowledge related to constituent organs and their function for an organism, including the work mechanism process [3,4]. Excretion and respiratory system learned at secondary school level refers to human physiology science [3,5,6]. The 2013 Curriculum applied in Indonesia includes topics on constituent organs and their functions, work mechanism, and disruptions occurred in an organism

[7–10].

Studying biology should not merely focus on knowledge related to the curriculum components. However, it should be able to empower a variety of thinking skills required by learners [11,12]. As human beings living in the 21st century, learners must be equipped with four skills, namely collaboration, communication, creative thinking, and critical thinking [7,13–15]. The research focuses on critical thinking skill empowerment. Various studies that empower critical thinking skills in Biology learning include [12,16–19]. It is proof that critical thinking skills are empowered through Biology learning.

Students with excellent critical thinking skills are more sensitive to social, scientific, and practical problems [20,21]. Critical thinking could also assist in determining careful assessment in decision making and solving daily-life biology problems [19,22]. Critical thinking implementation in Biology learning provides an opportunity to develop analytic, inductive, and deductive thinking skills to solve fundamental event-related problems [21,23].

Students with good critical thinking skills in a learning environment could provide favorable implications in terms of cultivating an attitude of self-confidence by considering self as a person who can give benefits by becoming an active contributor in the learning process [24,25]. Critical thinking skills in Biology learning could be developed through cooperative learning [16,26] emphasizing on reading activities [7,21] and scientific approach-oriented activities [20,23,27]. Scientific approach gives opportunity to students to discuss with others to make analysis of the natural phenomena and try to evaluate and solve problem, so this can improve critical thinking [13,14].

The scientific approach is recommended in the 2013 Curriculum in Indonesia [7,28,29]. Indonesian educational process standard states that learning is conducted by selecting a scientific approach adjusted to competence characteristics and level of education. Several activities in the scientific approach include observing, asking, trying,

reasoning, and communicating [7,30].

The obstacle in Biology learning in the 2013 Curriculum is that not all learning models accommodate those activities. A scientific approach-based Cooperative Integrated Reading and Composition (CIRC) or known as Cirsra has been developed [7]. Research results indicate that Cirsra learning has been stated as valid and effective to be applied in Biology learning and has potential to empower 21st-century skills [7,8].

Cirsra, as one of cooperative learning manifestation, is believed to be capable of empowering students to participate in learning process [31,32] actively. The activity could be skills in decision making, evaluating, and commenting to one another so as it could enhance critical thinking skills [33–35]. CIRC is a student-centered learning design focusing on critical study assignments on reading and presenting the result through class presentation [31,32]. The learning has proven to be able to improve critical thinking skills on motions in plants [36].

Many other studies on critical thinking skills have been conducted, for example, on students' critical thinking ability profiles [37–39]. Additionally, the implementation of various learning models has an impact on the increase in students' critical thinking ability [38,40]. In science learning, critical thinking ability has mainly been studied in school as well as college levels [41,42]. None of those studies, however, is related to Cirsra model implementation that impacts students' critical thinking ability in human excretion and respiratory systems contents. Therefore, the current research aims to know the influence of Cirsra learning model on critical thinking skills on human excretion and respiratory systems.

2. Methods

The research was a quasi-experiment using pretest-posttest non-equivalent control group design. The independent variables included learning models that consisted of CIRC, Cirsra, and conventional learning. Conventional learning is a learning design commonly implemented [43]. Thus it was used as a control in the research. The dependent variable was critical thinking skills on human excretion and respiratory systems. The research design is presented in Table 1.

