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# Learning Activity with Problem-Based Learning Using Student Worksheet Assisted by MathCityMap to Improve Students' Mathematical Literacy

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## ABSTRACT

The AKM results at SMP Negeri 6 Pati indicate low mathematical literacy among students, necessitating innovative learning approaches that connect mathematical concepts to real-world contexts through technology. This study aims to design Problem-Based Learning using student worksheets assisted by MathCityMap to enhance students' mathematical literacy. The method employed is Design Research, comprising three stages: preparation and design, teaching experiment, and retrospective analysis. The research sample consisted of seventh-grade students in class VII A at SMP Negeri 6 Pati. Data collection techniques included tests, interviews, observations, documentation, and literature reviews. Validation results indicated that the tools were highly valid, with average scores of 90% for the teaching module, 93.5% for the media, and 95% for the literacy questions. The average pre-test score of 51 increased to 86.7 on the post-test. The Paired Sample T-Test showed a significant difference, and the N-Gain test yielded a score of 0.73 (high category). It was concluded that the Problem-Based Learning teaching tool using student worksheets assisted by MathCityMap is valid, feasible, and capable of improving students' mathematical literacy.

**Keywords**: *Problem-Based Learning, Student Worksheet, MathCityMap, Students' Mathematical Literacy.*

## Introduction

Education is an important aspect of human life that aims to educate the nation's future generations. This is in line with Article 1 of Law Number 20 of 2003 of the Republic of Indonesia, which states that education plays a role in developing the potential of students to become individuals who are faithful, pious, have noble character, and possess knowledge and skills. The government has established compulsory basic education for all citizens as an effort to strengthen the quality of human resources (Ripai & Sutarna, 2019). In this context, mathematics plays an important role because it can develop logical, critical, systematic, and creative thinking patterns. Mathematics learning is not only aimed at instilling concepts, but also at improving mathematical thinking skills and shaping the character of students (Putri et al., 2023) .

One crucial aspect of mathematics learning is mathematical literacy, which is the ability to formulate, apply, and interpret mathematics in various contexts. Stacey & Turner in Firdaus et al. (2021) states that mathematical literacy is important for students to be able to solve real-world problems and prepare for future challenges. Unfortunately, the results of the 2015 PISA survey show that this ability in Indonesia is still low, with a mathematical literacy score of 386 and ranking 63rd out of 70 countries, far below the international average (OECD, 2016) . Pamungkas et al. (2019) adding that, in general, Indonesian students' mathematical abilities still lag behind those of other developing countries.

A similar situation was also found at SMP Negeri 6 Pati based on the implementation of the Minimum Competency Assessment (AKM) in the 2024 Teaching Campus Program. The AKM, conducted from February to June, aims to measure students' literacy and numeracy before and after learning. Although there was an increase in scores, the results showed that literacy achievements were still relatively low, particularly in understanding context, modeling problems, and solving them mathematically. Details of the AKM results can be seen in the following table.

Table 1. Results of the AKM of the Teaching Campus of SMP Negeri 6 Pati 2024

| Average | Literacy | Numeracy |
|---|---|---|
| AKM class pre-test | 42,375 | 23 |
| AKM class post-test | 44,5 | 38,625 |

Based on Table 1, it can be seen that the average literacy score of students on the pre-test was 42.375 and the average numeracy score was 23. After the learning process, there was an increase to 44.5 for literacy and 38.625 for numeracy. However, this increase has not shown optimal results, especially in literacy. Students still struggle with interpreting problems, creating mathematical models, and solving problems accurately. This indicates that they have not fully mastered the ability to identify, solve, conclude, and represent mathematical problems in real-world contexts (Firdaus et al, 2021) . This shows the need for innovative and contextual learning models that can help students understand and apply mathematics in a meaningful way. Problem-Based Learning (PBL) is one of the models recommended in the 2013 Curriculum to improve higher-order thinking skills. This model uses real-world problems as triggers for learning, encouraging students to think critically and solve problems independently (Pamungkas et al., 2019) . In its implementation, teachers act as facilitators who guide the investigation and discussion process (Anwar & Jurotun, 2019) . Research conducted by Pratiwi & Ramdhani (2017) shows that PBL is effective in improving students' mathematical literacy, especially when packaged in the form of student worksheets to guide the learning process systematically.

According to Effendi et al. (2021) emphasizes the importance of the quality of student worksheets, in terms of content, design, and media development. However, the use of student worksheets alone is not enough. There is a need for 21st-century technology-based learning media that supports contextual mathematical exploration, one of which is the MathCityMap application. MathCityMap is a GPS-based application that facilitates students in solving mathematical problems through Math Trail, which is a route containing contextual and location-based mathematical problems (Ismaya et al., 2018) .

