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The Effect of Guided Inquiry Learning Model with Flipped Classroom Method toward Critical Thinking

Lambang Subagiyo[1], Fitriya Diyan Sari[1*], Muliati Syam[1]

[1] Physics Education Program, Faculty of Education and Teacher Training, Mulawarman University, Indonesia

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Corresponding Author:
Fitriya Diyan Sari
fitriyads01@gmail.com

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Abstract: The poor condition of the ability to think critically in students is a concern of the education system for the success of twenty-first-century learning. The combination of the model with the right method during the learning practice is certainly needed in training the ability to think critically. Therefore, to find out the increase in the ability to think critically of students at MAN 1 Samarinda, research was carried out by applying guided inquiry combined with a flipped classroom. The research design is a pretest-posttest match control group research design, because it is a quasi-experimental research type. The research sample consisted of the class receiving treatment and the class not receiving treatment which was determined through sampling using the purposive sampling technique. Measuring students' critical considerations through giving tests in the form of essay questions related to momentum and impulse material. The Mann-Whitney test explained that the class that received treatment experienced a significant increase in the ability to think critically after the guided inquiry learning model was applied combined with the flipped classroom method.

Keywords: Critical Thinking; Flipped Classroom; Guided Inquiry.

Introduction

Optimizing the successful implementation of the 2013 curriculum to face the challenges of twenty-first-century learning is needed to realize students' critical thinking skills in a science learning environment such as physics (Jamaluddin et al., 2019; Komala et al., 2020). Critical thinking skills refer to serious and thorough thinking activities through information gathering to establish rational and systematic reasons to solve the problems encountered (Ramdani et al., 2020; Ridho et al., 2020). Someone who can think critically is identified based on the quality of the results to be obtained because he can determine the best choice in solving problems by using a series of thinking strategies (Tiruneh et al., 2017). This means that critical thinking skills will make students able to understand concepts and state various reasons to support their arguments based on relevant sources of information that indirectly have a relationship with problem-solving skills and argumentation skills, so the increase in good critical thinking skills will be followed by mastery of other skills. However, the research identification results explained that the condition of students' critical thinking skills remained in a low category, with difficulties in answering questions using basic skill indicators, so the impact could not be completed until the indicators concluded (Yuliana et al., 2020). The same result explains that when students have a relatively low interpretation dimension, it will result in other dimensions such as analysis, evaluation, and explanation being in a very low category (Hajrin et al., 2019). Classified as having low critical thinking skills, students need help being involved in activities that direct the discovery of conceptual changes and the creation of integrated knowledge structures, such as the use of learning models that reflect a scientific approach and are accompanied by the use of digital tools (Permana et al., 2019; Redhana, 2019).

The use of the guided inquiry learning model with the flipped classroom method is considered capable of minimizing the amount of direct instruction and developing thinking skills while still completing all the syntax of the guided inquiry learning model in achieving learning objectives (Koes et al., 2020; Mukhlisa et al., 2021). The concept of the structure of the guided inquiry learning model is oriented towards finding

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relationships between concepts and practicing critical thinking skills through scientific inquiry (Anjelina & Mawardi, 2021; Yhawita Sari et al., 2020). Learning practices that make the educator's role only that of a facilitator while students are more involved in learning that is active, independent, and confident in their intellectual abilities based on physics concepts are the advantages of the guided inquiry model (Arafah, 2020; Asiah, 2021). Students' ability to think and solve problems will improve as a result of scientific investigation activities that lead them to carry out the regulatory process in dealing with cognitive conflicts over the new understanding they construct (Hajrin et al., 2019). Another positive impact for educators is that it helps convey learning material, which is often difficult to visualize for students but can be overcome through the structured scientific investigation of the guided inquiry learning model.

