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EFFECTIVENESS OF PROJECT BASED LEARNING ON MATHEMATICAL CRITICAL THINKING ABILITY STUDENTS ON QUADRATURE FUNCTIONS IN CLASS X

Naomi Silaban[1], Adi Suarman Situmorang[2], Hardi Tambunan[3], Efron Manik[4], Sanggam P. Gultom[5]

Email : naomisilaban@student.uhn.ac.id
[1,2,3] Pendidikan Matematika, Fakultas Keguruan Dan Ilmu Pendidikan, Universitas HKBP Nommensen, Medan, Indonesia

Abstract

This study aims to determine the effectiveness of project-based learning on mathematical critical thinking skills in the quadratic function material of class X of St. Paul's Private High School T.A 2024/2025. The type of research used is quantitative descriptive. The research population is all class X and the research sample consists of 64 students of class X. The sampling technique is carried out by random sampling technique. The instruments used are tests in the form of description questions, questionnaires and observation sheets. The results of the study are seen from the indicators of effectiveness that are met, namely the systematics of learning in the good category, the communication of the teacher in the good category, the response of the students in the good category, the activities of the students in the good category, and the achievement of learning in the category is achieved. The results of the study show that project-based learning is effective on students' mathematical critical thinking skills.

Keywords: Effectiveness, Project-Based Learning, Critical Thinking

Abstrak

Penelitian ini bertujuan untuk mengetahui keefektifan pembelajaran berbasis proyek terhadap kemampuan berpikir kritis matematis pada materi fungsi kuadrat kelas X SMA Swasta St. Paul T.A 2024/2025. Jenis penelitian yang digunakan adalah deskriptif kuantitatif. Populasi penelitian adalah seluruh kelas X dan sampel penelitian sebanyak 64 siswa kelas X. Teknik pengambilan sampel dilakukan dengan teknik random sampling. Instrumen yang digunakan adalah tes berupa soal uraian, angket dan lembar observasi. Hasil penelitian dilihat dari indikator keefektifan yang terpenuhi yaitu sistematika pembelajaran dalam kategori baik, komunikasi guru dalam kategori baik siswa, respon siswa dalam kategori baik, aktivitas siswa dalam kategori baik, dan ketercapaian belajar dalam kategori tercapai. Hasil penelitian menunjukkan bahwa pembelajaran berbasis proyek efektif terhadap kemampuan berpikir kritis matematis siswa.

Kata Kunci : *Efektivitas, Pembelajaran Berbasis Proyek, Berpikir Kritis*

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INTRODUCTION

Mathematics has an important role in knowledge, so the world of education places mathematics as a compulsory subject in Indonesia which is studied from elementary school, junior high school, high school, even higher education (Ramanisa et al., 2020). Mathematics is a subject that needs to be given to all students with the aim of equipping students with the ability to think logically, critically and creatively, as well as the ability to work together (Walidah et al., 2020).

However, in reality, until now the learning outcomes of students in Indonesia in mathematics are still problematic in terms of ranking. The results of the Programme for International Student Assessment (PISA) 2022 showed that Indonesia was in a low position, namely 66th out of 81 other countries with an average score in Indonesia of 366, where this score is still far from the average OECD score, the decline in national mathematics exam scores in 2019 also showed that students' understanding of mathematics material was still weak. There are many causal factors that can affect student learning outcomes, including students tending to think that mathematics is a difficult subject (Huda, 2019) boring, uninteresting, and even tending to be considered boring for most students , students are less interested in studying mathematics. In addition, the learning process that takes place tends to be centered on the teacher . Untung, 2008 argues that mathematics consists of four broad insights, namely algebra, arithmetic, geometry, and analysis, based on the data obtained that students are very weak in algebra, especially in understanding quadratic functions.

Quadratic Function is part of algebra taught in Senior High School (SMA) class X according to the independent curriculum. The learning objective of quadratic functions is expected to enable students to think critically. Bag & Gursoy, 2021 argue that in learning mathematics, critical thinking skills are an important aspect that students need to have (Silviani et al., 2021).

In reality, the problems that occur in quadratic functions are students' low understanding of the concept of quadratic function material, students' critical thinking skills in quadratic function material are still relatively low, students also have difficulty in understanding quadratic function questions so that in determining solutions to answer questions it becomes less precise, students have difficulty in applying quadratic function formulas to solve problems. The causal factor is that the mathematics learning process that has been implemented in schools emphasizes students to memorize formulas rather than understand concepts. Ismaimuza, 2010 argues that the learning used is still teacher-centered and students only passively receive information from teachers which causes students' critical mathematical thinking skills to be less developed.

