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Exploring Biology Students' Critical Thinking Using Mind Maps

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Abstract: Critical thinking is one of the 21st-century skills that is important for students to have, because this ability is useful for developing knowledge, evaluating and connecting with facts or information from various sources. Critical thinking skills can be trained by implementing innovative learning strategies, including mind maps. This research aims to explore the critical thinking skills of biology students using mind maps. The type of experimental research used is a pre-experimental design. Treatment of research subjects was carried out without a control group. The research was conducted on biology students taking Human Physiology courses. The research results show that students' critical thinking skills are included in the very good category for the interpretation indicator (80.77) and the good category for the analysis, inference, evaluation, explanation and self-regulation indicators (75.00; 72.12; 71.15; 75.00; 74.00). Based on the results, using mind maps in learning helps students improve critical thinking skills.

Keywords: Critical thinking; Human physiology; Mind map

Introduction

Critical thinking is one of the 21st-century skills that is important for students to have, especially in developing thinking. Critical thinking is a core competency for all professional fields and academic disciplines (Shaw et al., 2019). The rapid development of science and technology requires each individual to have critical thinking skills to analyze and compare information, formulate arguments, separate facts from opinions, and have correct logical reasoning (Basri et al., 2019; Chukwuyenum, 2013). Critical thinking comprises six basic skills: interpretation, analysis, inference, evaluation, explanation, and self-regulation (Facione, 2013).

Critical thinking skills are needed for education graduates to develop abilities and solve increasingly complex life problems (Hashemi, 2011; Živkovil, 2016). Therefore, higher education is responsible for developing critical thinking skills that lead to higher-level thinking (Bassham et al., 2013). Critical thinking skills can also improve academic abilities and prepare individuals to become professionals in the work field (Mahanal et al., 2019). Critical thinking skills are needed to develop the ability to produce ideas and innovations comparatively and competitively in competition (Martincová et al., 2015). So, it can be concluded that critical thinking skills are very relevant in overcoming the challenges of the 21st century and are an important issue for future research (Marzuki et al., 2021; Van Peppen et al., 2021)

Developing critical thinking skills is the focus of attention to meet the job market's needs with social and complex challenges (Cruz et al., 2017). Several studies show that critical thinking skills are still low and must be utilized optimally in classroom learning. Research conducted by Seventika et al. (2018) and Asysyifa et al. (2019) explains that critical thinking abilities are still low and need to be improved. This low value is shown in almost all indicators of critical thinking (Hidayati et al., 2019; Puspita et al., 2017).

The biology learning process in the classroom is almost certainly not interested in efforts to empower critical thinking skills (Corebima, 2016). Various factors

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also have an influence, including the use of strategies, models, methods and learning processes that could be more optimal (Bustami et al., 2017). The dominant teaching method focuses on lectures and memorization, does not encourage critical thinking (Allamnakhrah, 2013; Alwadai, 2014), as well as teachers' inadequate ability to integrate critical thinking into teaching practice (Choy et al., 2012), causing critical thinking skills tend to be low, especially in college environments.

The results of a study conducted by Khalid et al. (2021) suggest changes in teaching methods and perceptions of critical thinking skills as possible steps to encourage the development of critical thinking skills in the classroom. Implementing appropriate learning strategies can also be done to improve critical thinking skills in the classroom (Fitriani et al., 2022). Empowerment of critical thinking skills is also influenced by other factors such as habits and training (Siburian et al., 2019). Teacher education and training are considered appropriate special programs and projects to train teachers in using strategies to develop higher-order thinking skills (critical thinking) in their teaching (Radulović et al., 2017). It was further explained that these programs aim to train teachers to carry out adequate learning and develop innovative teaching methods, techniques and strategies. Innovative learning strategies allow students to independently construct knowledge and transform new information. Mind maps are an example of innovative learning (Noonan, 2013; Ravindranath et al., 2016).