Minimizing the gap in the academic ability of students who find it difficult to accept learning material in text form, requires the freedom to study independently, and require unrestricted study time, the use of the flipped classroom method can be one of the efforts to fix problems in the learning process facilitated by digital devices (Mukhlisa et al., 2021; Zuhelmi et al., 2017). The flipped classroom method is known as the reverse classroom learning method (Hasanah et al., 2021) so that activities outside of formal class time are used to transfer learning material, and then formal class time is used for learning that involves students in solving problems interactively and collaboratively (Indah et al., 2020; Paristiowati et al., 2017). The flipped classroom method is in line with Bloom's taxonomy theory because activities outside the classroom apply lower-order thinking skills while face-to-face classes solve problems using higher-order thinking skills (Zainuddin & Halili, 2016). Therefore, planning learning activities that will be carried out before, during, and after learning in class is the educator's responsibility when using the flipped classroom method (Green et al., 2017; Jantakoon & Piriyasurawong, 2018). Giving assignments before class must have a background allowing students to participate actively during class. The activities provided while in class are more adapted to the learning models and methods applied. Likewise for after-class assignments, educators must relate what they have learned in class so that students can see the relevance of the material and build self-confidence. The structure of the flipped classroom method used by researchers will be summarized graphically in Figure 1.

Before Class, student will:	During Class, the student will:	After Class, the student will:
▪ Watching videos discussing practice questions and taking notes on learning materials in PowerPoint. ▪ Ask any questions you may have. ▪ Come to class ready to participate.	▪ Engage in guided inquiry scenarios. ▪ Collecting the results of notes on learning materials given outside the classroom. ▪ Collaborate with groups to complete scientific worksheets. ▪ Actively asking questions to peers or educators.	▪ Connecting the concepts learned from teaching materials with the results of scientific investigations. ▪ Solve practice questions on scientific worksheets independently.

Figure 1. Stages of the flipped classroom method

Efforts to collaborate the guided inquiry learning model with the flipped classroom method are considered capable of developing critical thinking skills because students can reflect on each learning process (Koes et al., 2020). When compared to expository learning strategies, the flipped classroom method produces better results for improving critical thinking skills (Widyasari et al., 2021). Therefore, researchers believe that to be able to deal with advances in information technology in the digital era, it is important to master the ability to solve problems using critical thinking. Research to measure how well students' critical thinking skills are certainly needed, one of which can be through the application of the guided inquiry learning model combined with the flipped classroom method.

Method

The study was conducted at MAN 1 Samarinda for the academic year 2021/2022 to measure critical thinking skills through the use of a guided inquiry learning model combined with the flipped classroom method. The study used a pretest-posttest match control group research design, because it was a quasi-experimental research type. The research sample was class X IPA 1 with 33 students and class X IPA 2 with 32 students, which were selected through the purposive sampling technique. The treatment in the form of using a guided inquiry learning model combined with the flipped classroom method will be applied in the experimental class while the use of conventional learning models in the control class. The test instrument

for critical thinking skills is in the form of essay questions with momentum and impulse materials that are adjusted to the indicators of critical thinking skills according to Tiruneh. Critical thinking indicators used in this study are; reasoning, likelihood and uncertainty analysis, problem-solving and decision-making, and argument analysis (Tiruneh et al., 2017). Data acquisition on critical thinking skills will be analyzed using the Mann-Whitney test. The percentage value of critical thinking skills indicators will be categorized based on the criteria of critical thinking skills according to Putri et al (2021) which is presented in Table 1.

Table 1. Critical thinking skills assessment criteria

Score Interval (%)	Criteria
86≤ N ≤ 100	Very High
76≤ N ≤ 85	High
60 ≤ N ≤ 75	Medium
55≤ N ≤59	Low
N ≤ 54	Very Low

Result and Discussion

The results showed an increase in the ability to use critical thinking in solving problems between the class that received treatment and the unknown class based on the analysis of pretest scores before learning and posttest scores after learning. Descriptive statistical analysis of classes that received treatment and classes that did not receive treatment related to pretest and posttest data are presented in Table 2.

Table 2. Descriptive statistics of pretest and posttest

Value	Class	N	Average	Standard Deviation
Pretest	Experiment	33	20.64	7.91
	Control	32	16.41	5.55
Posttest	Experiment	33	78.67	9.48
	Control	32	60.34	9.60

The average pretest obtained by the class that received treatment for critical thinking skills was 20.64 and the class that did not receive treatment for critical thinking skills was 16.41. However, the posttest results after learning about the ability to use critical thinking for the class that received treatment obtained a higher average of 78.67 than the class that did not receive treatment on critical thinking skills of only 60.34. This shows that the ability to use critical thinking in problem-solving for the treated class increased significantly after using the guided inquiry learning model combined with the flipped method compared to the critical thinking skills of the untreated class that only applied the direct learning model.

