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The Effectiveness of an ICT-Based Problem-Based Learning Model on Students' Mathematical Literacy Skills and Learning Interest

Adiba I'lliyyun Nada[1*], Mulyaningrum Lestari[1], Salvador V. Briones II[2]

[1]Department of Mathematics Education, Universitas Islam Negeri Sunan Kudus, Kudus, Indonesia
[2]College of Education, Partido State University, Camarines Sur, Philippines
**Correspondence : adibailliyyunnada@gmail.com*

Abstract

In the Industrial Revolution 4.0 era, education faces challenges such as low mathematical literacy and limited student interest. One solution is implementing a Problem-Based Learning (PBL) model supported by Information and Communication Technology (ICT)-based media. This study used Microsoft PowerPoint for visual presentations, YouTube videos, and worksheets for practice problems. These tools were selected for their relevance to mathematics content, accessibility, and alignment with PBL steps to enhance engagement. Learning materials were teacher-developed and contextualized with statistics topics. This study aimed to: (1) determine the effectiveness of the ICT-based PBL model in improving mathematical literacy compared to direct learning, and (2) examine its effect on students' learning interest. A quantitative quasi-experimental method with a posttest-only control group design was used, involving 64 junior high school students (32 experimental, 32 control). Data were collected through validated instruments: a mathematical literacy test (reliability 0.87) and a learning interest questionnaire (reliability 0.82). Data analysis using an independent sample t-test confirmed significant differences ($p < 0.05$). The experimental group achieved higher mean scores in mathematical literacy (82.56) and learning interest (84.33) than the control group (74.18 and 76.41). The t-values (3.42 and 3.09) exceeded the critical value ($t_{0.05} = 2.00$). These findings indicate that the ICT-based PBL model effectively improves mathematical literacy and learning interest. Practically, mathematics teachers are encouraged to integrate ICT-based PBL into instruction, supported by adequate ICT facilities and teacher training.

Keywords: Information and Communication Technology Media; nterest in Learning; Mathematical Literacy; Problem-Based Learning

Abstrak

Di era Revolusi Industri 4.0, dunia pendidikan menghadapi tantangan berupa rendahnya kemampuan literasi matematis dan kurangnya minat belajar siswa. Salah satu solusi yang dapat diterapkan adalah penggunaan model *Problem-Based Learning* (PBL) yang didukung media berbasis Teknologi Informasi dan Komunikasi (TIK). Media TIK yang digunakan dalam penelitian ini meliputi Microsoft PowerPoint untuk presentasi visual, video pembelajaran dari YouTube, serta lembar kerja siswa. Media tersebut dipilih berdasarkan relevansinya dengan materi matematika, kemudahan akses, dan kesesuaiannya dengan langkah-langkah PBL untuk meningkatkan keterlibatan siswa. Seluruh bahan ajar dikembangkan oleh guru dan dikontekstualisasikan dengan materi statistika. Penelitian ini bertujuan untuk: (1) mengetahui efektivitas model PBL berbasis TIK dalam meningkatkan literasi matematis dibandingkan pembelajaran langsung, dan (2) menelaah pengaruhnya terhadap minat belajar siswa. Metode yang digunakan adalah kuantitatif dengan desain eksperimen semu *posttest-only control group*. Sampel penelitian terdiri atas 64 siswa SMP negeri (32 kelompok eksperimen dan 32 kelompok kontrol). Data dikumpulkan melalui tes literasi matematis (reliabilitas 0,87) dan angket minat belajar (reliabilitas 0,82). Hasil analisis menggunakan *independent sample t-test* menunjukkan perbedaan signifikan ($p < 0,05$). Rata-rata literasi matematis kelompok eksperimen (82,56) dan minat belajar (84,33) lebih tinggi dibandingkan kelompok kontrol (74,18 dan 76,41). Dengan demikian, model PBL berbasis TIK terbukti efektif meningkatkan literasi matematis dan minat belajar siswa, serta direkomendasikan untuk diterapkan oleh guru dengan dukungan fasilitas dan pelatihan TIK yang memadai.