Based on the background of the problems that have been described, the problem formulation of this study is "How can Problem-Based Learning with student worksheet assisted by MathCityMap be designed to improve students' mathematical literacy?". Then from the formulation of the problem, it can be reduced to 2 sub-problems, namely: (1) How is the validity of learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap?; (2) Does students' mathematical literacy increase after learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap? Based on the formulation of the problem, the research objectives of this study are "To find out learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap can be designed to improve students' mathematical literacy", from these research objectives, can be reduced to 2 sub-research objectives, namely: (1) Knowing the validity of learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap; (2) Knowing the increase in students' mathematical literacy after learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap.

## Research Method

This research uses the Design Research method. Design Research is a systematic method for designing, developing, and evaluating educational interventions such as learning strategies, teaching materials, and learning environments, in order to answer complex problems in educational practice (Plomp & Nieveen, 2010). The main objective of this method is to produce practical solutions while developing or validating theories about the learning process and learning environment (Prahmana, 2017). In addition, Design Research also aims to produce actionable knowledge to achieve educational goals through effective design (Bakker, 2018). The Design Research procedure used refers to Bakker (2018), namely, (1) Preparation and Design; (2) Teaching Experiment; (3) Restrospective Analysis.

This research was conducted at SMP Negeri 6 Pati with a sample of students in class VII A SMP Negeri 6 Pati. In this study, the independent variables or independent variables taken are the Problem-Based Learning learning model with

student worksheet and MathCityMap learning media. Then, the dependent variable or the dependent variable taken is the ability of mathematical literacy. The data sources used for this study were quantitative and qualitative data. Quantitative data consisted of validation sheets, student work portfolios, pre-tests and post-tests, and trial tests. Qualitative data consisted of words, sentences, images, and theories obtained from literature studies, interviews, observations, and documentation.

The trial test questions administered before the study began were used as a reliability test to show the extent to which the measuring instrument could be trusted and relied upon. Observations and interviews were conducted before and during the learning process to students and mathematics teachers to explore their views regarding Problem-Based Learning with student worksheet assisted by MathCityMap, the results of observations and interviews before learning were analyzed as the basis for preparing the Hypothetical Learning Trajectory (HLT). Student work portfolios, observations and interviews during the learning process, relevant documentation, and literature studies were analyzed to determine students' mathematical literacy activities with Problem-Based Learning using student worksheet assisted by MathCityMap by triangulating data. The validation sheet is used when the validity test of the learning device is carried out, this is to analyze that the learning device is in accordance with the objectives. Literacy tests obtained through pre-test and post-test to analyze the improvement of students' mathematical literacy.

## Results and Discussion

The results obtained are the results of each stage that has been carried out by researchers. In accordance with the stages of the results of this study are divided into three, namely (1) Preparation and Design; (2) Teaching Experiment; (3) Restrospective Analysis.

### 1.1 Preparation and Design

The initial stage of this research is preparation and design, which includes interviews with mathematics teachers of SMP Negeri 6 Pati to review the curriculum, student characteristics, and learning conditions. This information is used to design Problem-Based Learning-based learning tools with student worksheet assisted by MathCityMap. At this stage, Hypothetical Learning Trajectory (HLT) was also developed to guide the learning process to improve students' mathematical literacy.

1. Curriculum Analysis, Student Characteristics, and Learning Environment

   As an initial stage, the researchers conducted observations and interviews with mathematics teachers at SMP Negeri 6 Pati to gather information about the implementation of learning, curriculum, learning media, student

characteristics, and learning environment. The results showed that mathematics learning is carried out face-to-face with the 2013 Curriculum as a reference. Students are allowed to use cell phones under certain conditions, which opens up opportunities for the use of technology-based media such as MathCityMap. However, mathematics learning still tends to be conventional, with the dominance of using textbooks and practice problems without linking the material to real contexts.

From the interviews, it is known that teachers have access to contextual media, but it has not been utilized optimally, as seen from the low ability of students to connect mathematical concepts with everyday life. This condition emphasizes the need for learning innovations that combine Problem-Based Learning with student worksheet and location-based digital media. In addition, the research sample, namely students of class VII A, are at the formal operational stage of thinking according to Piaget, where they begin to be able to think logically and abstractly. This ability is relevant to the problem-based approach, especially in algebraic topics that require an understanding of symbols and variable relations.

School facilities support the use of technology, such as the availability of projectors and computers in some classrooms. Although internet access is limited to the teachers' room, the policy of using cell phones in learning allows the implementation of MathCityMap. This application provides an opportunity for students to learn math through exploration of the surrounding environment, making learning more contextual, active and meaningful.

2. Learning Design

The learning design in this study uses the Problem-Based Learning model packaged in the student worksheet as the main device and assisted by the MathCityMap application. student worksheet serves to guide students to explore mathematical concepts and solve contextual problems actively. The student worksheet is designed to be 12 pages long to be used in four meetings with materials: algebraic forms, algebraic operations (addition, subtraction, multiplication, division), and simplification of algebraic forms. Each material is associated with real problems that can be found in the school environment, with the support of the MathCityMap application to strengthen the contextual approach. The structure of student worksheet consists of introduction (identity, learning outcomes, and objectives), content (core problem-based activities), and closing (reflection and evaluation). Student activities are divided into four meetings, each presenting two activities that integrate mathematical concepts with real situations.

