



The Impact of Implementing Guided Inquiry-Based Mathematics E-Worksheets Using the Blended Learning Method on Increasing Students' Critical Thinking

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Abstract

The development of mathematics e-worksheets focused on forming critical thinking skills for class VII students is still very minimally carried out by teachers. This research is critical to test the effectiveness of guided inquiry-based e-worksheets implemented using the blended learning method in improving students' critical thinking abilities. The type of research was a quasi-experiment with a *nonequivalent pretest-post-test control group design* involving two subjects: the experimental group that applied guided inquiry-based e-worksheets and the control group that used other e-worksheets. Each subject group consisted of 18 students from one of the Yogyakarta boarding schools, which became the research population. Research data came from pretest and post-test results collected using critical thinking test instruments developed based on indicators from Facione (2018). Data analysis was conducted using a *paired sample t-test* followed by an *independent sample t-test*. The results of data analysis show: (1) there is a significant difference between the pretest and post-test results in the experimental group; (2) there is a significant difference between the results of students' critical thinking tests in the experimental and control groups; and (3) the difference in increasing critical thinking skills of students in the experimental group is higher than students in the control group. These results conclude that applying guided inquiry-based e-worksheets using the blended learning method is more effective than other e-worksheets when viewed from the aspect of increasing students' critical thinking abilities.

Keywords: Blended learning, critical thinking, e-worksheet, guided inquiry

INTRODUCTION

The need for mathematics teachers in Indonesia to provide learning media that can be used to train students' critical thinking is very urgent. The great need for this arises because the ability of mathematics teachers to produce learning media is still very minimal. The causes include limited time and difficulties in determining the right media according to the characteristics of the teaching material (Andriyani, 2021; Cahyadi, 2019; Choirudin et al., 2021). The steps taken by teachers to cover the shortcomings of learning media are usually by accessing online learning resources (Choirudin et al., 2021), where online content

generally does not fully consider the aim of forming students' critical thinking skills.

The limitations experienced by mathematics teachers in Indonesia, especially in developing media oriented towards achieving students' critical thinking skills, of course, still require the intervention of many parties to overcome them. Moreover, the target of achieving critical thinking skills for primary to secondary education graduates has become the main demand emphasized in the Independent Curriculum implemented in Indonesia to date (Kurniawan et al., 2020). If educators in Indonesia do not seriously consider this, future generations' critical thinking abilities can lag behind other countries' progress. Other

countries have long set critical thinking skills as a target that their graduates must achieve (Ahonen & Kinnunen, 2015; Aizikovitsh-Udi & Cheng, 2015; Basri et al., 2019; Kadir, Lucyana, & Satriawati, 2017; Radulović & Stančić, 2017; Tiruneh et al., 2017).

The shortage of mathematics learning media, as has been explained, is a reason for researchers to carry out a series of research actions to find alternative solutions. The research stage begins with an analysis of media needs with the conclusion that there is a need to develop a student worksheet (Triyono & Suparman, 2018), which contains: (1) guided inquiry steps from (Kuhlthau, 2021; Kuhlthau, Maniotes, & Caspari, 2015); (2) teaching material for the concept of proportion in class VII, and; (3) a test instrument containing critical thinking indicators from (Facione, 2018; Facione, Facione, & Gittens, 2020). The next stage is the design and development process of the e-worksheet. Based on the procedures used, the e-worksheet has been declared valid based on the assessment of experts in the field (Triyono et al., 2022; Triyono & Suparman, 2019). An example of the display of the parts of a student worksheet can be seen in Figure 1.

