Students' critical thinking skills on human respiratory system material in flipped classroom

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Abstract: The learning process must actively involve students and provide opportunities for them to improve their critical thinking skills. This study determines the effect of the implementation flipped classroom on the critical thinking skills of students in the learning of the human respiratory system in class XI SMAN 16 Medan. This study included a quasi-experiment type with one group pretest-posttest design and was conducted in three meetings. The research instrument used is an essay test of 5 questions. Data obtained from this study include the value of students' critical thinking skills both in general and in each indicator, and the N-gain of students' critical thinking ability. The data obtained were analyzed to obtain an average value. The results of the data analysis showed that the average score of students' critical thinking skills in general increased from 39.6 before learning was carried out to 80.8 after learning was carried out. The average student score gets an N-gain score of 0.68 with the moderate improvement category. The average score of students after learning on each indicator is as follows: the basic classification indicator is in the high category (74), basic support is in the very high category (92), inference is in the high category (75), advance classification is in the high category (75), and strategy and tactics is in the very high category (88). Based on the results of the study, the flipped classroom learning model can improve the critical thinking skills of grade XI students in SMAN 16 Medan in learning the biology of the human respiratory system material.

Keywords: critical thinking; flipped classroom; human respiratory system learning

Introduction

Today, the education sector is highly correlated with technology and the internet, so information can be accessed easily by students (Meena, 2020; Selwyn, 2020; Szymkowiak et al., 2021). Students are expected to be able to process the information and knowledge they get from the outside world appropriately. In line with the demand, education in schools is required to teach 4C skills, namely creativity and innovation, critical thinking and problem solving, communication, and collaboration (Saleh, 2019; Soulé & Warrick, 2015).

Critical Thinking is one of the 4C skills that is emphasized in learning (Dwyer et al., 2014; Erdoğan, 2019; Shamboul, 2022). Critical thinking related to the ability to think and reason reflectively in making trusted decisions (Murawski. 2014; Renatovna & Renatovna, 2020). Critical thinking also related to the ability to analyze, and evaluate information to make decisions is also a definition of critical thinking (Mahanal et al., 2019; McPeck, 2016). Students who are allowed to use their thinking will be accustomed to distinguishing truth, truth, facts, and beliefs (Ku et al., 2019). Through critical thinking, students are expected to be active, argumentative, and able to solve complex problems and make new achievements

(Mahanal et al., 2019; Murawski. 2014; Renatovna & Renatovna, 2020).

However, based on PISA results, the critical thinking skills of Indonesian students are still low. Several research results from Indonesian researchers also show that Indonesian students' critical thinking skills are still low. Research in Sragen concluded that students' critical thinking skills are still low when studying the circulatory system (Suyamto et al., 2018). Other research involving high school students in Kediri also provides similar findings (Elisanti et al., 2017). In line with these findings, other study in other city also reported that the level of students' critical thinking skills was not satisfactory (As'ari et al., 2017). The right learning model can develop critical thinking skills. The flipped classroom is one of the learning models that can be used (Dehghanzadeh & Jafaraghaee, 2018; Kong, 2014; Mortensen & Nicholson, 2015). Flipped classroom is a learning model developed by Bergmann and Sams. Sams and Bergmann (2012) describe the flipped classroom as a learning model that transforms the traditional learning system into a medium that students can learn independently at home and changes classroom learning into more active learning. This kind of learning is learning in the 4.0 era (Rahmadani et al., 2020; Yusuf & Nur, 2019), where learning combines individual computer-based instruction with interactive learning in the classroom (Low et al., 2021; Mitsiou, 2019). In learning activities, students are guided to compile arguments and reasons for the answers to a problem (Sania et al., 2022). Learning activities like this shape the way students think in a more critical direction. By doing discussions in class, students can directly ask questions when experiencing difficulties with teachers and friends so that the problem is immediately solved (Mandasari & Wahyudin, 2021).

