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Problem-Based Learning with Manipulative Media: Enhancing Elementary Students' Conceptual Understanding in Area and Volume

Sintha Sih Dewanti[1*], Rahmawati[2], Sumardi[3]

[1,2,3] Universitas Islam Negeri Sunan Kalijaga Yogyakarta, Indonesia;
[2, 3] Sekolah Dasar Negeri Depok , Sleman, Indonesia

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ABSTRAK

Model pembelajaran memainkan peran kunci dalam memastikan pemahaman konsep siswa melalui pengalaman belajar yang aktif dan bermakna. Model yang terstruktur dan kolaboratif dapat menciptakan lingkungan belajar kondusif, yang mendorong siswa untuk aktif dalam menguasai konsep. Penelitian ini bertujuan mengembangkan model Problem-Based Learning (PBL) *berbantuan media manipulatif untuk meningkatkan pemahaman konsep pengukuran luas dan volume pada siswa Sekolah Dasar. Penelitian ini merupakan penelitian* Research & Development *dengan model* ADDIE, *yang melibatkan siswa kelas IV sebagai subjek penelitian. Teknik pengumpulan data mencakup wawancara, observasi kelas, dan tes. Analisis data dilakukan secara deskriptif kualitatif. Hasil penelitian menunjukkan bahwa siswa lebih aktif terlibat dalam pembelajaran dan mampu mengaitkan konsep abstrak dengan praktik menggunakan media manipulatif. Tingkat aktivitas mandiri mencapai 91,84%, aktivitas kelompok mencapai 96,85% pada kegiatan pertama dan 97,30% pada kegiatan kedua. Hasil tes pengukuran luas dan volume menunjukkan ketuntasan belajar siswa dengan rata-rata persentase 96,76%. Pemahaman konsep siswa berada pada kategori sangat tinggi dengan persentase tingkat penguasaan konsep antara 85-100% berdasarkan Penilaian Acuan Patokan. Simpulan penelitian ini menunjukkan bahwa penerapan model* PBL *berbantuan media manipulatif efektif dalam meningkatkan pemahaman konsep siswa, terutama dalam pengukuran luas dan volume, serta mendorong keterlibatan siswa dalam kegiatan belajar kelompok untuk memecahkan masalah*

ABSTRACT

The learning model plays a crucial role in ensuring students' conceptual understanding through active and meaningful learning experiences. A structured and collaborative model fosters a conducive learning environment, encouraging students to actively grasp concepts. This study aims to develop a Problem-Based Learning (PBL) model assisted by manipulative media to enhance elementary students' conceptual understanding of area and volume measurement. The study follows a Research & Development approach using the ADDIE model, with fourth-grade elementary students as research subjects. Data collection techniques include interviews, classroom observations, and tests. The data were analyzed qualitatively using descriptive analysis. The findings reveal that students became more actively engaged in the learning process and were able to connect abstract concepts through hands-on practice using manipulative media. The independent learning activity level reached 91.84%, while group activities achieved 96.85% in the first session and 97.30% in the second session. The test results on area and volume measurement indicated a mastery learning rate of 96.76%. Students' conceptual understanding fell into the very high category, with a mastery percentage between 85-100% based on the Criterion-Referenced Assessment scale. The study concludes that implementing the PBL model assisted by manipulative media effectively enhances students' conceptual understanding and promotes their active participation in collaborative problem-solving activities.

Corresponding author
*E-mail addresses: sintha.dewanti@uin-suka.ac.id (Sintha Sih Dewanti)

1. INTRODUCTION

Mathematics learning in elementary schools has a very important role in forming a strong basis for understanding concepts for students. Mathematics learning is often seen as abstract learning with multilevel concepts and principles. Many students find it difficult to learn mathematics (Husna, 2020; Kusnadi et al., 2021). Concept understanding is very important as a basis in learning mathematics. Students with good conceptual understanding skills can support their learning process, so they are able to solve the mathematical problems they face (Kamalia et al., 2020; Sari & Hayati, 2019; Yulianty, 2019). The ability to understand concepts is an important element in every mathematics learning. The ability to understand concepts is a very important aspect in the principles of mathematics learning (Allen et al., 1982; Ismail et al., 2021). If conceptual understanding is mastered well, students will be able to link and relate one concept to another. Mathematical concepts the abstract is necessary understood by using learning models related to examples of real problems, in order to make it easier for students to understand mathematical concepts (Maulani, 2020; Nuranjani & Wijayanti, 2023). Area and volume measurement material is a basic concept in understanding geometry. Learning area and volume measurement material is often a challenge for students to understand the concept well, because not all learning models are appropriate and suitable for application in solving mathematical problems. Students also have difficulty understanding mathematical concepts because learning does not involve activeness in building knowledge, especially when they do not use concrete objects as learning media (Isnaniah & Imamuddin, 2020; Kawulich, 2021). Therefore, it is necessary to develop a learning model with the help of effective learning media to increase understanding of the concept of measuring area and volume in elementary school students.

