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SIRI Learning Model in Empowering Biology Students' Critical Thinking

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Abstract: This research aims to investigate the influence of the SIRI learning model, namely learning based on integrated problem solving in Indonesian Siri' culture in improving the critical thinking skills of biology students. This experimental research was conducted with a pretest-posttest nonequivalent control group design and involved 109 biology students at Universitas Negeri Makassar, Universitas Pendidikan Mandalika, and Universitas PGRI Sumatera Barat, Indonesia. Data was collected using a critical thinking skills essay test. A critical thinking skills rubric was used to assess student answers and the results were analyzed using ANCOVA at a significance level of 0.05. Research findings show that there is an influence of the SIRI learning model on the critical thinking skills of biology students. The LSD test results show that the critical thinking skills of the SIRI class are significantly different from those of the PBL class and conventional class. It was concluded that the SIRI learning model could improve biology students' critical thinking skills.

Keywords: Conventional; Critical Thinking; Learning Models; PBL; SIRI

Introduction

The 21st century education requires educators to prepare a generation that is ready and adaptive to respond to all demands, such as being able to analyze well, formulate questions, and find answers. This change in the concept of education was also followed by changes in biology learning (Glaze, 2018; Sudjimat et al., 2020). Biology learning today is not just memorizing facts, concepts or theories, but active learning involving thinking for problem solving, so that it requires prospective biology teachers to have skills. One of the skills that prospective biology teachers need to have is critical thinking skills.

Critical thinking skills are thinking skills that center on the ability to research assumptions, evaluate and review conclusions (Din, 2020; Firdaus et al., 2015; Garvey, 2020). Critical thinking skills include high-level thinking that leads to problem solving and decision making, and are important and beneficial for every individual, especially in the field of education (Abdurrahman et al., 2019; Khoroshikh et al., 2018). Critical thinking skills are important to train and empower because they describe other skills, such as communication and information skills, the ability to examine, analyze, interpret and evaluate evidence (Azizi & Herman, 2020; Mahanal et al., 2016). Prospective biology teachers with good critical thinking skills will be able to guide their students to develop critical thinking, deeper analytical abilities, and other skills, so that they are trained to solve problems and achieve learning success (Fatmawati et al., 2019; Setyoningsih, 2018).

However, facts on the ground show that students' critical thinking skills in Indonesia are relatively low. This is in line with the results of questionnaires at the end of 2022 for students at three universities, namely, Universitas Negeri Makassar (UNM), Universitas Pendidikan Mandalika (UNDIKMA), and Universitas

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PGRI Sumatera Barat (UPGRISBA), data obtained from 75.14% of 150 student respondents thought that the formation of students' critical thinking skills was difficult. Apart from that, several studies have also found that in recent years, the reasoning skills of Indonesian students have decreased, including Biology students.

Students' low critical thinking skills are caused by various reasons, one of which is complex material and foreign terms that are difficult to learn. There are many physiological processes that are difficult to understand, making it difficult for students to learn them. In fact, biology lectures are often considered difficult by students because the material concepts are fairly abstract, as a result of which students are not able to conceptually describe their ideas or understanding of the topics discussed (Munawwaroh et al., 2018). Apart from that, the lack of appropriate strategies by educators in teaching is one of the factors in students' low levels of critical thinking (Susanto & Lestari, 2020). However, the main cause of the low critical thinking skills of biology students and the emergence of problems in the learning process is because the learning model used has not been able to overcome the problems that exist in biology lectures (Jamaluddin et al., 2021b; Wajdi et al., 2022). The model used only focuses on low-level thinking processes, not high-level thinking so that the memorization process occurs more dominantly in lectures.

Students' critical thinking skills can be trained with questions that are contextual or related to everyday life so that they can be solved (Sudarmika et al., 2020). In addition, critical thinking skills can be maximized if you use a learning model containing investigative learning stages. The impact of investigation-based learning will shape students' critical thinking so that students are more skilled in solving problems (answering questions), understand concepts better, and have high self-confidence (Nugraha & Rachmadiarti, 2022; Ulger, 2018).

Several studies have used learning models to develop students' critical thinking, but this research has not succeeded in shaping students' critical thinking well. such as in Dafrita and Nawawi's research regarding the effectiveness of the STEM-based Inquiry learning model, the CIRC-based Scientific approach model (Cirsa), and the POGIL learning model on students' critical thinking skills in the biology learning context. In addition, research by Noordegraaf-Eelens (2019), which investigated improving students' critical thinking skills through PBL integrated with mind mapping also did not show maximum results. This research found that the learning process in biology classes does not encourage students to think critically, resulting in low learning outcomes (Bachtiar et al., 2018). These findings highlight the importance of implementing innovative learning models that have sales value in forming and improving the critical thinking skills of biology students (Al-rahmi & Zeki, 2017; Carrió et al., 2022).

