Indonesian Journal of Education Research (IJoER)
Vol. 6, No. 3, June 2025, pp. 285~292
ISSN: 2722-1326, DOI: 10.37251/ijoer.v6i3.1651

Quasi-experimental Study: The Effect of Problem Based Learning Model Assisted by Fyrebox on Students Mathematics Learning Outcomes

Farah Aprilia Rosyadi[1], Rica Wijayanti[2]
[1,2]Mathematics Education Study Program, STKIP PGRI Bangkalan, East Java, Indonesia

Article Info

Article history:

Received Apr 17, 2025
Revised May 20, 2025
Accepted Jun 7, 2025
Online First Jun 8, 2025

Keywords:

Fyrebox
Learning Outcomes
Mathematics
Problem Based Learning

ABSTRACT

Purpose of the study: This study aims to determine the effect of the Problem Based Learning (PBL) model assisted by Fyrebox on students' mathematics learning outcomes.

Methodology: This research employed a quantitative approach with a quasi-experimental Posttest-Only Control Group Design. The subjects consisted of 29 students in the experimental group and 30 students in the control group, all from grade XI of Kamal 1 State High School. The research instrument was a post-test in the form of problem-based essay questions. Data were analyzed using the Kolmogorov-Smirnov normality test, Levene's homogeneity test, and the Mann-Whitney U test with the assistance of SPSS 21.

Main Findings: The results showed a significance value of 0.000 < 0.05 in the Mann-Whitney U test, indicating a significant effect of the PBL model assisted by Fyrebox on students' mathematics learning outcomes. The experimental group outperformed the control group in both average score and percentage of completeness.

Novelty/Originality of this study: This study offers originality by integrating the Fyrebox game-based quiz platform into the Problem Based Learning model to enhance student engagement and performance in mathematics. Unlike previous studies that implemented PBL alone or used other digital tools, this research highlights the effectiveness of Fyrebox as a gamified medium that contributes to improved learning outcomes in the digital learning era.

Corresponding Author:
Farah Aprilia Rosyadi
Mathematics Education Study Program, STKIP PGRI Bangkalan, Jl. Soekarno Hatta No.52, Wr 07, Mlajah, Bangkalan District, Bangkalan Regency, East Java 69116, Indonesia
Email: farahapriliarosyadi@gmail.com

1. INTRODUCTION

The 21st century has brought major changes in almost all fields, including education. The development of digital innovation and the connectivity of the world encourages the growth of individual quality to be able to compete in the global arena. Current learning emphasizes more on developing analytical skills, interaction, teamwork, and creativity, known as the 4C [1], 21st century learning must be designed so that students can face complex challenges in the digital era. Students are expected to not only be able to understand theory, but also have the ability to solve problems, make decisions, and think logically and systematically.

Learning plays a crucial role in shaping a generation that can adapt to the transformation of the era. According to Siregar et al., [2], learning is not only limited to the activity of conveying knowledge, but also a place to form the personality and capacity of individuals to be ready to face the challenges of life. For that, an educational method is needed that does not only focus on the dissemination of information, but also encourages participation, innovation, and independence of students.

One form of adjustment of the education system in Indonesia to the development of the times is the introduction of the Independent Curriculum. This curriculum is designed to provide freedom to educational institutions and teachers in organizing the learning process according to the demands and characteristics of students. Kemendikbudristek [3] expresses the purpose of this curriculum to simplify basic skills and provide teachers with the freedom to develop learning activities that are meaningful, contextual, and directed at student needs.

The teacher's task in the Independent Curriculum is not only as a provider of knowledge, but also as a facilitator, guide, and motivator in creating a learning atmosphere that is fun, inclusive and provides freedom [4]. It was also stated that teachers need to adapt to the needs of the digital age, including utilizing information technology as a support in teaching and learning activities [5].