Previous research on the effect of flipped classroom on critical thinking skills by Zulhamdi et al., (2022) showed that flipped classroom can improve students' critical thinking skills through habituation in building arguments actively through problem-solving discussion activities in class. Students are trained to make inferences from their knowledge at home through discussion activities. Such activities build students' critical thinking. DeRuisseau (2016) research also shows that the flipped classroom can improve students' critical thinking skills by freeing up time to develop students' critical thinking in class. However, research regarding the effect of the flipped classroom on critical thinking skills has not yet been widely explored in Indonesia, especially in human respiratory material. The topic of the respiratory system is material that emphasizes hands-on experience because relates to everyday life with abstract concepts (Rafiqa et al., 2022). Students are required to actively and critically analyze the material on the human respiratory system, and be able to express ideas for answers to problems related to the material (Astuti et al., 2021).

This study contributes to efforts to improve student's critical thinking skills, which can be encouraged by consistent and appropriate implementation of the flipped classroom model. Therefore, the objectives of the study are as follows: (a) analyze the critical thinking skills of students taught with the flipped classroom model both in general and in each indicator, and (b) analyze the improvement of critical thinking skills of students taught with the flipped classroom model.

Method

Research design, context, and participants

This type of research is quasi-experimental with one group pretest posttest design. This research was conducted in class XI of SMAN (State Senior High School) 16 Medan with a population of 208 people consisting of 6 MIPA classes. The sample involved in this study was class XI MIPA 4 which amounted to 36 people. The sampling technique was carried out by purposive sampling. This sample selection is based on the division of classes at SMAN 16 Medan. Classes are divided based on student report cards, where class XI MIPA 1 is students with high report cards and class XI MIPA 6 is students with low report cards. Therefore, the sample used in this study is class XI MIPA 4 which has a rapport value in the middle with moderate ability.

Learning in this research was carried out three times. The learning steps in research according to the Flipped Classroom syntax by Hasjim and Siem (2021) include: The provision of media, teachers providing reading materials, and learning videos about the subject matter to be discussed at the next meeting to students and instruct students to study it. Then, there is a question and answer syntax, the teacher invites questions from the class, and students and the teacher will discuss with each other to answer the questions. Then, is the group discussion syntax, the teacher divides students into groups and assigns assignments. The teacher acts as a facilitator for students who need help in understanding and completing activities. At this stage students' critical thinking skills are honed well with problem-solving discussions. Next, there is the syntax Presenting the results of the discussion, the results of student work will be displayed in front of the class. Then, there is a syntax for evaluating the results of the discussion, after completion of all activities teachers and students make conclusions from the knowledge gained.
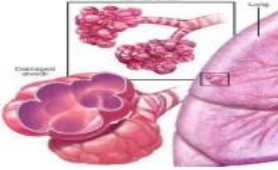
Data sources

The instrument in this research was used before and after learning using 5 valid essay questions according to Ennis (1985) critical thinking indicators which were created based on predetermined competency achievement indicators. The questions used in this research can be seen in Table 1.

Data analyses

The student's critical thinking ability scores that have been collected are tabulated averaged and then categorized. The scores obtained are also tabulated based on each indicator and categorized. To obtain data on improving students' critical thinking skills, N-Gain analysis was used. Data before and after learning were averaged and categorized.

Table 1. Question instrument

Indicator	Question
basic classification	Look at the picture below! The oxygen exchange event in the alveolus is the main key to the series respiratory process. In some cases this exchange process can be a disorders, one of which is caused by emphysema. A. Based on the picture, compare the condition of healthy and suffering alveoli of emphysema! B. Analyze the problems that can arise in oxygen exchange as a result emphysema! C. What impact can there be on the heart due to emphysema?
basic support	One evening there was a lively concert attended by 400 spectators at a building with a capacity of 300 people in the center of Medan City. At a concert while it was going on, it turned out that many spectators had fainted. A. Do you think it is possible that the above case could happen? B. Can you identify because of the large number of viewers who fainted at the concert?
inference	The main respiratory organ through which free air enters is the nasal cavity, but in some cases the mouth is also used as an entrance for air to the lungs. A. Which breathing is better, breathing with the nose or with the mouth? B. Give a conclusion from your answer! C. What effects will occur if you breathe through your mouth?
advance classification	The oxygen diffusion process occurs due to differences in levels between regions inside the body. Where is the oxygen pressure in the alveoli ($PO_2=105mmHg$) and arterial 100 mmHg. A. Can you prove the definition of diffusion as the movement of substances from high to low concentration based on the information above? B. What impact will this process have on human body cells? obstructed oxygen diffusion?
strategy and tactics	Currently the world is shocked by the first coronavirus outbreak identified in the city of Wuhan, China. Generally, transmission of this virus shows symptoms, such as fever, cough, sore throat, shortness of breath, etc difficulty breathing. A. Based on the case review above, if one day you are in a community environment who work as health workers, traders, and housewives. Which is more risky passing the virus on to you? Include reasons! B. What actions can you take to maintain the health of the coronavirus epidemic?