Model PBL is a learning model that uses problems as the main point of learning (Antara, 2022; Mandasari, 2021; Novianti & Fakhriyana, 2022). The PBL model provides free space for students to think about concepts and solve problems related to the material presented by the teacher. Because basically mathematics aims to make students understand mathematical concepts to solve everyday problems (Ramadhani et al., 2019; Sugiarti & Dewanti, 2018). This learning model encourages students to know how to learn and work together in groups to find solutions to problems in real situations. The PBL model provides real-life experiences that encourage active learning, knowledge development, and real integration of school learning with real life (Bahar et al., 2020; Hartinah et al., 2020; Sakir & Kim, 2020). The PBL model has the distinctive characteristics of using real world problems as a learning context for students in solving problems, acquiring important knowledge and concepts from the subject matter.

The PBL model in mathematics learning in elementary schools has several weaknesses, especially when it does not use learning media. Without media, students often have difficulty understanding abstract mathematical concepts, because the PBL model tends to demand a higher understanding from students in formulating and solving complex problems (Smith & Jones, 2020; Thomas & Seely, 2022). Students' inability to visualize mathematical concepts through pure abstraction can hinder their engagement in projects and negatively impact their learning outcomes (Johnson & Lee, 2023; Miller & Thompson, 2022). In addition, without the help of concrete teaching aids, students at the elementary level may feel burdened by project assignments that require more advanced mathematical reasoning, which can reduce their motivation in the learning process (Brown & Wilson, 2021; Miller & Thompson, 2022; Williams & Taylor, 2023). Therefore, to overcome this weakness, it is very important to integrate manipulative learning media in the PBL model, in order to provide physical representations of complex mathematical concepts, to improve students' understanding (Brown & Wilson, 2021; Johnson & Lee, 2023; Martin & Clark, 2022).

In learning, students can use various concrete objects around them, such as play money, Uno cards, used bottles, paper and water. These concrete objects are called manipulative learning media. Manipulative media are all materials that can be held, moved, installed, flipped, arranged, cut by students. Manipulative media is a real material or object and can be used by students to explore understanding of mathematical concepts (Latifa et al., 2022; Muhsetyo et al., 2021). Manipulative media in this research is focused on concrete objects that can be manipulated by hand, rotated, held, flipped, moved, arranged, laid out or cut into pieces, and can be demonstrated by teachers to make it easier for students to understand mathematical concepts and mathematical procedures (Taslima, 2021; Ummah & Azmi, 2020). Through the use of manipulative learning media, students can learn in a more interactive and fun way, making it easier for students to understand the concept of measuring area and volume. Measuring area and volume with standard and non-standard units is an important part of mathematics learning in elementary schools. Learning non-standard units helps students build a basic understanding for more complex and abstract learning, namely standard units. The presentation of material in mathematics learning must be appropriate to students' characteristics and help them understand concepts that are useful in everyday life (Dewanti, 2013; Mega & Madani, 2023). Characteristics that students must have in order to increase understanding of the concept of measuring area and volume, such as, students can analyze and solve problems related to

measuring area and volume, and can connect mathematical concepts with real situations. Students can relate mathematical concepts and integrate these concepts with real problems (Amin et al., 2020; Cotton, 2021). Good fine motor skills are needed in using measuring tools such as rulers, paper, bottles, glasses and objects that can be used as tools for measuring area and volume accurately. Students can communicate measurement results and the methods they use orally and in writing (Azhima et al., 2021; Monica et al., 2023). Students who have high curiosity and are actively involved in learning tend to understand the concepts being taught more quickly. This learning process encourages students to more easily understand and apply the concepts of measuring area and volume in various situations.