However, in reality in the field, we still often find traditional teaching methods that tend towards one-way communication [6]. Based on observations made during the School Field Introduction (PLP) activities, most mathematics teachers still apply the lecture approach without inviting students to participate directly in learning activities. The impact is that students become less active and not so involved in the learning process. This finding is in line with the results of observations Winda and Dafit [7] the lack of educators' capabilities in utilizing digital devices hinders breakthroughs in learning methods, thus impacting students' academic achievement in mathematics.

Mathematics as one of the main fields of study is often considered complicated and scary by many students [8]. Not a few students face challenges in grasping basic mathematical ideas, mainly due to the teaching methods applied are less stimulating and not directly related to everyday experiences. Therefore, a learning is needed that is able to arouse students' curiosity and make mathematical understanding activities feel more fun and interesting [9].

One method that has proven effective in improving mathematics learning achievement is the problem-oriented teaching method [10]. This approach emphasizes the direct involvement of students in the learning process, where they are directed to explore insights through handling real cases that are closely related to everyday life situations. According to Dewi et al., [11], PBL encourages the growth of critical thinking skills, team collaboration skills, and problem-solving skills. On the other hand, Suswati [12] highlighted that PBL forms a challenging learning environment and provides stimulus for students to formulate solutions to the problems they encounter. According to findings from Hermuttaqien et al., [13], Students who implement PBL strategies tend to have a deeper mastery of the material being taught, because they absorb knowledge through direct practice and independent research. In addition, students also consider that the topics they learn feel more meaningful because they are directly related to real conditions in everyday life [14]. Similar findings were also obtained by Butar et al., [15], which shows that PBL has a significant impact on high school students' mathematics learning outcomes. Fadilah et al., [16] In his research, he stated that PBL can improve the mathematical problem-solving abilities of grade VIII junior high school students.

In order for PBL to run optimally, interesting and interactive learning media are needed. One of them is Fyrebox, a digital platform for creating educational quizzes that can be accessed online. Syarifah et al., [17] mentioned that Fyrebox supports fun and challenging learning in accordance with learning objectives. Through Fyrebox, educators can strengthen student participation in teaching activities. Educational game applications in the form of quizzes like this have the potential to arouse students' curiosity, strengthen their enthusiasm for learning, and make it easier for them to absorb material in a more enjoyable way [18]. Ariyanto et al., [19] stated that the application of gamification in education is able to change students' views on difficult topics to become more exciting and challenging. Research by Hasibuan et al., [20] stated that the use of interactive digital media in mathematics learning can increase students' interest and learning outcomes. Likewise, Riny et al., [21] found that digital quizzes used in PBL can improve students' conceptual understanding and interest in mathematics material.

The collaboration between the Problem Based Learning approach and the Fyrebox platform is expected to produce a dynamic, communicative, and meaningful learning atmosphere. In the field of mathematics learning, the use of Fyrebox can be applied during the initial stage of problem presentation to arouse students' exploratory interest, and at the evaluation stage it is used to assess the extent of their understanding of the material that has been delivered. Thus, the combination of the problem-based approach and the Fyrebox platform has a significant opportunity to encourage improved mathematics learning outcomes for students.

Related to the previous explanation, this study aims to determine the effect of problem-based learning methods supported by Fyrebox on students' achievement of mathematics learning outcomes. It is hoped that this study can contribute ideas in designing a creative and modern educational approach, effective, and in line with the demands of education in today's era.

2. RESEARCH METHODS

This research was conducted in February of the 2024/2025 academic year at Kamal 1 State High School which is located in Kamal District, Bangkalan Regency, East Java. The researcher used a quantitative research type with a quasi-experimental research method. The design in this study used Posttest-Only Control Design which requires a control class and an experimental class. A detailed explanation of the Posttest-Only Control Design, according to Sugiyono [22] can be seen in the following table.

