Research Article

Increasing students' critical thinking ability in mathematics and fighting power through the implementation of an *Open-Ended Approach*

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ABSTRACT

One of the challenges for teachers in the world of education is to implement programs that can improve critical thinking skills and increase students' fighting power. One way to improve the quality of mathematics education is to use a learning model that supports the realization of the true goals of mathematics education, including improving students' critical thinking skills and fighting power. Therefore, the purpose of this research is to improve students' mathematical critical thinking skills and fighting power through the application of an open-ended approach. The design of this research is Experimental Factorial with the aim of improving critical thinking skills and fighting power. The subject of this study is Class X MAS Nurul Khair. In this study, the data collection tools used include a critical thinking ability test and a fighting force questionnaire. The results of the study are as follows: 1) the improvement of critical thinking skills is better if using the open-ended approach compared to the conventional, 2) the increase in fighting power is better if using the open-ended approach compared to the conventional.

Keywords: Mathematical critical thinking skills; Fighting power; Open-ended approach

1. INTRODUCTION

Education is a special process and way for humans to acquire knowledge, understanding and how to act according to their needs. Education also provides education regarding the skills and behaviors of a group of people to be passed down from one generation to another through education, training or research. Education is carried out under the guidance of others, but education can also be done by self-taught. (Sriwilujeng, 2017:2). Mathematics is one of the most important things in life. In all aspects of our lives, we cannot be separated from the concept of mathematical science. Because of its important contribution to science, mathematics is referred to as the root of science (Rachmantika & Wardono, 2019).

Critical thinking is an essential skill that helps students develop deep understanding, strong reasoning abilities, and critical evaluative skills. In a world filled with abundant information, critical thinking provides students with the necessary framework to filter information, identify the truth, and make informed decisions (B. Lena Nuryanti Sastradinata, 2023). According to Adleri's theory, adversity quotient (fighting power) is compensation (striving force as compensation) where humans have fighting power from birth. The human fighting power to achieve a goal is to recover a sense of inferiority, and the fighting power must be honed and developed so that the human soul remains healthy and balanced. Adler says that people can fight for what they want and for the sake of the environment. Therefore, we can conclude that fighting power is a person's ability to perform good actions and efforts to succeed and overcome all obstacles to achieve certain goals (Zubaidah Amir and Risnawati, 2015).

However, the reality in the field shows that mathematics is one of the subjects that is less in demand among students (Huzaimah & Risma, 2021). The psychological effect is one of the indicators: Students see mathematics as a difficult subject and a scary subject (Jeheman et al., 2019). Based on observations of learning activities and interviews with mathematics teachers in class X of MAS Nurul Khair, it can be seen that many students do not study independently. For example, learning is always focused on the teacher, they are not fully involved in the learning process because mathematics is less

interesting and difficult to learn, and often do not do the homework given by the teacher even though it has been repeatedly given, the lack of effort of students when completing the test can be seen only some students who complete with answers different from what the teacher taught, and when working on problems that are different from what the teacher explained, Students have difficulty solving it and if they are asked to come to the front of the class to work on a problem they are just waiting for their other friends to work on it, only a few students understand the material well. Based on this fact, it is concluded that critical thinking skills are still low and students' mathematical fighting power is still low.

According to Muhibbinsyah (2013) Factors that affect student learning included internal factors, namely the student's physical and mental state or condition, external factors, namely the student's surrounding environment, and learning style, namely the type of student learning. Testing involves strategies and methods. used to study subjects. Of the three things, one of them is a strategy or method. One of them is the Open-Ended approach. The Open-Ended Approach (Farida, Isro'atun and Amelia Rosmala, 2018) is open-ended learning where the teacher presents a problem whose answer or solution can be found in other ways. The problem-solving process is carried out by studying, researching, analyzing and analyzing the problems faced properly. When learning is open-ended, students are expected not only to find answers, but also to make connections with the process of finding answers to teach mathematics and students' thinking, and hope that they will improve students' critical thinking skills and mathematical fighting power.

The open-ended approach (Shoimin, 2014: 112) that the advantages are (1) students are more involved in learning and always exchange ideas; (2) students are empowered to use their knowledge and skills holistically; (3) low-level students are able to answer problems independently; 4) that the student is internally motivated to provide evidence or explanation; and (5) students who are highly experienced in finding solutions to problems. Using descriptive skills will help students understand the problems they face and help them find solutions to solve the problems they face. This allows students to understand the material more quickly in addition to searching on their own, students also obtain information through the teacher's explanation.