The ability to use critical thinking will be more effectively trained through the application of the guided inquiry learning model because educators will invite students to be active in scientific investigations (Asiah, 2021). In addition, the flipped classroom method combined with guided inquiry is one solution that has an impact on learning well, actively, anywhere, and by the time available during the learning phase at home (Anjelina & Mawardi, 2021). The activity of interacting with students during learning when using the Edmodo-based reverse class method is considered more qualified and effective (Hasanah et al., 2021). The following is an explanation of the data obtained from the N-Gain test for the treated class and the untreated class can be seen in Table 3.

Table 3. Normalized Gain Test

Class	Average	Category
Experiment	0.73	Medium
Control	0.53	Medium

Table 3 shows the N-Gain between the two classes, the results are the same in the medium category for the ability to use critical thinking. However, the highest average increase in N-Gain was in the class that received treatment at 0.73 while the class that did not receive treatment was 0.53. The N-Gain gain in the treated class is due to the use of student worksheets that are integrated with guided inquiry steps, starting with stimulating various questions so that students are required to connect their initial knowledge with the concepts that have been obtained to produce a complete understanding. Students who are accustomed to using critical thinking skills to solve a given problem will understand the concepts used to fill out answer sheets during the posttest. In addition, the class that did not get treatment also had N-Gain which was in the medium category because the lecture material was only given to 50% of students who were present in class due to limited face-to-face meetings while 50% of students who studied at home were given power points. interactive video that contains a video discussion of practice questions according to the researcher's explanation when teaching in class. The analysis of posttest score analysis on the percentage of each critical thinking indicator in the treated and untreated classes is shown in Table 4.

The percentage obtained by reasoning indicators shown in Table 4 shows that the class that received the treatment received a percentage of 86% while the class that did not receive the treatment received a percentage of 74%. Therefore, it is known that 24 students from the class received treatment, and 20 students from the class that did not receive treatment were able to answer the low difficulty level correctly. The difference in the percentage results that are not much difference between the class receiving treatment and the class not receiving treatment, because they are not accustomed to using the understanding of the concept of momentum that is connected to the phenomena of everyday life so they are

doubtful to determine the magnitude of the momentum and velocity of an object accurately based on the presentation of the event of a lorry moving under rainwater.

Table 4. Percentage score of each critical thinking indicator

Critical Thinking Skills Indicator	Question Difficulty Level	Experiment Class		Control Class	
		Percentage (%)	Criteria	Percentage (%)	Criteria
Reasoning	Medium	86	Very High	74	Medium
Argument Analysis	Medium	93	Very High	59	Low
	Difficulty	75	Medium	44	Very Low
	Medium	96	Very High	55	Low
Likelihood and	Medium	96	Very High	66	Medium
Uncertainty Analysis	Difficulty	61	Medium	37	Very Low
Problem Solving and	Medium	93	Very High	85	Very High
Decision Making	Very Difficulty	64	Medium	44	Very Low
	Medium	71	Medium	63	Medium
	Very Difficulty	39	Very Low	29	Very Low

Providing activities that connect various concepts that have been learned to be applied in everyday life can be a solution, such as critical reading activities on science news or providing stimulation to identify the presence of phenomena in scientific investigation worksheets. Practicing critical thinking based on facts or principles as a constructive process to be able to state conclusions, reasoning becomes a provision that must first be mastered. Mastery of critical thinking skills will be difficult for students if during the learning process educators do not apply appropriate learning models to practice critical thinking skills during scientific investigations (Asiah, 2021). Learning practices that use guided inquiry will be better for increasing students' understanding of physics concepts than using lecture learning models (Arafah, 2020). An example of a draft question to measure critical thinking skills on reasoning indicators is shown in Figure 2.

Sample questions:

Pay attention to the image on the side. A cart whose roof is exposed is moving at a constant speed in the heavy rain. If the rainwater falls vertically, the cart is filled with rainwater as shown in the picture above. Based on the event, determine the magnitude of momentum and speed that occurs on the cart!

