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Enhancing Junior High School Students' Numeracy Literacy Through a Competency-Based Problem-Based Learning Model: Development and Implementation

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Abstract

The Minimum Competency Assessment (AKM) emphasizes the importance of numeracy literacy among students. In response, this study aims to develop a valid and practical problem-based learning (PBL) model to enhance numeracy skills in junior high school students, offering a reference framework for mathematics educators. A Research and Development (R&D) methodology was employed using the 4D model: Define, Design, Develop, and Disseminate. The research involved iterative trials to evaluate and refine the effectiveness of the proposed PBL model. The developed PBL model showed high validity and practicality. Students' mathematical numeracy achievement reached 87.50% using the classical PBL approach. Additionally, average numeracy scores improved from 2.73 in Trial I to 3.05 in Trial II. Students demonstrated active engagement throughout the learning process, meeting criteria for effective learning as defined in the study. The results confirm that the PBL model effectively enhances students' numeracy literacy and supports active learning. The novelty of this study lies in the validated and effective instructional device developed through a structured R&D process. The final model provides a practical tool for mathematics instruction in junior high schools, concluding the development cycle with promising implications for curriculum design and pedagogical practice.

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1. INTRODUCTION

In the 21st century, mathematics education requires students to develop three core abilities: character qualities, competencies, and literacy (Darmayanti, 2022). In line with this, the curriculum becomes a reference for improving these skills, namely by using one of the ideas behind the independent curriculum, namely that in implementing learning, students must learn independently and meet current educational demands. This curriculum requires students to work together with their teachers, learn to write and

analyze and be able to convey their experiences through, the media to improve their thinking and reasoning skills so that they can improve their learning outcomes (Wandari, Wijaya, & Agustin, 2018)

In 2015, the World Economic Forum identified six fundamental literacies: reading and writing, numeracy, scientific literacy, digital literacy, financial literacy, and cultural and civic literacy (Maulina, Slamet, & Indriayu, 2019). Numeracy literacy, closely linked to the ability to think and reason, plays a crucial role in enhancing skills for interpreting and solving real-world problems involving symbols, numbers, and data, which may be represented in various forms such as charts, diagrams, graphs, and tables (Kurniawan, Elmunsyah, & Muladi, 2018). Numeracy literacy skills refer to an individual's capacity to think critically in order to understand, interpret, apply, and analyze problems. These skills encompass the use of mathematical models and symbols in various forms, both written and oral, and their application to real-life contexts. Numeracy literacy skills are very important to apply to solve real problems.

The Ministry of Education, Culture, Research, and Technology (Prameswari & Lestariningrum, 2020) defines the ideal condition of numeracy skills as possessing knowledge and abilities closely related to understanding numbers and symbols, as well as analyzing quantitative information such as graphs, tables, and charts—competencies that are highly essential for the current generation. Strong numeracy skills enable students to effectively apply their mathematical knowledge in real-world contexts (Yusri, 2018). Numeracy literacy skills are characterized by three key indicators: (1) applying various types of numbers and mathematical symbols to solve problems across diverse everyday contexts; (2) analyzing information presented in multiple formats, such as graphs, tables, charts, and diagrams; and (3) interpreting analytical results to make predictions and informed decisions. The criteria for the learning model needed are being able to solve a problem contained in the question, student-centered learning, learning in groups, and solving a problem through discussion, a learning model that can increase self-confidence, making students independent because students are required to compile their own knowledge through the information they get (Chen & Huang, 2023). The Problem-Based Learning (PBL) model has been shown to positively influence students' conceptual development (Hasibuan, Fitri, & Dewi, 2022). Consequently, PBL is considered an appropriate instructional approach (Fauzia, 2018).

Problem-Based Learning (PBL) is an instructional approach designed to develop students' ability to solve real-life problems. This learning model has a unique characteristic in the form of learning that begins and focuses on problems. In the PBL method, students can be active in small categories/groups and need to recognize what is understood and what is not understood and need to learn to find solutions to a problem (Haddar, Hendriyanto, Munandar, & Kelibia, 2023). This problem-solving process can foster students' ability to address numeracy literacy challenges. (Falloon, 2020).

Based on the foregoing discussion, it is necessary to conduct a study entitled "Development of a Problem-Based Learning Model to Enhance the Numeracy Literacy Skills of Junior High School Students." This research focuses on two primary questions:

1. How valid is the developed Problem-Based Learning model in improving junior high school students' numeracy literacy skills?
2. How practical is the implementation of the Problem-Based Learning model in enhancing junior high school students' numeracy literacy skills?

The Problem-Based Learning learning model has steps or learning syntax (Fredy, Prihandoko, & Anggawirya, 2020). According to Syahril, Saragih, & Heleni, (2021) the syntax of the Problem Based Learning learning model includes, (1) introducing problems to students based on the material taught to students; (2) orientation of students to the problem; (3) students are organized into groups to discuss problem solving; (4) guiding individual and group investigations; (5) the results of the student group analysis are presented to other student groups; (6) the teacher helps students to evaluate their investigations and helps to reflect on the results of the investigations. The problems given are used to bind students to curiosity to face students' numeracy literacy abilities.