In this study, critical thinking skills refer to indicators by Ennis in five activities, including: 1) providing simple explanations 2) Building basic skills 3) Summarizing 4) Making further explanations 5) Strategies and Tactics (Samin, 2023). And according to Stoltz (in Tatang Herman, et al., 2024), fighting power is an ability consisting of four dimensions abbreviated as CO2RE, namely the dimensions of control, origin and ownership, reach and endurance. Based on the explanation above, researchers are encouraged to conduct research that can improve students' critical thinking skills and mathematical fighting power. Therefore, the researcher prefers to conduct research in the form of a scientific paper entitled "Increasing Students' Critical Thinking Ability in Mathematics and Fighting Power through the Implementation of an Open-Ended Approach".

2. RESEARCH METHOD

According to Hartono (2019), the type of research used Experiment with a research design is Factorial, Experimental. Experimental Factorial is a modification of the true experimental design, namely by paying attention to the possibility of moderator variables that affect the treatment of the results. It was held at MAS Nurul Khair in the odd semester of the 2024/2025 school year with a population of all students in class X and the researcher used the Nonprobability Sampling technique with Saturated Sampling. Therefore, the sample in this study is 19 students of Class X-A as an experimental class and class X-B as a control class of 19 students. The research procedure is the conceptual stage, the compounding and planning phase, making instruments and collecting research data, the empirical phase and the analytical phase. The data collection technique uses test sheets in the form of descriptions to measure students' mathematical critical thinking skills on relationship materials and questionnaires to measure students' fighting power. Instrument tests are validity tests, reliability tests, difficulty indexes and discriminating power. The data analysis technique uses the t-test and prerequisite tests, namely the normality test and the homogeneity test as well as the statistical hypothesis tested in the study.

3. RESULTS AND DISCUSSION

Results

1.   Critical Thinking Skills

Descriptive analysis seen from the results of pretest, posttest and N-Gain of students of class X-A (experimental class) and class X-B (control class) of MAS Nurul Khair can be obtained in **Table 1**.

Table 1. Results of the Pretest and Posttest of Experimental and Control Class

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experiment	19	4	9	6,37	1,383
Posttest Experiment	19	8	12	10,26	1,147
Pretest Control	19	3	7	5,05	1,268
Posttest Control	19	5	10	7,95	1,471

Based on the **Table 1**, it can be seen numerically that the average pretest of the experimental class is superior to the control class with a difference of 1.32 between the two classes. The standard deviation obtained by the experimental class at the time of pretest was larger than the data of the Control class. The distribution of data obtained by the experimental class is closer to the average compared to the control class. In line with the range of values obtained by the Control class is 7 and the range of values obtained by the experimental class is 9. After being given the average treatment and the distribution of the data obtained has greatly increased. The average obtained by the experimental class was even superior and much different from the control class and the average difference obtained by the two classes was 2.31. Then the standard deviation of the experimental class data was smaller, namely 1.147, which means that the distribution of experimental class data was closer to the average compared to the distribution of control class data.

Table 2. Results of the N-Gain Pretest and Posttest for Experimental and Control Class

Class	N	Minimum	Maximum	Mean of N-Gain	Category
Experiment	19	0	100	0,69	Middle
Control	19	0	75	0,40	Middle

Based on the **Table 2,** it can be seen that numerically the average N-Gain of the experimental class is superior to the average N-Gain of the control class with a difference of 0.29. Where the average N-Gain of the experimental class is 0.69, where 0.69 < 0.7, then the increase in the experimental class can be said to be in the medium category, while for the control class where the average N-Gain of the control class is 0.40 where 0.40 < 0.7, then the increase in the control class can be said to be in the medium category.

a. N-Gain Normality Test for Critical Thinking Ability

The normality test was calculated using SPSS 29. The results of the normality test can be seen in **Table 3**.

Tabel 3. Results of the N-Gain Normality Test for Critical Thinking Skills in the Experimental and Control Class

	Class	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
N-Gain	Experiment	,113	19	,200*	,912	19	,080
	Control	,134	19	,200*	,945	19	,324

Based on **Table 3**, the significant value of the experimental class was 0.200 > 0.05, and the significant value of the control class was 0.200 > 0.05. Because the significant value of the two data > 0.05, it was accepted. This means that it can be concluded that the N-Gain data H_0 of critical thinking of the experimental class and the control class are normally distributed.

b. N-Gain Homogeneity Test for Critical Thinking Ability

The homogeneity test was carried out to find out whether the experimental class and the control class had the same variance (homogeneous) or not the same (non-homogeneous) after getting different treatments. The results of the homogeneity of variances test can be seen in **Table 4**.