Purpose:

This question item measures one of the critical thinking skills, that is, the indicator of providing reasoning. The domain-specific result that learners receive is being able to interpret the great statement of momentum and momentum speed of a phenomenon from a lorry filled with rainwater.

Scoring guide for the sample questions: 8 points

The following is an ideal complete answer that the researcher from a student:

The momentum of the cart will not change, due to the absence of force that changes the pace of the cart. There is a force from rainwater on the tub of the cart, but the direction of this force is perpendicular to the direction of movement of the cart so that it will not change the momentum of the cart in the horizontal direction. So that if the momentum of this cart is constant and its mass increases due to rainwater, the speed of the cart will decrease.

Note:

Before writing the correct answer, if the student who wrote it is known and asked from the information about the question, if yes award 2 points.

Figure 2. Examples of reasoning questions and corresponding scoring guide

Table 4 shows that the percentage of indicators analyzing the arguments obtained by the class receiving treatment is 75% while the class that does not receive treatment is 44%. This is because the questions given include the level of difficulty in which students are required to criticize the validity of Robin's statement on the acquisition of experimental data. Although given a question with a low level of difficulty such as analyzing the greatest throwing speed between two tug-of-war players, the class that received treatment still showed a higher percentage gain of 93% compared to the class that did not receive treatment at 59%. The cause of the high percentage of indicators analyzing arguments in the class that received treatment was that during the learning practice they were given the freedom to propose ideas based on their prior knowledge on the completion of scientific investigation sheets, especially in problem identification activities and verification

hypotheses. The low percentage of indicators analyzing arguments in the untreated class, because on average students are still confused about the use of the right velocity value to analyze the amount of kinetic energy of object A and object B before the collision against the truth of Robin's statement. In addition, some students are not able to complete the answer completely so the stage of concluding the statement of the experimental results is not carried out.

The best learning process is to guide students to construct skills that can assess how appropriate the reasons and evidence are in supporting a conclusion (Sadidi & Pospiech, 2019). In addition, if the implementation of learning does not involve students, the skills students are very lacking to be able to conclude or make generalizations from an experiment or phenomenon (Ridho et al., 2020). The implementation of learning that does not involve students' reasoning will result in not being able to make generalizations from an experiment or phenomenon (Ridho et al., 2020; Y. Yuliana et al., 2020). Activities that stimulate or expand students' initial knowledge will be more appropriately given outside the learning phase by using an inquiry-based reverse classroom approach (Schallert et al., 2021). The following is an example of a draft with a high level of difficulty to measure the ability to think critically, especially in the indicator of analyzing arguments in Figure 3.

Analyzing the possibility and uncertainty of the questions with the difficulty level, it is difficult to know that the class that received the treatment obtained a percentage of 61% while the class that did not receive the treatment obtained a percentage of 37%. The low percentage is because it requires students to determine the greatest velocity value of the three ball illustrations using known probabilities. In addition, many uses of equations to answer questions completely and correctly will certainly require a long processing time as well. Although given a question with a low level of difficulty such as considering the safety of the seatbelt design from the data provided, the class that received treatment still showed a higher percentage gain of 96% compared to the class that did not receive treatment at 66%.

Sample questions:

Object A and object B collided over a slippery horizontal flat plane and suffered a non-elastic impact at all. The initial velocity of bodies A and B was initially equally valued at 2 m/s. If the mass of object A is 5 kg and the mass of object B is 3 kg. Robin gave the following statement.

1. The total energy (A+B) after the impact is 1 Joule.
2. The kinetic energy of A before the impact is 12 Joule.
3. The kinetic energy of B before the impact is 6 Joules.
4. The magnitude of the speed after impact is 0.5 m/s.

Based on the statement Robin has given. Determine Robin's true statement!

Purpose:

This item measures one of the critical thinking skills, which is an indicator of analyzing arguments. Domain-specific results received by students are critiquing the credibility of information and being able to predict the correct statement from a set of data given in Robin's experimental results on collision events that are not flexible at all.

