Effectiveness of the Scientifically based Flipped Classroom Model to Increase Students' Critical Thinking Ability

Ngadimin 1*, Abdul Hamid 2, Yuni Sahara 3, Musdar 4

1,2,3,4 Department of Physics Education, Syiah Kuala University, Banda Aceh – Indonesia.

INTRODUCTION

In 21st-century learning, students and teachers are required to have soft and hard skills. This ability is necessary because human lifestyles have experienced large changes due to scientific developments and the sophistication of technology, information, and communication (Daryanto, 2017). 21st-century learning is demanded because education should produce human resources to master critical thinking, communication, creativity, and collaboration (Nabilah, 2020). Thinking skills need to be trained and developed during learning because they are the basic capital in facing the challenges of the world of work and the social environment (Yasifa et al., 2023). Teachers can improve the critical thinking skills of students by choosing the right learning model (Rizkiani et al., 2019).

The flipped classroom is a learning model that reverses conventional learning, where the material is generally delivered in class, while learning with the flipped classroom model delivers the material at home. Students are directed to study the material first before learning activities in class. These activities can make it easier for students to take part in learning in class because they already know the material and have studied it at home, and when learning in class, students repeat the material to deepen the material. With discussion activities to support active learning (Walsh, 2016). The application of conventional physics learning can be completed using the flipped classroom model. This
Critical thinking ability is one of the thinking skills that can be trained and developed. Critical thinking is the ability to think rationally and orderly, which aims to understand the relationship between ideas and facts with complex critical thinking skills and involves several skills such as analyzing, evaluating, and inferring, which aims to make logical decisions about what to do in solving a problem (Dwyer, 2014). Critical thinking is a process that involves the integration of personal experience, training, and skills, as well as reasons for making decisions to explain the truth of information.

Based on the results of observations of physics study teachers from Kutacane 3 public high school on December 16, 2022, the lessons teachers often use in physics lessons are still conventional. With this kind of learning, students become less active in interacting and thinking and lack motivation and interest in studying physics. Students' less active study habits can cause them to be lazy in thinking and more comfortable with teacher explanations (Nurlianti 2020). Students' critical thinking
abilities have not been trained in the learning process, students are not given the opportunity to analyze a problem, identify, conclude, or put forward new ideas or actions towards a problem. Research shows that the physics learning process in schools does not encourage students to think critically, which impacts low learning outcomes (Soleh, 2021). This is shown by the results of the daily physics test for class to convey arguments and provide conclusions related to learning. Based on the results of previous research and several findings in the field related to critical thinking skills, this research aims to determine the effectiveness of the scientific-based flipped classroom model for improving students' critical thinking skills at Public Senior High School 3 Kutacane.

RESEARCH METHODS

Research Approach
This research uses a quantitative approach, where data analysis focuses more on numerical data (numbers) processed using statistical methods (Sugiyono, 2016). The type of research used in this research is an experiment with a nonequivalent pretest posttest control group design because, in this study, we wanted to see students’ critical thinking abilities in the control and experimental classes after and before being given treatment.

Research Subject
The subject of this research is 10th-grade Science at Public Senior High School 3 Kutacane, which consists of two classes with 46 students. Sampling used a total sampling technique where 10th-grade Science 1 was the experimental class, and 10th-grade Science 1 was a control class.

Research Instrument
The test instrument in this research is a critical thinking ability test in the form of a description consisting of 6 questions covering five aspects of critical thinking ability: providing basic explanations, building basic skills, concluding (inference), and providing further explanations (advance clarification) and organizing strategy and tactics (strategy and tactics) (Ennis, 1962). The non-test instrument is a student response questionnaire comprising 15 statements regarding learning using a scientifically based flipped classroom model.

Data Collection
Data collection was carried out by providing test questions on critical thinking ability in the form of descriptions with six questions. Test questions were given before and after treatment, and then a student response questionnaire was given with 15 statements regarding learning using the scientific-based flipped classroom model in the experimental class.

Data Analysis
The data taken in this research were based on students’ answers to the critical thinking ability test instrument and analyzed using a percentage formula. The effectiveness of the learning model in this research was measured based on the achievement of the minimum completeness criteria at Public Senior High School 3 Kutacane with a score of 70 in class and 75 individually. The formula obtains classical completeness:

\[
\text{Classical completeness} = \frac{\text{The total of students who completed}}{\text{The total number of students}} \times 100
\]

Based on the calculations that have been carried out, the numerical scores are interpreted into categories. The criteria for achieving classical completeness in this study are presented in Table 1.
Table 1. Criteria for achieving classical completion