The contextual approach presented in the student worksheet and assisted by MathCitymap on algebra material can be seen in Figure 1.

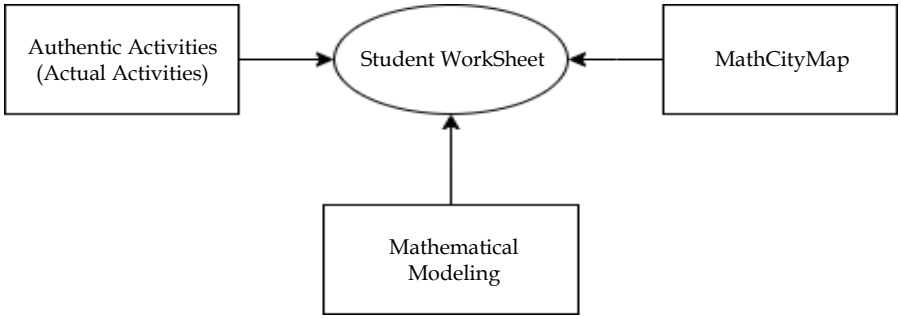



Figure 1. student worksheet component chart

One of the main advantages in this design is the utilization of authentic activities through MathCityMap, where students are invited to observe, measure, and collect data from real objects in the school environment, such as library cabinets, hall windows, and mading boards. These objects are used as a context for mathematical modeling in algebraic form. The mathematical modeling process involves students in formulating real situations into algebraic form, simplifying them, and interpreting the results in the original context. For example, students are asked to calculate the total number of books based on the number of shelves and the number of cabinets, which are represented in the form of variables. This approach strengthens representation, reasoning, and problem-solving skills and connects mathematical symbols with real contextual meaning. The MathCityMap application is used as a digital media that allows teachers to design location-based problems and students to access the problems via cell phones with the help of GPS. After arriving at the designated location, students will solve the problem based on direct observation. This activity encourages active, collaborative learning and strengthens algebraic understanding through meaningful hands-on experience.

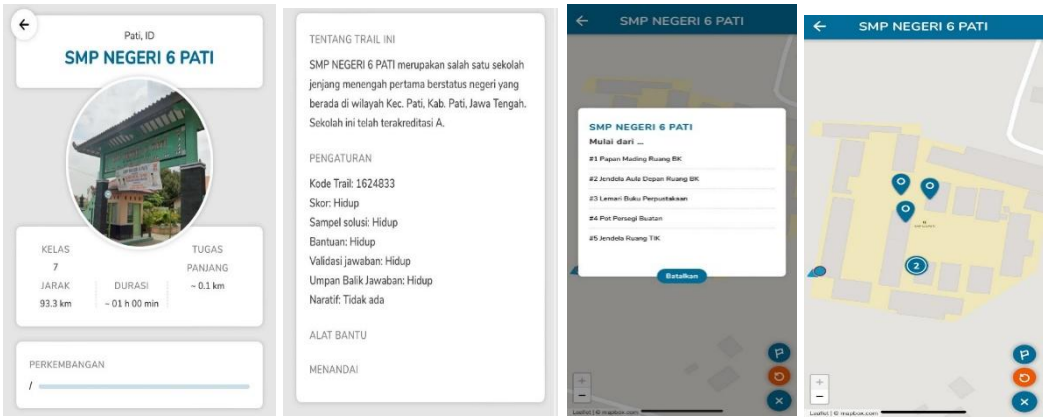



Figure 2. Dashboard display and task location on MathCityMap at SMP Negeri 6 Pati

The closing section of the student worksheet includes reflection and evaluation of learning. Reflection aims to encourage students to think back to the learning experience, while evaluation is used to assess the achievement of

learning objectives. The overall design supports the improvement of students' mathematical literacy through a contextual approach that integrates technology and field activities in a meaningful way.

3. Validity of Learning Tools

Before the learning devices were implemented, formative evaluation was conducted in the form of validation of teaching modules, learning media, and mathematical literacy test questions. Validation was conducted by two validators, namely UNNES Mathematics lecturers as media experts and SMP Negeri 6 Pati teachers as material experts. The media expert was in charge of assessing the device in terms of design and display feasibility, while the material expert evaluated the suitability of learning content with the applicable curriculum. Both validators also assessed the literacy test questions, to ensure the questions were able to measure students' mathematical literacy skills according to the specified indicators. The results of this validation include an assessment of aspects of material, language, appearance, and relevance to real context. The recapitulation of the validation results is presented in Table 2 (teaching module), Table 3 (learning media), and Table 4 (literacy questions).