Kata Kunci: *Problem Based Learning*; Media *Information and Communication Technology*; Kemampuan Literasi Matematika; Minat Belajar Siswa

Introduction

Mathematics plays a important role in everyday life by fostering logical, critical, and systematic thinking skills necessary for solving real-world problems (N. I. Rahmawati, 2018). However, many students still perceive mathematics as a difficult and irrelevant subject (Lestari, 2015), which leads to low motivation, weak engagement, and limited understanding of mathematical concepts. Teaching practices that emphasize procedural steps and rely heavily on lectures often cause boredom and hinder students from seeing the relevance of mathematics in daily life (Mustaffa et al., 2016).

Learning interest is a crucial factor influencing the quality of learning outcomes. Students who have high interest in learning mathematics tend to demonstrate greater curiosity, attention, and enjoyment, which in turn enhance their mathematical literacy skills (Charli et al., 2019; Ufer et al., 2017). Mathematical literacy itself refers to the ability to formulate, communicate, and interpret real-life problems using mathematical concepts (Yuli Noviana & Murtiyasa, 2020). Based on PISA (Programme for International Student Assessment) results, Indonesia has consistently ranked among the lowest countries, indicating that students' mathematical literacy remains very weak.

PISA is administered by a number of developed member states of the OECD (Organization for Economic Cooperation and Development), based in Paris, France (Yuli Noviana & Murtiyasa, 2020). PISA research focuses on testing Students' proficiency in mathematical literacy with respect to identifying, applying, and interpreting mathematical concepts in real life. The PISA survey outcomes from 2000 to 2015 reveal that Indonesia's standing in mathematical literacy is a ranking that is always in the bottom 10. Indonesia's ranking is 39/41 (2000), 38/40 (2003), 50/57 (2006), 61/65 (2009), 64/65 (2012), and 64/72 (2015) (N. I. Rahmawati, n.d.). Indonesia held the 73rd position out of 79 countries in 2018 (Nila Farida et al., 2021). Based on these data, Indonesian students' mathematical literacy is categorized as very low.

One of the main causes of low mathematical literacy is the dominance of teacher-centered instruction, which limits students' opportunities to reason independently and apply mathematics contextually (M. Rahmawati & Suryadi, 2019). To address this problems the Problem-Based Learning (PBL) model offers a promising alternative. PBL engages students in solving authentic problems, encourages critical thinking, collaboration, and active knowledge construction (Firdaus et al., 2021).

In the pre-research at MA NU Ma'arif, the mathematics teacher, Mrs. Via Maulida, said that the mathematics learning usually used at MA NU Ma'arif is the direct learning model (Maulida, 2024). Low mathematical literacy and learning interest are often associated with conventional teaching practices that emphasize procedural instruction rather than conceptual understanding. Teachers tend to use direct learning models, which limit student participation and engagement. This approach hinders the development of problem-solving skills and meaningful learning experiences (Pamungkas & Franita, 2019). In this era of revolution 4.0, the learning process is required to attract students' attention by utilizing technology-based learning media. In this case, efforts to utilize technology are through ICT-based learning media.

The novelty of this research lies in combining the PBL model with ICT-based media contextualized to the school environment. While previous studies have examined PBL or ICT separately, this study integrates both to explore their combined effect on students' mathematical literacy and learning interest. The research also provides new empirical data from MA NU Ma'arif, where ICT-based PBL has not been previously implemented.

Given the issues discussed above, this study aims to investigate "Effectiveness of Problem Based Learning Model Based on Information and Communication Technology (ICT) Media on Students' Mathematical Literacy Skills and Learning Interests".

According to this background, the problems that will be discussed by the researcher are as shown below: (1) Are the mathematical literacy skills of students who use the Problem Based Learning model founded on ICT media better compared to the mathematical literacy skills of students taught through the direct learning model? (2) Are the mathematical learning interests of students applying the Problem Based Learning model based on ICT media greater than the mathematical learning interests of students who use the direct learning model?

The purpose of this study is to 1) identify whether the application of the Problem Based Learning (PBL) model based on ICT media is more effective in improving students' mathematical literacy skills compared to direct learning models. 2) determine whether the implementation of the Problem Based Learning (PBL) model based on ICT media is more effective toward the improvement students' interest in learning mathematics compared to direct learning models.