Table 1. Research method design

	Treatment	Post-test
R_1	X_1	O_1
R_2	X_2	O_2

Explanation:
R_1= random grouping of experimental groups.
R_2= random grouping of control groups.
X_1= the treatment applied to the experimental group sample was in the form of teaching with the Problem Based Learning model supported by fyrebox.
X_2= problem Based Learning model without fyrebox support.
O_1= final assessment conducted on the experimental group.
O_2= final assessment conducted on the control group.

The population that is the focus of this study includes all students from class XI. Which consists of classes XI-1, XI-2, XI-3, XI-4, XI-5, XI-6, XI-7, XI-8, XI-9, XI-10 and XI-11. As an alternative, the subjects used in this study were a group of students from class XI-10 totaling 29 students as the experimental group, and students from class XI-11 consisting of 30 students as the control group. The independent variables in this study are the problem-based teaching model supported by fyrebox and the problem-based teaching model that does not involve fyrebox. The dependent variable in this study is the learning outcomes of students in mathematics lessons [17].

The method of collecting information in this study uses a tool in the form of a learning evaluation which is given after the teaching session is finished or what is better known as a post-test [23]. The evaluation was distributed to two groups, namely the experimental group that received teaching with the Problem Based Learning (PBL) approach supported by Fyrebox media, and the control group that received teaching with the Problem Based Learning approach without any assistance from Fyrebox media.

The test applied in this research involves essay questions designed to evaluate the extent to which students understand mathematical concepts after following the learning process. These questions are designed according to the criteria for achieving competencies that are relevant to the topics being studied and have been aligned with teaching objectives. The selection of the essay format aims for students to not only provide final answers, but also be able to describe their thinking process and understanding of the mathematical concepts they have learned.

The design of the test tool is carried out through various steps, starting from the preparation of the question framework, making questions, to evaluation by experts (validators). This evaluation process aims to ensure that the questions used can properly measure students' abilities according to the research targets [24].

The main purpose of conducting this post-test is to collect numerical information related to students' learning achievement after they receive different treatments [25]. The information will then be analyzed using analytical techniques to identify whether there is a significant difference between the academic performance of students in the experimental group and the comparison group. Thus, this analysis serves as a means to directly evaluate whether the application of the Problem Based Learning learning approach supported by Fyrebox media affects students' mathematics learning outcomes.

Once all the information is collected, the next step is data examination and processing:

1. Kolmogorov Smirnov Normality Test

Kolmogorov-Smirnov *Test* menurut The Normality Test is used to ensure whether the data to be tested is normally distributed or not. Kolmogorov-Smirnov Test according to [26] is a method applied to examine the distribution of random and structured data in a group. This process is carried out with the help of the SPSS version 21 application. If the significance value in the research sample is greater than 0.05, then the data can be considered normally distributed.

2. Homogeneity Test

Homogeneity Test according to Li et al., [27] is a procedure carried out to evaluate whether the variation between groups shows similarities. This process is carried out using the Levene test. If the Significance value is greater than 0.05, then the data group is considered to come from a group with similar variations (homogeneous). However, if the Sig value is less than 0.05, then the data group comes from a group with significantly different variations (heterogeneous).

3. Statistical Hypothesis Testing

The statistical hypothesis testing applied in this research is the T-Test [22]. The testing stages were carried out using the SPSS 21 application, with the analysis of the test results explained as follows:

1) If Sig is more than 0.05, H_0 is accepted, meaning that there is no significant influence of the problem based learning model assisted by fyrebox on students' mathematics learning outcomes.
2) If Sig is less than 0.05, H_1 accepted, meaning that there is a significant influence of the problem based learning model assisted by fyrebox on students' mathematics learning outcomes.