Table 2. Recapitulation of Teaching Module Validation Results by Media Experts and Material Experts

| Validator | Average | Percentage | Categories and Criteria |
|---|---|---|---|
| Media expert | 4,77 | 95% | Very valid and very good |
| Material expert | 4,23 | 85% | Very valid and very good |

The validation results show that the teaching module is very valid. Media experts gave an average score of 4.77 (95%), while material experts gave 4.23 (85%). The module is considered to be in accordance with the curriculum, with a coherent and systematic learning flow, supporting the improvement of students' mathematical literacy.

Table 3. Recapitulation of Media Validation Results by Media Experts and Material Experts

| Validator | Average | Percentage | Categories and Criteria |
|---|---|---|---|
| Media expert | 4,73 | 95% | Very valid and very good |
| Material expert | 4,6 | 92% | Very valid and very good |

The results of media validation showed that media experts gave an average score of 4.73 (95%) and material experts 4.6 (92%), both of which were categorized as very valid and very good, with minor revisions from media experts.

Table 4. Recapitulation of Literacy Problem Validation Results of Media Experts and Material Experts

| Validator | Average | Percentage | Categories and Criteria |
|---|---|---|---|
| Media expert | 4,8 | 96% | Very valid and very good |
| Material expert | 4,7 | 94% | Very valid and very good |

The results of media validation showed that media experts gave an average score of 4.8 (96%) and material experts 4.7 (94%), both of which were categorized as very valid and very good. The material expert also stated that the literacy questions prepared were in accordance with the learning objectives. Overall, the validation of the teaching modules, media and literacy questions received excellent ratings from both validators. This shows that the learning tools have met the eligibility criteria in terms of content, design and conformity with the curriculum. Thus, the device is declared feasible to be used in an effort to improve students' mathematical literacy.

4. Hypothetical Learning Trajectory (HLT)

   At this stage, researchers conducted a *literature review*, interviews with math teachers, and designed the *Hypothetical Learning Trajectory* (HLT). The HLT starts from the introduction of algebraic forms and their elements as the basis of student understanding, followed by the operations of addition, subtraction, multiplication, and division of algebraic forms, to the simplification stage. The HLT design is then implemented into learning activity with the *Problem-Based Learning* model using student worksheet assisted by *MathCityMap*.

## 1.2 Teaching Experiment

The learning experiment was conducted in class VII A SMP Negeri 6 Pati by applying the Problem-Based Learning model using student worksheet assisted by MathCityMap application. Before learning begins, students are given a pre-test to measure their initial ability to solve mathematical literacy problems based on algebraic material.

Table 5. Statistical Data of Student Pre-Test Values

| Darfta Student Pre-test Value Before Learning with Problem-Based Learning using student worksheet assisted by MathCityMap application | |
|---|---|
| Number of Students | 29 |
| Highest Score | 72 |
| Lowest Score | 30 |
| Average | 51 |

The pre-test results show that the average student score is 51, with the highest score of 72, which indicates that students' mathematical literacy is still low. Learning begins with the first meeting student worksheet which focuses on introducing

algebraic forms and their elements through the context of everyday life. The activities are done individually and aim to train students to translate real situations into algebraic form and build conceptual understanding through symbolic modeling activities.

In the second and third meetings, students are divided into groups and start using the MathCityMap application to solve location-based problems. Learning is focused on the operations of addition, subtraction, multiplication, and division of linear algebraic forms. Students explore certain points in the school environment, read problems through the application, and solve problems by representing them in algebraic form directly in the student worksheet.