As shown in Figure 1, the worksheet is ready to be applied, but it is still limited to direct learning. Meanwhile, in implementing the Independent Curriculum in Indonesia, teachers are required to utilize information, communication, and technology facilities as part of the educational digitalization process (Lestari, Westhisi, & Aprilia, 2024; Wahyudiono, 2023; Zidan & Qamariah, 2023). For mathematics teachers whose digital literacy skills are still minimal, of course, this demand adds further problems (Aulia, Asbari, & Wulandari, 2024; Hehakaya & Pollatu, 2022; Supriatna et al., 2023). However, what the government hopes is true, namely that if we reflect on learning during the Covid-19 pandemic, the learning process must be carried out using blended learning, namely a combination of face-to-face learning processes with distance learning using online devices (Hrastinski, 2019; Lestari, Gunawan, & Yulianci, 2020). Another condition that requires implementing blended learning is when the city of Jakarta, Indonesia, is declared unhealthy by the local government. So, it is not wrong that the government highly recommends the blended learning process as an integral part of the implementation of the Merdeka Curriculum that is currently being implemented (Ahid & Sufirmansyah, 2022). Moreover, the blended learning method may continue to develop in the coming years (Castro, 2019; Sohaya, 2020).

Based on the explanations above, student worksheets, which were previously thought to be able to be implemented directly, apparently still need to be integrated into certain applications so that they can be used during the blended learning process. These supporting applications must meet practical criteria when used online by teachers and students. The Liveworksheet application was chosen because it had been tested for its practicality in learning (Putra & Ekasari, 2018). Once student worksheets are integrated into the Liveworksheet Application, they can be called e-worksheets. An example of an e-worksheet



Figure 1. Example of Student Worksheet Display (Triyono et al., 2022)

display assisted by the Liveworksheet Application is presented in Figure 2.

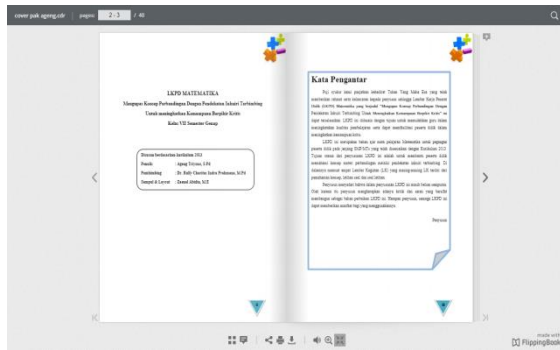


Figure 2. Example of an E-Worksheet Display Using the Liveworksheet Application

Up to this stage, researchers have had an e-worksheet with a guided inquiry approach developed to develop critical thinking skills in class VII students. The next questions are: (1) what kind of blended learning process design will the teacher carry out when teaching comparative material?; (2) Is the use of e-worksheets effective in terms of increasing students' critical thinking skills? These two research questions will be answered through this research. The implementation of e-worksheets will be declared effective if the critical thinking abilities of students who use them are proven to be better than those of students who learn using other e-worksheets.

This research is important because the results will positively contribute to the critical thinking development program being launched by the Indonesian government. Apart from being important, this research also has novelty value when compared with similar research that has existed before, where previous research did not focus on forming students' critical thinking skills, and there was no correlation with the implementation of blended learning. Among these are tests of the effectiveness of guided inquiry-based e-worksheets by Ermawati & Tambunan (2023) on the topic of polynomials and the development of guided inquiry-based e-worksheets on the topic of integers by Saputri & Widodo (2022). Because these two studies have not yet focused on increasing critical thinking and applying of blended learning, it is hoped that the research will bridge this gap.

Apart from that, if it turns out that e-worksheets can improve students' critical thinking skills effectively, teachers can duplicate e-worksheets that researchers have developed for teaching purposes on different topics. This also includes adapting the blended learning process flow which has been proven to be effective in achieving learning objectives.