Table 4. Results of the N-Gain Homogeneity Test for Critical Thinking Ability of the Experimental and Control Class

		Levene Statistic	df1	df2	Sig.
N-Gain	Based on Mean	,010	1	36	,922
	Based on Median	,010	1	36	,922
	Based on Median and with adjusted df	,010	1	32,706	,922
	Based on trimmed mean	,005	1	36	,946

Based on **Table 4**, it was obtained that the statistical significance of the Levene test was 0.922. The significance value is greater than the significance level of 0.05, which is (0.922 > 0.05), so accept that the variance of the two groups is homogeneous H_0. After knowing that the N-Gain data of the experimental group and the control group were normally and homogeneously distributed, then continued with the test of the average difference in N-Gain values using the t-test (Independent Sample Test) with the following significant levels $\alpha = 0,05$.

Table 5. Results of the t-N-Gain Test for Critical Thinking Skills in the Experimental Class and Control Class

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	Df	Sig. (2-tailed)
N-Gain	Equal variances assumed	,010	,922	3,848	36	0,001
	Equal variances not assumed			3,848	35,370	0,001

In **Table 5**, it can be seen that the significance value (sig.2-tailed) with the t-test is 0.001. Because 0.001 < 0.05, it was rejected and accepted. Thus, it can be concluded that the improvement of students' critical thinking skills taught using the $H_0 H_1$ Open Ended approach is higher than the improvement of students' critical thinking skills taught in a conventional way.

2. Fighting Power

Descriptive analysis seen from the results of pretest, posttest and N-Gain of students of class X-A (experimental class) and class X-B (control class) of MAS Nurul Khair can be obtained in **Table 6.**

Table 6. Results of the Pretest and Posttest for Experimental and Control Classes

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experiment	19	17	28	21,58	2,589
Posttest Experiment	19	32	50	40,00	6,209
Pretest Control	19	15	23	20,63	2,241
Posttest Control	19	22	47	34,74	8,225

Based on the **Table 6**, it can be seen numerically that the average pretest of the experimental class is superior to the control class with a difference of 0.95. The standard deviation obtained by the experimental class at the time of pretest was larger than the data of the Control class. The distribution of data obtained by the experimental class is closer to the average compared to the control class. In line with the range of values obtained by the Control class is 23 and the range of values obtained by the experimental class is 28. After being given the average treatment and the distribution of the data obtained has greatly increased. The average obtained by the experimental class was superior and much different from the control class and the average difference obtained by the two classes was 5.26. Then the standard deviation of the experimental class data was smaller, namely 6.209, which means that the distribution of the experimental class data was closer to the average compared to the distribution of the control class data.

Table 7. Results of the N-Gain Pretest and Posttest for Experimental and Control Classes

Class	N	Minimum	Maximum	Mean of N-Gain	Category
Experiment	19	33	94	0,60	Middle
Control	19	6	84	0,44	Middle

Based on **Table 7**, it can be seen numerically that the average N-Gain of the experimental class is superior to the average N-Gain of the control class with a difference of 0.16. Where the average N-Gain of the experimental class is 0.60, where 0.60 < 0.70, then the increase in the experimental class can be said to be in the medium category, while for the control class where the average N-Gain of the control class is 0.44 where 0.44 < 0.70, then the increase in the control class can be said to be in the medium category.

a. N-Gain Normality Test for Fighting Power

The normality test was calculated using SPSS 29. The results of the normality test can be seen in **Table 8**.

Table 8. Results of N-Gain Normality Test for Fighting Power of Experimental and Control Class

	Class	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
N-Gain	Experiment	,185	19	,088	,903	19	,054
	Control	,170	19	,150	,903	19	,054

Based on **Table 8**, the significant value of the experimental class was 0.088 > 0.05, and the significant value of the control class was 0.150 > 0.05. Because the significant value of the two data > 0.05, it was accepted. This means that it can be concluded that the N-Gain data H_0 of the experimental class and the control class are normally distributed.

b. N-Gain Homogeneity Test for Fighting Power

The homogeneity test was carried out to find out whether the experimental class and the control class had the same variance (homogeneous) or not the same (non-homogeneous) after getting different treatments. The results of the Homogeneity of Variances test can be seen in **Table 9**.

Table 9. Results of the N-Gain Homogeneity Test for Fighting Power of the Experimental and Control Class

		Levene Statistic	df1	df2	Sig.
N-Gain	Based on Mean	1,775	1	36	,191
	Based on Median	,806	1	36	,375
	Based on Median and with adjusted df	,806	1	27,548	,377
	Based on trimmed mean	1,757	1	36	,193

Based on **Table 9**, it was obtained that the statistical significance of the Levene test (1.775) was 0.191. The significance value is greater than the significance level of 0.05, which is (0.191 > 0.05), so accept that the variance of the two groups is homogeneous H_0. After knowing that the N-Gain data of the experimental group and the control group were normally and homogeneously distributed, then continued with the test of the average difference in N-Gain values using the t-test (Independent Sample Test) with the following significant levels $\alpha = 0,05$.