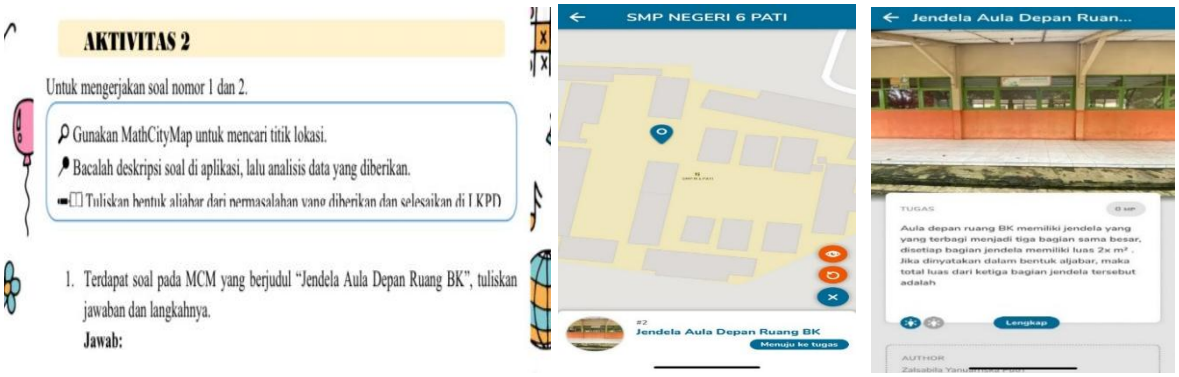



Figure 3. Problem Location Display of MathCityMap Application student worksheets

The fourth meeting focused on simplifying algebraic forms in contextual problems. Despite technical constraints such as weather and time constraints, all activities in the student worksheet and the use of MathCityMap can run well. Students' activities were observed using an observation sheet to assess their engagement and mathematical thinking process. After the whole series of learning was completed, students were given a post-test to measure the improvement of mathematical literacy. The post-test results showed significant improvement, with the highest score of 98 and an average of 86.7, indicating that the learning was successful in significantly improving students' mathematical literacy.

Table 6: Statistical data of students' post-test scores

| Darfta Students' Post-test Value after Learning Activity with Problem-Based Learning using student worksheet assisted by MathCityMap application | |
|---|---|
| Number of students | 29 |
| Highest Score | 98 |
| Lowest Score | 70 |
| Average | 86,7 |

## 1.3 Retrospective Analysis

Retrospective analysis was conducted to evaluate the suitability between learning design and implementation, as well as to see the development of students' mathematical literacy before and after the application of student worksheet assisted by *MathCityMap* application.

1. Mathematics Learning Activities using student worksheet assisted by MathCityMap application

   Learning is carried out in accordance with the Hypothetical Learning Trajectory (HLT) that has been designed, and observed through documentation and observation sheets. In the first meeting, students learned to recognize algebraic forms and their elements individually through student worksheet. With scaffolding from the researcher, students were able to identify variables, coefficients, constants, and compose algebraic forms according to the context of the problem. Most students showed good initial understanding and were able to solve problems logically.


Apakah anda bisa menuliskan pernyataan ini dalam bentuk ekspresi matematika?

| No | Banyaknya kelereng | Bentuk Aljabar |
|---|---|---|
| 1 | 3 kelereng | 3 |
| 2 | 1 keranjang kelereng | $x$ |
| 3 | 2 keranjang kelereng | $x + x$ atau $2x$ |
| 4 | 4 keranjang kelereng dan 3 kelereng | $4x + 3$ |
| 5 | 1 plastik kelereng | $y$ |
| 6 | 1 keranjang kelereng dan 2 plastik kelereng | $x + 2y$ |
| 7 | 3 keranjang kelereng, 2 plastik kelereng, dan 7 kelereng | $3x + 2y + 7$ |
| 8 | 2 plastik kelereng dan 3 kelereng | $2y + 3$ |
| 9 | 7 keranjang kelereng, 3 plastik kelereng, dan 9 kelereng | $7x + 3y + 9$ |

3. Seorang siswa membeli 3 batang pensil dan 5 buah buku. Keesokan harinya, ia membeli lagi 10 buku. Jika x dan y berturut-turut menyatakan harga pensil dan harga buku, maka bentuk aljabar yang tepat untuk merepresentasikan pengeluaran siswa tersebut.

Jawab:

Memahami masalah:
- Seorang siswa membeli 3 batang pensil dan 5 buah buku
- Keesokan harinya, ia membeli lagi 10 buku

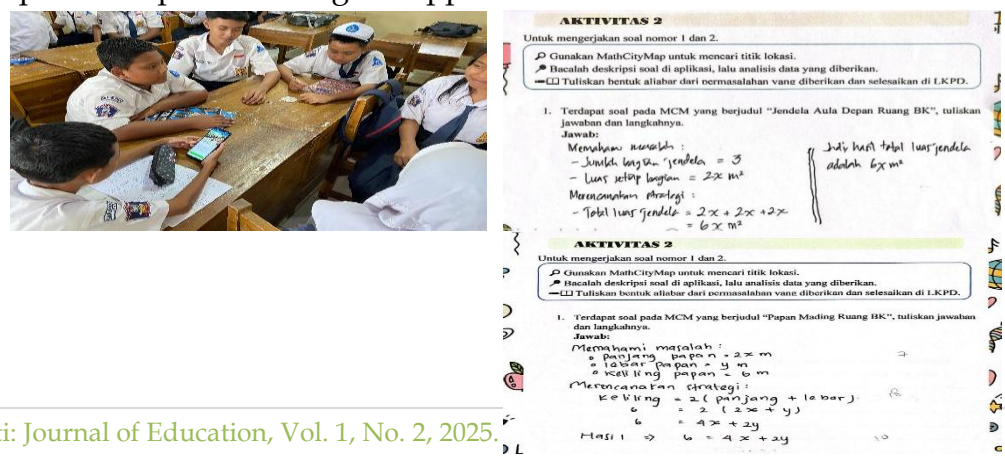
Merencanakan strategi:
- Total pensil: $3x$
- Total buku: $5y + 10y$

Menuliskan hasil dalam bentuk aljabar:

Jadi, bentuk aljabar total perhitungan buku dan pensil siswa tersebut adalah: $3x + 5y + 10y = 3x + 15y$

Figure 4. Activity and Results of Student Work at the First Meeting

The second and third meetings focused on the operations of addition, subtraction, multiplication, and division of algebraic forms with the help of the *MathCityMap* application. Students work in groups, solving contextual problems based on location in the school environment. Students show an increased ability to translate real situations into algebraic models, organize solution steps systematically, and apply algebraic operations appropriately. Students' enthusiasm, cooperation, and independence also increased during the exploration process using the application.