METHODS

The research aims is to prove the effectiveness of guided inquiry-based mathematics e-worksheets in improving the critical thinking of class VII students, which is applied using the blended learning method. The research objectives were achieved using a quasi-experimental research method with a nonequivalent pretest-post-test control group design, which focused on directly testing the influence of one variable on other variables (Sugiyono, 2018). The variables in question are the application of guided inquiry-based e-worksheets as the independent variable, increasing critical thinking as the dependent variable, and students' initial critical thinking abilities as the control variable. This research design involved two subjects, namely the experimental group and the control group, which were selected using stratified random sampling techniques from the population. The research population was class VII students from one of the junior high schools in Yogyakarta who took part in a boarding education program that consisted of 5 groups of students. Using the stratified random sampling technique, the 5 groups of students were combined into 3 sub-groups, the combination of which was based on the average ranking of exam scores in the previous semester. These sub-groups are: high ranking sub-group (1 group); middle-ranking subgroups (2 groups); and lower ranking subgroups (2 groups). Those used as research subjects were 2 groups of students in the middle-ranking sub-group, with 18 students in each group.

The design and strategy of this research are adapted from the quasi-experimental

research used by Triyono et al., (2024), generally presented in Figure 3.

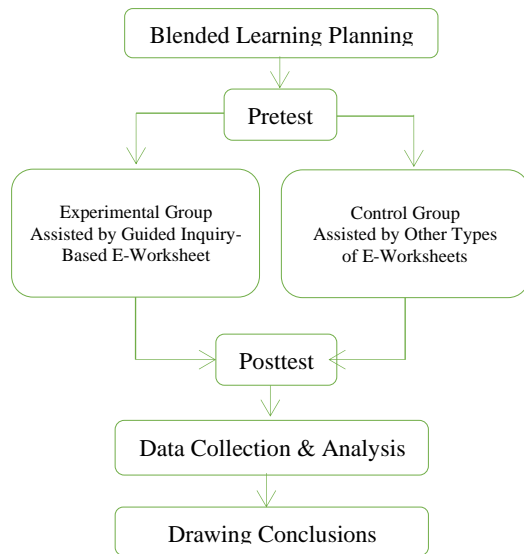


Figure 3. The Research Design Used (adapted from Triyono et al., 2024)

Figure 3 shows that the research began with implementing of blended learning. The blended learning stages are planned according to the Flex Model, which allows: (1) students to access all learning content in e-worksheets online; (2) students who determine their online learning schedule; (3) the teacher monitors student discussion groups; (4) teachers provide tutoring for students who need guidance, and; (5) face-to-face learning is scheduled according to student needs (Horn & Staker, 2017). The next stage is giving a pretest before implementing blended learning. Both groups of students will carry out blended learning under the same conditions and study the same topic, namely mathematical comparisons. The difference is in the e-worksheet used, where the experimental group applied a guided inquiry-based e-worksheet, while the control group applied another type of e-worksheet. After the learning, a post-test is given, which continues with data collection and analysis and ends with drawing conclusions.

Research data consists of pretest and post-test scores collected using critical thinking test instruments. The test instrument consists of 5 descriptive questions declared valid based on the results of expert assessment. The pretest and

post-test results for each student are given a score based on the provisions in the rubric for measuring students' critical abilities, with measurement indicators consisting of interpretation, analysis, evaluation, and inference (Facione, 2018). Data analysis was carried out using a series of statistical tests, the main aim of which was to conclude the effectiveness of e-worksheets in blended learning. Stages of data analysis: (1) Paired Sample t -Test to determine whether there is a significant average difference between the pretest and post-test results of each group; (2) the Independent Sample t -Test aims to determine whether there is a significant difference between the critical thinking test results of students in the experimental group and the control group, and; (3) calculate the difference in the average increase in critical thinking test results for the experimental and control groups. The application of e-worksheets based on guided inquiry using blended learning is concluded to be effective in improving students' critical thinking skills, namely if: (1) the results of the Paired Sample t -Test state that there is a significant difference between the average pretest scores and post-test data in the experimental group; (2) the results of the Independent Sample t -Test show that there is a significant difference between the critical thinking test results of experimental and control group students, and; (3) the calculation of the average difference in the increase in critical thinking test results in the experimental group is higher than in the control group. However, before statistical tests are carried out, they must be preceded by prerequisite tests, which consist of a normality test using the Shapiro-Wilk test and a homogeneity test using the Levene Statistics test.

