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Effectiveness of Desmos Application Integrated with PjBL in Multimedia Mathematics Learning in Terms of Mathematical Literacy Skills

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Abstract: This study aims to determine the effectiveness of the desmos application integrated with PjBL in terms of mathematical literacy skills, the effectiveness of multimedia mathematics learning in terms of mathematical literacy skills and the effectiveness of the desmos application integrated with PjBL in multimedia mathematics learning in terms of mathematical literacy skills. This research design is quasi-experiment with a post-test only control group design. The research subject were 60 students of senior high schools at SMA Negeri 3 Bireuen with a total research population of 102 students. The sample in this study was determined by a convenience sampling technique. The instrument used was a diagnostic test consisting of three questions based on mathematical literacy skills. The data were analyzed using the classical completeness test, different proportion test and t-test. Based on the research findings, it is deducible that the Desmos application yields better results when integrated with PjBL concerning mathematical literacy skills. Moreover, mathematics learning supported with multimedia is more efficacious for enhancing mathematical literacy skills. Lastly, when evaluating mathematical literacy skills, combining Desmos application with PjBL and multimedia in mathematics learning proves to be the most effective approach.

Keywords: Desmos Aplication; Mathematical Literacy; PjBL

Introduction

The rapid progress of technology necessitates education to keep pace with technological developments. Evidence of technology's integration into education can be observed through the development of an array of applications that can function as learning tools, promoting more efficient teaching and learning activities. The use of learning media in teaching and learning activities can help meaningful teaching and learning activities (Sulisworo & Permprayoon, 2018). Learning media has developed along with technological developments (Nurmawati et al., 2020). Therefore, teachers are expected to continue to adapt to the development of science and technological innovation.

Teachers need to develop their knowledge of the effective use of technology in learning, especially mathematics (Kristanto, 2021). In the 21st century, learners must proficiently combine knowledge, attitudes, and technological abilities. This is attainable through the utilization of technology-based learning media during the learning process (Husniyah & Ramli, 2023). Digital technology can be utilized as one of the learning media, especially mathematics learning to introduce students that digital technology is not only a means of communication but can also help understand mathematics material (Harisman et al., 2019; Nurmawati et al., 2020). The success of mathematics learning is influenced by the teacher's ability to carry out learning, especially the integration of technology as a learning medium (Nuri, 2019).

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In the 21st century era, in addition to skills in technology, mathematical literacy is one of the abilities that students must have. Learners who have mathematical literacy not only understand mathematics but are also able to use it in solving everyday problems in accordance with the times (Masjaya & Wardono, 2018; Yildirim & Sidekli, 2018). Mathematical literacy is one of the abilities that must be possessed by 21st century learners because mathematical literacy skills are related to the ability to propose, formulate and solve problems within and outside of mathematics in various contexts.

Mathematical literacy is a basic ability that needs to be developed so that they succeed in the learning process and can understand and apply basic mathematics in everyday life (Kusuma, 2020; Nitasari et al., 2018). Learners need not only calculation skills but also mathematical thinking skills in analyzing, evaluating and drawing conclusions on the basis of logical, rational and critical thinking about a problem.

Mathematical literacy is also one of the measurements in the PISA (*Program for International Student Assessment*) assessment. Based on the results of the PISA test, the mathematical literacy of Indonesian students is still relatively low. The results of the PISA test from 2000 to 2015 stated that the achievements of Indonesian students were always at the bottom (Ahmad et al., 2018). At the upper secondary level students, it was found that the mathematical literacy of students was classified in a very low category with details for understanding indicators classified as low, while for indicators of making mathematical models, using concepts-facts-objects, interpreting and evaluating were in the very low category (Sari & Wijaya, 2017).

Low levels of mathematical literacy may be due to students' lack of experience in solving problems that require in-depth analysis and reasoning. Mathematical literacy helps students to understand the usefulness of mathematics in everyday life. The importance of mathematical literacy in everyday life is such that it can be used to help learners to understand mathematics through the contexts of their everyday lives.