Various previous studies support the application of the PBL model in mathematics learning. Research result by previous study shows that the effectiveness of the ethnomathematics-based PBL model can optimize students' competence in solving mathematical problems (Maharani & Waluya, 2023; Maulana et al., 2022). The average value of critical thinking skills observed in the group of students who used the PBL model was higher than the group of students who used conventional teaching methods. The results of teacher perceptions in implementing the PBL model show advantages and disadvantages as a basis for modifying learning models, and the importance of collaboration skills for elementary school students (Monalisa et al., 2019; Sajidan et al., 2022). Student responses to learning using the PBL model have a positive impact on the learning process in terms of process skills and learning outcomes. The PBL model forms teaching that encourages students to identify problems, explore interpretations, determine alternatives as solutions, communicate conclusions and integrate, monitor and improve strategies to improve problems (Fauziah & Ruqoyya h, 2022; Nadeak & Naibaho, 2020). The application of the learning model can increase understanding of the concept of spatial construction material in elementary school students.

The results of previous studies show that the application of the PBL model in mathematics learning is effective in increasing students' competence in solving mathematics problems. The application of the PBL model also has a positive impact on the learning process and student responses, and can encourage students to identify problems, explore solutions, and improve their learning outcomes. The findings from these various studies provide strong support for the application of the PBL model in mathematics learning, including in the context of learning area and volume measurement material in elementary schools. Therefore, the aim of this research was to develop a PBL model assisted by manipulative media to improve understanding of concepts, especially in area and volume measurement material for elementary school students. The novelty of this study introduces a unique integration between the Problem-Based Learning Model and the use of manipulative media to improve elementary school students' conceptual understanding. This combination is rarely found in previous studies and provides a more interactive approach to problem-based learning.

2. METHOD

This research uses Research & Development methodology with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model to develop a PBL model assisted by manipulative media in increasing elementary school students' understanding of mathematical concepts (Sugiyono, 2012). The Analysis Stage involves identifying needs, analyzing problems faced by students in understanding mathematical concepts, and reviewing literature on PBL models and manipulative media. The Design Stage focuses on designing a learning model that combines the PBL model with manipulative media, as well as preparing relevant teaching materials and tools. In the Development stage, the designed learning product is developed and validated by experts to ensure its suitability to student needs. After that, the Implementation stage involves testing the model in class, where the teacher applies the PBL model assisted by manipulative media in the learning process. The final stage is Evaluation, where data from implementation results is collected, analyzed, and used to improve and perfect the learning model. With this ADDIE model, the development of a PBL model that is effective and appropriate to the basic education context is expected to significantly increase students' understanding of concepts. The following flow of the ADDIE development model in this research can be presented in Figure 1.