4. Mann Whitney U test

Mann-Whitney U test according to Normelia et al., [28] is a statistical technique that does not rely on the assumption of normal distribution, used to compare learning outcomes between two groups. This approach is used when the data analyzed is in the form of an ordinal scale, with the interpretation of the test results as follows :

1) If the Sig value (2-tailed) is greater than 0.05, the null hypothesis (H_0) is accepted and the alternative hypothesis (H_1) is rejected, which means that there is no significant influence of the problem based learning model assisted by fyrebox on students' mathematics learning outcomes.
2) If the Sig value (2-tailed) less than or equal to 0.05, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, which means that there is a significant influence of the problem based learning model assisted by fyrebox on students' mathematics learning outcomes.

The research procedure goes through several stages as follows:

1. Planning

Planning and creating learning tools, research instruments, designing the use of Fyrebox and validating instruments with validators.

2. Implementation

Selecting two groups of students from class XI-10 totaling 29 students as the experimental group, and students from class XI-11 consisting of 30 students as the control group with purposive sampling technique. The experimental group received learning using the Problem Based Learning model assisted by Fyrebox. The control group received learning with the Problem Based Learning model without the help of Fyrebox [18].

3. Giving Post-test

After the learning process, both groups were given a final test in the form of problem-based essay questions to measure mathematics learning outcomes.

4. Data Processing and Analysis

The post-test data were analyzed using the Kolmogorov-Smirnov normality test, Levene's homogeneity test, and the Mann-Whitney U hypothesis test using SPSS 21.

3. RESULTS AND DISCUSSION

3.1. Results

1. Learning outcomes

Table 2. Post-Test Results of Control Class and Experimental Class

Class	Mean	Standard Deviation	Percentage Completed (%)	Incomplete Percentage (%)
Control	63.3	18.86	26.67	73.33
Experimental	89.5	14.99	82.76	17.24

After the learning outcome information has been obtained from the comparison group and the test group, the next stage is to conduct data analysis. Some of the tests carried out in this study include:

a. Normality Test

Normality check according to Sonjaya et al., [29] is the first step in a series of data analysis that aims to determine whether the collected data follows a normal distribution pattern or not. Normal distribution is one of the main conditions that must be met in various parametric statistical tests, such as the t-test. Therefore, normality testing plays a crucial role in ensuring that the data obtained can be analyzed using appropriate statistical methods [30].

In this study, normal distribution testing was applied to the final exam score data of all participants, both those in the control group and the experimental group. The control group refers to students who follow the learning process with the Problem-Based Learning approach without using Fyrebox media, while the experimental group consists of students who undergo learning with a similar approach, but supported by the use of Fyrebox media`.

Data normality testing was carried out using SPSS software version 21 using the Kolmogorov-Smirnov approach [26]. This technique was chosen because the number of samples in this study exceeded 50, which is in accordance with the requirements for using the Kolmogorov-Smirnov method. If the probability value (Sig.) obtained from the test is greater than 0.05, then the data is considered normally distributed. Conversely, if the value is less than 0.05, then the data is considered not normally distributed.

This normality test serves as an initial reference in choosing the right hypothesis testing method, whether using a parameter-based approach or one that does not depend on parameters. If the data distribution does not show a normal pattern, then further analysis will be continued using non-parametric methods, such as the Mann-Whitney test. The following are the results of the normality test on the post-test values for the experimental group and the control group:

Table 3. Normality Test

Class		Kolmogorof-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Result	Experiment	.289	29	.000	.765	29	.000
	Control	.165	30	.037	.942	30	.100

Based on table 3, the normality test obtained significant values of 0.000 < 0.05 and 0.037 < 0.05 which means that the data is not normally distributed.

b. Hypothesis Test

The examination of the normal distribution is used as a starting point in determining the appropriate approach for hypothesis testing, whether to use a parameter-based technique or one that does not depend on parameters. If the data distribution pattern does not reflect a normal distribution, then the analysis step is continued with a non-parametric approach, for example the Mann-Whitney test. Below are the results of the evaluation of the normal distribution of the post-test scores of the treatment group and the comparison group [28].