Results and Discussion

Students' critical thinking skills

This study has collected data on students' critical thinking skills, both before and after participating in biology learning human respiratory system material in a flipped classroom. Based on the data obtained in Table 2, the average score of students' critical thinking skills before learning falls into the very low category of 39.6. The average critical thinking ability of students after learning falls into the high category

of 80.8.

Furthermore, based on the data obtained in Figure 1, before learning was carried out using the Flipped Classroom model, no student scored critical thinking skills in the very high category. Even 66% of students still obtained the very low category. However after learning with the implementation of Flipped Classroom, the value of students' critical thinking skills increased and the number of students who obtained very high category scores became 57%.

Then, the indicators of students' critical thinking ability before learning are still dominated by very low categories (Table 3). The highest indicator achieved by students is the indicator of advance classification and the lowest is the Inference indicator. Indicators of students' critical thinking ability after learning are already in the high and very high categories. The highest indicator is the indicator of basic support, and the lowest is the indicator of basic classification. After the learning was carried out, the indicators concluded and provided further explanations both got a value of 75. But there is a difference in improvement in these two indicators. The inference indicator has the highest increase among other indicators, while the indicator advance classification there is no prominent improvement between before and after learning.

Table 2. Students' critical thinking skills

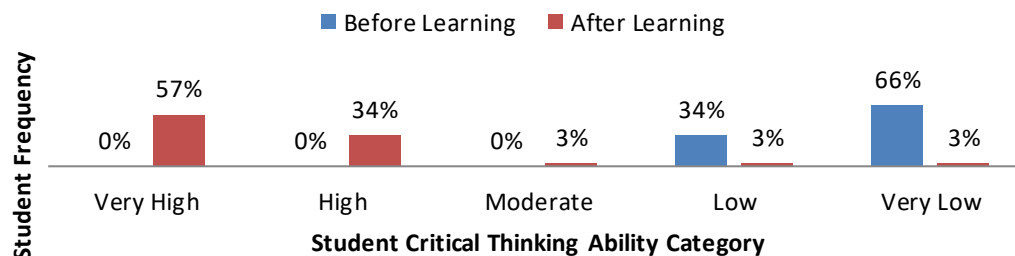| Range | Category | Frequency | |
		Before Learning	After Learning
81.25-100	Very High	0	20
71.50-81.25	High	0	12
62.50-71.50	Moderate	0	1
43.75-62.50	Low	12	1
0-43.75	Very Low	23	1
Average		39,6	80,8
Category		Very Low	High

Figure 1. Percentage frequency of students in each category of critical thinking ability

Table 3. Students' critical thinking skills on each indicator

Indicator	Before Learning	Category	After Learning	Category
Basic Classification	33	Very Low	74	High
Basic Support	25	Very Low	92	Very High
Inference	8	Very Low	75	High
Advance Classification	73	High	75	High
Strategy and Tactics	60	Low	88	Very High

The improvement of students' critical thinking skills is determined by measuring N-gain. In Table 4, it can be seen that the N-gain of students' critical thinking ability in general is 0.68 with the medium category.