Table 1. Research Design of the Randomized Pretest- Posttest Control Group

Pretest	Treatment	Posttest
T ₁	X ₁	T ₂
T ₃	X ₂	T ₄
T ₅	X ₃	T ₆

Note: T_{1,3} = Pretest; T_{2,4} = Posttest; X₁ = CIRSRA learning; X₂ = CIRC learning; X₃ = Conventional learning

The research population were all eight grade students at a Madrasah (junior high school) in Bogor Regency. Samples included 160 students taught on human excretion and respiratory systems. The sample was determined using random sampling technique preceded by the equality test of 10 classes. Random sampling was conducted by randomly selecting three classes. Each class received a similar learning opportunity yet different treatment based on the developed learning design. Each research group represented one class, which was class using CIRC, Cirsra, and conventional learning model.

Instruments used in the research had been stated as valid and reliable in terms of construct, content, and empirical according to Ratumanan [29]. The independent variable instruments consisted of syllabus, lesson plan, and students' worksheet developed, referring to the learning syntax of CIRC, Cirsra, and conventional worksheets. The learning was observed using learning implementation sheet. The dependent variable instruments were in the form of essay test questions on critical thinking skills on human excretion and respiratory systems. The questions of Biology-Critical thinking were developed adapted from Ennis [37], and also referring to the basic competences in the 2013 Curriculum. The learning objectives are presented in Table 2. In its implementation, the learners were given a set of critical thinking skill questions on human excretion and respiratory systems to be solved independently for 50 minutes.

Table 2. Learning objectives of human excretion system and respiratory system

Biology content concept	Learning indicators
Excretion system	Analyze organs contained in the human excretion system
	Analyze the excretion system structure and functions
	Evaluate disruptions occurred in the excretion system
	Develop ideas in maintaining the health of the excretion system
Respiratory system	Analyze the respiratory system organs
	Analyze respiration mechanism
	Evaluate disruptions in the respiratory system
	Provide arguments on maintaining the respiratory system health

The research data obtained were analyzed using descriptive statistics of average scores, deviation standard, and minimum and maximum values in each class. Hypothesis prerequisite tests included the normality test in the form of one-sample Kolmogorov-Smirnov test and homogeneity test using Levene's Test of Equality of Error Variance. The hypothesis testing was done using Ancova technique. All the data analysis techniques were conducted using statistical analysis application of SPSS 24.0 for Mac using significance level of 0.5%.

3. Result and Discussion

The research aimed to find out the influence of CIRC and Cirsa learning models on critical thinking skills on human excretion and respiratory systems. The descriptive data measurement results on pretest and posttest in the form of critical thinking skill scores are indicated in Table 3.

Table 3. Descriptive Data in Each Research Class

Learning Variable	Average and Category			
	Pretest	Category	Posttest	Category
CIRSA Model	57,38	Less	83,36	Good
CIRC Model	53,01	Less	72,49	Good
Conventional Learning	55,89	Less	69,66	Less

Based on Table 3, it can be seen that after the learning process on human excretion and respiratory systems through Cirsa learning model, the critical thinking average was the highest compared to those through CIRC and conventional learning model. The Cirsa and CIRC learning models, according to the posttest scores, were learning models with good categories. The normality and homogeneity tests on the critical thinking skill data had been conducted before the hypothesis testing, and the results are described in Table 4.

Table 4. Summary of data analysis prerequisite test results

Test	Sig.	α	Description
Normality	0.112	0.05	Normal
Homogeneity	0.220	0.05	Homogeneous

Based on Table 4, it can be inferred that critical thinking skill data had sig. values (level) in the normality and homogeneity tests that were greater than the alpha; thus, the data have not deviated from the normal distribution data, and the variance between the critical thinking data was not different or homogeneous.