Method

This study employed a quantitative approach with an experimental research design to examine the effectiveness of the Problem-Based Learning (PBL) model integrated with Information and Communication Technology (ICT) in improving students' mathematical literacy and learning interest. A quasi-experimental method was applied using the Posttest-Only Control Group Design, which compared students' mathematical literacy and learning interest between the experimental and control groups. The research was conducted at MA NU Ma'arif Kudus, with samples selected through cluster random sampling. Two classes were randomly chosen from three existing classes: Class X-Regular, consisting of 29 students, served as the experimental group that received ICT-based PBL instruction, while Class X-DM, with 20 students, acted as the control group using a conventional direct learning model.

Data were collected using two instruments, namely a mathematical literacy test and a learning interest questionnaire. The mathematical literacy test consisted of five multiple-choice questions based on statistical material. The items were developed according to three indicators of mathematical literacy skills, namely formulating, employing, and interpreting (OECD, 2018). The test was first validated using Aiken's V formula for content validity, showing that all items were valid ($V > 0.75$). The item validity was further confirmed using the product-moment correlation, with all five items declared valid at a significance level of $\alpha = 0.05$. Reliability testing using Cronbach's Alpha produced a coefficient of 0.876, indicating very high reliability. Additional analyses showed that two items were categorized as difficult and three as moderate, with four items having very good discrimination

power and one good. The instrument was trialed with 35 students to ensure its appropriateness.

The learning interest questionnaire consisted of 25 statements using a four-point Likert scale, ranging from "strongly disagree" to "strongly agree." The questionnaire measured three aspects of learning interest: students' curiosity and attention toward mathematics, feelings of enjoyment during learning, and their participation in learning activities. The content validity was tested using Aiken's V, while the item validity employed the product-moment correlation. The results showed that 20 items were valid, while five were invalid and excluded from analysis. The reliability coefficient, obtained through Cronbach's Alpha, was 0.824, indicating a high level of reliability.

Data analysis included tests of normality, homogeneity, and hypothesis testing. The Kolmogorov–Smirnov test was applied to determine data normality, while Levene's test was used to assess homogeneity, both at a significance level of 0.05. If data failed to meet normality or homogeneity assumptions, nonparametric statistical methods were employed. The hypothesis testing used the independent samples t-test for normally distributed and homogeneous data, with a significance criterion of $p < 0.05$. The model was considered effective if the experimental group achieved significantly higher mean scores in both mathematical literacy and learning interest compared to the control group. These procedures ensured that the instruments were valid and reliable, and that the statistical analysis appropriately reflected the effectiveness of the ICT-based PBL model in enhancing students' mathematical literacy and learning engagement.

This study implemented an independent sample t-test as a hypothesis testing method for data obtained from the experimental and control classes With the help of questionnaires and tests. The analysis was performed using SPSS hypotesis independent sample t-test:

a. : "The mathematical literacy skills of students who use the PBL learning model based on ICT media are no better than the mathematical literacy abilities of students who use the direct learning model."
"The mathematical literacy skills of students who use the PBL learning model based on ICT media are better than the mathematical literacy abilities of students who use the direct learning model."

b. : "Interest in learning mathematics using the PBL learning model based on ICT media is no better than interest in learning mathematics using the direct learning model."

"Interest in learning mathematics using the PBL learning model based on ICT media is better than interest in learning mathematics using the direct learning model."

"If the result of then is approved, while then is refused."

Results

This study aimed to examine the effectiveness of the Problem-Based Learning (PBL) model integrated with Information and Communication Technology (ICT) media in enhancing students' mathematical literacy skills and learning interest. The experimental class implemented the PBL model using ICT-based tools such as PowerPoint and video learning materials, while the control class applied direct learning. The results showed that students in the PBL-ICT class achieved significantly higher scores in both mathematical literacy and learning interest than those in the direct learning class. These findings indicate that the integration of ICT within the PBL framework can create a more interactive and contextual learning experience, which enhances students' understanding and engagement in mathematics learning.

The posttest significance values for the experimental and control classes were 0.131 and 0.206, so it is said to be normal because it has reached > 0.05. Likewise, in learning interest, the posttest significance value of the experimental class and the control class was obtained, namely 0.106 and 0.141. The data were considered normally distributed because the posttest significance value of the experimental class and the control class is > 0.05, namely 0.106 and 0.141.