<table>
<thead>
<tr>
<th>Completion range (%)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>Very less effective</td>
</tr>
<tr>
<td>21-40</td>
<td>Less effective</td>
</tr>
<tr>
<td>41-60</td>
<td>Effective enough</td>
</tr>
<tr>
<td>61-80</td>
<td>Effective</td>
</tr>
<tr>
<td>81-100</td>
<td>Very effective</td>
</tr>
</tbody>
</table>

(Yusrizal, 2016)

The increase in students' critical thinking skills between pretest and posttest scores is analyzed using the gain score with the formula:

\[
g = \frac{\text{skor posttest} - \text{skor pretest}}{\text{skor ideal} - \text{skor pretest}}
\]

\(g\) = increase in critical thinking skills. Interpretation of the N-gain value according to Meltzer (2002) is presented in Table 2.

Table 2. Gain Index Category

<table>
<thead>
<tr>
<th>Gain Score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g \geq 0.70)</td>
<td>Tall</td>
</tr>
<tr>
<td>(0.30 \leq g &lt; 0.70)</td>
<td>Currently</td>
</tr>
<tr>
<td>(g &lt; 0.30)</td>
<td>Low</td>
</tr>
</tbody>
</table>

(Meltzer, 2002)

Calculate the percentage of student response questionnaire scores using the following percentage formula.

\[
p = \frac{A}{B} \times 100
\]

Based on the calculations that have been carried out, the numerical scores are interpreted into categories. The categories of student response questionnaires in this study are presented in Table 3 following.

Table 3. Student response questionnaire categories

<table>
<thead>
<tr>
<th>Score interval (%)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>Very less</td>
</tr>
<tr>
<td>21-40</td>
<td>Not enough</td>
</tr>
<tr>
<td>41-60</td>
<td>Enough</td>
</tr>
<tr>
<td>61-80</td>
<td>Good</td>
</tr>
<tr>
<td>81-100</td>
<td>Very good</td>
</tr>
</tbody>
</table>

(Kartini & Nyoman, 2020)

RESULTS AND DISCUSSION

Below, we discuss the results of research on the effectiveness of the scientifically based flipped classroom model in improving students' critical thinking skills in physics learning. This research was conducted in 3 meetings in 10th-grade Science 1 as an experimental class using a scientific-based flipped classroom model and 10th-grade Science 2 as a control class.

1. The results of the completion of students' critical thinking skills

The results of completing students' critical thinking skills based on posttest scores can be seen in the following table.
Based on Table 4, it was found that the completeness of the experimental class was 82% and the control class was 75%, so it can be said that learning using the scientific-based flipped classroom model in the experimental class was very effectively used to improve students' critical thinking skills at Public Senior High School 3 Kutacane. A student is said to be complete if they achieve a Minimum Completeness Criteria score or more. The Minimum Completeness Criteria score at Public Senior High 3 Kutacane is set at 70 for class completion and 75 for individual completion. A total of 21 students in the experimental class achieved the minimum completeness criteria score, and two students did not complete because they had not yet reached the minimum completeness criteria score, so 91% of experimental class students were declared complete, and 9% of students did not. In the control class, 13 students achieved the Minimum Completeness Criteria score and 10 students who did not achieve the Minimum Completeness Criteria score, so 56% of students in the control class were declared complete, and 44% of students did not. Based on the N-Gain test results, the control class obtained an average N-Gain score of 0.68, which is included in the medium gain index category. Meanwhile, in the experimental class, it was 0.78, which is included in the high gain index category. Even though the final abilities of both classes increased, the critical thinking abilities of experimental class students were higher than those in the control class.

2. The Results of N-Gain Test
Data on improving students' critical thinking skills will be more clearly seen in the following table 5:

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Min</th>
<th>Max</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Test</td>
<td>8.3</td>
<td>33.3</td>
<td>21.92</td>
</tr>
<tr>
<td>Post Test</td>
<td>70.8</td>
<td>100</td>
<td>82.98</td>
</tr>
</tbody>
</table>

| N-gain | 0.78 |
| N-gain % | 78% |

Based on the data in Table 5, it is known that the average pretest score is 21.92. After being given treatment in the form of learning using a scientifically based flipped classroom model, there was an increase in critical thinking skills by 78% with an average posttest score of 82.98, and was in the great improvement category.