Table 4. N-Gain students' critical thinking skills

Average Grades Before Learning	Average Grades After Learning	N-Gain	Category
39.6	80.8	0.68	Moderate

In general, student's critical thinking skills after the highest learning are basic support. This is because in the learning that has been carried out students are accustomed to comparing various reading sources, which are needed to solve problems in syntax discussion groups. So that students have a deep concept of the human respiratory system. Zulhamdi et al., (2022) in their research argue that student activities to explore various information provide maximum understanding for students. This also does not escape the role of teaching students independently at home in the first syntax. Student comprehension from home usurps the role of facts in the search for other reading sources. So that students can more easily

eliminate less relevant reading sources. Hasjim and Siem (2021) argue that the knowledge built by students at home is the initial capital to add new knowledge. Students also oppose their belief in involving conjecture scientifically in learning, because the discussion presented to students in syntax three requires students to speculate based on facts they know. According to the research of Zulhamdi et al., (2022) student understanding allows students to analyze their thoughts to ensure that they have made correct guesses.

Indicators of students' critical thinking skills that also fall into the very high category are indicators of strategy and tactics. In Flipped Classroom, the freedom of time in class no longer makes students listeners and note-takers only (Hasjim & Siem, 2021). Discussions conducted in the flipped classroom encourage students to interact. Student interactions help students figure out the cause and effect of an activity. This supports students in identifying problems, and then determining solutions to overcome them. This is supported by Sonia (2022) research that flipped classroom encourages students to interact and collaborate with fellow students and teachers. Zulhamdi et al., (2022) argue that flipped classroom learning helps students make decisions and actions from interactions in the classroom.

After the learning is carried out, the indicator inference by getting a high category. Although it only gets a high category, this indicator has the highest increase. The acquisition of this indicator increased from before learning was carried out with a value of 8 to 75 after learning. Such an increase is due to interference through discussion in third syntax students to have the ability to narrow the core of their reading. This is supported by research by Sania et al., (2022) that student discussion activities encourage the improvement of students' inference skills. For problems that are not so complex students can immediately conclude the answer, because students already have facts in mind through independent learning in the first syntax (Putra et al., 2022).

After the learning is carried out, the indicator advanced classification, getting a high category. But there is no notable improvement in this indicator. This is because students still have difficulty providing a complete definition of a term. The indicator of the critical thinking ability of students with the lowest flipped classroom model is the indicator of basic classification. Despite being in the last order, this indicator still gets a high category. This is because students are faced with various problems in their learning. To arrive at a solution, students are first required to understand the problem. Students are also accustomed to analyzing various arguments and making arguments. This is supported by the research of Zulhamdi et al., (2022) that in discussion activities, students are allowed to deepen the material by analyzing arguments. Students are trained to investigate the reasons for an argument to find out the real situation. Moreover, based on N-Gain results, students experienced an N-Gain of 0.68 in the medium category. So, it can be concluded that the implementation of the Flipped Classroom model can improve students' critical thinking skills on human respiratory system material. Increasing critical thinking skills in this research can occur because all flipped classroom learning syntax is done very well so that it improves students' critical thinking skills. Students are familiarized with discussions related to topics in real life so that problem-solving activities arise in learning. In learning activities, students are guided to compile arguments and reasons for the answers to a problem (Sania et al., 2022). Learning activities like this shape the way students think in a more critical direction.

Conclusion

Based on the results of research that have been conducted, students' critical thinking skills in general with the implementation of the flipped classroom model are in the high category with an average of 80.8. Students' critical thinking skills are highest on indicator basic classification followed by indicators basic support, inference, advance classification, and indicator strategy and tactics occupies the lowest place. The student's critical thinking ability scores before and after learning also increased from 39.6 in the very low category to 80.8 in the high category. The calculation result of N-gain obtained is 0.68 with the category of moderate increase.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

E. C. Simatupang: writing original draft preparation, drafted manuscript, conception and design of research, performed experiments, analyzed data, approved final version of manuscript, edited and revised manuscript. **M. Silitonga**: conception and design of research, analyzed data, approved final version of manuscript. **S. H. Rajagukguk**: validation, performed experiments.

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