Mathematical critical thinking skills are the skills of analyzing, concluding, evaluating and making conclusions (Cahya et al., 2022). The problem that occurs is the low mathematical critical thinking skills caused by several factors, namely students tend to memorize materials and formulas rather than understanding concepts, so that students have difficulty in solving problems that require analysis.

This research is important to do because mastery of quadratic function material is a basic foundation in algebra that supports the understanding of further mathematical concepts. Based on Hakim's research, there is an influence of mathematical concepts in various subjects on students' mathematical abilities (Nizammudin et al., 2022). In learning mathematics, one material is a prerequisite for other materials, or one concept is needed to explain another concept, if students do not master the concept of quadratic functions well, students will have difficulty understanding the next mathematical material (Habibatul Izzah & Azizah, 2019). Quadratic functions not only involve skills in solving equations and solving problems related to graphs, but also involve important critical thinking skills.

To overcome various problems related to students' low critical mathematical thinking skills, learning is needed that is considered capable of overcoming the difficulties of teachers in carrying

out teaching tasks and also the difficulties of student learning. Several types of learning are expected to be able to overcome problems in mathematics learning, including project-based learning. According to Tambunan et al., 2021, project-based learning is a learning approach that focuses on meaningful questions and problems, the process of searching, solving problems, and drawing conclusions (Mulyaningsih et al., 2020). Istarani, 2011 stated that project-based learning is an innovative learning approach that emphasizes contextual learning through student activities working independently, and producing real products (Kurniasih et al., 2023)

Based on several studies, including stating: project-based learning can improve students' critical thinking skills (Lieftink et al., 2019). Through project-based learning, it is hoped that high school students' critical mathematical thinking skills will be better than before.

Based on the description above, the researcher will conduct a study entitled The Effectiveness of Project-Based Learning on Students' Mathematical Critical Thinking Skills on Quadratic Function Material in Class X of Santo Paulus Private High School, Medan, Academic Year 2024/2025

METHOD

This research was conducted at SMA Swasta Santo Paulus Medan Jl Pancing No. 9 Martubung, Medan Labuhan District, Medan City, North Sumatra. This research was conducted in the even semester of the 2024/2025 academic year. Population is a generalization area consisting of objects and subjects that have certain qualities and characteristics that are selected by researchers to be studied and then draw conclusions.

Based on the above understanding, the population in this study were students of class X of Santo Paulus Private High School Medan in the academic year 2024/2025 consisting of 4 classes totaling 128 people. The sample is part of the number and characteristics possessed by the population (Heaviside et al., 2018). The determination of the sample was done randomly (random sampling). The sample used in this study consisted of 2 classes of X of Santo Paulus Private High School Medan in the academic year 2024/2025 totaling 64 people.

The type of research used by researchers is quantitative descriptive. According to Sugiyono (Jusita, 2019) that "The quantitative method is a way of collecting data with research instruments and data analysis based on quantitative descriptive statistics with the aim of testing the formulated hypothesis". According to Sugiyono (Pramesti et al., 2022) that "Descriptive is a method used to analyze data by describing or describing the objects studied that are collected without intending to make general conclusions".

Descriptive quantitative research is part of non-experimental research. According to Creswell, quantitative research is a method for testing certain theories by examining the relationship between variables measured by quantitative descriptive data analysis research instruments that aim to propose predetermined hypotheses (Purwanti et al., 2022). The purpose of this study is to describe variables without making comparisons or connecting independent variables with dependent variables (Tanjung et al., 2022).

The design used in this study is a one-shot case study design which is selected randomly and used as an experimental class (Aprianti et al., 2017). To further clarify the research design, it can be seen in Table 3.1 as follows:

Research variables are objects that have certain variations created by researchers to be studied so as to produce information about what has been created, then conclusions are drawn In this study, there are two variables measured, namely project-based learning and students' critical thinking skills.

Basically, research is conducted by measurement, so a good measuring instrument is needed. A research instrument is a tool used to measure data in a study (Anggiehlia et al., 2019).. The goal is

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to make the research simpler and more systematic. The instruments used in this study are tests in the form of descriptive questions, questionnaires and observation sheets (Fitri et al., 2018).