2. METHODS

This study employed a Research and Development (R&D) approach, selected to align with the objective of producing a Problem-Based Learning model designed to enhance the numeracy literacy of Grade VIII students at SMP Negeri 3 Sampuran. The research adopted the 4D development model proposed by Thiagarajan, Semmel, and Semmel, which consists of four stages: Define, Design, Develop, and Disseminate (ASLACH, 2020). However, due to time constraints, this study was conducted only up to the development stage. The research instruments used included questionnaires and numeracy literacy ability tests (Hardhienata, Suchyadi, & Wulandari, 2021). The learning model feasibility questionnaire was used to obtain the value of the learning model's feasibility from the validator's assessment. The feasibility questionnaire contains an assessment of the learning model that refers to the National Education Standards Agency (BSNP), including content feasibility, language feasibility, and presentation feasibility. In addition, there is also a practicality questionnaire instrument used to obtain the practicality value of the learning model based on teacher and student responses. A numeracy literacy test was administered to assess students' abilities before and after the implementation of the developed learning model. The model's feasibility was evaluated by a team of experts, while its practicality was assessed by students who participated in the learning activities using the developed model. (Chang & Hwang, 2018).

The research employed the 4D Research and Development model developed by S. Thiagarajan, Dorothy Semmel, and Melvyn I. Semmel, consisting of four stages: Define, Design, Develop, and Disseminate. The procedural flow of the 4D model is illustrated in the following diagram:

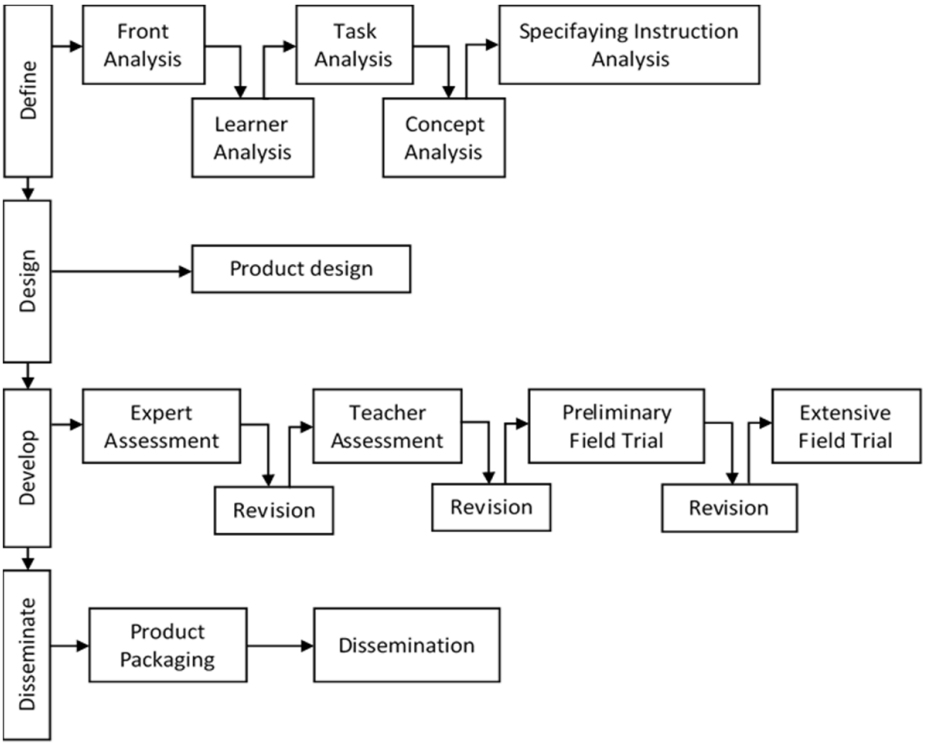

Figure 1. 4D Flowchart

3. FINDINGS AND DISCUSSION

This study developed a Problem-Based Learning model aimed at enhancing students' numeracy literacy skills. In line with the learning device development stages of the modified Thiagarajan model, the outcomes of the model's development are presented as follows.

3.1. Description of the Results of the Definition Stage (Define)

3.1.1. Needs Analysis

A review of mathematics learning implementation and outcomes at SMP Negeri 3 Jorlang Hataran revealed that the primary issue is students' low numeracy literacy skills, which contribute to their low achievement in mathematics. This condition underscores the need to identify alternative solutions. (Novianti, Bentri, & Zikri, 2020).

Based on interviews with Grade VIII mathematics teachers at SMP Negeri 3 Jorlang Hataran and observations by the researcher, the current learning process is predominantly teacher-centered, with limited student involvement. Consequently, students lack opportunities to construct their own knowledge or develop independent solutions.

The constructivist independent curriculum requires students not only to be agile in solving problems but also to be able to construct concepts, principles, or procedures with teacher guidance. So students are expected to be active in learning activities. In other words, learning is student-centered. In addition, the independent curriculum also emphasizes the importance of using problems in starting mathematics learning activities. The same thing is also required by the Problem-Based Learning learning model (Farida, Hasanudin, & Suryadinata, 2019).