Therefore, there is a requirement for mathematics applications that can cater to the mathematical literacy of students. Applications of mathematics as learning media through multimedia are user-friendly, fascinating, ignite students' interest in learning and enable two-way communication between teachers and students, even during online and limited face-to-face learning (Karindra & Ekawai, 2022). Through a variety of activities, the use of multimedia technology encourages learners to become actively involved in the learning process (Widiasanti et al., 2023). Learning media that can be used in the form of Desmos applications integrated with *Project Based Learning* (PjBL).

Desmos application is a geometric graph application that can be accessed online through the Desmos website or offline using the downloaded Desmos application and can draw graphs such as linear programs, trigonometry, linear equations straight circles and quadratic functions (Husna et al., 2020). Desmos is one of the technologies that has great potential to improve the quality of mathematics (Attard & Holmes, 2022; King, 2017; Meyer, 2020; Orr, 2017). The use of Desmos in learning activities can create learning activities that provide opportunities for students to learn mathematical concepts productively and comprehensively (TLS & Herman, 2020). Desmos application is suitable for integration with the PjBL model because the use of PjBL models that are in accordance with the demands of the skills needed in the 21st century can improve students' mathematics abilities (Yunita et al., 2021).

PjBL is an innovative learning model. It focuses on contextual learning through complex activities (Chintya et al., 2023). The principle of project-based learning emphasizes students' skills in overcoming problems experienced in real life and helps learners to integrate, reconstruct knowledge, improve professionals, increase interests and abilities with others (Guo et al., 2020; Zen et al., 2022). The PjBL model is suitable for achieving the expected learning objectives, namely improving math skills (Yunita et al., 2021). Some of the results of previous research studies related to digital LKPD based on the Desmos application are alternative media that can be used in learning because they are suitable for online and face-to-face and can develop students' skills (Karindra & Ekawai, 2022). The use of an independent task-based PjBL model can improve mathematical literacy (Nitasari et al., 2018). Based on the results of the analysis, it is found that there is no research that examines the application of Desmos integrated PjBL in terms of mathematical literacy skills. So this research is worth doing.

The research objectives are to determine the effectiveness of desmos application integrated with PjBL in terms of mathematical literacy skills; the effectiveness of multimedia mathematics learning in terms of mathematical literacy skills; and the effectiveness of desmos application integrated with PjBL in multimedia mathematics learning in terms of mathematical literacy skills.

Method

This research is a quasi-experiment research with a post-test only research design with control group design. The research subject were 60 students of senior high schools at SMA Negeri 3 Bireuen with a total

research population of 102 students. The sample in this study was determined by a convenience sampling technique. The characteristics of the sample are based on students who have not learned the material of geometry transformation but have learned the material of the basic concepts of geometry.

The research design was carried out by designing two classes consisting of experimental and control groups with 32 and 28 students respectively. The experimental group was given an action in the form of PjBL presented using the desmos application which contained audio visuals while the control group carried out learning using the PjBL model without the help of desmos. The research variable was mathematical literacy ability. Indicators of mathematical literacy assessment include formulating problem situations systematically; using concepts, facts, procedures and reasoning; and interpreting, applying and evaluating mathematical outcomes. The research flow is described in the chart below (Figure 1).