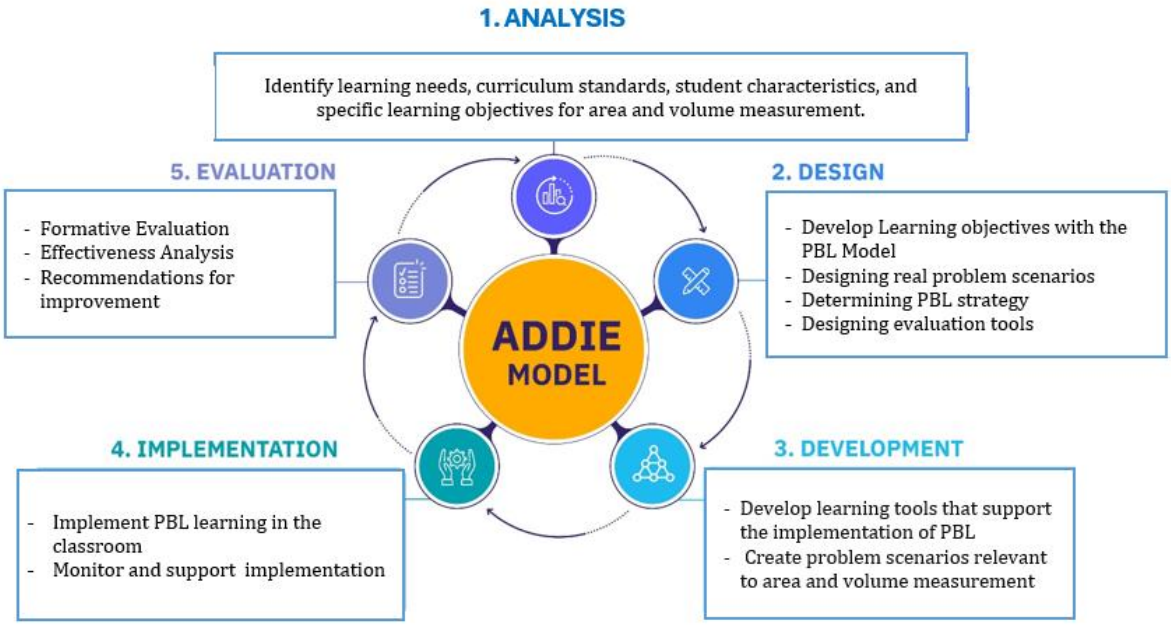

Figure 1. ADDIE Development Model

This research was conducted at Depok 1 Public Elementary School, Special Region of Yogyakarta. The subjects of this research were all fourth-grade students, totalling 12 boys and 14 girls as well as teachers. This research was carried out in the Even Semester of the 2023/2024 academic year. The research instrument used participant interview guides and classroom observations. Interviews were conducted to gain in-depth insight into the experiences, views and perceptions of educators regarding the implementation of this learning model. Interviews allow researchers to understand the perspectives, experiences, and motivations of participants directly involved in implementing the learning model, thereby providing richer context to the quantitative data that may have been collected. In addition, interviews allow for flexibility in extracting information, as researchers can adjust questions based on participant responses, thereby exploring emerging issues in more detail (Creswell & Creswell, 2018; S B Merriam & Grenier, 2019). Furthermore, classroom observations allow researchers to directly observe how the model is implemented and how students and teachers interact in a real learning environment. Observations provide rich empirical data, which helps in more accurately assessing the effectiveness of learning models, including how teaching strategies are implemented and how students respond and engage in learning activities. Through observation, researchers can identify key elements such as classroom dynamics, use of time, and application of media or tools that may not appear in other data collection methods such as interviews or questionnaires (Kawulich, 2021; McGrath & Coles, 2018). Observations allow researchers to see the reality on the ground, including challenges that may not be reported by teachers or students, thereby providing deeper insight into what really happens during the learning process.

Interviews were conducted to explore teachers' understanding of the basic principles of the PBL model and how they integrated manipulative media into their learning. Interviews focused on students' experiences with PBL models assisted by manipulative media, including how these tools helped them understand abstract mathematical concepts (Johnson & Lee, 2023; Smith et al., 2021). In addition, interviews were conducted to evaluate the challenges and obstacles faced during the implementation of this model, such as difficulties in managing time or lack of resources (Brown & Wilson, 2022; Miller & Thompson, 2020), as well as interviews to ask about the impact and learning outcomes felt by students after using manipulative media in the PBL model, including changes in engagement, motivation, and understanding of concepts.

Classroom observation was conducted to determine student involvement in the learning process, especially how students interact with manipulative media and the extent to which they are actively involved in problem solving. Observations include teacher teaching strategies, including how teachers facilitate the use of manipulative media in the context of the PBL model and encourage students to think critically and creatively (Johnson & Lee, 2023; Smith et al., 2021). Observations also to determine the impact of manipulative media on students' understanding of mathematical concepts must be evaluated, paying attention to whether the use of these tools helps students link abstract concepts with concrete representations. Observations also record group dynamics in the PBL model, seeing how students work

together, collaborate, and share ideas when using manipulative media to solve problems (Brown & Wilson, 2022; Miller & Thompson, 2022). Furthermore, observations record students' reflections about their learning experiences, such as improvements in understanding or challenges they faced (Williams & Taylor, 2021).

The data analysis technique used qualitative descriptive analysis that describes and understands in depth how the PBL model is applied and how manipulative media plays a role in improving students' conceptual understanding. Data obtained from various sources, such as interviews, observations, and field notes, were processed through a process of coding, categorization, and identification of main themes (Creswell, J. W., & Poth, 2018). This analysis technique allows researchers to explore interaction patterns, student behavior, and the effectiveness of using manipulative media in supporting problem-based learning (Sharan B. Merriam & Tisdell, 2016). Qualitative descriptive analysis also helps in identifying challenges that arise during the implementation of the PBL model, as well as potential improvements to increase the effectiveness of the model. By linking the findings to existing theory and literature, the results of this analysis provide rich and in-depth insight into the application of the PBL model in the context of basic education, while providing a strong basis for practical recommendations and further development. Then, the results of the analysis of students' level of conceptual understanding are determined by the average student score and learning completeness using the five-scale Benchmark Assessment based on the criteria in Table 1.