Problem-Based Learning Learning Model that emphasizes the cognitive aspects of students, prioritizes student activity, and emphasizes the importance of using problems in starting learning. By using the Problem-Based Learning learning model, it is expected that:

1. Learning is no longer centered on the teacher but on the students;
2. Students find it easier to understand mathematics lessons when the material is connected to their own environment.
3. Students can apply the material they have learned to solve questions and problems in everyday life;
4. Students will be independent and have longer memories of the material they study, because students themselves construct mathematical concepts and principles from the material they study and feel that they own the mathematical concepts and principles they study.

The effective implementation of mathematics learning based on the Problem-Based Learning model requires appropriate instructional tools. At the research site, no existing learning model aligned with the Problem-Based Learning approach was available. Hence, the development of a suitable learning model is necessary. (Jufrida, Basuki, Kurniawan, Pangestu, & Fitaloka, 2019).

3.1.2. Student Analysis

The characteristics of Grade VIII students at SMP Negeri 3 Jorlang Hataran during the 2023/2024 academic year, including their cognitive development and prior knowledge, were examined. Although these students are generally at the formal operational stage (aged 13 and above), they still require concrete learning materials, especially in mathematics, that relate to their everyday experiences. Therefore, initiating mathematics instruction with contextual problems relevant to students' daily lives is highly appropriate. (Long, Koyfman, & Gottlieb, 2019).

Reviewing the students' background knowledge, the researcher found that the students of class VIII of SMP Negeri 3 Jorlang Hataran had studied the material of numbers, fractions, and comparisons in Elementary School (SD) as prerequisite material for studying numeracy literacy material in class VIII of SMP. Students have also never participated in learning with the Problem-Based Learning learning model.

3.1.3. Concept Analysis

The lesson material used in this research is numeracy literacy material for class VIII junior high school, with reference to the independent curriculum.

3.1.4. Task Analysis

Referring to the results of the concept analysis, the results of the analysis of the numeracy literacy material assignments are that the skills that students are expected to master in learning are:

1. Applying various types of numbers and mathematical symbols;
2. Analyzing information presented in diverse formats such as graphs, tables, charts, and diagrams;
3. Interpreting analytical results to make predictions and informed decisions

3.2 Description of the Design Stage

The results of each activity at this design stage are as follows:

3.2.1 Test Preparation

The test was designed based on learning objectives and student analysis, resulting in a mathematical numeracy literacy assessment tailored to students' cognitive levels. Scoring follows an evaluation guide that includes answer keys and detailed scoring criteria for each item. The assessment consists of four descriptive questions, with a total completion time of 40 minutes (Siregar, 2017).

3.2.2 Format Selection

The lesson plan format used follows the Independent Curriculum guidelines. According to the Minister of Education and Culture's Circular Letter No. 14 of 2019, the lesson plan's three core components—efficiency, effectiveness, and student-centeredness—should fit on one page. Efficiency implies that the lesson plan is concise and minimizes unnecessary time and effort. Effectiveness means the plan is designed to achieve the intended learning objectives. Student-centeredness requires that the lesson plan takes into account students' readiness, interests, and learning needs (Sudrajat, Dewi, Rizqy, & Anggraini, 2023).

3.2.3 Initial Design

The main activity in the final stage of design activities is preparing the development of learning models and students' mathematical numeracy literacy tests, along with scoring guidelines and answer keys. All results at this design stage are called Draft-I.

3.3 Description of Development Stage Results

The following are the outcomes of each activity conducted during the development stage of the Problem-Based Learning model.

3.3.1 Expert Validation Results

Expert validation was conducted to assess the validity of the learning model, including its content and language, across all developed materials. The validation results served as a basis for revising and refining the model. Following revisions informed by expert feedback, the learning model was tested, yielding an average score of 4.30, indicating valid criteria. The three validators agreed that the Problem-Based Learning model was suitable for use with minor revisions. Their evaluations provided corrections, critiques, and suggestions that guided further improvements, including the correction of several writing and spelling errors as per their recommendations.

3.3.2 Data Analysis of Validation Results and Revisions of Students' Mathematical Numeracy Literacy Tests

The validators' assessments focused on content validity, language clarity, question formulation, and overall recommendations. Revisions were made based on their suggestions and guidance. The expert validation results for the mathematical numeracy literacy test, which aims to assess students' mathematical abilities, are presented in the following sections.

Trial I Results

Trial I was conducted with 32 Grade VIII students over four sessions, aligned with the designated lesson plans. During this phase, both the assessment instruments and the Problem-Based Learning (PBL) model were tested. Data collected from Trial I were analyzed to evaluate the validity, reliability, and effectiveness of the PBL model based on empirical findings.