One model that has zerovelty whose syntactic stages have distinctive characteristics in forming critical thinking is the SIRI learning model. The SIRI model has 4 main stages such as stimulation, investigation, review, and inference (Jamaluddin et al., 2023). The main characteristic of the SIRI model is PBL and culture-based learning which can encourage students' attitudes to always learn optimally. These four stages can lead students' thinking processes to become more focused and meaningful. According to Jamaluddin, the SIRI model can not only shape thinking skills, but can also provide further benefits in learning, such as building student character or morals.

Based on the description that has been explained, the positive values contained in the SIRI learning model are expected to be able to overcome problems in the formation of critical thinking skills in biology students. Therefore, the effort made to overcome the problem is to apply the SIRI learning model to empower biology students' critical thinking skills. The research hypothesis is that the SIRI learning model has the potential to improve the critical thinking skills of biology students.

Method

Type of the Study

This study used a pretest-post-test non-equivalent control group design (Cohen et al., 2011). There were three treatment groups in this study, namely the experimental group, positive control and negative control. The experimental group was taught using the SIRI learning model (Figure 1), the positive control group was taught using the PBL model and the negative control group was taught without using a special learning model (Conventional). The research design is presented in Table 1.

Figure 1. SIRI Model Syntax

Table 1. Design of the study

Pre	Model	Post
O1	SIRI	O2
O3	PBL	O4
O5	Conventional	O6

Population and Sample

The population of this research is all biology education students class of 2021 at UNM, UNDIKMA, and UPGRISBA in the 2022/2023 academic year. Meanwhile, the sample in this study was 38 students in the SIRI (UNM) class, 36 students in the PBL class (UNDIKMA) and 35 students in the class which had an Animal Physiology course with an age range of 18-19 years. Sample determination was carried out by random sampling. All class samples used are equivalent classes based on an equality test using a data grouping test.

Learning Procedures

Each class, namely SIRI, PBL and Conventional (direct learning) receives different treatment in the learning process. The learning stages carried out in the SIRI class consist of stimulation, investigation, review and inference stages. Apart from that, each stage of the SIRI learning model is embedded with Makassar Bugis cultural values in oral and written form. In PBL classes, the learning process consists of presenting problems, organizing groups, searching for information, group discussions, preparing solutions, presenting solutions, and reflecting.

The learning process carried out in conventional classes (direct learning) is mostly dominated by discussion and question and answer sessions. In conventional classes, lecturers direct students to present material and hold discussion and question and answer sessions for them. At the end of the lesson, the lecturer provides reinforcement and students listen carefully to the lecturer's information. Finally, together the lecturer and students closed the lecture. In conclusion, in Conventional (Direct Learning) classes, the role of the lecturer is more active or dominant than the students.

Instruments of the Study

This research data was collected using syllabi, lesson plans, student worksheets, and instruments to measure critical thinking skills. The research instrument consists of an essay test and assessment rubric. The test contains 15 questions about Animal Physiology which have been categorized as valid with a validity value of 0.433-0.591 and reliable with a value of 0.811-0.853, while a rubric is used to assess students' answers to the questions. The scoring rubric for critical thinking skills refers to Finken and Ennis (2001) with critical thinking indicators (FRISCO) consisting of focus, reason, inference, situation, clarity and overview which has been modified and developed by Zubaidah et al., (2018) with a reliability value of 0.905.

Prior to data collection, all instruments underwent expert validation. Five lecturers validated lesson plans, student worksheets, and critical thinking skills rubrics with expertise in biology lessons. The results show that the syllabus, lesson plans, student worksheets, and critical thinking skills rubric are categorized as valid with scores (respectively: 4.56, 4.63, 4.55, and 4.51).

Data Analysis

Critical thinking skills data were analyzed using Analysis of Covariance (ANCOVA) and the Least Significant Difference (LSD) test with SPSS for Windows version 22.0. Before analysis, normality and homogeneity of data were checked. The normality test was carried out using the Kolmogorov-Smirnov One Sample Test, and the homogeneity test was carried out using Levene's Test. After that, ANCOVA and LSD tests were run to investigate the effects of the SIRI learning model on students' critical thinking skills. The LSD test was carried out to investigate the level of significance of the significant learning model.

Result and Discussion

The Results of the Normality Test and Homogeneity Test of the Students' Critical Thinking Skills

The normality test shows the results that the critical thinking skills data is normally and homogeneously distributed as presented in Table 2.