AKTIVITAS 2

Untuk mengerjakan soal nomor 1 dan 2.

Gunakan MathCityMap untuk mencari titik lokasi.
Bacalah deskripsi soal di aplikasi, lalu analisis data yang diberikan.
Tuliskan bentuk aljabar dari permasalahan yang diberikan dan selesaikan di LKPD.

1. Terdapat soal pada MCM yang berjudul "Jendela Aula Depan Ruang BK", tuliskan jawaban dan langkahnya.

Jawab:

Memahami masalah:
- Jumlah lingkaran jendela = 3
- Luas setiap lingkaran = $2x$ m²

Merencanakan strategi:
- Total luas jendela = $2x + 2x + 2x$ = $6x$ m²

Jadi, hasil total luas jendela adalah $6x$ m²

AKTIVITAS 2

Untuk mengerjakan soal nomor 1 dan 2.

Gunakan MathCityMap untuk mencari titik lokasi.
Bacalah deskripsi soal di aplikasi, lalu analisis data yang diberikan.
Tuliskan bentuk aljabar dari permasalahan yang diberikan dan selesaikan di LKPD.

1. Terdapat soal pada MCM yang berjudul "Papan Mading Ruang BK", tuliskan jawaban dan langkahnya.

Jawab:

Memahami masalah:
- panjang papan = $2x$ m
- lebar papan = $y$ m
- keliling papan = 6 m

Merencanakan strategi:
Keliling = 2 (panjang + lebar)
6 = 2 ($2x + y$)
6 = $4x + 2y$
Hasil ⇒ 6 = $4x + 2y$

Figure 5: Activities and Results of Student Work in the Second and Third Meetings

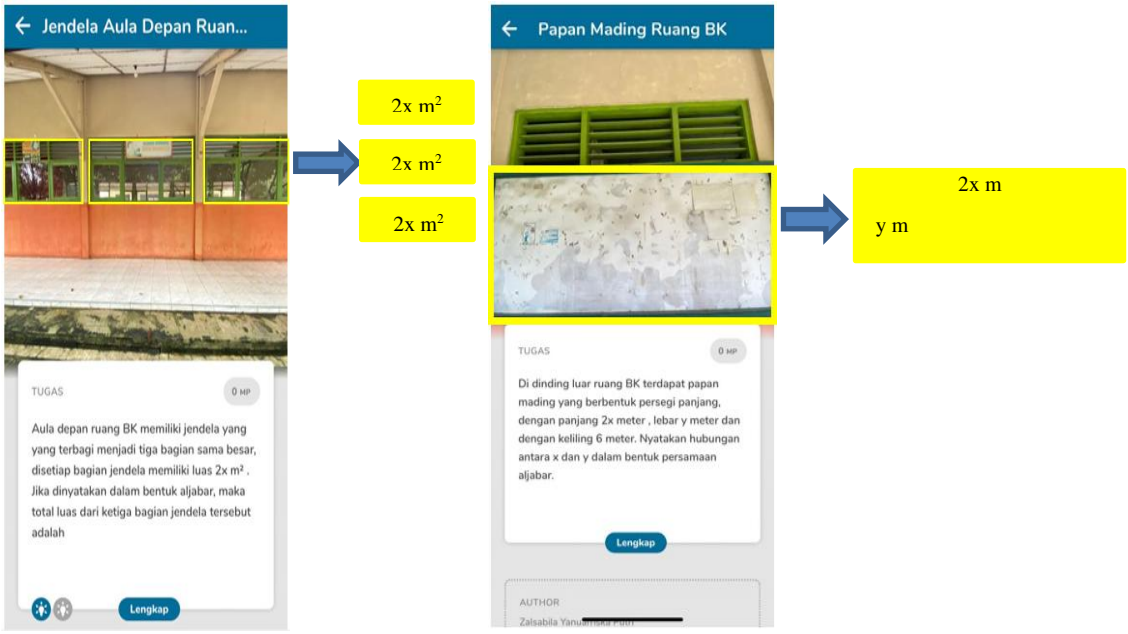



Figure 6. Contextual Objects in MathCityMap that Relate to Algebra

In the fourth meeting, students solve contextual problems that focus on simplifying algebraic forms. Without the help of the app, students worked on the student worksheet individually with results that showed a better understanding of the solution strategy and the use of the properties of arithmetic operations. Although some students still need guidance, most have been able to compose algebraic forms and simplify independently and appropriately. Overall, the learning implementation went according to the design, and the data from the student worksheets showed that students' mathematical literacy had improved, both in terms of concept understanding and the ability to solve contextual problems in a logical and structured manner.