1) Instrument Test Results

The research instruments, after undergoing qualitative validation and revision, were tested during the implementation of the PBL model. The goal was to empirically examine the instruments' validity and reliability. Details from the instrument trial analysis are as follows:

a) Validity and Reliability of the Mathematical Numeracy Literacy Test

The mathematical numeracy literacy test was administered to 32 students before and after instruction on the topic of numbers. Supporting data and calculations are provided in the appendix. As shown in Table 3, the test achieved a Cronbach's alpha coefficient of 0.93, indicating a very high level of reliability according to the criteria described in Chapter III. This demonstrates that the instrument consistently measures students' numeracy literacy skills within the topic of numbers (Yulaichah, Mariana, & Wiryanto, 2024).

Regarding validity, item validity coefficients (also in Table 3) indicate that test items fall within very high, high, and moderate validity levels. These values meet the standards outlined in Chapter III. Therefore, the pretest version of the numeracy literacy test is suitable for assessing students' understanding of number-related content (Misidawati, Ernawati, & Shofwani, 2021).

In conclusion, the assessment instrument demonstrates strong reliability and validity. Hence, data from Trial I can be further utilized to evaluate the effectiveness of the Problem-Based Learning model. The next section presents an analysis of Trial I using the developed learning model and the validated instruments (Diani, Irwandani, Al-Hijrah, et al., 2018, 2019).

b) Data Analysis of Students' Mathematical Numeracy Literacy Performance

Students' mathematical numeracy literacy performance was assessed through a pretest (administered before instruction) and a posttest (administered afterward). The following table summarizes the test results of Grade VIII students from Trial I:

Table 1. Description of the Results of the Mathematical Numeracy Literacy Skills of Grade VIII Students

Information	Pretest	Posts
The highest score	2.08	3.79
Lowest value	0.64	1.44
Average	1.16	2.73

The table above indicates that the average score for students' mathematical numeracy literacy ability increased from 1.16 in the pretest to 2.73 in the posttest, reflecting an improvement of 1.57. Categorization of student achievement levels based on the pretest results from Trial I is detailed in Table 5 as follows:

From the test, the students' mathematical numeracy literacy ability in the results of the pretest I trial test was obtained that the number of students who obtained a score with a D predicate was 15 people (46.87%), who obtained a D $^{+}$ predicate score of 7 people (21.88%), who had a C- predicate score of 7 people (21.88%), who obtained a C predicate score of 2 people (6.25%), who had a C $^{+}$ predicate score of 1 person (3.12%), who obtained a B- predicate score of 0 people (0%), who obtained a B predicate score of 0 people (0%), who obtained a B $^{+}$ predicate score of 0 people (0%), who obtained an A- predicate score of 0 people (0%), who obtained an A predicate score of 0 people (0%).

As for the level of students' mathematical numeracy literacy ability in the results of post test I, it can be seen in the following table:

Table 2. Level of Achievement of Mathematical Numeracy Literacy Skills of Grade VIII Students in Post-test Results

Mark	Number of Students	Percentage	Predicate
$0.00 < value \leq 1.00$	0	0%	D
$1.00 < value \leq 1.33$	0	0%	D $^{+}$
$1.33 < value \leq 1.66$	4	12.50%	C-
$1.66 < value \leq 2.00$	1	3.12%	C
$2.00 < value \leq 2.33$	2	6.25%	C^{+}
$2.33 < value \leq 2.66$	2	6.25%	B-
$2.66 < value \leq 3.00$	10	31.25%	B
$3.00 < value \leq 3.33$	7	21.88%	B^{+}
$3.33 < value \leq 3.66$	4	12.50%	A-
$3.66 < value \leq 4.00$	2	6.25%	A

From Table 2 of students' mathematical literacy and numeracy skills in the results of the posttest of trial I, it was found that the number of students who obtained a score with a D predicate was 0 people (0%), who obtained a D $^{+}$ predicate score of 0 people (0%), who had a C- predicate score of 4 people (12.50%), who had a C predicate score of 1 person (3.12%), who obtained a C $^{+}$ predicate score of 2 people (6.25%), who obtained a B- predicate score of 2 people (6.25%), who obtained a B predicate score of 10 people (31.25%), who obtained a B $^{+}$ predicate score of 7 people (21.88%), who obtained a A- predicate score of 4 people (12.50%), who obtained an A predicate score of 2 people (6.25%).

Based on the explanation of the analysis of the student answer sheets above, it can be seen that because during the implementation of trial I the material had not been achieved to be taught to students, therefore a revision was needed (trial II) and it is hoped that in the implementation of trial II the students' numeracy literacy skills will increase. which is indicated by all questions being answered. For more details, see Figure 1 below.