RESULTS AND DISCUSSION

RESULTS

Pretest Results

Giving the pretest is intended to determine students' initial critical thinking abilities. The pretest results are presented in Table 1.

Table 1. Pretest Results
Experimental and Control Groups

| Student Number | Experimental Group | Control Group |
|----------------|--------------------|---------------|
| 1 | 58 | 62 |
| 2 | 63 | 16 |
| 3 | 37 | 41 |
| 4 | 45 | 20 |
| 5 | 24 | 41 |
| 6 | 53 | 29 |
| 7 | 25 | 12 |
| 8 | 65 | 32 |
| 9 | 68 | 24 |
| 10 | 24 | 20 |
| 11 | 37 | 37 |
| 12 | 12 | 32 |
| 13 | 32 | 41 |
| 14 | 8 | 24 |
| 15 | 37 | 16 |
| 16 | 34 | 54 |
| 17 | 45 | 62 |
| 18 | 58 | 45 |
| Highest score | 68 | 62 |
| Lowest score | 8 | 12 |
| Average | 40.28 | 33.78 |

The mean score of the pretest results in Table 1 reflects students' initial critical thinking abilities, namely 40.28 for the experimental group and 33.78 for the control group.

Implementation of Blended Learning

Teaching materials, namely proportion concepts, were taught using the blended learning method with the help of e-worksheets to the two sample groups. The difference in treatment was that an e-worksheet with a guided inquiry approach was used in the experimental group, while in the control group, another e-worksheet was used. The planning for implementing learning using the blended learning method in this research adapted the Flex Model (Staker & Horn, 2017). The blended learning process flow is presented in Figure 4.

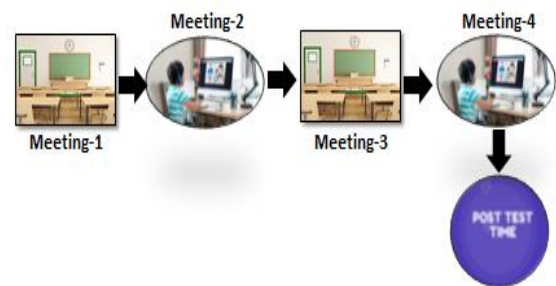


Figure 4. Blended Learning Process Flow that Adapts the Flex Model (Staker & Horn, 2017)

According to the process flow in Figure 4, the material on proportion concepts was taught in 4 meetings in both sample groups. Meetings 1 and 3 were held face to face, where the teacher fully utilized this session to deliver teaching material. Meetings 2 and 4 were held online, where students actively completed the quiz questions presented in the e-worksheet. During online learning sessions, the teacher's role is limited to providing direction and monitoring students virtually using the Webex application while students carry out the learning guide delivered by the teacher from the place or dormitory room they live in.

At meeting 1, the teacher explained the direct proportion concept material face-to-face, which was then used as a basis for students to complete the quiz in the e-worksheet at meeting 2, which was held online. The quizzes faced by students in the experimental group must be completed using the guided inquiry steps listed in the e-worksheet, which consist of the steps: presenting questions, making hypotheses, designing experiments, conducting experiments to obtain information, collecting and analyzing data, as well as drawing conclusions (Eggen & Kauchak, 2006). Meanwhile, students in the control group could complete the quizzes in their e-worksheet using steps other than guided inquiry. At the 3rd meeting, the material on the concepts of inverse proportion was explained, which will be used as a basis for students to complete the quizzes at the 4th meeting. After the 4th meeting, there was a post-test, which took place face to face.

Post-test Results

The post-test was given to determine the increase in students' achievement of critical thinking skills after participating in blended learning with the help of e-worksheets. The post-test results are presented in Table 2.