Table 5. Ancova Test of the Influence of Learning Models on Critical Thinking

Source	type iii sum of squares	df	mean square	f	sig.
corrected model	12598.0 ^a	2	6299.0	111.8	.000
intercept	16048.2	1	16048.2	284.9	.000
Pretest	764.4	1	764.4	13.5	.000
learning model	11857.5	1	11857.5	210.5	.000
Error	8842.3	157	56.3		
total	1015266.0	160			
corrected total	21440.3	159			
a. r squared = .588 (adjusted r squared = .582)					

The ancova test was performed to proof the research hypothesis. The test, as indicated in Table 5, was resulted from sig. value = 0.000, which was less than alpha of 0.05. It could be inferred that there was an influence of learning models on critical thinking. The explanation is that the learning model applied in the excretion and respiratory systems learning on students of Madrasah influenced critical thinking skills. The post hoc test result (Table 6) shows that Biology learning through Cirsa was proven better than those through CIRC and conventional learning models. Critical thinking skill is related to one's cognitive development stage [44]. Madrasah students were at the formal operational level where an individual could think logically on abstract propositions and could formulate hypothesis and test them systematically.

Table 6. Summary of LSD Test Result on Critical Thinking

(I) Learning Model	(J) Learning Model	Sig.
Cirsa	CIRC	.000
	Conventional	.000
CIRC	Cirsa	.000
	Conventional	.080
Conventional	Cirsa	.000
	CIRC	.080

The research findings could be examined according to the applied learning model potentials. Critical thinking is related to a well-organized mental process. It plays a role in the decision-making process to solve problems by analyzing and interpreting data in scientific inquiry activities [45–47]. Those activities are part of a scientific approach. The conventional and CIRC learning models, however, have not accommodated activities that support those activities. Cirsa learning model, on the contrary, is CIRC learning model in the form of reading and writing activities integrated using scientific approach.

Based on one's skill related to critical thinking development and its association with cognitive development according to Piaget, Madrasah students should have entered the critical thinking skill development stage [44]. One effort to accelerate one's cognitive development is by involving and providing an environment suitable for the cognitive stage. This method could train learners to conduct investigation independently to solve problems, propose a solution, and compare their findings to others' [13,48]. The condition is following Cirsa learning model syntax that after the learners were given with assignments of analyzing contextual excretion and respiratory system contents and investigating the content from various sources where they had a responsibility to create a complete conclusion and problems occurred were written on the students' worksheet and presented during a discussion to be solved together.

Critical thinking ability intended in the research was a mental process consisting of ability to interpret, analyze,

evaluate, conclude, communicate, and self-regulation. Thinking requires logical and analytical reasoning and indicates high-level critical thinking skills [49]. Further, theoretically and if related to Bloom's taxonomy, critical thinking skills that inherent to the high-level are analysis and synthesis. Technically, critical thinking comprises: understanding argumentation, recognizing false thinking, differentiating premise with the conclusion, separating issues with information [18,50].

Familiarizing students to think critically should also be a conscious and planned effort [23,25,26]; thus, in the learning process of implementation, teachers bear responsibilities to integrate model to be used to critical thinking empowerment appropriately. Cirsa learning model contains study habituation that allows students' critical thinking empowerment by compiling questions, answering, and discussing answers through cooperative learning [8]. The cooperative-based activities are capable of training learners to ask and make questions; hence, critical thinking skills are well developed [33,34]. The link between Cirsa learning syntax and the critical thinking skill indicator is indicated in Table 7.

In the Cirsa learning model conducted cooperatively, learners are required to cooperate in a small group to discuss, analyze to understand and solve a variety of problems and encourage learners to communicate and exchange ideas; thus, it has potential for critical thinking ability empowerment. One of the essential elements in cooperative learning is the occurrence of social skill learning concerning leadership learning, decision making, building trust, communication, and handling problems together[31,32,51]. In cooperative work, providing learners with an opportunity to think with their peers and

conduct discussion makes the thinking process becomes open to all learners. Training students to think critically through problem analysis method repeatedly helps students to master complex contents as well as empowers the critical thinking ability [52,53].