A test is a series of questions or exercises and other tools used to measure the skills, knowledge, intelligence, abilities or talents of an individual or group. In this study, a test in the form of essay questions (description) was used, the purpose of this test was to determine the extent of the level of effectiveness of student learning using project-based learning by providing a description in the form of a final test (post-test) (Pratiwi et al., 2018). The test is used to see the achievement of learning and learning outcomes after project-based learning

HASIL DAN PEMBAHASAN

Research result

This research was conducted at SMA Swasta Santo Paulus Medan which is a descriptive quantitative research with the aim of determining the effectiveness of project-based learning on students' critical mathematical thinking skills in class X of SMA Swasta Santo Paulus Medan. The research was conducted on January 20, 2025 to February 4, 2024, with 6 meetings for the experimental class. The experimental class consisted of 64 class X students who were taught by researchers using project-based learning (Fitz et al., 2022).

The material taught by the researcher is a quadratic function to determine students' ability in mathematical critical thinking. The research instrument used by the researcher is a descriptive test (*post-test*) consisting of 6 critical thinking ability questions, a questionnaire and an observation sheet (Furi et al., 2018).

Research Instrument Trial Results

Before the test is used on the research sample, the questions are first tested to see the validity of the questions, the reliability of the questions, the level of difficulty of the questions, and the discriminating power of the questions. To determine the feasibility of the questions to be used in accordance with the indicators and learning objectives achieved.

The validity test of the mathematical critical thinking ability test was carried out using the *Product Moment Correlation formula* , in processing the data the researcher used the help of SPSS 25.0 *for windows* with the provision that if $r_{hitung} > r_{tabel}$then the test items are valid at the level $\alpha = 5$ %. The results of the calculation of the test validity test are presented in Table 4.1 below:

Table 1. Validity of Mathematical Critical Thinking Ability Test

Question Number	r_{hitung}	r_{tabel}	Information
1	0.600	0.246	Valid
2	0,234		Tidak Valid
3	0,447		Valid
4	0,769		Valid
5	0,540		Valid
6	0,613		Valid
7	0,462		Valid
8	0,242		Tidak Valid

Based on the table, it can be concluded that the test results of the test instrument for question number 1 which measures mathematical critical thinking ability are declared valid, found in **(** Appendix 13, page 99), the results obtained r_{hitung}= 0.600 for the level $\alpha = 5$ %, $dk = n - 2$with a

value of n = 62, then in (Appendix 21, page 115), the value obtained r_{tabel}= 0.246. In the same way, the test was tested for questions number 2, 3, 4, 5, 6, 7, and 8. So, it can be concluded that the test results of the mathematical critical thinking ability test instrument on questions number 1, 3, 4, 5, 6 and 7 are declared valid.

The reliability test of the mathematical critical thinking ability test uses the *Alpha Cronbach formula* , in processing research data using the help of SPSS 25.0 *for windows* with the provision that if $r_{hitung} > r_{tabel}$then the test items are reliable at the level $\alpha = 5$ %. For the reliability test of the mathematical critical thinking ability test, see Table below:

Table 2. Reliability of Mathematical Critical Thinking Ability Test

r_{hitung}	r_{tabel}	**Information**
0.639	0.246	High Test Reliability

Based on the table, it can be concluded that the results of the reliability test of the mathematical critical thinking ability test instrument in (Appendix 13, page 99) obtained a value of r_{hitung}= 0.601 for $\alpha = 5$ %, $dk = n - 2$with a value of n = 62, then in (Appendix 21, page 115), the value obtained wasr_{tabel} = 0.246. With the provision of value $r_{hitung} > r_{tabel}$or 0.639 > 0.246, it can be concluded that the results of the mathematical critical thinking ability test instrument are stated to be reliable.

Research Data Analysis

Research data analysis can be described as follows:

Questionnaire Results

Describe the results of the questionnaire with effectiveness indicators. Based on the results of the learning systematics questionnaire, it can be categorized into four categories as follows:

Very Good = M + 1.5 x SD < X
Good = M + 0.5 x SD < X ≤ M +1.5 x SD
Not Good = M - 0.5 x SD < X ≤ M + 0.5 x SD
Very Poor = M – 1.5 x SD < X ≤ M – 0.5 x SD

The results of the questionnaire are described as follows:

Learning Systematics

Based on the results of the learning systematics questionnaire (Appendix 15, Page 102) processed using SPSS 25.0 For Windows, the average value (mean) obtained was 44, a standard deviation of 6.5 can be seen in Appendix 20, page 114.