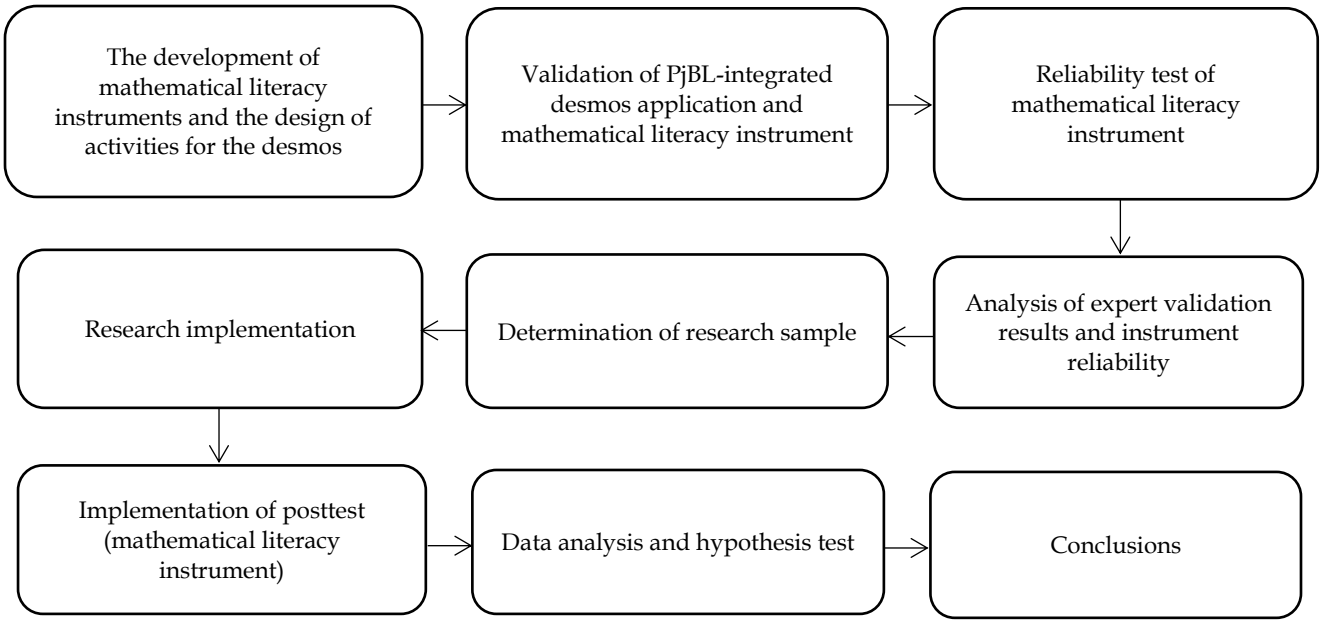

Figure 1. The research flow

In this study, researchers developed an instrument to measure mathematical literacy in the form of essay questions and designed activities in the desmos application according to the PjBL syntax, equipped with the use of multimedia in the form of audio-visuals on the concept of reflection. The results of the design of the PjBL integrated desmos application and the mathematical literacy tools were then subjected to expert validation, including media experts and materials experts, in order to obtain suggestions for improvement. Once the developed product is valid, the next step is to test the reliability of the mathematical literacy instrument.

The valid and reliable products will then be tested on the previously identified research sample class. The researcher then administered a post-test in the form of questions to measure the students' mathematical literacy. In the last step, the researcher analysed the data and carried out a hypothesis test to determine the effectiveness of the integrated desmos application of PjBL on the mathematical literacy skills.

The data collection technique used tests. The data collection test instrument used was in the form of mathematical literacy test questions which were arranged according to the indicators and had been tested for validity and reliability. The data obtained were analyzed using the classical completeness test, difference in proportion test and t-test.

The study attempted to address three research hypotheses: 1) The combination of the Desmos application with PjBL might be more effective in terms of mathematical literacy; 2) Learning mathematics with multimedia is more effective for developing mathematical literacy skills; 3) The Desmos application appears to enhance the effectiveness of multimedia mathematics learning when combined with project-based learning (PjBL) in developing mathematical literacy.

Result and Discussion

The PjBL integrated desmos application that has been designed will be implemented in the learning process first measured its validity. The validity measurement was carried out using content validity and then the Aiken index (V) was used to categorize the

validity of the instrument. The results of data analysis showed that the desmos application designed had a very valid validity level with an Aiken index value of 0.93. The aspects of validation assessment of the desmos application consist of six aspects including material, suitability for learning models, illustrations, media quality and appearance, language suitability and attractiveness. The Aiken index of the six aspects can be seen in Figure 1.