Table 2. Post-test Results
Experimental and Control Groups

| Student Number | Experimental Group | Control Group |
|----------------|--------------------|---------------|
| 1 | 90 | 52 |
| 2 | 90 | 74 |
| 3 | 78 | 82 |
| 4 | 95 | 92 |
| 5 | 85 | 66 |
| 6 | 58 | 61 |
| 7 | 83 | 66 |
| 8 | 49 | 32 |
| 9 | 95 | 74 |
| 10 | 61 | 45 |
| 11 | 95 | 75 |
| 12 | 100 | 73 |
| 13 | 73 | 61 |
| 14 | 100 | 87 |
| 15 | 78 | 66 |
| 16 | 62 | 95 |
| 17 | 95 | 66 |
| 18 | 66 | 61 |
| Highest score | 100 | 95 |
| Lowest score | 49 | 32 |
| Average | 80.71 | 68.22 |

Table 2 shows the average score of the experimental class post-test results of 80.71, which is higher than the control group, with an average score of 68.22.

The impact of guided inquiry-based e-worksheets on improving students' critical thinking skills in the experimental group can also be seen from the achievement of each indicator, as presented in Table 3. Table 3 shows an increase in students' achievement of critical thinking skills for each indicator used, namely, students' interpretation skills increased by 32.22%, analysis skills increased by 33.61%, evaluation skills increased by 49.16%, and inference skills increased, amounting to 45.18%. However, on the other hand, the

experimental group also increased the average score on the critical thinking ability test, namely from an initial ability of 33.78 to 68.22. Therefore, it is necessary to carry out an effectiveness test to prove the assumption that applying guided inquiry-based e-worksheets using blended learning is more effective in facilitating increased students' critical thinking than other e-worksheets.

Table 3. Critical Thinking Achievement in the Experimental Group Based on Indicators

| Indicator | Pretest | Post-test | Enhancement |
|----------------|---------|-----------|-------------|
| Interpretation | 65% | 97.22% | 32.22% |
| Analysis | 65% | 98.61% | 33.61% |
| Evaluation | 30% | 79.16% | 49.16% |
| Inference | 26% | 71.81% | 45.18% |
| Average | 46.5% | 86.54% | 40.04% |

Normality and Homogeneity Test Results

The normality test is carried out to ensure whether the data comes from a normally distributed population. This must be done so that subsequent research steps do not deviate from the truth and can be accounted for (Sugiyono, 2018). The pretest and post-test data normality test was carried out using the Shapiro-Wilk test with the help of SPSS software. The decision to test the hypothesis at a significance level of $\alpha = 5\%$ with the criteria for normally distributed data is if the significance value (Sig.) of the experimental and control groups is ≥ 0.05 . A summary of the normality test results of pretest and post-test data is presented in Table 4 and 5.

Table 4. Normality Test Results
Pretest Data

| Class | Shapiro Wilk (a) | | |
|------------------|------------------|----|-------|
| | Statistic | df | Sig. |
| Experiment Group | 0.128 | 18 | 0.200 |
| Control Group | 0.127 | 18 | 0.200 |

Table 4 shows that the significance values for the experimental and control groups are $0.200 \geq 0.05$, respectively, so it can be concluded that the distribution of students' initial critical thinking ability test data comes from a normally distributed population.

Table 5. Normality Test Results
Post-test Data

| Class | Shapiro Wilk (a) | | |
|------------------|------------------|----|-------|
| | Statistic | df | Sig. |
| Experiment Group | 0.164 | 18 | 0.200 |
| Control Group | 0.118 | 18 | 0.200 |

Table 5 shows the significance value for the experimental and control groups of $0.200 \geq 0.05$, so it can be concluded that the distribution of post-test data also comes from a normally distributed population.

The homogeneity test was carried out to obtain the assumption that the research sample started from the same or homogeneous conditions (Sugiyono, 2018). Homogeneity tests were carried out on pretest and post-test data using the Levene Statistics Test assisted by SPSS software. The decision to test the hypothesis at a significance level of $\alpha = 5\%$ with the variance criteria of the two homogeneous samples is if the significance value for the control and experimental classes is ≥ 0.05 . The results of the homogeneity test of pretest and post-test data are presented in Table 6 and 7.

