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Boosting Students' Mathematical Problem-Solving Skills with PBL-Based LiveWorksheets: Focus on Whole Numbers and Fractions Topic

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Abstract. Problem-solving skills is one of the important skills that students must master through learning mathematics. One alternative to improve students' mathematical problem-solving skills is using the Problem-based Learning (PBL) learning model combined with technology-based learning media. This research aims to produce PBL-based electronic student worksheets (e-worksheets) on the topic of whole numbers and fractions that are valid, practical and effective to improve students' mathematical problem-solving skills. The development of e-worksheets uses a 4D development model involving seventh-grade students from one of the junior high schools in Rokan Hulu, Riau, Indonesia as field test subjects. The results of data analysis show that the e-worksheet developed using LiveWorksheet application has met the valid criteria based on experts judgement and practical based on the practicality questionnaires. E-worksheets have also been proven effective in improving students' mathematical problem-solving skills with an average N-gain at high criteria.

Keywords: E-Worksheet; MPSS; Problem-based Learning; Whole Numbers and Fractions

Abstrak. Kemampuan pemecahan masalah merupakan salah satu kemampuan penting yang harus dikuasai siswa melalui pembelajaran matematika. Salah satu alternatif untuk meningkatkan kemampuan pemecahan masalah matematis siswa adalah dengan menggunakan model pembelajaran Problem-based Learning (PBL) yang dipadukan dengan media pembelajaran berbasis teknologi. Penelitian ini bertujuan untuk menghasilkan lembar kerja peserta didik elektronik (e-LKPD) berbasis PBL pada topik bilangan bulat dan pecahan yang valid, praktis dan efektif untuk meningkatkan kemampuan pemecahan masalah matematis siswa. Pengembangan e-worksheets menggunakan model pengembangan 4D yang melibatkan siswa kelas VII salah satu SMP di Rokan Hulu, Riau, Indonesia sebagai subjek uji coba. Hasil analisis data menunjukkan bahwa e-LKPD yang dikembangkan dengan aplikasi LiveWorksheet telah memenuhi kriteria valid berdasarkan penilaian ahli dan praktis berdasarkan angket kepraktisan. E-LKPDjuga terbukti efektif meningkatkan kemampuan pemecahan masalah matematis siswa dengan rata-rata N-gain pada kriteria tinggi.

Kata kunci: Bilangan Bulat dan Pecahan; LKPD Elektronik; Kemampuan Pemecahan Masalah Matematis; Problem-based Learning

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INTRODUCTION

Problem-solving skills are very important in learning mathematics, with good problem-solving skills it is expected that students can understand a real problem well, transfer basic mathematical knowledge easily, and understand concepts in solving everyday mathematical problems (Sumartini, 2016). Problem-solving skills is one of the learning objectives of mathematics. Therefore, problem-solving skills in mathematics is said to be one of the skills that must be possessed by students because by having problem-solving skills, students can see the relevance between mathematics and real life.

The reality found in the field shows that the mathematical problem-solving skills (MPSS) mastered by students are still relatively low. This can be seen from previous research which shows that students still have difficulty in solving and understanding story problems with contextual substance, incorrectly determining the solution steps used as a strategy to solve problems (Samosir et al., 2024). In line with the above, the factor causing the low problem-solving skills of students is because students are not accustomed to doing the problem-solving process correctly (Dwianjani et al., 2018). Learners cannot model equations related to arithmetic operations and after writing the answer to the calculation, do not interpret the answer they get from the calculation results (Rio & Pujiastuti, 2020; Damayanti & Kartini, 2022).

Seeing the low MPSS of students, teachers must improve it, taking into account the characteristics of students and learning objectives. In the implementation of this research, a suitable learning model that can optimize students' MPSS is needed. One of the recommended learning models in Curriculum 2013 is problem-based learning (PBL). PBL is a student-centered learning model that empowers students to conduct research/discovery, integrate theories, and apply knowledge and skills to develop the right solution to a predetermined problem (Khoeriah et al., 2024). Some previous studies stated that the PBL model improved problem-solving skills (Hasriyani et al., 2022), and had a positive effect on mathematics learning (Nay & Rudhito, 2020; Suprihatin, 2022). Based on what has been described, it shows that the PBL model is effective in improving students' MPSS.

PBL is a learning model that uses real-world problems as a context for students to learn about problem-solving skills, as well as to gain essential knowledge and concepts from the subject matter (Nurfitriyanti, 2016). The PBL model has five stages, namely orienting students to the problem, organizing students to learn, guiding individual/group experience, developing and presenting work, and analyzing and evaluating the problem-solving process so that it can train students' MPSS (Sofyan & Komariah, 2016).