The four categories of questionnaire results, if described in data, are as follows:

Very Good Category = M + 1.5 x SD < X
= 44 + 1.5 x 6.5 < X = 54 < X
Good Category = M + 0.5 x SD < X ≤ M +1.5 x SD
= 44 + 0.5 x 6.5 < X ≤ 44 + 1.5 x 6.5
= 47 < X ≤ 54
Bad Category = M - 0.5 x SD < X ≤ M + 0.5 x SD
= 44 - 0.5 x 6.5 < X ≤ 44 + 0.5 x 6.5
= 41 < X ≤ 47
Very Poor Category = M – 1.5 x SD < X ≤ M – 0.5 x SD
= 44 – 1.5 x 6.5 < X ≤ 44 – 0.5 x 6.5

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$= 34 < X \leq 41$

Table 3. Frequency Distribution of Learning Systematics Questionnaire Results

No	Counting	Interval	Frequency	Categorization
1	$54 < X$	54-56	19	Very good
2	$47 < X \leq 54$	47-54	25	Good
3	$41< X \leq 47$	41-47	10	Not good
4	$34 < X \leq 41$	34-41	10	Very Bad

Based on the Frequency Table, the second interval has the largest frequency of 25 people in the good category, thus it can be concluded that the learning systematics indicator is in the Good category (Chen & Yang, 2019).

Based on the results of the teacher communication questionnaire (Appendix 16, Page 105) which was processed using *SPSS 25.0 For windows* s, the average value (*mean*) obtained was 21, a standard deviation of 1.7 can be seen in appendix 20, page 114.

The four categories of questionnaire results, if described in data, are as follows:

Very Good Category $= M + 1.5 \times SD < X$

$= 21 + 1.5 \times 1.7 < X \qquad = 24 < X$

Good Category $= M + 0.5 \times SD < X \leq M + 1.5 \times SD$

$= 21 + 0.5 \times 1.7 < X \leq 21 + 1.5 \times 1.7$

$= 22 < X \leq 24$

Bad Category $= M - 0.5 \times SD < X \leq M + 0.5 \times SD$

$= 21 - 0.5 \times 1.7 < X \leq 21 + 0.5 \times 1.7$

$= 20 < X \leq 22$

Very Poor Category $= M - 1.5 \times SD < X \leq M - 0.5 \times SD$

$= 21 - 1.5 \times 1.7 < X \leq 21 - 0.5 \times 1.7$

$= 18 < X \leq 20$

Table 4. Frequency Distribution of Teacher Communication Questionnaire Results

No	Counting	Interval	Frequency	Categorization
1	$24 < X$	24	12	Very good
2	$22 < X \leq 24$	22 – 24	29	Good
3	$20 < X \leq 22$	20 – 22	18	Not good
4	$18 < X \leq 20$	18 – 20	5	Very Bad

Based on the Frequency Table, the second interval has the largest frequency of 29 people in the good category, thus it can be concluded that the teacher communication indicator is in the Good category.

Based on the results of the student response questionnaire (Appendix 17, Page 108) which were processed using SPSS 25.0 For Windows, the average value (mean) obtained was 15.9 with a standard deviation of 2.3, which can be seen in Appendix 20, page 114.

The four categories of questionnaire results, if described in data, are as follows:

Very Good Category $= M + 1.5 \times SD < X$

$= 15.9 + 1.5 \times 2.3 < X \qquad = 20 < X$

Good Category $= M + 0.5 \times SD < X \leq M + 1.5 \times SD$

$= 15.9 + 0.5 \times 2.3 < X \leq 15.9 + 1.5 \times 2.3$

$= 17 < X \leq 20$

Bad Category = M - 0.5 x SD < X ≤ M + 0.5 x SD
= 15.9 - 0.5 x 2.3 < X ≤ 15.9 + 0.5 x 2.3
= 14 < X ≤ 17
Very Poor Category = M – 1.5 x SD < X ≤ M – 0.5 x SD
= 15.9 – 1.5 x 2.3 < X ≤ 15.9 – 0.5 x 2.3
= 12 < X ≤ 14

Based on the Frequency Table, the second interval has the largest frequency of 28 people in the good category, thus it can be concluded that the student response indicator is in the Good category.