Table 6. Homogeneity Test Results
Pretest Data

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|-------|
| 0.553 | 1 | 34 | 0.462 |

Table 6 shows a significance value of $0.462 \geq 0.05$, so the conclusion is that the pretest data from the experimental group and the control group have homogeneous variance, or in other words, they start from the same conditions.

Table 7. Homogeneity Test Results
Post-test Data

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|-------|
| 0.205 | 1 | 34 | 0.653 |

Table 7 shows the results of calculating a significant value of $0.653 \geq 0.05$, so the conclusion is that the post-test data for the experimental and control groups had homogeneous variance after blended learning was carried out.

Effectiveness Test Results

Paired Samples T-Test is intended to determine whether there is a significant difference in mean between the pretest and post-test results. If there is a significant difference in mean, it can be assumed that this achievement is the impact of using e-worksheets. The basis for decision-making used is: (1) if the sig. (2-tailed) < 0.05 , then there is a significant difference between the average score of the critical thinking test results in the pre-test and post-test data, and; (2) if the sig (2-tailed) value is > 0.05 , then there is no significant difference between the average score of the critical thinking test results in the pre-test and post-test data. Paired Sample *t*-Test results in the experimental and control groups are presented in Table 8 and Table 9.

Table 8. Paired Sample *t*-Test Results for
Experimental Groups

| Data | Paired Sample <i>t</i> -Test Results | | |
|---|--------------------------------------|----|-----------------|
| | <i>t</i> | df | Sig. (2-tailed) |
| Experiment group pretest-post-test scores | -6.396 | 17 | 0.000 |

Table 8 shows the sig value (2-tailed) = $0.000 < 0.05$, so the test decision is that there is a significant difference between the mean score of the critical thinking test results in the pretest and post-test data in the experimental group.

Table 9. Paired Sample *t*-Test Results for the Control Group

| Data | Paired sample <i>t</i> -test results | | |
|--|--------------------------------------|-----------|-----------------|
| | <i>t</i> | <i>df</i> | Sig. (2-tailed) |
| Control group pretest-post-test scores | -6.891 | 17 | 0.000 |

Table 9 shows the significance value (2-tailed) = 0.000 < 0.05, so the test decision is that there is a significant difference between the mean score of the critical thinking test results in the pretest and post-test data in the control group.

The results of the Paired Sample *t*-Test show that there is a significant difference between the pretest and post-test results experienced by the experimental group and the control group. Next, it needs to be shown whether there is a significant difference between the results of students' critical thinking tests in the experimental and control groups. The data analyzed were post-test data from two groups of subjects. Data analysis was carried out using an Independent Sample *t*-Test assisted by SPSS software, and the basis of test decisions was as follows: (1) if the sig. (2-tailed) < 0.05, then there is a significant difference between the results of the critical thinking test for experimental and control group students, and; (2) if the sig (2-tailed) value is > 0.005, then there is no significant difference between the results of the critical thinking test for experimental and control group students. Independent Sample *t*-Test results are presented in Table 10.

Table 10. Independent Sample *t*-Test Results

| Data | Sig. | Sig.2-tailed | Means Differences |
|-----------|-------|--------------|-------------------|
| Post-test | 0.597 | 0.024 | -12.500 |

Table 10 shows the sig value (2-tailed) = 0.024 < 0.05, so the conclusion is that there is a significant difference between the critical thinking test results of experimental and control group students. This significant difference can be seen from the increase in the average score of the critical thinking test results, as presented in Table 11.

Table 11. Improvement in Critical Thinking Test Results for Experimental and Control Groups

| Aspect | Experiment Group | | Control Group | |
|---------------------------|------------------|------------------|-----------------|------------------|
| | <i>Pre-test</i> | <i>Post-test</i> | <i>Pre-test</i> | <i>Post-test</i> |
| Total Students | 18 | 18 | 18 | 18 |
| Total score | 725 | 1453 | 608 | 1228 |
| Average | 40.28 | 80.71 | 33.78 | 68.22 |
| Increase in average score | 40.43 | | 34.44 | |

Table 11 shows an increase in the average critical thinking test score for the experimental group by $x = 40.43$ and the control group by $y = 34.44$ if compared, $x > y$, which shows that the application of e-worksheets with an inquiry approach is more effective in increasing students' critical thinking achievements than the application of other e-worksheets.