Table 1. Benchmark Assessment Criteria Scale Five

Mastery Level	Category
85% -100%	Very high
70% -84%	High
55% -69%	Enough
40% -54%	Low
0-39%	Very Low

Students are said to be complete in this study, if the average level of mastery of grades and learning completeness each reaches a minimum score of 69%. Meanwhile, this research is said to be successful if the average score of students' understanding of concepts and class completion reaches a mastery level percentage of between 70%-84% with high criteria (Astiti et al., 2021).

3. RESULT AND DISCUSSION

Result

The development of the PBL model assisted by manipulative media was carried out through 5 stages, namely (1) Analysis, identifying student needs regarding the level of student understanding of the concept of measuring area and volume, identifying difficulties and problems that students often face in this material, determining curriculum standards, learning outcomes and formulate learning objectives that are specific, measurable, and in accordance with the results of the needs analysis. Stage (2) Design, determines learning objectives that focus on students' abilities to solve real problems related to measuring area and volume, developing problem scenarios that are relevant for students' understanding of concepts. Choosing the right teaching strategy for the PBL model, including the teacher's role as a facilitator and the steps that students must follow in solving problems, developing evaluation tools used to measure students' understanding of concepts. Stage (3) Development, developing teaching modules, learner worksheets, learning videos, manipulative media tools used to support PBL model learning create problem scenarios that are relevant to measuring area and volume, this stage is validated to ensure the model and learning tools developed are in accordance with the learning objectives. Stage (4) Implementation of the PBL model in the classroom, guiding students through the problem-solving process, supporting collaborative learning, monitoring the learning process and providing feedback, and helping students who experience difficulties. Stage (5) Evaluation, analyzing the evaluation results to assess the extent to which the learning objectives have been achieved through giving formative test questions to students. Recommendations for improvement and revision of material and learning methods for the next learning stage.

Researchers conducted field observations and direct interviews with teachers and class IV students as participants and informants. Interview activities were carried out with 1 teacher, 1 male student and 2 female students regarding learning and teaching activities in the classroom. The results of the interviews obtained information regarding students' lack of understanding of concepts related to learning and teaching activities in the classroom. Factors such as lack of in-depth explanations, lack of clear examples, lack of

student involvement in learning, and obstacles in discussions are things that need to be considered in improving students' understanding of the material being taught. Therefore, there is a need for a more collaborative and in-depth learning model and to create an environment that supports students to be more active in the learning process.

Learning tools using the PBL model which refer to the development of the independent curriculum and refer to accompanying books for teachers and students learning mathematics in grade IV elementary school (Bahar et al., 2020; Bains et al., 2022). The development of teaching modules, Student worksheets, and manipulative media are used to support the implementation of the PBL model by designing independent activity grids, group activities and student formative test question grids, as well as student assessment instruments. The learning strategy design is adapted to the PBL model being implemented. The syntax of the PBL model is adjusted to student characteristics, media, materials and learning objectives. The syntax of the PBL model includes, orienting students to problems, organizing students into study groups, guiding students in problem solving, developing and presenting work results, analyzing and evaluating the problem-solving process, feedback and support, formative assessment (Isrok'atun & Rosmala, 2019; Sudejamnong et al., 2014). Table 2 show the steps for the PBL model assisted by manipulative media in mathematics learning with area and volume measurement material.