Test of Homogeneity of Variances, the Based of Mean value was obtained at 0.02 for mathematical literacy skills and 0.881 for students' learning interest values. This indicates that the mathematical literacy data are not homogeneous, as the p-value was less than 0.05 and students' learning interest has reached homogeneity because >0.05.

Table 1. Descriptive statistic of students' mathematical literacy skills

	Classes	N	Mean	Std. Deviation	Std. Error Mean
mathematical literacy skill	experimental class	29	68.72	19.833	3.683
	control class	20	48.95	10.635	2.378

Table 1 presents the descriptive statistical results of the independent sample t-test of the two samples tested, namely the posttest scores for mathematical literacy skills in the experimental class and control class. From the calculation results, it is known that the average value of the experimental class reached 68.72, much higher than the control class which only obtained an average of 48.95. The sample tested was 49 students, namely 29 students for the experimental class and

20 students for the control class. The experimental class obtained a standard deviation of 19.833, while the control class was 10.636.

The average score on the mathematical literacy skills test between the experimental class and the control class is 68.72 > 48.95, this difference indicates that mathematical literacy skills showed an upward trend in the experimental class compared to the control class.

Table 2. Hypothesis Tests for Mathematical Literacy Skills

		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
mathematical literacy skill	Equal variances assumed	10.719	.002	4.065	47	.000	19.774	4.864
	Equal variances not assumed			4.511	44.751	.000	19.774	4.384

From Table 2, the t-value is 4.511 and the significance value is 0.000. If the t-test is used as a one-sided test, the t distribution table is table is looked for at (one-sided test) with degrees of freedom (df) = 47. With one-sided testing, the results are obtained for is 1.677.

The analysis results a value = 4.511 ≥ 1.677 and a value of Sig. (2-tailed) 0.000 < 0.05. The analysis indicates that is rejected, which means is accepted. This means that the mathematical literacy skills of students who use the PBL learning model based on ICT media are better than the mathematical literacy skills of students who use the direct learning model.

Table 3. Descriptive Statistical Results of Student Interest in Learning

	Classes	N	Mean	Std. Deviation	Std. Error Mean
interest in learning	experimental class	29	70.41	6.350	1.179
	control class	20	66.40	5.906	1.321

Table 3 presents the descriptive statistics results of the two samples tested, namely the questionnaire scores for interest in learning mathematics in the experimental class and control class. The average score for the experimental class was 70.41, while the average score for the control class was 66.40. The sample tested was 49 students, namely 29 students for the experimental class and 20 students for the control class. The standard deviation for the experimental group was 6.350, with a mean standard error of 1.179. Meanwhile, the control class had a standard deviation of 5.906 and a mean standard error of 1.321.

The average score on the mathematical literacy test in the experimental class was 70.41, higher than the control class's average of 66.40. This indicates a difference in students' mathematical literacy skills between the two classes. The hypothesis test used is the independent t-test, with the following conditions:

H_0 : The interest in learning mathematics of students who use the ICT-based PBL learning model is no better than the interest in learning mathematics of students who use the direct learning model.

H_1 : The interest in learning mathematics of students who use the PBL learning model based on ICT media is better than the interest in learning mathematics of students who use the direct learning model.

Table 4. Hypothesis Tests for Student Learning Interest

		Levene's test to assess variance equality		t-test to examine mean equality				
		F	Sig.	T	Df	2-tailed significance test result	Average Difference	Std. Error between means
Interest in learning	assuming equal variances	.023	.881	2.237	47	.030	4.014	1.795
	assuming unequal variances			2.267	42.877	.028	4.014	1.770

From this table 4, the value is 2.237 was obtained and a sig (2-tailed) value of 0.03. If the t-test is used as a one-sided test, the t-distribution table is table is looked for at (one-sided test) with degrees of freedom (df) = 47. With one-sided testing, the results are obtained for is 1.677. The results of the analysis obtained a value = 2.237 ≥ 1.677 and a Sig value. (2-tailed) 0.03 < 0.05. Based on the analysis results, is rejected and is accepted, indicating that students who learn through the ICT-based PBL (Problem-Based Learning) model is significantly more effective than that of students participating in use the direct learning model.