Scoring guide for the sample questions: 12 points

The following is an ideal complete answer that the researcher from a student:

In solving this problem, it can be done by finding the speed after a collision using the equation of the law of conservation of momentum as follows:

$\vec{p}_{awal} = \vec{p}_{akhir}$

$m_a\vec{v}_a + m_b\vec{v}_b = (m_a+m_b)\vec{v}'$

$(5\text{ kg})(2\text{ m/s}) + (3\text{ kg})(-2\text{ m/s}) = (5\text{ kg} + 3\text{ kg})\vec{v}'$

$10\text{ kgm/s} + (-6\text{ kgm/s}) = (8\text{ kg})\vec{v}'$

$4\text{ kgm/s} = (8\text{ kg})\vec{v}'$

$\vec{v}' = 0{,}5\text{ m/s}$

Followed by searching for values of the kinetic energy of object A before impact.

$E_k = \frac{1}{2}m_a\vec{v}_a' = \frac{1}{2}(5\text{ kg})(2\text{ m/s})^2 = 10\text{ Joule}$

And the kinetic energy of object B before impact

$E_k = \frac{1}{2}m_b\vec{v}_b' = \frac{1}{2}(3\text{ kg})(2\text{ m/s})^2 = 6\text{ Joule}$

While the total kinetic energy obtained after the collision:

$E_k = \frac{1}{2}m_{total}\vec{v}' = \frac{1}{2}(5\text{ kg} + 3\text{ kg})(0{,}5\text{ m/s})^2 = 1\text{ Joule}$

So, it can be stated that Robin's true statement is indicated in options a and c.

Note:

Before writing the correct answer, if the student who wrote it is known and asked from the information about the question, if yes award 2 points.

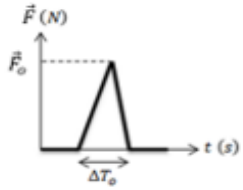
Figure 3. Examples of Argument Analysis and Corresponding Scoring Guide

The data obtained showed that the untreated class used the right strategy, which refers to making good decisions about an uncertain event. Being able to make the right decisions, of course, requires scientific inquiry worksheets that familiarize students with being able to propose hypotheses and analyze work procedures to obtain experimental data or additional information. Therefore, the class that gets the exact treatment gets a better percentage than the control class based on the results of calculating the expected value in a situation using known probabilities.

Analysis of the indicators of problem-solving and decision-making, it known that the percentage obtained by the class receiving treatment can solve problems with a very difficult level of difficulty of 39% while the class that does not receive treatment is 29%. The difficulties faced by the average student when analyzing an impulse graph to determine the velocity of an object after a collision. Another contributing factor is getting used to using only the equations available in physics books without knowing the origin of the equation. Therefore, students who master the reasoning aspect will certainly be able to solve problems related to reason and logic in science, because reasoning is an element of problem-solving. This is shown by the results of the percentage of indicators of problem-solving and decision-making on questions with a low level of difficulty, it is known that the percentage obtained between the classes that receive treatment is 93% and did not receive treatment by 85% of which both classes were included in the very high criteria. The following is an example of a draft question with a very difficult level of difficulty to measure critical thinking skills on the indicators of problem-solving and decision-making shown in Figure 4.

Sample questions:

If an object of mass A m_A moves along the positive x-axis with a constant $\vec{v}_0$. Then object A pounded the still and mass object B m_B. The picture beside is a graphic illustration that illustrates the magnitude of the interaction force experienced by object A during the collision. Based on the event, determine the rate of object B after the impact!



Purpose:

This question item measures one of the critical thinking skills, namely indicators of problem solving and decision making. The domain-specific result received by students is to be able to recognize the problem and identify the best alternatives in problem solving.

Scoring guide for the sample questions: 10 points

The following is an ideal complete answer that the researcher from a student:

From the graph of the relationship of forces to time for body B, then the impulse values are:

$$\vec{I}_B = \text{luas grafik} = \frac{1}{2}at = \frac{1}{2}\Delta T_o \vec{F}_o$$

Then to find the magnitude of the velocity of the body B after the collision can use the equation of the relationship between impulse and momentum, where the impulse is equal to change momentum.

$$\vec{I}_B = \Delta \vec{p}_B$$

$$\frac{1}{2}\Delta T_o \vec{F}_o = m_B(\vec{v}'_B - \vec{v}_B)$$

$$\frac{1}{2}\Delta T_o \vec{F}_o = m_B(\vec{v}'_B - 0)$$

$$\vec{v}'_B = \frac{\Delta T_o \vec{F}_o}{2m_B}$$

So, it can be concluded that the speed of object B after being impacted by object A is:

$$\vec{v}'_B = \frac{\Delta T_o \vec{F}_o}{2m_B}$$

Note:

Before writing the correct answer, if the student who wrote it is known and asked from the information about the question, if yes award 2 points.

