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The Effectiveness of Blended Learning Examined Critical Thinking and Mathematics Learning Independence for High School Students

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ABSTRACT. *This study was aimed to describe: (1) the effectiveness of learning with a blended learning model using scientific (2) the effectiveness of scientific approach; and (3) the difference in the effectiveness of learning with a blended learning model using scientific approach and learning using scientific approach in terms of critical thinking, and learning independence of mathematics students in high school. The research type is quasi-experiment. The population was all 11th grade students of SMA in semester II of 2024/2025. The sample was established randomly consisting of class XI MIA 2 as the experiment class and XI MIA 1 as the control class. The data collection method uses research instruments in the form of a Learning Independence Test of 15 multiple choice questions, a Critical Thinking Test of 4 descriptive questions, and a Learning Independence Questionnaire of 20 statement, administered as pretests and posttests. To assess the effectiveness of blended learning with a scientific approach and the scientific approach alone, a one-sample mean vector test was conducted, followed by a one-sample t-test. Differences in effectiveness were analyzed using an independent two-sample mean vector test (T^2 Hotelling). If analysis revealed significant differences between the two classes, an independent sample t-test for comparison was conducted. The results showed that: (1) learning with blended learning model using scientific approach is effective in terms of critical thinking, and independence of learning mathematics of high school students; (2) learning using scientific approach is effective in terms of critical thinking, and independence of learning mathematics of high school students; and (3) learning with blended learning model using scientific approach is more effective than learning using scientific approach in terms of critical thinking, and independence of learning mathematics of high school students.*

Keywords: *Effectiveness, Blended, Critical, Independence*

1. INTRODUCTION

According to Minister of National Education Regulation number 22 of 2006 concerning content standards for primary and secondary education units, it is stated that mathematics is a universal science that underlies the development of modern technology and is also seen as having an important role in various scientific disciplines and can advance human thinking. Peter (2012) emphasized that instilling critical thinking skills in students is one of the goals of learning mathematics, namely not only making students as recipients of information but also as users of information. Aizikovitsh-Udi and Cheng (2015) state that critical thinking is an important ability to have in today's life because the benefits of critical thinking are lifelong, namely supporting students in managing their learning abilities and then empowering them to contribute creatively to their chosen profession. . Furthermore, critical thinking can help students face many future challenges both in work and personal life. Therefore the task of higher education is to promote students' critical thinking (Evens, Verburgh, & Ellen, 2013).

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Jacob's (2012) research shows that there is a significant linear relationship between critical thinking skills and mathematics learning achievement. This research concludes that critical thinking skills when properly encouraged can improve mathematics learning achievement. This is confirmed by the results of research by Chukwuyenum (2013) showing that developing critical thinking skills will be able to increase students' understanding of mathematical concepts.

Mathematics is a subject that is difficult to teach or learn, this is because mathematics lessons are continuous learning where to learn new material requires an understanding of previous material, this is because if students have previous knowledge that is incomplete, poorly understood or interrupted then they will not be able to understand new information (Villafane, et.al, 2011). Failure to develop students' understanding of mathematical concepts can have an impact on students' difficulties in learning mathematics. The lack of conceptual understanding of Indonesian students can be seen from the mathematics learning achievement which is still relatively low when viewed from TIMSS. The problem with students in Indonesia is that they are only able to solve questions in the easy category, while for questions with a medium or difficult level of difficulty, students are not able to provide answers correctly. Correct.

The results of Rahmawati's (2016) study of the 2015 TIMSS results as shown in Figure 1 and Figure 2 show that if the questions given are simple and routine, the percentage of students answering the questions correctly is in the high range, whereas if the questions given are not simple and requires an analysis process so students experience difficulty in answering questions.

One aspect that needs to be developed is learning independence. Adodo (2013) explains that learning independence is a process by which students manage their thoughts, behavior and emotions in order to successfully organize and guide their learning experience. The existing trend is that students with low learning independence will be directly proportional to student learning achievement. This is supported by the results of Fitriana's research showing (2010) that students' independent mathematics learning can influence students' mathematics learning achievement.