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One of the characteristics of PBL is that it emphasizes problems and learner activities and fosters problem-solving skills through various activities carried out. According to Lestari & Afriansyah (2021), efforts can be made by using teaching materials, one of which is student worksheets because it can improve MPSS. Based on the initial study, it was found that student worksheets used in schools generally only contains knowledge competencies and does not include indicators of mathematical problem-solving skills in learning materials at school. Student worksheets used in the mathematics learning process focuses on achieving knowledge competencies, while mathematical problem-solving skills are still not included.

For students to have mathematical problem-solving skills in the mathematics learning process, one effort that can be made is to prepare student worksheets by the stages of mathematical problem-solving skills indicators. Conventional student worksheets in the form of paper sheets has several limitations. These limitations include space and time limitations, requiring large costs, and the material presented is limited to descriptive text only. Meanwhile, the results of research by Adawiyah et al. (2021) show that problems in the PBL model are more effective if presented in the form of images, animations, or videos to improve students' MPSS than in text form. In this study, the student worksheets developed was electronic student worksheets or e-worksheets. This is because using e-worksheets can encourage students to be actively involved in the learning process and make it easier for students to use it (Hendriani & Gusteti, 2021).

E-worksheets is a student worksheet done digitally and systematically. E-worksheets can be accessed anytime and anywhere by students using the electronic devices they have. The advantages of using e-worksheets are saving space, time, and costs, allowing users to mark important things, being environmentally friendly, and always available at all times (Zaini & Kapsul, 2023). E-worksheets is a teaching material that is packaged so that students can study the material independently it makes students more active in solving existing problems through activities to solve problems related to everyday life. In this study, the development of e-worksheets uses liveworksheet. Liveworksheet is a website that utilizes new technology that can be applied to the world of education because it can produce images, text, videos, and even produce voice/audio messages. E-worksheets with Liveworksheets can provide learning variations to students so that learning is not boring and encourage students to be active in learning (Rosyidah et al., 2022). E-worksheets using Liveworksheets can be designed by the teacher to facilitate students' problem-solving skills.

The material of integers and fractions is one of the materials studied at the junior high school level. However, there are still many students who have difficulty solving problems and solving this material. Previous research conducted by Lahinda & Jailani (2015) and Mulyati (2016) found that the ability to solve mathematical problems in whole numbers and fractions was still low. The cause

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of the low mathematical problem-solving skills in this material is that students are not used to solving problems related to problems in everyday life. Research conducted by Febrianto et al. (2023) said that the cause of the lack of mastery of students in the material studied will make difficulties or mistakes continuously. This is because students are not used to working on maths problems in the form of description questions or story problems. In line with Rahayu & Aini (2020) also stated, that there are still many students experiencing difficulties in solving mathematical story problems, including difficulty understanding the main content of the story and misunderstanding the meaning of the problem so they often make mistakes. From some of these opinions, it can be concluded that whole numbers and fractions are among the materials that are difficult for students to understand.

The developed e-worksheets can function well in learning, so e-worksheets must be valid, practical and effective. According to Putra et al. (2018) learning has good quality if the device is valid, practical and effective. The developed e-worksheets must have a good level of validity so that the developed product can be used properly in the learning process. In addition, the level of practicality of e-worksheets also needs to be considered. Practicality is the ease of the product produced when used. Furthermore, the effectiveness referred to by the researcher is a condition that shows the extent to which the development of e-worksheets can be achieved. The development of e-worksheets can be said to be effective when it is able to provide influence or change in students' learning abilities. Based on the explanation above, the development of PBL-based e-worksheets is expected to be able to meet the criteria of validity, practicality, and effectiveness of the stages of developing a product.

METHOD

This type of research is research and development (R&D) using the 4D model (define, design, develop, and disseminate) (Maksum et al., 2024). In this study, the *define* stage consists of preliminary analysis; learner analysis, concept analysis, task analysis and formulation of learning objectives; the *design* stage consists of preparation of standard tests, media selection, format selection and initial design. Then at the *develop* stage consists of expert review, developmental testing and the last stage is disseminate.

This research was conducted at junior high school in Rokan Hulu, Riau, that involved 25 seventh-grade students. Sampling in this study used a purposive sampling technique, which is a sampling technique with certain considerations (Sugiyono, 2016). Data collection techniques consist of interviews, observations, tests, and questionnaires. In this study, several research instruments were used, namely validation sheets containing components contained in the e-worksheets developed according to the PBL model. This instrument is used to obtain data on the

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level of validity of the e-worksheets developed. The grid of the student worksheets validation sheet can be seen in Table 1.