Figure 4. Examples of Problem-Solving or Decision-Making and Corresponding Scoring Guide

Based on the exposure scores of each critical thinking indicator, it has been explained that the ability to use critical thinking in solving problems for the untreated class gets a lower percentage than the treated class. This is because the use of a direct learning model that only gives lectures is not appropriate for a large number of students. Therefore, it takes a combination of learning models with special learning methods that stimulate the use of the ability to think rationally about what to do in solving problems and reducing activities as a source of information on the learning material being studied. This is in line with the results of research by (Darmaji et al., 2021) which explains that students will tend to be passive and not take the initiative to use

critical thinking skills in solving problems due to not being able to solve problems. Another supporting factor is that during the learning process teachers are still the main learning resource so the use of online media such as learning videos, e-books, e-libraries, and virtual laboratories as independent learning resources is still low introduced to students (Mukhlisa et al., 2021).

Hypothesis testing to determine the difference in critical thinking skills obtained by the class receiving treatment and the class not receiving treatment, a prerequisite test was first carried out, namely the normality test using the Kolmogorov-Smirnov test which is shown in Table 5.

Table 5. The normality test in the class received treatment and the class did not receive treatment

Class	Value	Normality
Experiment	Pretest	0.01
	Posttest	0.20
Control	Pretest	0.00
	Posttest	0.20

The normality test of the pretest data shown in Table 5 in the class that received treatment and the class that did not receive treatment was known to be not normally distributed because the significance value obtained was less than 0.05. However, the posttest data between the treated and non-treated classes were normally distributed because the significance value was more than 0.05. Convinced that the two-sample data come from populations that have the same variance, then proceed with conducting a homogeneity test using the Levene Statistic test shown in Table 6.

Table 6. Homogeneity test and Mann-Whitney test in the class receiving treatment and the class not receiving treatment

Class	Homogeneity	Asymp. Sig. (2-tailed)
Experiment Control	0.84	0.00

The significance value of the homogeneity test between the treated and untreated classes was obtained at a value greater than 0.05 so that it was concluded that the two classes had the same variance or were homogeneous. The research data that has been tested for prerequisites shows that the data are not normally distributed, but the data is homogeneous, so the Mann-Whitney test is continued. In the Mann-Whitney test shown in Table 6, it is known that the significance value obtained is less than 0.05 so the initial hypothesis is rejected and the alternative hypothesis is accepted. Therefore, it can be concluded that the critical thinking skills of the treated class will be better when using the learning model combined with the flipped classroom method, while the critical thinking skills of the untreated class will be lower due to the use of conventional learning models. In line with the results of research by (Novsimapera & Mawardi, 2021), showing the comfort aspect of students during the implementation of online learning during the pandemic through the use of flipped classrooms combined with guided learning models based on the Edmodo application and Zoom Meeting is considered very practical. Student learning achievement will be higher with the combination of the inquiry-flipped classroom model than using the guided inquiry learning model without being combined with significant learning methods because during the learning practice students are required to prepare themselves by making a summary of the material or noting things that have not been studied. understood from the video material that was distributed before participating in face-to-face learning (Paristiowati et al., 2017).

Conclusion

The results showed that through quantitative studies and empirical evidence the ability to use critical thinking was known to increase higher after applying the guided inquiry learning model combined with the flipped classroom method. Classes that do not receive treatment using conventional learning models are known to have a lower ability to think critically about solving problems. This is evidenced by the attachment of Table 4 for the class that received treatment was able to maximize the posttest results, especially on the indicators of analyzing arguments. Therefore, improving critical thinking skills can be done through the use of learning models combined with the flipped classroom method.

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