Table 10. Results of the t N-Gain Test of Fighting Power in the Experimental and Control Classes

Independent Samples Test						
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	df	Sig. (2-tailed)
N-Gain	Equal variances assumed	1,775	,191	2,010	36	,026
	Equal variances not assumed			2,010	34,008	,026

In **Table 10,** it can be seen that the significance value (sig.2-tailed) with the t-test is 0.026. Because 0.026 < 0.05, it was rejected and accepted. Thus, it can be concluded that the improvement of students $H_0 H_1$' fighting power taught using the Open-Ended approach is higher than the improvement of students' critical thinking skills taught in a conventional way.

Discussion

1. Critical Thinking Skills

Based on the results of the analysis after the two classes were given treatment, it can be seen that there was an increase in critical thinking skills. This can be seen from the N-Gain score that there were ten students who obtained satisfactory scores from the experimental class, namely three students with a score of 100, one student with a score of 0.85, three

students with a score of 0.83, one student with a score of 0.8, one student with a score of 0.75, and one student with a score of 0.71 and based on the N-Gain category which is more than 0.70, then the classification is high. From the control class, there were only three people who obtained satisfactory N-Gain scores, namely one student with a score of 0.75, and two students with a score of 0.71 and based on the N-Gain category, the classification was high.   However, although both sample classes succeeded in improving critical thinking skills, of course there are differences in improving critical thinking skills, based on research that has been conducted in the field, it is concluded that the open-ended approach is better in improving critical thinking. This approach brings out more usefulness in learning and also facilitates students to participate more actively and express their ideas.

This study also has relevance to the previous research conducted by Nasrun Ode Amir, et al. (2022) stated that the improvement of students' mathematical critical thinking skills increased by applying an open-ended approach in mathematics learning, especially in the Quadratic equation material, significantly better than students who obtained learning with conventional learning models. And from the increased mathematical critical thinking ability, it can be said that there is an increase that occurs from the use of an open-ended approach to the mathematical critical thinking ability of square equation material in grade VIII-3 students. So, mathematics learning that refers to the open-ended approach is declared complete. According to Lilis Lismaya (2019), critical thinking skills can be defined as one of the processes used as a guide in the thinking process, by arranging a framework of thinking by dividing it into real activities. Critical thinking is an activity carried out by a person that involves a cognitive process to receive all kinds of information obtained so that they can decide the right action for a problem. Based on the analysis of data and discussions that have been presented by the researcher and the supporting theory, the hypothesis is acceptable which states that there is an improvement in the mathematical critical thinking ability of grade X students of MAS Nurul Khair through an open-ended approach.

2. Fighting Power

Based on the results of the analysis after the two classes were given treatment, it can be seen that there was an increase in fighting power. This can be seen from the N-Gain score that there are seven students who obtained satisfactory scores from the experimental class, namely one student with a score of 0.94, one student with a score of 0.85, a student with a score of 0.85, one student with a score of 0.83, one student with a score of 0.79, and two students with a score of 0.76 based on the N-Gain category which is more than 0.70, then the classification is high. From the control class, there were only five students who obtained satisfactory N-Gain scores, namely one student with a score of 0.84, one student with a score of 0.83, one student with a score of 0.81, one student with a score of 0.79, and one student with a score of 0.77 based on the N-Gain category, the classification is high. This study also has a reference to the previous research conducted by Dian Mayasari, et al. (2020), stating that 1) there is a difference in the effectiveness of problem solving with conventional models on students' fighting power and learning outcomes, 2) problem solving is more effective than conventional models on mathematical fighting power. According to Stoltz (in Indri Fitriyaningsih, et al. 2023), fighting power or called Adversity Quotient is a person's ability to respond to and overcome difficulties and pressures that occur in their lives. According to Arifin (2020), this shows how important fighting power is that is able to build confidence and behavior. So, it is necessary for the role of parents, duru/lecturers as educators to pay attention to the development of fighting power. Based on the analysis of data and discussions that have been presented by the researcher and the supporting theory, the hypothesis is acceptable that there is an increase in the fighting power of class X MAS Nurul Khair through an open-ended approach.

4. CONCLUSION

Based on the results of the research and data analysis, several conclusions were obtained. Firstly, the improvement in students' mathematical critical thinking skills taught using an open-ended approach was significantly higher than that of students taught using conventional methods. This is evidenced by the p-value (2-tailed) being less than .001 with $\alpha = 0.05$, leading to the rejection of H0. Secondly, the increase in students' fighting power when taught using the open-ended approach was also significantly higher compared to those taught through conventional methods, as indicated by the p-value (2-tailed) of 0.026 with $\alpha = 0.05$, resulting in the rejection of H0.

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