Table 2. Syntax of PBL Model Assisted by Manipulative Media

Syntax	Learning Activities
Student orientation to the problems	• Introduction to Material: The teacher explains the learning objectives for measuring area and volume. • Problem Presentation: The teacher presents a problem that requires understanding of concepts • Media Demonstration: The teacher introduces the manipulative media that will be used, such as origami paper to measure area, and mineral water bottles and buckets to measure volume
Organize students into study groups	• Group Division: Students are divided into small, heterogeneous groups. • Media Distribution: Each group was given manipulative media such as origami paper, Uno cards, play money, mineral water bottles, buckets, food containers and water. • Role Assignment: Each group member is assigned a specific role
Guiding students in problem solving	• Active Mentoring: The teacher goes around to each group to provide guidance and answer questions about the use of manipulative media. • Strategy Guide: The teacher provides strategies on how to use manipulative media to measure area and volume.
Develop and present work results	• Data Collection and Solutions: Students use manipulative media to solve problems and present results. • Making Presentations: Each group prepares a presentation explaining how they use manipulative media to solve problems
Analyze and evaluate	• Class Discussion: After the presentation, the entire class discusses the solutions that have been presented, highlighting the use of manipulative media
Feedback and Support	• Feedback from teachers: Teachers provide constructive feedback on students' presentations and understanding of concepts.
Formative assessment	• Formative Test: The teacher gives a test to measure students' understanding of the concept of measuring area and volume • Observation and Notes: The teacher makes observations during the activity and takes notes

Product validation includes PBL models, teaching modules, formative test question grids and assessment instruments as well as the suitability of the manipulative media used which have been revised and meet the suggestions given. Validation was carried out by the fourth-grade teacher at Depok 1 State Elementary School and the results of student responses were obtained through direct interviews. Product validation results is show in Table 3.

Table 3. Product Validation Results

Product Validation	Review from Validator	Results
PBL model	Suitability to the curriculum: the PBL model developed follows the applicable curriculum and the needs of students in class IV. Suggestions: material experts suggest adding more varied examples of problems related to students' daily lives.	The PBL model was accepted with some revisions to add variety to the problem examples provided
Manipulative media	Relevance of material: the manipulatives used are relevant to the concepts taught and help students understand the concept of measurement. Ease of use: the media is easy for students to use.	Use of manipulative media tools and materials relevant to learning objectives
Teaching module and learner worksheet	Teaching modules have been developed according to student needs based on PBL syntax Clarity of instructions: the instructions in the learner worksheet are clear enough and easy for students to understand.	The teaching module and learner worksheet have been revised by PBL syntax and learning materials
Formative test question grid	Suitability to the material: the questions in the formative test have covered all the material taught. Level of difficulty: the level of difficulty of the questions is on the ability of fourth-grade students. Suggestions: adding a variety of forms of questions, such as short fill-in questions or story problems.	The question grid was accepted with revisions to add a variety of question forms.
Assessment instrument	Clarity of assessment criteria: the assessment criteria in the instrument are clear and easy to understand. Suggestion: add a more detailed description of each assessment criteria to reduce subjectivity.	The assessment instrument accepted with revision to add description to the assessment criteria.

Implementation was carried out to test the effectiveness of the learning design through application to 27 grade IV students who had high, medium and low abilities. Teachers in the PBL model act only as facilitators to convey and explain learning material, while students are active in running the class starting from giving problems, collaborating and students are given the opportunity to develop their understanding of concepts in solving the problems given. This activity can familiarize students with being actively involved in learning in class as well as developing students' abilities in solving problems. Students complete area and volume measurement tasks using manipulative media is show in Figure 2.

Figure 2. Students Complete Area and Volume Measurement Tasks Using Manipulative Media

Figure 2 show students use manipulative media (Uno cards, origami paper and play money) to solve area measurement problems, while students use manipulative media to measure volume (used bottles, buckets, food containers and glasses) through independent and group activities by following instructions and problems given on the student worksheet students work on, discuss and present the

activities given. The PBL model takes place actively and conducively, students understand concepts more easily when they are actively involved in the learning process, by providing problems related to everyday life, students can practically apply the concepts of measuring area and volume. Interaction with peers and teachers in group discussions can enrich students' understanding. Through collaboration, students can share strategies and their understanding of the concepts of measuring area and volume, using manipulative media, students can develop fine motor skills to use these tools appropriately. Mastery of fine motor skills is essential for taking accurate measurements and avoiding errors. Each group was given the opportunity to present the results of their work, thereby helping students develop presentation communication skills and strengthening their understanding of the measurement process.

The effectiveness of students' understanding of concepts using independent activity test instruments, group activities and formative tests at the end of learning. The results of student formative assessments are determined by the average score which is converted into a five-scale benchmark assessment. Percentage of formative assessment results of concept understanding is show in Figure 3.