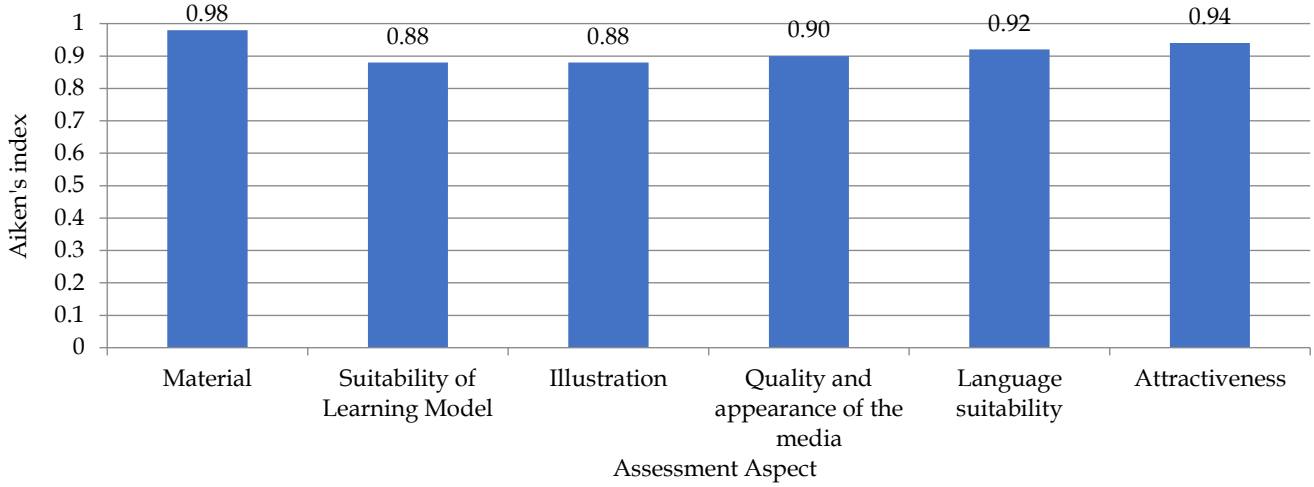

Figure 2. Results of Expert Validation of PjBL Integrated Desmos Application

Based on Figure 1, it can be seen that the material aspect has the highest validity value of 0.98 with a very valid category while the illustration aspect and suitability for the learning model have the lowest validity index of 0.88 with a very valid category. The mathematical literacy measurement instrument also has a very valid validity level with an Aiken index value of 0.94. The results of expert validation of the question instrument to measure mathematical literacy can be seen in Table 1.

In Table 1, it can be seen that the mathematical literacy measurement instrument is very valid for use. The highest validity value is in the aspect of conformity with the research objectives and the lowest validity value is in the aspect of the language used.

Table 1. Results of Expert Validation of Mathematical Literacy Measurement Questions

Assessment aspect	Aiken index (V)	Category
Appropriateness of the language used	0.89	Very valid
Conformity with research objectives	1	Very valid
The suitability of mathematical literacy indicators with mathematical literacy ability questions prepared	0.94	Very valid

In Table 1, it can be seen that the mathematical literacy measurement instrument is very valid for use. The highest validity value is in the aspect of conformity with the research objectives and the lowest validity value is in the aspect of the language used.

Hypothesis Test Results

Hypothesis Test I (Classical Completeness Test)

In hypothesis testing I, the classical completeness test was used to prove the research hypothesis related to the application of desmos which is more effective when combined with PjBL in terms of mathematical literacy skills. The research hypotheses are as follows: 1) $\pi \leq 70\%$ if the proportion of students in PjBL learning with desmos application who have achieved competency is less than or equal to 70%; and 2) $\pi > 70\%$ if the proportion of students in PjBL learning with desmos application has achieved more than 70% competency.

The test criteria used are reject H_0 for $Z_{hitung} > Z_\alpha$ and accept H_0 for other prices. The value Z_α obtained from the z table with a significance level of 5%. The data analyzed in this test is the post-test score data using the classical completeness test with the help of Ms. Excel. The results of hypothesis testing I can be seen in Table 2.

Table 2. Hypothesis Testing Results I

Proportion	Student completion	Number of students	Z_{hitung}	Z_α
0.70	30	32	2.93	1.65

Based on the calculation results presented in Table 2 shows $Z_{hitung} > Z_\alpha$ then H_0 rejected. So it can be concluded that the proportion of students in PjBL learning with desmos application has achieved

competency achievement of more than 70%). This proves that desmos application is more effective when combined with PjBL in terms of mathematical literacy skills.