Since the previous normality test indicated that the data was not normally distributed, the analysis steps were continued using non-parametric methods [31]. The technique applied is the Mann-Whitney U Method, which functions as a substitute for the t-test for two independent groups (independent sample t-test) when the data does not have a normal distribution [32]. The following is the output of the Mann-Whitney method:

Table 4. Hypothesis Test

	Result
Mann-Whitney U	106.000
Wilcoxon W	571.000
Z	-5.009
Asymp. Sig. (2-tailed)	.000

Referring to table 4 related to hypothesis testing conducted using the Mann-Whitney Test because the data is not normally distributed. a significance figure of 0.000 is obtained which is smaller than 0.05 which means there is a significant difference between the mathematics learning outcomes of students in the experimental class and the control class. Thus, it indicates the influence of the Problem Based Learning learning model assisted by fyrebox on students' mathematics learning outcomes.

3.2. Discussion

Based on Table 3.1 post-test results, the average score of students in the control class was 63.3 and a standard deviation of 18.86 with a completion rate of 26.67%, while in the experimental class, the average score reached 89.5 and a standard deviation of 14.99 with a completion rate of 82.76%. This shows that students who study using the Problem Based Learning model assisted by Fyrebox achieve higher learning outcomes than students who study with Problem Based Learning without Fyrebox. Table 3.2 explains the results of the normality test, which indicates that the final exam data from the experimental group and the control group are not normally distributed. Therefore, the analysis was continued using a non-parametric hypothesis testing method. In Table 3.3, it can be seen that the Problem Based Learning model assisted by Fyrebox has a significant effect on students' mathematics learning outcomes. This finding is in line with a study conducted by

[33] which revealed that the application of the Problem Based Learning method can improve learning achievement, where 85% of students achieved a score of at least 70.

In general, the Problem Based Learning method has proven to be effective in the process of learning mathematics because it emphasizes solving challenges. This result is in line with the findings of research Yuna and Oviana [34] which indicates that Problem Based Learning can deepen students' understanding of concepts and learning outcomes. The difference lies in the point of attention; this study prioritizes the impact that is more focused on how to improve the process.

Research Husanah and Fitria [35] is in line with these findings, although it only implements the Problem Based Learning approach without the support of digital tools, while this study combines the Problem Based Learning method with an interactive tool called Fyrebox. Then, the results of research from Syarifah et al., [17] revealed that Fyrebox is able to facilitate students in understanding and solving problems in a structured and enjoyable way, while also fostering a spirit of learning. This indicates that collaboration between innovative teaching strategies and interactive technology is able to enrich students' insights into mathematical ideas.

3.2.1. The Influence of Fyrebox Based on ARCS Theory

The application of Fyrebox in mathematics learning can be analyzed through the ARCS motivation theory framework developed by Keller. First, in terms of Attention, Fyrebox is able to attract students' attention through interactive visual displays, the use of game elements, and the presentation of challenge-based quizzes. Second, in terms of Relevance, the material packaged in Fyrebox can be directly linked to the mathematics learning topic being studied, so that students feel that the activity is relevant to their academic needs and their interests who like games. Third, in terms of Confidence, Fyrebox allows students to build self-confidence through compiling quizzes so that they are easy to understand, namely from easy to difficult, which strengthens their self-confidence in facing mathematics problems. Fourth, in terms of Satisfaction, the success of completing the challenges given by Fyrebox provides a sense of satisfaction for students, which then strengthens their intrinsic motivation to continue learning.

3.2.2. Practical Implications for Mathematics Teachers

Mathematics teachers can integrate Fyrebox into their lesson plans by designing problem-based quizzes that are tailored to the learning objectives. For example, teachers can create quizzes that contain problem-based questions to train students' critical thinking skills. This integration can be done at the beginning of learning to activate students' prior knowledge, or at the end of the session to evaluate their understanding. However, there are several technical challenges that need to be considered. Optimal use of Fyrebox requires stable internet access and adequate digital devices. In addition, teachers need to adapt in designing questions, namely ensuring that the quizzes are in the form of problem solving and maintain the depth of the mathematics material being taught.