2. Student Mathematical Literacy Test

The mathematical literacy test instrument used was validated by UNNES Mathematics lecturers and SMP Negeri 6 Pati teachers to ensure the feasibility of the content and quality of the questions. Tests of the questions showed valid, reliable results, with difficulty levels in the easy to moderate categories, and sufficient to very good differentiating power. After revision, the

instrument is ready to be used to measure students' mathematical literacy before and after learning activity with the Problem-Based Learning model using student worksheet assisted by MathCityMap application. The normality test was conducted using Shapiro-Wilk because the number of samples < 30. The results showed a pre-test significance value of 0.220 and post-test of 0.207 (p> 0.05), so the data were normally distributed and qualified for parametric analysis.

Table 7. Normality Test Table

**Tests of Normality**

| | Kolmogorov-Smirnov [a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Pretest Literacy | ,100 | 29 | ,200* | ,953 | 29 | ,220 |
| Literacy PostTest | ,129 | 29 | ,200* | ,952 | 29 | ,207 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Hypothesis testing using Paired Sample T-Test to determine the average difference in pre-test and post-test scores. The analysis results show a significance value of 0.000 <0.05, so there is a significant difference between students' mathematical literacy before and after learning activity with *Problem-Based Learning* using student worksheet assisted by MathCityMap.

Table 8. Hypothesis Test Table

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Literacy Pretest - Literacy PostTest | -35,655 | 11,766 | 2,185 | -40,131 | -31,179 | -16,318 | 28 | ,000 |

The N-Gain test was used to determine the improvement of students' literacy. The results of data processing show the average N-Gain score of 0.73 which is in the high category. From the classification, 17 students experienced

high improvement, and 11 students in the medium category. This finding shows that learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap can significantly improve students' mathematical literacy.

Table 9. N-Gaim Test Table

| N-Gain Test | Pretest | Posttest | Post-Pre | 100-Pre | N-Gain Score | (%) N-Gain Score | Category |
|---|---|---|---|---|---|---|---|
| MEAN | 50,97 | 86,69 | 35,72 | 49,03 | 0,73 | 73% | High |

## 1.4 Discussion

This discussion answers the problem formulation regarding learning design with *Problem-Based Learning* using student worksheet assisted by *MathCityMap* to improve students' mathematical literacy. Student worksheet is designed in four meetings with structured activities based on algebraic form material, addition-subtraction operations, multiplication-division, to simplification, which is associated with a real context using *MathCityMap* as a location-based supporting media.

In the first meeting, students are introduced to the concept of algebraic form and its elements through simple contextual activities. Learning has not used *MathCityMap*, but focused on the initial understanding of the concepts of variables, coefficients, and terms. This activity is in line with Widjajanti (2015), who states that the real context helps students understand the symbolic structure of algebra meaningfully. Hasibuan & Surya (2017) also emphasized that contextualized student worksheet encourages active student involvement and strengthens understanding of basic concepts. In the second meeting, students learn the operations of addition and subtraction of algebraic forms through collaborative activities and location-based exploration using *MathCityMap*. Students solve story problems and model them into algebraic form. Zender & Ludwig (2021) mentioned that *MathCityMap* connects real objects with mathematical symbols to improve modeling skills. In addition, Erbas & Yenmez (2011) state that group work encourages mathematical discussion and systematic thinking. This is in line with OECD (2019) which emphasizes the importance of data-based decision-making in real contexts.

The third meeting discussed the operations of multiplication and division of algebraic forms. Activities were conducted inside and outside the classroom, linking contextual problems to specific locations in the school. Ludwig & Zender (2020) state that *MathCityMap* helps students relate abstract concepts to real situations. Wijaya (2012) also emphasized that the realistic approach encourages stronger algebraic representations. Fischer et al. (2022) added that exploration-

based learning increases student motivation and engagement. In the fourth meeting, students learn the simplification of algebraic forms through story problems that are done manually. This activity strengthens the understanding of algebraic structures and properties of operations, without the help of applications. According to NCTM (2000), this activity strengthens representation and modeling in mathematical literacy. Kieran (2007) emphasizes the importance of context-based simplification so that students understand the logic behind combining like terms and using coefficients.

Overall, the learning design with *Problem-Based Learning* using student worksheet assisted by *MathCityMap* has been implemented as planned and shows the ability to improve students' mathematical literacy, especially in terms of modeling, representation, and solving real context-based problems.