Based on the explanation above, it shows that there are still problems in implementing mathematics learning. One solution offered to overcome the problems above is to improve the learning process, namely by developing conceptual understanding, critical thinking and student learning independence in mathematics learning through a blended learning model using a scientific approach. The use of the blended learning model in mathematics learning

is to utilize the technological and innovative advances offered by online learning with the interaction and participation offered by traditional learning. The application of the blended learning model in mathematics learning will allow teachers to have additional time allocated for teaching where teachers can utilize meetings in class (face to face) to deliver material and teach mathematical concepts while assignments can be done online (e-learning) by uploading learning materials and assignments into the e-learning portal. One of these innovative learning models is the flipped classroom. Flipped classroom is a relatively new learning strategy. This learning strategy is increasingly developing with the traditional progress of educators delivering material, then to increase understanding of the material, students will do assignments at school and be given homework.

Based on several things stated above, researchers are interested in researching the effectiveness of blended learning in terms of conceptual understanding, critical thinking and independence in learning mathematics for high school students. In this research, learning will be carried out using a scientific approach in accordance with the demands of the 2013 curriculum.

2. METHODOLOGY

This type of research is quasi-experimental research, this type of research was chosen for the reason that not all factors can be controlled and this research uses two groups, namely the experimental class and the control class. The experimental design used was pretest-posttest, nonequivalent two group design. Schematically, the experimental design used in the research can be seen in Figure 1.

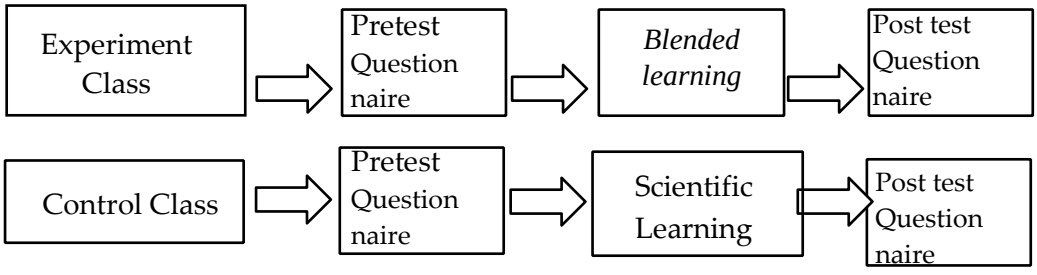

Figure 1. Pretest-posttest Nonequivalent Twogroup Design

This research was carried out at SMA 2 Nunukan, North Kalimantan Province, even semester of the 2024/2025 academic year. The research was carried out in February - March 2024. Meanwhile, the population in the research was all class XI students of SMAPNegeri 2 Nunukan for the 2024/2025 academic year. There are 231 students consisting of seven

majors, namely: X.1 (1 class), X.2 (1 class), X.3 (1 class), XI MIA 1 (1 class), XI IIS 1 (1 class) and XI IIS 2 (1 class). The samples used were two study groups of high school students in class XI MIA 2, namely class and XI MIA 1. The samples in this study were chosen randomly using a lottery.

The data analyzed in this research includes critical thinking scores and student learning independence scores in mathematics learning. These data were analyzed using descriptive analysis and inferential analysis.

3. RESULT AND DISCUSSION

Research Results

a. Description of research results

The implementation of learning is adjusted to the mathematics lesson schedule that has been set at the school, namely every Tuesday and Thursday with an allocation of two hours of lesson time (2 x 45 minutes) per meeting. Overall, learning activities in the experimental class take place in accordance with the learning implementation plan (RPP).

Implementation of learning with a blended learning model using a scientific approach to statistical material was carried out in 6 meetings (12 x 45 minutes). In general, learning in the experimental class took place according to plan, based on the results of observations of learning implementation carried out by Diana, S.Pd as observer, it showed that the average percentage of learning implementation in the experimental class reached 90.3%.

Data on the results of students' critical thinking mathematics tests (pretest and posttest) in the experimental class (scientific approach plus blended learning model) and control class (scientific approach) obtained results as in Table 1.

Table 1. Description of Mathematical Critical Thinking Data

Description	Experimental Class		Control Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Average	22,11	74,74	22,62	74,66
Standard Deviation	7,15	8,05	7,17	6,42
Variance	51,17	64,81	51,44	41,24
Maximum score (ideal)	100	100	100	100
Minimum (ideal) score	0	0	0	0
Maximum score (test)	33,33	90,48	33,33	92,86
Minimum score (test)	7,14	59,52	7,14	64,29
Completion percentage (%)	0	75	0	82,14

The data in Table 1 shows an increase in the average score for critical thinking in mathematics in the experimental class and control class based on pretest and posttest scores. The average pretest score for critical thinking in mathematics in the experimental class was 25.95, increasing to 80.71, then the percentage of learning completion increased from 0% to 89.29% (25 students). Meanwhile, in the control class there was also an increase when viewed from the average score and percentage of completeness in the pretest and posttest, the average score for the critical thinking mathematics pretest was 23.81, increasing to 75, then the percentage of completeness increased, namely from 0% to 82 .14% (23 students).