This research can still be further researched with indicators of the influence of Fyrebox on student activity, student motivation and can be used for research in other fields of study. In my research, it was only on learning outcomes and there are still gaps, I have not studied the responses and activities of students, that could be an opportunity for other researchers for further research. It is also possible that Fyrebox and Problem Based Learning can be tested for other subjects.

4. CONCLUSION

Based on the results of the research that has been conducted as well as the data analysis and discussion that has been presented, it can be concluded that the use of the Problem Based Learning (PBL) learning model assisted by Fyrebox media has a significant influence on students' mathematics learning outcomes. Thus, the application of the Problem Based Learning learning model assisted by Fyrebox is worthy of being an alternative learning strategy in mathematics classes, especially in efforts to improve the quality of the process and student learning outcomes in the digital era that demands learning with creative and technology-oriented teaching methods.

REFERENCES

[1] R. S. W. Sahmanita and Y. Sutopo, "Penerapan Model Problem Based Learning Berbantuan Wordwall Tipe Matchup Untuk Meningkatkan Hasil Belajar Peserta Didik," *Pendas J. Ilm. Pendidik. Dasar*, vol. 09, no. 02, 2024.

[2] A. M. . Siregar, M. br . Sembiring, and D. . Pradesa, "Penerapan Model Problem Based Learning Berbantuan Media Interaktif Wordwall Untuk Meningkatkan Hasil Belajar Peserta Didik ", *ej*, vol. 8, no. 2, pp. 458–465, 2024, doi: 10.31537/ej.v8i2.1955

[3] Kemendikbudristek, "Kurikulum Merdeka," 2024.

[4] A. P. Lubis and I. Nuriadin, "Efektivitas Aplikasi Wordwall untuk Meningkatkan Hasil Belajar Siswa dalam Pembelajaran Matematika Sekolah Dasar," *J. Basicedu*, vol. 6, no. 4, pp. 6884–6892, 2022, doi: 10.31004/basicedu.v6i4.3400.