Mind mapping is a strategy that can encourage individuals as thinkers to take action, support the generation of new ideas, and integrate new knowledge into these ideas (Polat et al., 2020). Mind mapping is characterized as a useful strategy to facilitate the development of critical thinking skills (Tsirkunova, 2013). Using colours and images in mind maps causes information to last longer in students' memories (Şeyihoğlu et al., 2013). Mind maps can also enrich students' knowledge and serve as a medium for providing feedback (Simonova, 2015).

Combining images with words in mind mapping enables learners to store and extract information effectively and improves learning efficiency (Kotcherlakota et al., 2013). The research results of Wu et al. (2020) also explain that mind maps are conducive to improving students' critical thinking skills. Based on the background description, this research aims to learn more about the critical thinking skills of biology students using mind maps.

Method

This experimental research involves treatment by applying mind maps in the classroom. The type of experimental research used is a pre-experimental design. Treatment of research subjects was carried out without a control group. The research was conducted at one of the State Universities in Palembang City. The research sample included all 26 students taking the Human Physiology course. Critical thinking ability data was collected using a critical thinking assessment instrument with an essay test which refers to 6 critical thinking skills, including: (1) interpretation, (2) analysis, (3) conclusion; (4) evaluation; (5) explanation; and (6) self-regulation (Facione, 2013). The six critical thinking skills are presented in Table 1.

Table 1. Critical Thinking Skills and Sub-skills (Facione, 2013)

Skills	Sub-Skills
Interpretation	Categorize
	Decoding significance
	Clarify the meaning
Analysis	Check ideas
	Identify arguments
	Identify reasons and claims
Inference	Query evidence
	Conjecture alternative
	Draw logically valid or justified conclusions
Evaluation	Assess the credibility of claims
	Assess the quality of arguments made using inductive or deductive reasoning.
Explanation	State the results
	Justify the procedure
	Provide arguments
Self-Regulation	Monitor yourself
	Self-correction

This research has received ethical approval from the university and the participating students. All students involved have been asked to agree to participate in the research through informed consent, and all students have agreed. Data analysis was carried out using a quantitative descriptive approach. Each student's answer is given a score of 0-4, then the average score will be categorized into poor (<60), moderate (60-69), good (70-79), and very good (80-100) (Sudjana, 2016). The formula used to calculate student scores is Formula 1.

$$P = \frac{SC}{SM} x\ 100 \quad (1)$$

Note:
P = Score per indicator
SC = Obtained score
SM = Maximum score

Result and Discussion

Students' critical thinking skills can be seen in Table 2. Table 2 shows that students' overall critical thinking skills are in a good category, scoring 74.68. This analysis includes all indicators of critical thinking, including interpretation, analysis, conclusion, evaluation, explanation, and self-regulation. This increase in critical thinking skills shows that mind mapping is an appropriate innovative learning strategy to help students think. Innovative learning can change the educational paradigm from teacher to student-centred (Bustami et al., 2017; Karim et al., 2018).

Table 2. Average Critical Thinking Skills Score

Critical Thinking Indicators	Average	Category
Interpretation	80.77	Very good
Analysis	75.00	Good
Inference	72.12	Good
Evaluation	71.15	Good
Explanation	75.00	Good
Self-Regulation	74.00	Good
Total score	74.68	Good

Table 2 explains a detailed description of the achievement of students' critical thinking skills for each indicator. The first indicator, interpretation, has the highest average score, 80.77, in the very good category. Students can understand and express the meaning of various situations, data and events related to human physiology. This interpretation involves students' high-level reasoning and evaluation, especially to clarify intentions and categorize the information obtained Facione (2013) related to Human Physiology.

The Human Physiology course is synonymous with abstract and difficult-to-understand material, so students need a way to help construct the knowledge gained. The research results of Stokhof et al. (2020) show that mind maps help visualize and construct knowledge so that more complete knowledge is obtained. Mind mapping during learning will make it easier for students to identify main ideas, visualize, externalize understanding, and develop summaries of the texts they have read (Yang, 2015). Besides helping analyze reading material, mind mapping also helps extract and summarize diverse information obtained from informants (Avdagic et al., 2021).