Hypothesis Test II (Proportion Difference Test)

In hypothesis testing II, a difference in proportions test was used to prove the research hypothesis related to multimedia mathematics learning being more effective in terms of mathematical literacy skills. The research hypotheses are as follows:1) $\pi_0 \leq \pi_1$ if the proportion of classical achievement of students' mathematical literacy competence in PjBL learning with desmos application is less than or equal to the proportion of classical achievement of students' mathematical literacy competence in PjBL learning; and 2) $\pi_1 \leq \pi_2$ if the proportion of classical achievement of students' mathematical literacy competence in PjBL learning with desmos application is more than the proportion of classical achievement of students' mathematical literacy competence in PjBL learning.

The test criteria used are reject H_0 for $Z_{hitung} > Z_\alpha$ and accept H_0 for other prices. The value $Z_\alpha$obtained from the z table with a significance level of 5%. The data analyzed in this test is the post-test score data using the difference in proportions test with the help of Ms. Excel. The results of hypothesis II testing can be seen in Table 3.

Table 3. Hypothesis II Testing Results

π_1	π_2	p	q	Z_{Count}	Z_α
0.93	0.60	0.78	0.21	3.09	1.65

Based on the calculation results presented in Table 3 shows $Z_{hitung} > Z_\alpha$ then H_0 rejected. So it can be concluded that the proportion of classical achievement of students' mathematical literacy competence in PjBL learning with desmos application is more than the proportion of classical achievement of students' mathematical literacy competence in PjBL learning. This proves that multimedia mathematics learning is more effective in terms of mathematical literacy skills.

Hypothesis Test III (t-test)

In hypothesis III test, t-test was used to prove the research hypothesis related to desmos application can be more effective when combined with PjBL with multimedia mathematics learning in terms of mathematical literacy skills. The data analyzed in this test is the post-test score data using t-test with the help of SPSS *software*. The use of t-test statistical techniques requires prerequisites that must be met, including data normality and homogeneity.

The normality test of students' mathematical literacy data was carried out using the *Kolmogorov-Smirnov test* which aims to determine whether the data fit the normal distribution or not. The data analyzed in this test is post-test data. The normality test results showed that the mathematical literacy data of the control and experimental classes were normally distributed with a sig value of 0.20 > 0.05 (Table 4).

Table 4. Student Mathematical Literacy Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experiment	.12	32	.20*	.96	32	.32
Control	.11	28	.20*	.94	28	.13

The results of the homogeneity test using the Levene test showed that the mathematical literacy data had the same variance (homogeneous) because the significance value was greater than the significance level of 0.05 (Table 5).

Table 5. Results of Homogeneity Test of Students' Mathematical Literacy

Levene Statistic	df1	df2	Sig.
2.51	1	58	.11

The results of the student mathematical literacy t-test show that the sig (*2-tailed*) value of student mathematical literacy is 0.002 <0.05 then H0 is rejected and Ha is accepted which means there is a difference in the average mathematical literacy of experimental and control class students (Table 6). This proves that desmos application can be more effective when combined with PjBL with mathematical learning when viewed from students' mathematical literacy skills.

Table 6. Independent Sample t-test Results of Students' Mathematical Literacy

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.51	.11	3.19	58	.002	6.92	2.16
Equal variances not assumed			3.14	50.70	.003	6.92	2.20

Discussion

In order to promote mathematical literacy, the learning process provided by teachers seeks to make the best use of information technology. The use of IT in mathematical literacy can help students to analyse and communicate ideas effectively. The use of information and communication technology as a means of making learning activities more effective and efficient. (Maryani et al., 2022; Prastyo & Wulandari, 2023). Literacy is indispensable in the 21st century learning process. Learners' competencies can be maximised through literacy skills. Literacy makes the learning process meaningful and provides skills to students (Abidin et al., 2020). In mathematics learning in particular, it is important for students to have mathematical literacy skills so that they are able to use and interpret mathematics in the process of solving problems in everyday life.