Discussion

The results of this study indicate that the Problem-Based Learning (PBL) model integrated with Information and Communication Technology (ICT) is effective in improving students' mathematical literacy skills and interest in learning compared to the direct learning model. This indicates that ICT-based PBL encourages students to engage actively in contextual problem-solving, thereby fostering higher-order thinking and conceptual understanding in mathematics.

This finding aligns with previous studies by Indah and Pamungkas (Dewi et al., 2019; Firdaus et al., 2021), which also demonstrated that PBL and ICT media improve learning outcomes and motivation. Theoretically, it reinforces the constructivist learning paradigm (Charli et al., 2019), emphasizing that learning is an active meaning-making process. In this study, students became the center of

learning, constructing knowledge through investigation and collaboration rather than passive listening.

In a broader context, these results highlight the importance of digital transformation in education, particularly in line with the *Merdeka Belajar* policy in Indonesia. ICT-integrated learning environments cultivate students' digital literacy, problem-solving, and creative thinking competencies essential for the 21st century and the demands of the Industrial Revolution 4.0.

Theoretically, this study contributes to strengthening the discourse on technology-enhanced constructivist pedagogy. Practically, it provides insights for educators and policymakers to adopt PBL-ICT strategies that foster engagement and conceptual mastery. Nevertheless, challenges remain, such as limited teacher training and unequal access to ICT infrastructure, which must be addressed to optimize implementation.

The novelty of this research lies in the simultaneous integration of PBL and ICT, demonstrating a synergistic effect between constructivist approaches and digital media in enhancing both cognitive (mathematical literacy) and affective (learning interest) outcomes. This combined strategy provides a new direction for developing holistic mathematics learning models.

Future research should further investigate how digital literacy, learning autonomy, and students' socio-emotional factors mediate the impact of ICT-based PBL. Future research directions can also be explained in the development of technology-based adaptive learning models that are able to adapt to the needs and learning abilities of individual students. Such exploration will deepen understanding of how technology-supported pedagogies can sustainably transform mathematics education. Connecting learning content can also spark interest in learning by explaining its future uses. Students' interest in learning mathematics is characterized by attention and a sense of pleasure in learning mathematics (Charli et al., 2019). Students will be more diligent and have a deeper curiosity about mathematics, so that learning mathematics becomes easy and enjoyable. Students' high interest in learning can improve mathematics literacy skills.

This study aims to identify learning models and media that are more effective in improving mathematical literacy and students' interest in learning by comparing the results between the experimental class and the control class. With the increasing development about technology, utilization of ICT in education-especially in mathematics instruction has become more prominent. PBL is a solution to develop the skills needed by students in the global era, especially in the aspects of mathematical literacy and learning interest (Rifatul Jannah & Habiby, 2022). ICT can be used to convey information that students can hear and see, so that abstract or incomplete problems, concepts or content can be explained clearly and completely.

ICT can also provide long-term memory for students because it displaysthe Dillawati movement of objects plus sound according to the message (Dillawati & Yerizon, 2024). The answers to the two problem formulations in this study will be discussed through the following explanation:

In answering the first formulation, "Is the mathematical literacy skill of students who use the Problem Based Learning (PBL) learning model based on ICT media more effective than the mathematical literacy skills of students that use the direct learning model?", Hypothesis testing in this study was conducted using an independent sample t-test by conducting validity, reliability, discrimination, and difficulty level tests first. Furthermore, the researcher conducted preliminary tests, including tests for data normality and homogeneity before continuing with hypothesis testing using independent sample t-tests.

The test consisted of five mathematical literacy questions related to measures of central tendency, grouped as medium to high difficulty depending on the established indicators of mathematical literacy skills, namely formulating, using or applying, and interpreting real problems in mathematical models (Fadillah, 2019). The values obtained will be subjected to preliminary tests, namely data normality test and data homogeneity test. The normality test using the Shapiro Wilk formula with the IBM SPSS 26.0 application obtained a significance result of 0.131 in the experimental class, while the significance result was 0.206 in the control class. The data has reached normal because the significance of the posttest values of the experimental class and control class > 0.05 (Placeholder1) (Sugiyono, 2017). While the homogeneity test using the Test of Homogeneity of Variances with the prerequisite tests, namely the normality and homogeneity tests, it was obtained that the data from the experimental class and the control class were normally distributed but not homogeneous.