The second indicator "analysis", obtained an average score of 75.00 in the good category. Learning is important in training critical thinking, especially analytical skills (Prasasti, 2015). Implementing mind maps in learning is the right choice because it is effective in helping students learn better (Hwang et al., 2013). Learning that utilizes effective strategies (including mind maps) will help develop critical thinking skills and dispositions in students at all levels of education and disciplines (Abrami et al., 2015). So, it can be concluded that using active strategies with mind maps during learning can improve students' critical thinking skills, especially in the "analysis" indicator. Mind maps, a visual mind mapping strategy, play an important role in helping students explore, analyze, synthesize, share ideas, organize and organize information, and relate information to one another (Hazaymeh et al., 2022).

The third indicator, inference, has the same category as the second indicator (good), with an average score of 72.12. Making mind maps during learning allows students to develop their brain's working potential and thought patterns (Tendrita et al., 2022). Students can use mind maps to plan, record information, exchange ideas, summarize, organize and present ideas based on information obtained visually (Kotcherlakota et al., 2013). The presentation of this mind map is also a form of summarizing information based on the results of discussions and studies that students have carried out during learning. These results are also supported by research by Hazaymeh et al. (2022), which explains that mind maps are a visual tool that effectively helps improve students' critical thinking, especially in analyzing and deducing context. So, mind mapping is the right strategy for improving critical thinking skills, especially on the "inferring" indicator related to Human Physiology material.

The fourth indicator, namely evaluation, is included in the good category with an average score of 71.15. Mind mapping can be used to evaluate data and content validly (Avdagic et al., 2021). Good evaluation indicators show that using mind maps during learning helps students develop understanding and uncover conceptual errors (Yorulmaz et al., 2021). So, making a mind map helps improve critical thinking skills, especially in evaluating valid information and content related to human physiology. Research results from Ristiasari et al. (2012) also strengthen the argument that the increase in critical thinking is due to the assignment to make a mind map.

The fifth indicator is "explanation", with an average score of 75.00 and in the good category. Learning Human Physiology presents complex information and facts from various sources, so students use mind maps to make learning easier. Complex information obtained from relevant sources will be recorded and depicted visually (mind map) with attractive words, colours, images and arrows to make it easier to understand (Jain, 2015). Mitchell et al. (2017) added that visualizing core concepts (or Big Ideas) in mind maps supports teachers in sharing intellectual control with their students. The presentation of this mind map is also a form of explaining information related to human physiology material more shortly and interestingly. Images,

symbols, and links in mind maps help students understand and remember information well (Betancur et al., 2014).

The sixth or final indicator, self-regulation, is in a good category, with an average score of 74.00. Using mind maps in studying positively impacts students' self-regulation because it can make managing their time, activities (exams, groups) and the learning environment easier (Tanriseven, 2014). The research results presented by Hilmiyah et al. (2020) also explain that using a mind map pocketbook can improve students' self-regulation, making discussion and asking questions easier. So, making mind maps used in learning, either directly or with books, can improve students' critical thinking skills, especially regarding self-regulation indicators. Mind maps are useful in developing and implementing activities to improve thinking skills, such as taking notes, analyzing, completing assignments, preparing for exams, and reflecting on practice (Rosciano, 2015).

Conclusion

Implementing the use of mind maps in learning helps students improve critical thinking skills. Students' critical thinking skills are included in the very good category for the interpretation indicator and the good category for the analysis, inference, evaluation, explanation and self-regulation indicators. The application of learner strategies, including mind maps during learning, has limitations due to various factors. Therefore, educators need to prepare well for all activities that will be carried out so that learning limitations can be overcome.

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Author Contributions

Conceptualization, methodology, N.N.; validation, R.N.A.; formal analysis, N.N.; investigation, N.N. and R.N.A.; resources, data curation, N.N.; writing—original draft preparation, writing—review and editing, visualization, funding acquisition, N.N. and R.N.A.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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