[5] M. P. Putri, L. S. Hariani, and M. Ekowati, "Penerapan model pembelajaran problem based learning (pbl) berpadukan dengan word wall game quis untuk meningkatkan motivasi dan hasil belajar pada materi perdagangan internasional kelas xi ips 1," vol. 1, pp. 783–794, 2024.
[6] I. Ainurrohmah, T. Y. E. Siswono, and W. Wiryanto, "Pengaruh Model Pembelajaran TGT Berbantu Media Wordwall terhadap Kemampuan Berpikir Kritis Siswa," *Ideas J. Pendidikan, Sos. dan Budaya*, vol. 10, no. 2, p. 267, 2024, doi: 10.32884/ideas.v10i2.1725.
[7] R. Winda and F. Dafit, "Analisis Kesulitan Guru dalam Penggunaan Media Pembelajaran Online di Sekolah Dasar," *J. Pedagog. dan Pembelajaran*, vol. 4, no. 2, p. 211, 2021, doi: 10.23887/jp2.v4i2.38941.
[8] M. A. Akhmad, M. Mustari, M. A. Putra, T. A. Arif, I. Fadollah, and A. Sila, "Penerapan Model Pembelajaran Problem Based Learning Dalam Meningkatkan Hasil Belajar Matematika Siswa Sd," *J. Ilm. Pendidik. Citra Bakti*, vol. 10, no. 2, pp. 341–355, 2023, doi: 10.38048/jipcb.v10i2.1462.
[9] M. A. Baalwi, "Pengembangan Media Pembelajaran Teknologi Augmented Reality Berbasis Smartphone Android pada Materi Bangun Ruang," *Journal On Teacher Education*, vol. 4, no. 3, pp. 756–761, 2023.
[10] N. Nadila and S. Sitompul, "Pengaruh model pembelajaran problem based learning terhadap peningkatan kemampuan (the influence of problem based learning learning models," vol. 04, no. 01, pp. 45–54, 2021.
[11] S. S. Dewi, F. Chasanatun, and L. N. Pradana, "Problem Based Learning (PBL) Berbantuan Video Pembelajaran Dapat Meningkatkan Kemampuan Siswa Dalam Menyelesaikan Soal," *Pros. Konf. Ilm. Dasar*, vol. 3, pp. 979–984, 2022.
[12] U. Suswati, "Penerapan problem based learning (pbl) meningkatkan hasil belajar kimia umi suswati sman 1 purwanegara," vol. 1, no. 3, pp. 127–136, 2021.
[13] B. P. F. Hermuttaqien, L. Aras, and S. I. Lastari, "Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Hasil Belajar Kimia Elektrolisis," *J. Pendidik. dan Profesi Kegur.*, vol. 2, no. 2, p. 218, 2023, doi: 10.59562/progresif.v2i2.30313.
[14] W. A. Tiyasrini, "Penerapan Model Pembelajaran Berbasis Masalah Problem Based Learning (PBL) Dalam Meningkatkan Hasil Belajar IPS Materi Kegiatan Ekonomi Di Negara Asean Pada Siswa Kelas VI SDN Dawuhansengon II Tahun 2020," *Educ. J. Educ. Res.*, vol. 3, no. 1, pp. 208–217, 2021, doi: 10.36654/educatif.v3i1.198.
[15] F. E. B. Butar, R. Sidabutar, and G. N. Sauduran, "Jurnal Pendidikan Sains dan Komputer Pengaruh Model Pembelajaran Problem Based Learning (PBL) Terhadap Hasil Belajar Matematika," *J. Pendidik. Sains dan Komput.*, vol. 2, no. 2, pp. 420–426, 2022.
[16] F. Fadilah, Arjindin, T. W. Triutami, and Sripatmi, "Pengaruh Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar Matematika Siswa," *Kogn. J. Ris. HOTS Pendidik. Mat.*, vol. 3, no. 2, pp. 148–157, 2023, doi: 10.51574/kognitif.v3i2.955.
[17] A. Syarifah, E. N. Sa'adah, E. Qotrunnada, and A. A. A. Aziz, "Penerapan Aplikasi Fyrebox sebagai Instrumen Penilaian Evaluasi Siswa Sekolah Dasar," *Edukatif J. Ilmu Pendidik.*, vol. 6, no. 1, pp. 353–362, 2024, doi: 10.31004/edukatif.v6i1.5327.
[18] N. Q. Ahmad and R. Babo, "Pengaruh Model Pembelajaran Problem Based Learning (PBL) Berbantuan Aplikasi Quizizz terhadap Minat dan Hasil Belajar Siswa Pada Mata Pelajaran IPS Kelas IV SD Inpres Bontomanai," vol. 07, no. 01, pp. 3175–3192, 2024.