Tabel 2. The Results of the Normality and Homogeneity Tests of the Students' Critical Thinking Skills Skills

Treatment Group	N	Normality	Homogeneity
Critical thinking pretest	109	0.70	0.29
Critical thinking post-test	109	0.53	0.21

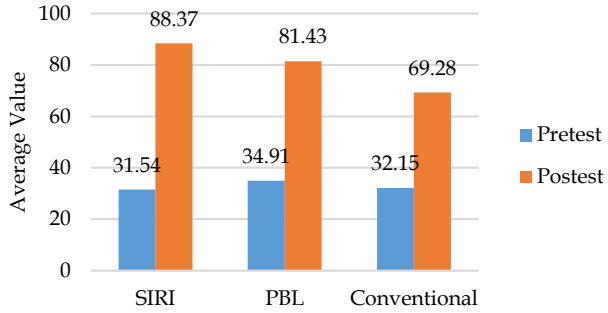

Figure 2. Mean Critical Thinking Score in Three Learning Models

The results of the Ancova test on differences in students' mastery of concepts in the SIRI, PBL and conventional learning models are presented in Table 3.

Table 3. Ancova Test Results of the Influence of Learning Models on Students' Critical Thinking

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1931.723[a]	3	678.152	417.467	.000
Intercept	15816.942	1	14897.822	7831.732	.000
Tes Awal	735.708	1	702.911	329.364	.003
Model	893.354	2	484.335	262.906	.000
Error	182.793	105	1.792		
Total	670233.791	107			
Corrected Total	2203.602	109			

Based on the summary of the Ancova test results in Table 3, it can be seen that the p-value = 0.000. p-value < α (α = 0.05). Thus, H1 which states that there is an influence of the learning model on students' critical thinking skills is accepted. This means that there is an influence of the learning model on critical thinking skills. Next, to see how significant the differences between the three learning models are in students' mastery of concepts, a further test was carried out using the LSD test. The LSD test results can be seen in Table 4.

Table 4. Summary of LSD Test Results on the Effect of Learning Models on Critical Thinking

Models	Pre-chara-cter	Post-chara-cter	Devi a-tion	Increase (%)	Mean score	LSD Nota t-ion
SIRI	31.54	88.37	56.83	180.18	88.49	a
PBL	34.91	81.43	46.52	133.26	80.93	b
Konvensional	32.15	69.28	37.13	115.49	70.52	c

The LSD test results show that students' critical thinking skills in the SIRI learning model are significantly different from the PBL learning model and conventional learning. This can be seen from the notation differences between the three learning models. Based on Table 4, it can be seen that there is a difference in the corrected mean of concept mastery between the three learning models. The corrected mean of student concept mastery in the SIRI learning model was 88.49, higher than PBL of 80.93 and conventional learning which had the lowest corrected mean of 70.52. Further test results show that the SIRI learning model has the potential to better empower students' mastery of concepts.

Critical thinking is a skill that students must have. The existence of critical thinking skills in a person indicates that he has been able to discover concepts independently, is able to interpret them, is able to process and analyze his thought patterns, and is able to apply his understanding in a more understandable form (Chukusol & Piriyasurawong, 2022; Lestari et al., 2021). Therefore, critical thinking skills have become one of the variables that is used as a benchmark in assessing students' abilities in the lessons they have been given.

The critical thinking that is expected from students in the Animal Physiology MK is to be able to master the regulation of life functions, connect life functions and be able to integrate these life functions into the function of the organism. The expected critical thinking skills are being able to focus, reason, inference, situation, clarity and overview of all material in the learning process at Animal Physiology MK. Good and critical mastery of concepts in material that is good and correct indicates that the learning processes carried out are meaningful for someone (Phakakat & Sovajassatakul, 2020).

Based on the results of the Ancova test on the learning model, it is known that there is an influence of the learning model on students' critical thinking skills. The results of the follow-up test (LSD) show that on the corrected average, the SIRI learning model is better at growing and improving students' critical thinking skills with a higher score than the PBL learning model and conventional learning. These results provide an illustration that overall, the SIRI learning model is very appropriate to be used in empowering students' critical thinking skills in the learning process.

Basically, the high critical thinking skills of students in the SIRI learning model are due to the characteristics of the model that has been developed. The SIRI learning model is designed based on a problem-based learning model and local cultural values which can have a positive impact on students' mastery of biology concepts. According to Bachtiar et al., (2018), problem and culture-based learning models can shape students' critical thinking skills well during the learning process. Apart from that, models with characteristics of problem solving and instilling cultural values can help students understand material concepts contextually and correctly (Hidayati et al., 2020).

The SIRI learning model can empower students' critical thinking skills because it is supported by several learning theories such as constructivism theory, discovery theory, and social cognitive theory. Overall, these learning theories are attached to the syntax of the SIRI learning model, namely at the stimulation, investigation, review and inference stages.