Test the differences in learning effectiveness in terms of Critical Thinking Ability, critical thinking and independence in students' mathematics learning, posttest data using the two group MANOVA test by fulfilling the normal and homogeneous assumption requirements. In previous calculations, it was shown that the posttest data met the assumptions of normality and were homogeneous in a multivariate manner, so the data was then analyzed using the two group MANOVA test. The results of the two group MANOVA test are presented in Table 2.

Table 2. Two group MANOVA test results

Effect	Value	F	Sig
Hotelling Trace	0,472	8,140[b]	0,000

Based on Table 2, the significance value obtained is less than the α value (0.000 < 0.05), which means that H0 is rejected and it can be concluded that there is a significant difference between the average score of learning with a blended learning model using a scientific approach (experimental class) and learning using scientific approach (control class).

4. RESEARCH DISCUSSION

Learning with a blended learning model using a scientific approach has a positive impact on improving students' mathematics. Based on the results of descriptive analysis, it was obtained that the average score increased from pretest to posttest with a completion percentage of 0% in the pretest to 89.29% in the posttest. This was also supported by the results of inferential analysis, namely the one sample ttest which obtained a significance value of less than 0. 05 so it can be concluded that learning with the blended learning model using a scientific approach is effective in terms of students' critical mathematical thinking.

Learning using a blended learning model using a scientific approach has a positive impact on improving students' critical mathematical thinking. Based on the results of descriptive analysis, it was obtained that the average score increased from pretest to posttest with a completion percentage of 0% on the pretest to 75% on the posttest. This was also supported by the results of inferential analysis, namely the one sample t-test which obtained a significance value of less than 0. 05 so it can be concluded that learning using the blended learning model using a scientific approach is effective in terms of students' critical mathematical thinking.

Learning with a blended learning model using a scientific approach has a positive impact on increasing students' independence in mathematics learning. Based on the results of the descriptive analysis, an increase in the average score was obtained from filling in the initial condition questionnaire to completing the final condition questionnaire, namely from 52.95 to 81.30. Furthermore, based on the results of inferential analysis, namely the one sample t-test, a significance value of less than 0.05 was obtained, so it can be concluded that learning with a scientific approach using the blended learning model is effective in terms of students' independent mathematics learning. This gives students the opportunity to access learning independently so that students do not use the teacher as the only source of information. Apart from that, the use of a scientific approach in learning also facilitates student independence in learning because the characteristics of the scientific approach are student-centered (Hosnan, 2014) so that the teacher only acts as a facilitator and designs learning so that students are actively involved in constructing concepts, laws or principles through the stages of observing, formulate problems, propose hypotheses, collect data, analyze, draw conclusions and be able to communicate them.

Learning using a scientific approach has a positive impact on improving students' critical mathematical thinking. Based on the results of descriptive analysis, it was obtained that the average score increased from pretest to posttest with a completion percentage of 0% in the pretest to 82.14% in the posttest. This was also supported by the results of inferential analysis, namely the one sample t-test which obtained a significance value of less than 0.05 so it can be concluded that learning using a scientific approach is effective in terms of students' critical mathematical thinking. Mantu & Katircioglu (2013) stated that students will easily understand when learning uses a scientific approach and will like the lesson. Furthermore, Zaim (2017) stated that in the learning process using a scientific approach there are several steps that make it easier for students to understand the material, these steps

guide students to learn while conducting experiments, a learning process like this can make students understand the concept better. which is being studied.

5. CONCLUSION

Based on the results of the research and discussion, it was concluded that learning with the blended learning model using a scientific approach was effective in terms of critical thinking and independent mathematics learning for class XI high school students. Learning using a scientific approach is effective in terms of critical thinking and independent mathematics learning for class XI high school students. Learning with a blended learning model using a scientific approach is more effective than learning using a scientific approach in terms of critical thinking and independent learning in mathematics.

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