DISCUSSION

Based on the paired sample *t*-test results, researchers showed that the application of guided inquiry-based e-worksheets resulted in a significant difference between the mean scores of the pretest and post-test results in the experimental group. This difference can be seen in the percentage achievement of each critical thinking indicator, as presented in Table 3. The graph of the percentage increase for each critical thinking indicator can be seen in Figure 5.

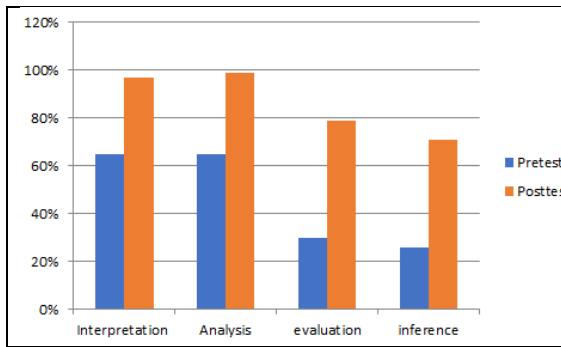


Figure 5. Graph of Percentage Increase in Critical Thinking Indicator Achievement

Based on the Independent Sample t-Test results, the researchers showed a significant difference between the critical thinking test results of experimental and control group students. This difference can also be seen from the increase in the experimental group's average score, which was higher than the average score in the control group, as presented in Table 11 above. Thus, researchers have concluded that students' critical thinking abilities will be more effective if guided inquiry-based e-worksheets are improved compared to other e-worksheets, where the learning process for the two sample groups is carried out following the blended learning flow.

The increase in students' critical thinking skills in the experimental group was more significant than students in the control group. This condition was influenced by the guided inquiry steps on the e-worksheet, which they had to follow when practicing solving quiz questions. These results confirm the previous conclusion, which states that the guided inquiry steps in e-worksheets positively improve student learning outcomes Ermawati & Tambunan (2023) and Saputri & Widodo (2022). A more specific student learning outcome is an increase in the ability to think critically, as shown by the results of this research. Sari, Subagiyo, & Syam (2023) research, which measured students' critical thinking abilities in physics learning on momentum and impulse, also stated the same conclusion. Subagiyo et al. (2023) did combined guided inquiry steps in the flipped

classroom method. Furthermore, Miftakhurrohmah, Masykuri, & Ariyani (2023) research conclusions also stated that there was a significant positive impact from the use of guided inquiry steps in the e-module he developed. Miftakhurrohmah et al. (2023) measured the progress of students' critical thinking in biology learning on the human excretory system. Wayan Wartini (2021), who tried to improve students' learning motivation and critical thinking abilities, also stated that they succeeded after conducting classroom research using the guided inquiry method.

The description above proves that the guided inquiry steps successfully improve students' critical thinking abilities. The learning process carried out by teachers can be done through various methods and with the help of learning media, as tested by the researchers above. The results of this research have enriched mathematics learning media and learning methods that can be used as an alternative to improve students' critical thinking skills, namely guided inquiry-based mathematics e-worksheets applied using the blended learning method.

CONCLUSION

Based on the data analysis and discussion results, it can be concluded that the application of guided inquiry-based e-worksheets can be used to improve the critical thinking skills of class VII students. This is proven by the results of statistical tests, which show that there are: (1) significant differences between the mean scores of critical thinking test results in pre-test and post-test data in the experimental group; (2) significant differences between critical thinking test results for experimental and control group students, and; (3) the difference in increasing critical thinking skills of students in the experimental group is higher than students in the control group. Thus, this research has achieved the stated objectives.

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