Stimulation is the first stage of the SIRI learning model, the characteristics of which are that students learn independently or collaborate (constructivist) in forming their initial knowledge from material provided by the lecturer online on the Edmodo website. When in class, the process of remembering (recognition) and

recalling (recalling) previously learned knowledge is carried out before starting the learning process in class. This is to determine the extent of students' critical thinking skills regarding previously studied material as a basis for learning in class. Constructivist theory, this theory emphasizes the importance of each student to actively construct knowledge through the mutual influence of previous learning with new learning outcomes. These relationships are constructed by students for their own interests. The main concept of constructivism is the process of continuously building structures to form strong critical thinking skills (Redifer et al., 2019; Yu-shan et al., 2020).

The second stage of the SIRI learning model is the investigation stage of concepts related to Animal Physiology MK. This stage is identical to discovery learning theory. During the investigation process on real problems contained in the LKM provided, students practice finding concepts through stimulus in the form of problem-solving processes. According to Bachtiar, et al. (2018), problem-solving-based learning can hone and develop a person's cognitive abilities when faced with real-life contexts. Students' success in solving problems gives them the ability to reason in finding an existing answer concept (Arsih et al., 2023; Fatmawati et al., 2019).

The investigation processes contained in the SIRI learning model which are carried out collaboratively can have an impact on students' critical thinking skills (Jamaluddin et al., 2021a; Jamaluddin et al., 2023). The SIRI learning model can shape students in finding the concepts they are looking for, starting with independent discovery or collaborating through analysis activities and a solution search process. Apart from that, constructivist learning theory at this stage will always be attached to always updating new knowledge discovered during the investigation process.

The review stage is a stage that is said to be one of the stages that can maximize students' critical thinking skills. This can happen because at this stage, students carry out an in-depth analysis process of the results of assignments carried out by other groups during the investigation stage. Review is one way of forming new knowledge or updating incorrect concepts during the learning process (Wajdi et al., 2022). At this stage there is also a presentation and discussion process which can provide new knowledge concepts for students. According to Desnita et al., (2022), the discussion process during presentations can provide new understanding of the material being studied. Apart from that, the process of clarifying answers by lecturers to incorrect concepts is a reinforcement in improving students' critical thinking skills when studying. The existence of a feedback process makes students' understanding better (Pugsley & Acar, 2018).

At the investigation and review stages, which are identical to constructivist and discovery learning theories, this stage is also identical and emphasizes social cognitive learning theory, namely the interaction of individuals with the social, cultural-histological and individual environment as the key to human development. Apart from being actively determined by the individual himself, a person's cognitive development is also determined by an active social environment (Saenab et al., 2021). The interactions that occur between students, lecturers and the surrounding environment can stimulate development and encourage cognitive growth which has an impact on the students' critical thinking skills.

The final stage of the SIRI learning model is inference. This stage is said to be an evaluation stage of students' understanding of the Animal Physiology MK material. Providing opportunities for students to conclude is one of the strategies used by lecturers to look critically at students regarding the material. Evaluating the material and learning process provides students with the opportunity to build their knowledge again (Bahri et al., 2021). Apart from that, the reflection process given to students is one way and indicator in improving students' critical thinking skills. According to Mahanal et al., (2016), the evaluation process is an important component, without feedback students will only gain little knowledge.

The results of this research also reveal that students taught with the PBL learning model and conventional learning have lower critical thinking skills scores compared to the SIRI learning model, even though it appears that the three learning models can empower students' critical thinking skills during the learning process. The low level of critical thinking skills in PBL and conventional learning is due to different model syntax in empowering the growth and improvement of biological critical thinking skills. Apart from that, students in both classes are less empowered to express feelings of shame towards themselves in order to develop further. Jamaluddin et al, (2021b) also revealed that character values have a positive relationship in a person's academic success. The advantages of the SIRI model can provide opportunities to advance the quality of character and thinking skills of Indonesian students.

In the PBL learning model, the class is able to present students' critical thinking skills better than conventional learning. This is because the PBL model is able to introduce problems to students, ask them questions, facilitate their investigations and provide support so that they are able to develop their cognitive skills (Waite et al., 2020). PBL is also able to improve students' ability to think about various strategies in studying new topics and finding solutions to these problems, so that these processes are able to create a

meaningful learning environment (Amin et al., 2020). In conventional learning, learning cannot develop well because it is inactive, students are only recipients of information without a meaningful learning process. According to Kopzhassarova (Perusso & Baaken, 2020), the educational process with an active learning environment contributes greatly to developing a person's thinking and cognitive improvement.

Conclusion

The research results show that the implemented SIRI learning model has an effect on students' critical thinking skills (p-value <0.05). Apart from that, the SIRI learning model makes a better contribution in forming students' critical thinking skills compared to other learning models. These findings indicate that SIRI as a learning model can be used in learning to improve students' critical thinking skills.

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Conflicts of Interest
The authors declare no conflict of interest.

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