[19] M. P. Ariyanto, Z. R. Nurcahyandi, and S. A. Diva, "Penggunaan Gamifikasi Wordwall untuk Meningkatkan Hasil Belajar Matematika Siswa," vol. 5, no. 1, pp. 1–10, 2023.
[20] S. M. U. Hasibuan, F. . Rakhmawati, dan R. U. . Hasanah, "Pengaruh model problem based learning terhadap hasil belajar dan motivasi belajar matematika siswa ", *Relevan*, vol. 4, no. 5, 2024.
[21] R. N. Riny, H. S. Astutik, and S. F. Rabia, "Pengaruh model problem based learning (pbl) terhadap hasil belajar matematika siswa sd", *theorema*, vol. 5, no. 2, Dec. 2024.
[22] Sugiyono, "Metode Penelitian Kuantitatif, kualitatif, dan R&D," 2018, *Alfabeta*.
[23] T. Samuel, R. Azen, and N. Campbell-Kyureghyan, "Evaluation of Learning Outcomes Through Multiple Choice Pre- and Post-Training Assessments," *J. Educ. Learn.*, vol. 8, no. 3, p. 122, 2019, doi: 10.5539/jel.v8n3p122.
[24] S. Sainuddin, B. Subali, Jailani, and M. Elvira, "The Development and Validation Prospective Mathematics Teachers Holistic Assessment Tools," *Ing. des Syst. d'Information*, vol. 27, no. 2, pp. 171–184, 2022, doi: 10.18280/isi.270201.
[25] P. T. Shivaraju, G. Manu, M. Vinaya, and M. K. Savkar, "Evaluating the effectiveness of pre- and post-test model of learning in a medical school," *Natl. J. Physiol. Pharm. Pharmacol.*, vol. 7, no. 9, pp. 947–951, 2017, doi: 10.5455/njppp.2017.7.0412802052017.
[26] A. Quraisy, "Normalitas Data Menggunakan Uji Kolmogorov-Smirnov dan Saphiro-Wilk," *J-HEST J. Heal. Educ. Econ. Sci. Technol.*, vol. 3, no. 1, pp. 7–11, 2022, doi: 10.36339/jhest.v3i1.42.
[27] X. Li *et al.*, "A Comparative Study of Tests for Homogeneity of Variances with Application to DNA Methylation Data," *PLoS One*, vol. 10, no. 12, pp. 1–12, 2015, doi: 10.1371/journal.pone.0145295.
[28] R. Normelia, T. D. Fortuna, E. P. Putri, and E. Widodo, "Analisis Mann-Whitney untuk Mengetahui Efektivitas Vaksin pada Jumlah Penderita Covid-19 di Indonesia," *J. Sains Mat. dan Stat.*, vol. 8, no. 1, p. 27, 2022, doi: 10.24014/jsms.v8i1.15087.
[29] R. P. Sonjaya, F. R. Aliyya, and S. Naufal, "Pengujian Prasyarat Analisis Data Nilai Kelas : Uji Normalitas dan Uji Homogenitas," vol. 9, pp. 1627–1639, 2025.
[30] I. Sintia, M. D. Pasarella, and D. A. Nohe, "Perbandingan Tingkat Konsistensi Uji Distribusi Normalitas Pada Kasus Tingkat Pengangguran di Jawa," *Pros. Semin. Nas. Mat. Stat. dan Apl.*, vol. 2, no. 2, pp. 322–333, 2022.
[31] Z. Mufarrikoh, "Analisis Mann-Whitney pada Pemahaman Materi Statistika Pendidikan," *Students' Difficulties Elem. Sch. Increasing Lit. Abil.*, vol. 4, no. 1, pp. 1–12, 2022.
[32] A. Damanhuri and A. Solikin, "Implementasi uji mann-whitney dalam evaluasi prestasi hasil belajar kegiatan pelatihan

sails fakultas syariah dan hukum uinsa," vol. 7, no. 1, pp. 17–23, 2022.

[33] E. Listyaningsih, N. Nugraheni, and I. B. Yuliasih, "Peningkatan Hasil Belajar Melalui Pendekatan TarlModel PBL Dalam Matematika Kelas V SDN Bendan Ngisor," *Madani J. Ilm. Multidisipline*, vol. 1, no. 6, pp. 620–627, 2023, doi: 10.5281/zenodo.8139269

[34] L. Yuna and W. Oviana, "Problem based Learning: A Learning Model to Improve Student Learning Outcomes," *Indones. J. Educ. Soc. Humanit.*, vol. 1, no. March, pp. 19–27, 2024.

[35] M. Husanah and Y. Fitria, "Pengaruh Model Problem Based Learning Terhadap Kemampuan Kognitif IPA pada Pembelajaran Tematik Terpadu," *J. Basicedu*, vol. 5, no. 5, pp. 3(2), 524–532, 2020.