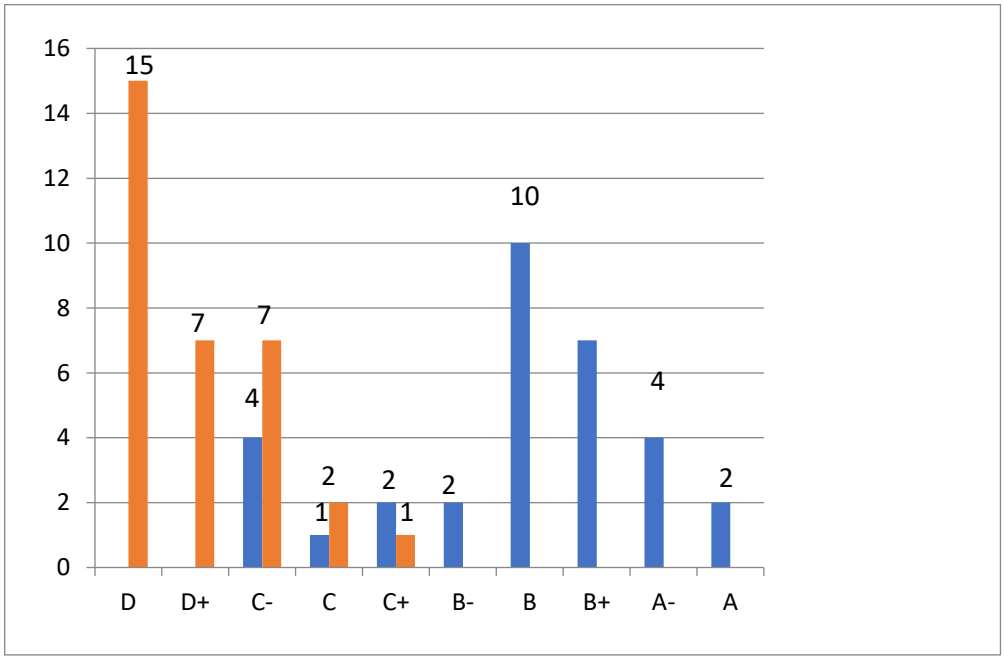

Figure 2. First Trial Results

Based on the table and figure above, the posttest results for Grade VIII students' mathematical numeracy literacy abilities show improvements across several achievement levels compared to the pretest. Specifically, the number of students attaining predicate A increased from 0 to 2, predicate A- from 0 to 4, predicate B+ from 0 to 7, predicate B from 0 to 10, and predicate B- from 0 to 2. Predicate C+ rose slightly from 1 to 2 students. However, there was a decrease in the number of students at predicate C, from 2 to 1, and at predicate C- from 7 to 4. More notably, predicates D+ and D saw declines from 7 and 15 students, respectively, to zero.

The accompanying figure illustrates the distribution of pretest and posttest achievements on the topic of linear equations and inequalities with one variable in Trial I. From this data, 23 students (71.88%) out of 32 demonstrated mastery of mathematical numeracy literacy related to numbers in the posttest. According to the criteria outlined in Chapter III, this percentage indicates that the target mastery level has not yet been achieved (Lesmana & Deliati, 2022).

The following is the average condition of students' mathematical numeracy literacy abilities in trial I for each aspect of mathematical numeracy literacy. The average mathematical numeracy literacy ability in trial I can be described in Figure 3 below:

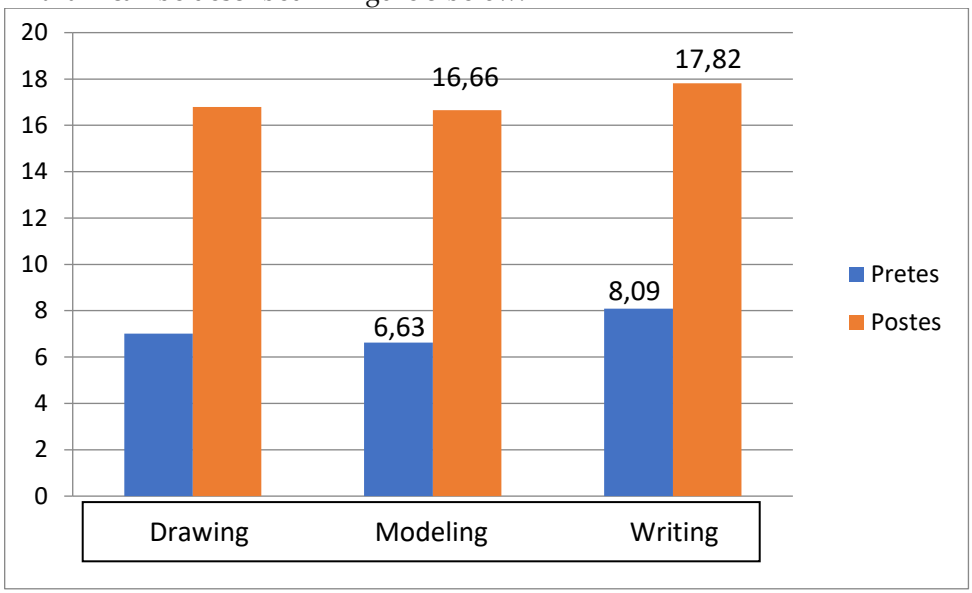

Figure 3. Average Aspect of Mathematical Numeracy Literacy Ability in Trial I

Based on Table and Figure 3, the average mathematical numeracy literacy ability increased across all assessed aspects. Specifically, students' skills in the drawing aspect improved from an average score of 7.01 in the pretest to 16.79 in the posttest. In the model-making aspect, the average score rose from 6.63 to 16.66, while in the writing aspect, it increased from 8.09 to 17.82. These results demonstrate a consistent improvement in every aspect of students' numeracy literacy.