Biology learning through Cirsa is helpful for students to enhance critical thinking abilities. The use of Cirsa was suitable for Biology topics that require abilities to solve problems, such as topics on organ systems, genetics, ecosystem, and environment. In its implementation, Cirsa could be used in every face to face meeting or on a scheduled basis. The implementation of a model must consider students' characteristics [54–56]. It is related to a concern that if students who are taught using the Cirsa model have no sufficient basic ability, they will not be able to follow the learning. Hence, analysis is required as well as an observation of students' characteristics before the implementation of Cirsa in the classroom.

The effectiveness of Cirsa usage also depends on the number of students. In a class with a large number of students, such as >50 students in a classroom, it seems to be less effective since to train critical thinking ability demands discussion and question and answer process from every student. The Cirsa model would be difficult to implement in a large number of students since students will tend to be passive. Also, there is time limitation regarding discussion process where large number of students require a more extended time. Therefore, the Cirsa model should be implemented in a class with number of students in a range of 20-35 students. A small number of students results in better discussion, and students tend to be active in question and answer [57–59].

Table 7. Link between Cirsa learning syntax and critical thinking skills

CIRC Syntax	Learning Activities		
	Student Activities	Scientific Approach	Critical Thinking Skills
Stage 1. Group division.	1. Listening to the explanation from the teacher and the steps of learning. 2. Formulating learning objectives. 3. Link the excretion and respiratory system to be studied with the previous concepts. 4. Form heterogeneous groups (4-5 students).	Observe	<i>Self-regulation</i>
Stage 2. Reading Discussion Finding the main concepts.	1. Exploring reading material or articles about the system of excretion and breathing from various sources (internet and books). 2. Reading, discussing with friends and understanding reading about the system of excretion and respiratory. 3. Finding facts, articles' main concept of the system of excretion and respiratory, and re-write them on the students worksheet.	Exploration Exploration Association, Ask	Analyzing, Intepreting, Concluding
Stage 3 Group presentation.	1. Present the results of reading analysis and discussion about the system of excretion and respiration, and continued with class discussion.	Communicate	Communication, Self-regulation

Note: Critical thinking indicators refers to Ennis [37], and learning activities adapted from Djamahar, et al., [7]

Cirsa is an innovation in Biology learning. It can be implemented broadly at various levels, although the current research was limited to the secondary school level. Its usage is deemed suitable for primary school level since students' critical thinking skills begin to be trained at this level. It is related to changes in learning paradigms that lead more toward contextual matters. Moreover, the 21st-century demand requires students to have high-level critical thinking ability. Thus, they could compete and adapt well with technology advancement [60–62]. At the college level, the Cirsa could also be applied since not all students have excellent critical thinking abilities. The Cirsa could be applied in, for example, college biology learning, such as in physiology, genetics and ecology courses.

The next step of the research was developing various Cirsa-based media. It aimed to integrate learning media with Cirsa model. A model that has integrated into Cirsa learning would facilitate teachers to apply both. As a consequence, teachers are no longer having difficulties in selecting suitable media to be applied to the Cirsa model. In addition to the development of Cirsa model-integrated media for students, a more general Cirsa-based media could be developed across disciplines. It, indeed, would require cooperation from various parties besides researchers and Biology teachers. Additionally, the use of Cirsa must be conducted consistently. It is due to the students' critical thinking ability enhancement that will grow if it is treated with a suitable learning model and is given consistently, and support with other learning media[40,63-67].

4. Conclusions

Based on the research findings, it can be inferred that the Cirsa learning model has proven to be more effective in enhancing critical thinking skills on human excretion and respiratory system. The influence of Cirsa learning on critical thinking skills was affected by the CIRC learning syntax that gave emphasize on group learning process to discuss and read contents related to human excretion and respiratory system based on scientific approach. The research results can be used as recommendations to empower critical thinking skills in Biology learning and support previous research findings [8]. Moreover, it is expected that Cirsa learning model could be implemented in a larger population and sample to strengthen the research findings. Also, further researches could consider analyzing the relationship between the mastery of biological concepts, metacognitive, and critical thinking skills after the implementation of Cirsa learning model.

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