The development of learners' mathematical literacy skills must be on the basis of the facts that are present in the learners' environment. (Dewi & Maulida, 2023). Various mathematical problems faced by students generally require mathematical literacy skills. Students who have mathematical literacy skills can estimate, understand facts, solve everyday problems, have reasoning in numerical, graphical, and geometric contexts and communicate effectively mathematically (OECD, 2017). Mathematical literacy emphasizes the importance of problem solving and communication thus encouraging students to engage in mathematical discourse (Casey & Ross, 2022; OECD, 2022; Ojose, 2011; Wilkinson, 2019). To be able to train students' mathematical literacy requires various smart efforts that must be made by the teacher.

One of the efforts made is by using applications as learning media in the form of multimedia that supports mathematics learning that can improve students' mathematical literacy skills. The use of multimedia can facilitate the creation of an interesting and fun learning process such as the Desmos application. The desmos application is a web-based application that can help students learn math and make math fun (Kristanto, 2019). Desmos has many free digital activities and graphing calculators to help students learn math (Haryani & Hamidah, 2022).

Teachers must have a plan for the learning given to students, from instruments to learning models used to help improve mathematical literacy skills (Dewi & Maulida, 2023). Education involves not only the transfer of knowledge but also the development of students' competency and skills. Therefore, educators must provide an effective learning experience by choosing the appropriate model (Nafiah et al., 2023).

Project-based learning is frequently utilised in diverse educational programmes since it can foster students' activeness, creativity, and critical thinking skills (Atika et al., 2023). The PjBL approach proves more efficient for learners when applied to everyday fields such as science and technology. Furthermore, the PjBL method can attain balance through technology integration, which accomplishes students' concept understanding, enhances problem-solving capacities, fosters creativity, and cultivates students' character (Subiki et al., 2023).

In this study, during the learning process, the PjBL integrated desmos application was used. The deployment of technology in learning media as a tool for aiding independent learning among students (Yulia et al., 2023). Students are directed to learn according to the project given so as to train students to solve any problems that may be faced either by using calculators, graphic design, image design or various other types of support in desmos. Giving this project trains students to be independent and trains students' ability to formulate problem situations systematically, use concepts, facts, procedures and reasoning as well as interpret, apply and evaluate mathematical outputs. Providing projects through the desmos application helps students explore function graphs and produce the desired curves by entering equations (Haryani & Hamidah, 2022).

The PjBL model is based on active learning (Shin et al., 2021), which emphasizes the formation of new knowledge, increasing innovation competence and student skills in overcoming problems experienced in real life (Zen et al., 2022). The learning syntax of the PjBL model involves various student abilities in developing problem-solving strategies (Yunita et al., 2021). Project-based learning (PBL) provides a significant learning experience as it employs a multi-stage project-based learning process (Chalsum et al., 2023). The learning stages in using the PjBL integrated desmos application will train students' mathematical literacy skills. In addition, the use of this application trains students to effectively use their mathematical knowledge and understanding that is relevant to the problem presented.

Some research results related to desmos include desmos providing new knowledge to visualize abstract mathematical objects, especially in function and geometry or graph material (Taufik & Pagiling, 2021). Giving projects to 8th grade students to create graphs with desmos using different ways of functions and transformations can develop students' understanding of desmos and how online graphing calculators work (King, 2017). LKS integrated with desmos technology provides interactive and meaningful real-life experiences for students (Haryani & Hamidah, 2022). The use of polygraph desmos can foster mathematical literacy and improve mathematical conceptual understanding (Haryani & Harso, 2023). Therefore, the application of desmos integrated with PjBL is effectively

used in multi-media mathematics learning to improve mathematical literacy skills.

Conclusion

Based on the results of the study, it can be concluded that desmos application can be more effective when combined with PjBL when viewed from mathematical literacy skills, mathematics learning with multimedia is more effective when viewed from mathematical literacy skills, and desmos application can be more effective when combined with PjBL with multimedia mathematics learning when viewed from mathematical literacy skills.

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Author Contributions
Preparation for writing - initial draft of article manuscript, review of results, B. N.: methodology, discussion, conclusion; Iqbal: analysis, correction, review, and editing, L. Z. and B. N.

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Conflicts of Interest
The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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