2) Results of Student Activity Data Analysis

Student activities during the learning process were observed by two evaluators, with the results presented in the following table. Analysis indicates that, for each session, student activity levels met the effectiveness criteria outlined in Chapter III. Since the percentage of student activity across all observation categories and sessions falls within the established effectiveness thresholds, no revisions to the learning device were necessary based on these observations. (Nofziarni, Hadiyanto, Fitria, & Bentri, 2019).

3) Analysis of student response questionnaire data

Student responses to the learning process were categorized as positive or negative. Positive responses included expressions of happiness, novelty, and interest in the learning components and

activities, while negative responses indicated dissatisfaction, lack of novelty, or disinterest. Data collected from 32 students, detailed in the appendix, show that the percentages of students expressing strong interest in the learning components and activities ranged between 90.63% and 93.75%. Additionally, 93.75% of students reported being happy with the subject matter. These percentages were calculated by dividing the number of students expressing positive sentiments by the total respondents and multiplying by 100%. Similarly, high percentages were recorded for students perceiving the components and activities as novel, with figures ranging from 93.75% to 96.87%. Furthermore, 100% of students expressed interest in continuing with Problem-Based Learning (PBL), 90.62% indicated clarity regarding the language used in the PBL model and student worksheets (LKPD), and 93.75% appreciated the visual presentation of the materials.

Overall, student responses exceeded 80% across all assessed aspects, which, based on criteria in Chapter III, indicates a positive reception toward the PBL-oriented learning tools (Hadi, Susantini, & Kuntjoro, 2022). The analysis of Trial I data leads to the following conclusions: (1) students' mathematical numeracy literacy skills improved; (2) however, their skills in the Numbers topic using the PBL model have yet to meet the established criteria; (3) student engagement levels did not fulfill effectiveness benchmarks; and (4) student feedback on learning components and activities was positive (Istiana, Yamtinah, & Ardianto, 2023).

Given that some effectiveness indicators remain unmet as outlined in Chapter III, a revision of the developed learning tools is warranted.

Trial Results II

The learning devices and research instruments that have been tested in class VIII have not met the effectiveness criteria set out in chapter III previously. Therefore, the next activity is to conduct a re-trial (trial II) by paying attention to the indicators of learning effectiveness aspects that have not been met. Trial II was conducted in class VIII again with a large number of test subjects of 32 students. The results of the data analysis of trial II are described as follows:

1) Results of Data Analysis of Students' Mathematical and Numeracy Literacy Abilities

Data on students' mathematical numeracy literacy abilities were collected through two assessments: a pretest administered before instruction and a posttest conducted afterward. The results from Trial II are provided in the appendix.

Table 3. Description of the Results of the Mathematical Numeracy Literacy Skills of Class VIII Students

Information	Pretest	Posts
The highest score	2.08	3.73
Lowest value	0.80	2.24
Average	1.27	3.05

Table 3 shows that the average mathematical numeracy literacy ability of students increased from 1.27 in the pretest to 3.05 in the posttest, reflecting an improvement of 1.78. Categorization of achievement levels based on the pretest results of Trial II is detailed in Table 12 as follows (Wicaksono, Susilo, & Sueb, 2019):

From table 12 above, the students' mathematical numeracy literacy skills in the results of the pretest II trial test were obtained as follows: the number of students who obtained a score with a D predicate was 7 people (21.87%), who obtained a D $^{+\text{ predicate score}}$ was 16 people (50%), who had a C- predicate score was 6 people (18.75%), who obtained a C predicate score was 2 people (6.25%), who had a C $^{+}$ predicate score was 1 person (3.12%), who obtained a B- predicate score was 0 people (0%), who obtained a B predicate score was 0 people (0%), who obtained a B $^{+\text{ predicate score}}$ was 0 people (0%), who obtained an A- predicate score was 0 people (0%), who obtained an A predicate score was 0 people

(0%). As for the level of students' mathematical numeracy literacy ability in the results of test post II, it can be seen in the following table 13:

Table 4. Level of Achievement of Mathematical Numeracy Literacy Skills of Grade VIII Students in Post-Test Results

Mark	Number of Students	Percentage	Predicate
$0.00 < value \leq 1.00$	0	0%	D
$1.00 < value \leq 1.33$	0	0%	D +
$1.33 < value \leq 1.66$	0	0%	C-
$1.66 < value \leq 2.00$	0	0%	C
$2.00 < value \leq 2.33$	2	6.25%	C +
$2.33 < value \leq 2.66$	2	6.25%	B-
$2.66 < value \leq 3.00$	10	31.25%	B
$3.00 < value \leq 3.33$	9	28.12%	B+
$3.33 < value \leq 3.66$	6	18.75%	A-
$3.66 < value \leq 4.00$	3	9.38%	A