1. Validity of Learning activity with Problem-Based Learning Using MathcityMap-assisted student worksheets

   The validation process is carried out to assess the feasibility of *Problem-Based Learning* tools using *MathCityMap-assisted* student worksheet. Validation was conducted by two validators, namely UNNES Mathematics lecturers (media experts) and SMP Negeri 6 Pati teachers (material experts), on three main components: teaching modules, learning media, and mathematical literacy test questions. The validation results showed that all components were declared **very valid and very good** by both validators. This assessment shows that the device has met the eligibility standards in terms of content, design, and conformity with the curriculum, so it is suitable for use in learning. This finding is in line with Yulianti et al. (2018), who stated that devices that received high validation from material and media experts have met pedagogical principles and relevant mathematical content. The same thing was also conveyed by Nurhayati & Handayani (2020), that a well-validated device can be implemented to support the achievement of learning objectives.
2. Improvement of Students' Mathematical Literacy

   This research was conducted in one experimental class, namely class VII A SMP Negeri 6 Pati consisting of 29 students. Students were given a pre-test before learning and a post-test after learning using the *Problem-Based Learning* model with student worksheet assisted by the *MathCityMap* application. The pre-test aims to determine students' initial understanding, while the post-test is to measure the results after learning. The analysis begins with a normality test using Shapiro-Wilk, which shows that the pre-test and post-test data are normally distributed (Sig. pre-test= 0,220 and post-test= 0,207 $>$ 0,05). Next, hypothesis testing was conducted using *Paired Samples T-Test,* which showed a significance value of $0{,}000 < 0{,}05$ . This means there is a significant difference between students' mathematical literacy before and after using

Problem-Based Learning using student worksheet assisted by MathCityMap. For more details on the results of the hypothesis test, see Table 8. To determine the level of improvement, the N-Gain test was conducted which resulted in an average of 0.73 (high category). A total of 17 students were included in the classification of high improvement, and 12 students in the medium category.

This finding shows that learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap can improve students' mathematical literacy with a high classification. This is in line with Pratiwi & Ramdhani (2017), who stated that Problem-Based Learning can significantly improve mathematical literacy compared to conventional learning. The use of technology such as *MathCityMap* in the Problem-Based Learning model also encourages an active, creative, and fun learning atmosphere, and increases students' motivation and achievement in mathematics learning (Puspitasari et al., 2022; Purwanto et al., 2016). Sirajuddin et al. (2023) emphasized that the integration of digital applications in Problem-Based Learning has a positive impact on learning outcomes. In addition, Wahyuningsih et al. (2023) also proved that Problem-Based Learning with *MathCityMap* can improve mathematical literacy through *math trails* activities.

## Closing

Based on the results of this study, it can be concluded that learning with the Problem-Based Learning model through the main tool in the form of LKPD assisted by MathCityMap has been successfully designed. This means that the design of learning tools with Problem-Based Learning using LKPD assisted by MathCityMap that has been applied in the learning process in the classroom has been successful in improving students' mathematical literacy. This success is supported by two main findings, namely:

1. Learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap is declared valid based on the results of the assessment by material, media, and learning evaluation experts, so it is feasible to use to support the improvement of students' mathematical literacy.
2. Learning activity with Problem-Based Learning using student worksheet assisted by MathCityMap is proven to improve students' mathematical literacy, especially in understanding and solving contextual problems.

## Suggestion

Based on the research results that have been obtained, the researchers suggest the following.

1. The Problem-Based Learning model using MathCityMap-assisted student worksheets should not only be applied to one subject, but also developed for

various other mathematics subjects by adjusting to the characteristics of students, the curriculum, and school conditions, so that it can be widely implemented in various educational units.

2. Teachers are advised to integrate problem-based learning activity with MathCityMap regularly in teaching and learning activities to create more interactive, contextual, and fun learning.
3. Student worksheet with MathCityMap is expected to continue to be refined so that it can maximally encourage student involvement in solving contextual mathematical problems, so that students' mathematical literacy can develop optimally.

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Zalsabila Yanuarriska Putri was born on January 25, 2003 in Pati. The author studied at SDN Semampir (2009-2015), SMPN 4 Pati (2015-2018), SMAN 3 Pati (2018-2021). The author continued her studies in the Mathematics Education Program, Faculty of Mathematics and Natural Sciences, State University of Semarang (UNNES). During her education, the author was active in various organizational activities and self-development programs. In 2022, the author became a staff of Infocom Department of Mathematics English Club (MEC), with roles as Secretary of English Class, Treasurer of MEC's Trial 2022, Coordinator of Kestari Rehearsal, and Coordinator of PDD Sie MEC's Timeline 2022. In addition, the author participated in the Batch 7 Merdeka Campus Internship program from February to June 2024 through the Teaching Campus program at SMP Negeri 6 Pati. In this program, the author is involved in teaching and learning activities, assisting the implementation of the Merdeka Belajar program, documenting activities, supporting technology adaptation, and assisting school administration.

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