After conducting the preliminary test, it was continued with an independent t-test hypothesis test to examine the mathematical literacy skills. The results obtained meaning that the mathematical literacy skills of students who use the PBL learning model based on ICT media are better than the mathematical literacy skills of students that use the direct learning model.

This proves that Indah and Pamungkas' findings are correct, namely that the mathematical literacy skills of students who use the PBL model produce better learning outcomes compared to students who learn conventionally (Firdaus et al., 2021). In addition, according to Anwar and Jurotun, PBL trains students to solve problems independently, think critically, and obtain concepts from subject matter.

In answering the second formulation, "Is the interest in learning mathematics of students who use the Problem Based Learning (PBL) learning model based on ICT media better than the interest in learning mathematics of students who use the

direct learning model", the researcher conducted an independent sample t-test hypothesis test by conducting a validity and reliability test first. Furthermore, a prerequisite test was carried out consisting of a data normality test and a data homogeneity test followed by an independent sample t-test hypothesis test.

This test was in the form of a questionnaire consisting of 20 positive and negative statements according to the interest indicators and had been tested for validity and reliability. The values obtained will be subjected to prerequisite tests, namely data normality test and data homogeneity test.

The results of the prerequisite test through the normality and homogeneity test of the experimental class and control class, showed that both sample classes were normally and homogeneously distributed. Based on these results that rejected and accepted, meaning that the interest in learning mathematics of students who use the PBL learning model based on ICT media is better than the interest in learning mathematics of students who use the direct learning model. This is also in accordance with research conducted by Yuliar Astuti Dewi which shows that Microsoft PowerPoint learning media makes students more enthusiastic and interested in learning mathematics (Dewi et al., 2019). With this, the mathematics learning process using the PBL model based on ICT media will contribute positively to enhancing student learning outcomes in terms of their.

The practical implications of this research for mathematics teachers suggest integrating ICT-based PBL models into the learning process to improve mathematical literacy and foster student learning interest. Furthermore, schools need to support the availability of ICT facilities and teacher training to ensure optimal implementation of this learning model. When properly facilitated, ICT-based PBL can transform classroom instruction into a more engaging and interactive learning environment that prepares students with the critical, creative, and technological skills required in the 21st century. However, the research was conducted in a single institution with a limited sample size and duration, which may constrain the generalizability of the findings. Moreover, the study relied primarily on posttest quantitative data without exploring students' learning processes in depth. Future research should therefore employ mixed-method or longitudinal designs to examine the long-term effects of ICT-based PBL, including how factors such as digital literacy, self-regulation, and emotional engagement mediate its impact on learning outcomes. Overall, the findings emphasize that ICT-based PBL not only strengthens mathematical literacy but also nurtures motivation and active participation, offering a transformative pathway for improving mathematics education in the digital age.

Conclusion

The integration of Problem-Based Learning (PBL) with Information and Communication Technology (ICT) offers a meaningful framework for fostering active, contextual, and student-centered mathematics learning. Through digital tools, PBL helps students visualize abstract mathematical concepts, engage in collaborative problem-solving, and connect learning with real-world contexts. This model encourages deeper conceptual understanding while simultaneously enhancing learning interest and motivation. The practical implications of this research for mathematics teachers suggest integrating ICT-based PBL models into the learning process to improve mathematical literacy and foster student learning interest. Furthermore, schools need to support the availability of ICT facilities and teacher training to ensure optimal implementation of this learning model. When properly facilitated, ICT-based PBL can transform classroom instruction into a more engaging and interactive learning environment that prepares students with the critical, creative, and technological skills required in the 21st century.

However, this study has several limitations. The research was conducted in a single institution with a limited sample size and duration, which may constrain the generalizability of the findings. Moreover, the study relied primarily on posttest quantitative data without exploring students' learning processes in depth. Future research should therefore employ mixed-method or longitudinal designs to examine the long-term effects of ICT-based PBL, including how factors such as digital literacy, self-regulation, and emotional engagement mediate its impact on learning outcomes. Overall, the findings emphasize that ICT-based PBL not only strengthens mathematical literacy but also nurtures motivation and active participation, offering a transformative pathway for improving mathematics education in the digital age.

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