From Table 4 of students' mathematical literacy and numeracy skills in the results of the posttest of trial II, it was found that the number of students who obtained a score with a D predicate was 0 people (0%), who obtained a D + predicate score was 0 people (0%), who had a C- predicate score was 0 people (0%), who had a C predicate score was 0 people (0%), who obtained a C + predicate score was 2 people (6.25%), who obtained a B- predicate score was 2 people (6.25%), who obtained a B predicate score was 10 people (31.25%), who obtained a B + predicate score was 9 people (28.12%), who obtained an A- predicate score was 6 people (18.75%), who obtained an A predicate score was 3 people (9.38%). Based on the explanation of the analysis of the results of the correction of the student's answer sheet above, it can be seen that all questions can be worked on, it is possible that the completion procedure is not yet complete. For more details, see the image below (Fakhriyah, Masfuah, Hilyana, & Mamat, 2022).

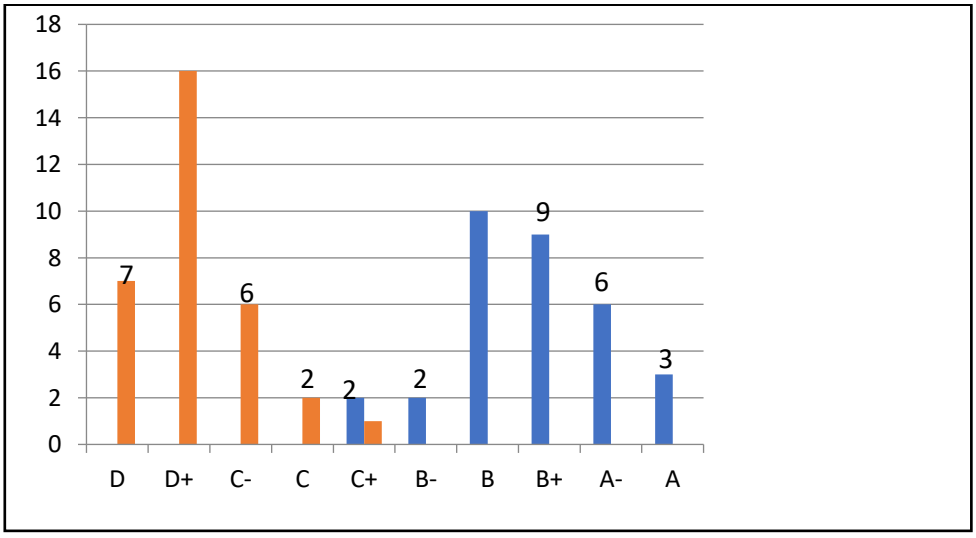

Figure 4. Achievement Value of Students' Mathematical Numeracy Literacy Skills in Class VII I on Pretest and Posttest Results

Based on the table and figure above, the posttest results for Grade VIII students' mathematical numeracy literacy abilities show improvements across several achievement levels compared to the pretest. Specifically, the number of students achieving predicate A increased from 0 to 3, predicate A- from 0 to 6, predicate B+ from 0 to 9, predicate B from 0 to 10, and predicate B- from 0 to 2. Predicate

C+ increased slightly from 1 to 2 students. Conversely, the number of students at predicates C, C-, D+, and D decreased from 2 to 0, 6 to 0, 16 to 0, and 7 to 0, respectively.

The accompanying figure illustrates the distribution of pretest and posttest achievements on the topic of linear equations and inequalities in one variable during Trial II. From this data, 28 students (87.50%) out of 32 demonstrated mastery of mathematical numeracy literacy related to this topic in the posttest. According to the criteria outlined in Chapter III, this percentage meets the established mastery threshold (Yanuarto, Jaelani, & Purwanto, 2021).

A comparison of posttest results showing the number of students mastering mathematical numeracy literacy on linear equations and inequalities between Trial I and Trial II is presented in Table 14 below.

Table 5. Comparison of Post-test Results of Students Who Have Understood Students' Mathematical Numeracy Literacy on the Numbers Material

Posts	Percentage (%) of students who have understood students' mathematical numeracy literacy	Percentage (%) of students who do not understand mathematical numeracy literacy
Trial I	71.88	28.12
Trial II	87.50	12.50

The following is a picture of the pretest and posttest achievements of students' mathematical numeracy literacy skills on the material of linear equations and inequalities of one variable in trials I and II.