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Min</th>
<th>Max</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Test</td>
<td>12.5</td>
<td>29.2</td>
<td>20.29</td>
</tr>
<tr>
<td>Post Test</td>
<td>41.7</td>
<td>100</td>
<td>75.01</td>
</tr>
</tbody>
</table>

| N-gain | 0.68 |
| N-gain % | 68% |

Based on the data in Table 4, it is known that the average pretest score is 20.29. After being given treatment in the form of learning using a guided inquiry model with a scientific approach, there was an increase in critical thinking skills by 68% with an average posttest score of 75.01, and was in the moderate improvement category.
3. Results of student response questionnaires

The results of the student response questionnaire can be seen in the following table 7.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of answers</td>
<td>115</td>
<td>101</td>
<td>105</td>
<td>105</td>
<td>99</td>
<td>103</td>
<td>104</td>
<td>100</td>
<td>101</td>
<td>105</td>
<td>48</td>
<td>104</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td>1491</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average value</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7 shows that the student response score data obtained with a percentage of 86% is included in the very good category. These results indicate that learning using the scientifically based flipped classroom model on rectilinear motion material received a very good response from students.

Discussion

Based on table 4, it was found that the completeness of the experimental class was 82% and the control class was 75%, so it can be said that learning using the scientifically based flipped classroom model in the experimental class was very effectively used to improve students' critical thinking skills at Public Senior High School 3 Kutacane. BNPS (2007) stated that the class had completed learning if it reached ≥75%. The minimum completeness criteria score at Public Senior High School 3 Kutacane is set at 70 for class completion and 75 for individual completion. A total of 21 students in the experimental class achieved the Minimum Completeness Criteria score, and two students did not complete because they had not yet reached the Minimum Completeness Criteria score so that 91% of experimental class students were declared complete and 9% of students did not complete. In the control class, 13 students achieved the minimum completeness criteria score and 10 students who did not achieve the minimum completeness criteria score, so 56% of students in the control class were declared complete, and 44% of students did not. Based on the N-Gain test results, the control class obtained an average N-Gain score of 0.68, which is included in the medium gain index category. Meanwhile, in the experimental class, it was 0.78, which is included in the high gain index category. Even though the final abilities of both classes increased, the critical thinking abilities of experimental class students were higher than those in the control class.

Several factors influence students' high final critical thinking abilities in experimental classes. Students in the experimental class have an initial understanding of the material that will be studied in class which results in students' abilities being trained in studying physics material in depth during the learning process. Research conducted by Maolidah (2017) shows that the flipped classroom learning model encourages students to be independent in understanding the material and actively discussing concepts that are not fully understood in class. In this way, the learning process can facilitate the development of students' critical thinking skills. The usefulness of the flipped classroom model can be achieved optimally with adequate learning media support. Research conducted by Suastra & Margunayasa (2023) By implementing the flipped classroom model in the learning process, students understand basic concepts and ideas better, helping interactions between students and their peers to create and use new knowledge, encouraging students to think inclusively and formulate their own hypotheses, provide intrinsic satisfaction, the teaching and learning process situation is more stimulating. Then, students in the experimental class were more enthusiastic and interested during the learning process because they already had an initial understanding of what they had watched in the learning video at home. This can be seen from the students' responses in the experimental class. The student response score data was obtained at 86%, including in the very good category. These results indicate that learning using the scientifically based flipped classroom model on rectilinear motion material received a positive response from students. Meanwhile, in the control class, the learning
material is delivered in class. So, based on the data obtained, learning using the scientifically based flipped classroom model is more effective in improving students' critical thinking skills.

Previous research results indicate that critical thinking abilities are significantly enhanced after instruction using the Flipped Classroom Model (Inayah et al., 2021). Delivering material through flipped classroom methodology before students enter class helps them become more critical in addressing issues. Several other studies also demonstrate that a flipped classroom methodology can improve students' critical thinking abilities (Kurnianto et al., 2019; DeRuisseau, 2016). Students who learn using the flipped classroom method perform better than those who learn through conventional models (Dehghanzadeh & Jarafraghaee, 2018). The flipped classroom model is superior in enhancing students' critical thinking abilities and learning achievements compared to direct instruction (Suarastra & Margunayasa, 2023).

CONCLUSION
Based on the results of the research that has been carried out, it can be concluded that the scientific-based Flipped Classroom learning model is effective in improving students' thinking abilities based on the Minimum Completeness Criteria values. Experimental class students responded positively to the use of the scientific-based flipped classroom learning model in physics learning about rectilinear motion material with a percentage of 86% in the very good category. The suggestions that researchers can convey based on the research that has been carried out are it is hoped that teachers can use the scientific-based flipped classroom model as an alternative in the physics learning process, it is hoped that students will maintain and improve their critical thinking skills using the scientific-based flipped classroom model. It is hoped that future researchers can adjust critical thinking indicators to the learning material, because in this study there was one of the questions that did not match the situation presented in the questions given.

Acknowledgment
The author would like to thank all parties who have helped carry out the research in this thesis and also helped write this journal so that it is complete.

References