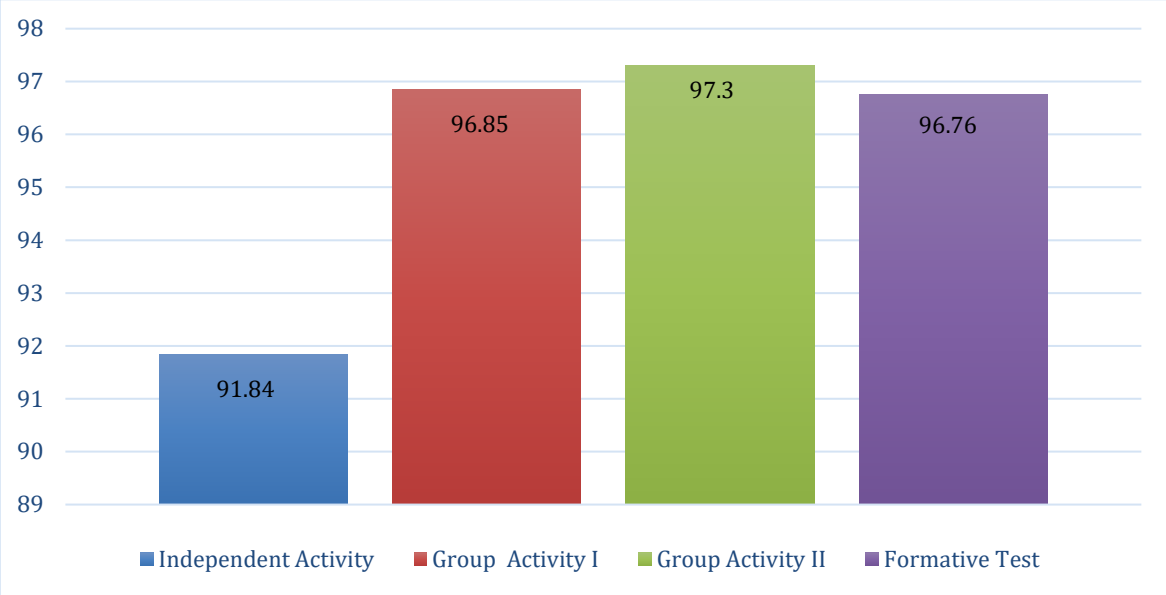

Figure 3. Percentage of Formative Assessment Results of Concept Understanding

Figure 3 contains the percentage results of students' formative test assessments on understanding the concept of area and volume measurement material by applying the PBL model. Formative assessment to achieve learning objectives, namely students can measure area using non-standard units and standard units, estimate area using non-standard units and standard units. , and measure volume using non-standard units and standard units. The average value of the student formative assessment results obtained from a total of 27 students obtained a percentage of 91.84% for independent activities, a percentage for group activities in activity I 96.85%, and a percentage for group activities in activity II with a percentage of 97.3%, as well as Formative test results At the end of the learning material measuring area and volume, a percentage of 96.76% was obtained. The results of the assessment above show that group activities through the PBL model provide significant improvements compared to independent activities or giving formative test questions at the end of learning. The average student understanding of concepts and class completion reaches a mastery level percentage using the five-scale benchmark assessment between 85-100% with very high criteria.

Discussion

Applying the PBL model in the classroom by carrying out various activities can increase students' understanding of concepts through involvement in solving problems. The PBL model makes it easier for students to solve problems by presenting contextual problems related to the surrounding environment (Amin et al., 2020; Nurwidodo et al., 2024). The PBL model begins with students learning through direct active involvement in solving real and relevant problems. Students' understanding of the concepts studied by relating them directly to real world situations and challenges. Students work in groups to define problems, gather information, analyze data, develop solutions, and present results. The PBL model focuses on students learning how to solve problems through group discussions in the formation of teamwork, social

and communication skills (Ghani et al., 2021; Maulana et al., 2022; Reed et al., 2021). This learning process encourages students to be active in problem solving, understanding concepts and applying knowledge.