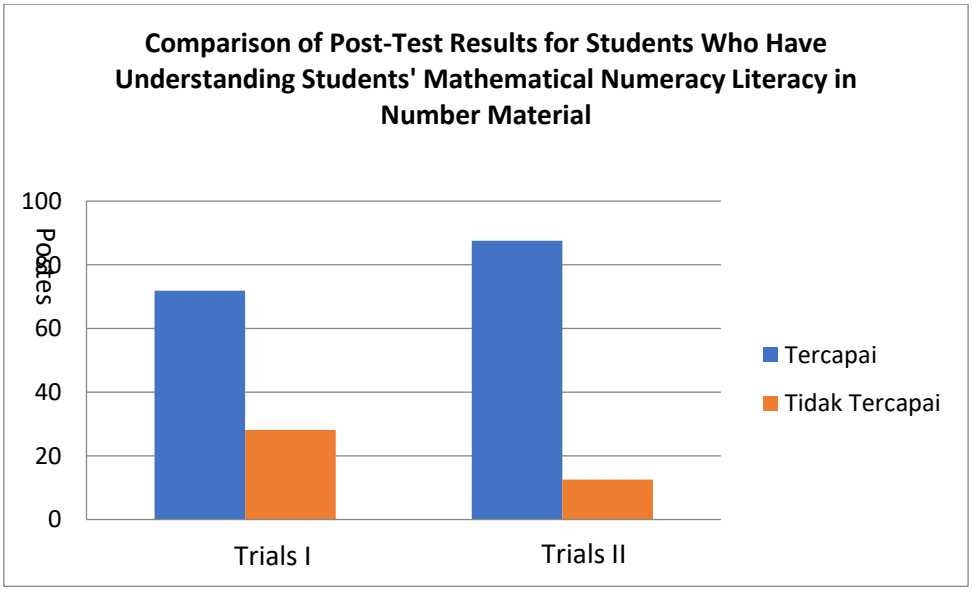

Figure 5. Comparison of Post-test Results of Students Who Have Understood Students' Mathematical Numeracy Literacy on Number Material

Based on Table 5 and the figure above, the percentage of students demonstrating mastery of mathematical numeracy literacy increased from 71.88% in Trial I to 87.50% in Trial II, reflecting an improvement of 15.62%. The following section presents the average performance of students' mathematical numeracy literacy across each assessed aspect.

Discussion

The evaluation of student engagement and satisfaction during the learning process was conducted through systematic observation and student feedback analysis. Two evaluators observed student activities, and average percentage frequencies were calculated to assess levels of engagement and satisfaction. The results indicate consistently high student involvement and positive perceptions of the Problem-Based Learning (PBL) model and its supporting materials.

According to the findings, students expressed strong satisfaction across various learning components. Specifically, 93.75% of students reported being pleased with the learning material, while similar satisfaction rates were recorded for other components, including learning activities (90.62%), instructional approach (90.62%), and overall experience (96.88%). These percentages were obtained by dividing the number of students with positive responses by the total number of participants (32), then multiplying by 100%, as described in McCarthey et al. (2020).

In addition to satisfaction, students also identified the novelty of the learning components. A substantial proportion of students—93.75%—indicated that the subject matter was new to them. Similar novelty ratings (90.62% to 96.88%) were observed for other elements of the learning process. This finding suggests that the instructional materials and activities provided an engaging, unfamiliar experience that likely stimulated cognitive interest.

Furthermore, student interest in the PBL model was notably high. All students (100%) expressed a desire to continue learning using the PBL approach. Additionally, 90.62% found the language used in the student worksheets (LKPD) and instructional materials to be clear, and 93.75% appreciated the visual design and illustrations provided. These findings are consistent with research by Ernia and Mahmudah (2023), who concluded that PBL-based e-modules are effective in enhancing students' numeracy literacy through engaging content and user-friendly presentation.

Student responses across all components exceeded 80%, surpassing the benchmark for effectiveness outlined in Chapter III. According to the established criteria, student responses at this level reflect strong engagement and a positive reception of the learning tools. This level of acceptance aligns with findings by Saeed Al-Sobhi and Preece (2018), who noted that clarity, relevance, and interactivity are essential for learner engagement and satisfaction in student-centered learning models.

Based on the data analysis from Trial II, three key conclusions were drawn:

1. Improvement in Mathematical Numeracy Literacy Skills: The post-instruction assessment showed an increase in students' numeracy literacy, demonstrating the effectiveness of the PBL model in facilitating learning.
2. Student Engagement: The observation and feedback data indicated that student activity met or exceeded the effectiveness criteria for active learning.
3. Positive Student Feedback: Feedback regarding the content, design, and delivery of learning materials was overwhelmingly positive.

Taken together, these findings support the conclusion that the developed PBL-oriented learning tools are valid and effective for improving students' mathematical numeracy literacy. The implementation not only met content and pedagogical expectations but also adhered to empirical standards for validation and effectiveness. As such, the development cycle of the learning model has reached completion, with all critical validation benchmarks successfully achieved.

4. CONCLUSION

The study concludes that the implementation of a problem-based learning (PBL) model significantly enhanced students' mathematical numeracy literacy, with classical achievement reaching 87.50%. The average student score improved from 2.73 in the first trial to 3.05 in the second, indicating measurable progress in numeracy skills. Additionally, students' active participation during the learning process met established criteria for learning effectiveness, and their responses reflected a consistently positive attitude toward the PBL components. However, the study was limited in scope,

focusing only on a specific sample group within a controlled educational setting, which may affect the generalizability of the findings. Future research is recommended to apply the PBL model across diverse educational contexts, larger sample sizes, and varying student proficiency levels to further validate its effectiveness and adaptability.

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