Student Activity Observation Results

Based on the results of observations of Student Activities (Appendix 18, Page 111) which were processed using SPSS 25.0 For Windows, an average value (mean) of 3 was obtained with a standard deviation of 0.5 which can be seen in Appendix 20, page 114.

The four categories of questionnaire results, if described in data, are as follows:
Very Good Category = M + 1.5 x SD < X
= 3 + 1.5 x 0.5 < X = 3.75 <
Good Category = M + 0.5 x SD < X ≤ M +1.5 x SD
=3 + 0.5 x 0.5 < X ≤ 3 + 1.5 x 0.5
= 3.25 < X ≤ 3.75
Bad Category = M - 0.5 x SD < X ≤ M + 0.5 x SD
= 3 - 0.5 x 0.5 < X ≤ 3 + 0.5 x 0.5
= 2.75 < X ≤ 3.25
Very Poor Category = M – 1.5 x SD < X ≤ M – 0.5 x SD
= 3 – 1.5 x 0.5 < X ≤ 3 – 0.5 x 0.5
= 2.25 < X ≤ 2.75

Table 5. Frequency Distribution of Student Activity Observation Results

No	Counting	Interval	Frequency	Categorization
1	3.75 < X	3.75 − 4	4	Very good
2	3.25 < X ≤ 3.75	3.25 – 3.75	0	Good
3	2.75< X ≤ 3.25	2.75 − 3.25	2	Not good
4	2.25< X ≤ 2.75	2.25 − 2.75	0	Very Bad

Based on the interval 3.75 – 4 has an average of 3.87. The interval 2.75 - 3.25 has an average of 3. The categories can be concluded as follows:

= ((average interval 3.75-4 × frequency)+@(average interval 2.75-3.25 × frequency))/(Total Frequency)
= ((3.87 × 4) + (3 ×2))/6
= 3.58

From the calculation results, a value of 3.58 was obtained. This value is in the interval 3.25 - 3.75, the interval is in the good category, thus it can be concluded that the student response indicator is in the Good category (Walunj et al., 2022).

Post Test Results of Students' Mathematical Critical Thinking Ability

Based on the results of the post-test for Learning Achievement (Appendix 19, Page 112) which were processed using Microsoft Excel, the frequency of the Learning Objective Achievement Criteria intervals was obtained as follows:

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Table 5. Results of Learning Objective Achievement Criteria

Interval	Frequency	Criteria
86% -100%	7	Already achieved, need enrichment or challenge
66% -85%	55	Already achieved, no need for remedial
41% - 65%	2	Not yet achieved, remedial in the required section
0% - 40%	0	Not yet achieved, remedial in all parts

Based on the Frequency Table, the highest in the interval 66%-85% has the highest frequency of 55 people in the category of having achieved, no need for remedial, thus it can be concluded that the Learning Achievement indicator is in the Achieved category.

Based on Table to Table it can be concluded in the following Table 4.16 that:

Table 6. Summary of Effectiveness Indicators

No.	Indicator	Category
1.	Learning Systematics	Good
2.	Teacher Communication	Good
3.	Student Response	Good
4.	Student Activities	Good
5.	Learning Achievements	Achieved

Based on the table, it can be stated that the 5 indicators have a good category, thus it can be concluded that project-based learning is effective for students' critical mathematical thinking skills in the function material.

Research Discussion

Project-based learning is effective for students' ability to think critically mathematically. This is in accordance with the results of Ariani's research, (Dahn & DeLiema, 2020) that project-based learning is effective in increasing student motivation and learning outcomes. Project-based mathematics learning is effective for students' ability to think critically mathematically (Vogler et al., 2018). Project-based learning is effective for students' mathematical abilities in critical thinking and mathematical literacy skills (Pusparini & Widyanarko, 2021).

Research Based on the results of the research analysis, the effectiveness of project-based learning on critical mathematical thinking skills was obtained with a Good category and learning achievement was in the achieved category.

SIMPULAN

From the results of the research data analysis, it can be concluded that project-based learning is effective for students' critical mathematical thinking skills in quadratic function material in class X of Santo Paulus Private High School, Medan, academic year 2024/2025.

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