Model PBL encourages students to think critically and creatively in finding solutions, which can deepen their understanding of abstract mathematical concepts. The advantages of this PBL model include the ability to increase student engagement, encourage collaborative learning, and develop higher-order thinking skills (Hmelo-Silver et al., 2019; Wijnia et al., 2020). In addition, the PBL model also allows students to apply the knowledge they gain to real life situations, thereby making learning more relevant and meaningful. However, research also shows that the implementation of the PBL model in mathematics learning in elementary schools has several weaknesses. One of the main challenges is the need for longer time to facilitate the learning process compared to conventional learning methods, which can be a barrier in a busy curriculum (Dolmans et al., 2021; Hung, 2019). In addition, not all students have enough basic skills to actively participate in group discussions, which can cause gaps in understanding between faster and slower students. Effective problem development and formulation also requires high teacher ability, which is a challenge for teachers who are not yet familiar with this method (Schmidt et al., 2018; Strobel & Barneveld, 2019). However, when designed and implemented well, the PBL model has great potential to improve understanding of mathematical concepts in elementary school students.

The research results show that the development of the PBL model with the help of manipulative media and supported by other learning tools (teaching modules, student worksheets, formative test questions) which have been validated supports the implementation of learning in accordance with the expected learning objectives. The PBL model is a learning process that utilizes real problems to be used as material for analysis and requires media assistance to solve the problems given (Carpathia Ellyana & Tegeh, 2023; Nuranjani & Wijayanti, 2023). The use of manipulative media helps students understand concepts in a more complex way for solving problems regarding area and volume measurement material (Muhsetyo et al., 2021).

Students can solve problems in a more complex manner through the experience gained, understanding of concepts that have been obtained and supported by the help of interesting and fun manipulative media. The learning abilities of class IV Depok State Elementary School students have high, medium and low abilities. The PBL model is effectively applied to students and is the right strategy for heterogeneous classes where students with different abilities can collaboratively combine their abilities to find solutions (Isnaniah & Imamuddin, 2020; Muhsetyo et al., 2021). Providing formative test questions to students supports the implementation of PBL model learning to improve students' understanding of concepts. Because formative assessment provides feedback for students to perfect learning objectives (Hindriyani et al., 2020; Maier et al., 2016). The percentage results of student formative assessments through independent activities, joint activities and giving formative test questions using the benchmark assessment, the percentage obtained for independent activities was 91.84%, for group activities in activity I the percentage was 96.85%, and for group activities in activities with the percentage was 97.3%, and the results of the formative test at the end of learning the area and volume measurement material obtained a percentage of 96.76%, the criteria for each activity were very high, but group activities provided a very significant improvement compared to independent activities and giving formative test questions. This shows that the application of the PBL model to improve students' understanding of concepts is more active when learning in groups to solve the problems given.

Results Research suggests the need for intensive and ongoing training for teachers to strengthen their understanding of the application of the PBL model, especially in problem structuring, facilitation of group discussions, and effective use of manipulative media. In addition, systematic integration of manipulative media needs to be carried out to help students visualize abstract concepts, so that their understanding can be strengthened through direct experience. Considering that the PBL model requires more time to implement, the curriculum also needs to be adjusted to provide enough time for implementing this model without sacrificing the achievement of other learning objectives. Therefore, PBL-based teaching materials must be developed and provided to support teachers in implementing this model more effectively. A continuous evaluation and reflection process also need to be carried out to monitor the effectiveness of the PBL model being implemented, ensuring that students' understanding of concepts is truly increasing. In addition, strengthening the involvement of parents and communities in the learning process is also important, because they can provide a real context for the problems solved by students and support learning outside the classroom. With these recommendations, it is hoped that the application of the PBL model in elementary schools can be optimized, so that it has a significant impact on increasing students' understanding of mathematical concepts.

4. CONCLUSION

The PBL model assisted by manipulative media to increase elementary school students' understanding of the concept of measuring area and volume offers an effective way to prepare students to face complex mathematical challenges in the real world. students learn through solving relevant problems and using manipulative media to support understanding of concepts, this model not only improves students' academic competence but also helps them develop essential critical thinking, collaboration and communication skills. The use of manipulative media can provide a more interesting and motivating learning experience for students, increasing their interest in mathematics subjects. The PBL model prepares students for the challenges and situations they will face outside the school environment. Students are better prepared to apply their conceptual understanding knowledge and skills in everyday life and in the future. The limitation of this research is only measuring students' conceptual understanding, so this research is an initial step in further understanding the effectiveness of the PBL model with manipulative media, and further research is needed to support and expand the findings found.

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