Table 1. Grid of e-Worksheets Validation Sheet

Aspect	Indicator	Number of Items
Face validity	Feasibility of Presentation	4
	Feasibility of graphics	5
	Accuracy of word selection and language used	5
Conten validity	Suitability of e-worksheets with Material	8
Construct validity	Suitability of e-worksheets with PBL Steps	6
	Suitability of e-worksheets with MPSS	4
Total		32

The practicality sheet is in the form of a student response questionnaire, namely questions or statements answered by students. The response questionnaire that will be evaluated is used to determine students' responses related to the e-worksheets that was developed. The outline of the student response questionnaire that the researcher used in this study can be seen in Table 2.

Table 2. Outline of Student Response Questionnaire

Aspect	Number of Items
Presentation of e-worksheets	5
Ease of use of e-worksheets	4
Readability of e-worksheets	3
Time of use of e-worksheets	1
Total	13

The effectiveness sheet is in the form of student MPSS questions. The MPSS test are a tool to determine the MPSS of students before and after learning using the developed e-worksheets. The form of questions given is in the form of descriptive questions arranged based on MPSS indicators. The MPSS test questions in this study are in the form of pretest and posttest questions. The effectiveness instrument is used to see the impact of using e-worksheets obtained from the results of the MPSS test. The MPSS test uses an instrument consisting of 6 descriptive questions.

After obtaining the calculation results from the validation questionnaire and the practicality test questionnaire, the results are categorized according to the criteria listed in Tables 3 and 4.

Table 3. Validity Criteria (Akbar, 2013)

Interval	Validity Level
85,01% − 100%	Very valid, or can be used without revision
70,01%− 85%	Valid, or can be used but needs minor revisions
50,01% − 70%	Less valid recommended not to be used because it needs major revisions
0,1% − 50%	Not valid or should not be used

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Based on Table 1, the e-worksheets is said to be valid if the average validation is in the interval 70.01% - 100.00% and is categorized as valid or very valid.

Table 4. Practicality Criteria (Akbar, 2013)

Interval	Practicality Level
85,01% − 100%	Very practical
70,01% − 85%	Practical
50,01% − 70%	Less practical
0,1% − 50%	Not practical

E-worksheets is said to be practical if the average results of the learner response questionnaire are in the interval 70.01% - 100.00% and are categorized as practical or very practical. Furthermore, the magnitude of the increase in problem-solving skills test results was analyzed using the normalized gain formula with the following criteria.

Table 5. N-Gain score criteria (Arafah et al., 2023)

N-Gain Value	Practicality Level
N-Gain ≥ 0,70	High
0,30 < N-Gain < 0,70	Medium
N-Gain ≤ 0,3	Low

E-worksheets is said to be effective if the N-Gain is more than 0.3 with medium or high criteria (Firmansyah & Masriyah, 2024). The indicator of the success of effective treatment is if the learning outcomes after treatment are better than before treatment.

RESULTS AND DISCUSSION

Define

Based on the *front-end analysis*, it was found that the students' MPSS was still low, especially in the material of whole numbers and fractions, the teacher only used exercises in the package book and worksheets distributed by the publisher, but the worksheets used had not been adapted to the characteristics of students and learning was still teacher-centered. Furthermore, from the *learner analysis* activities, it was found that the age range of grade VII students was between 12 to 13 years. This is according to Piaget (in Arafah et al., 2023)), these students are already at the formal operation stage, thus they can engage in the problem-solving process in the classroom.

Furthermore, *concept analysis* was conducted to identify the material of whole numbers and fractions. This material is adjusted to the 2013 curriculum, namely whole numbers and fractions with the subject matter of addition and subtraction of whole numbers, multiplication and division of whole numbers, addition and subtraction of fractions, and multiplication and division of fractions. Furthermore, *task analysis* is carried out, namely, this analysis can be in the form of tasks

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that lead to MPSS so that the achievement indicators are maximized. Then determine *the specifying instructional objectives*. What is done is to describe the learning objectives by the results of task and concept analysis.

Design

At this stage, the preparation of standard tests (*Constructing Criterion-Referenced Test*) is carried out, namely compiling instruments used for validity, practicality, and effectiveness of e-worksheets. *Media selection* uses electronic media, namely Chromebooks provided by the school. The site used to create e-worksheets is Liveworksheets. *Format selection* in the development of e-worksheets is adjusted to the steps of the PBL model. The format made for e-worksheets consists of cover, content consisting of PBL model stages and MPSS indicators, and practice questions. Furthermore, the *initial design* makes the initial format of the product in the form of PBL-based e-worksheets on whole numbers and fractions. Then, the design of the e-worksheets user manual is prepared to assist teachers in using e-worksheets based on the PBL model to improve students' MPSS.

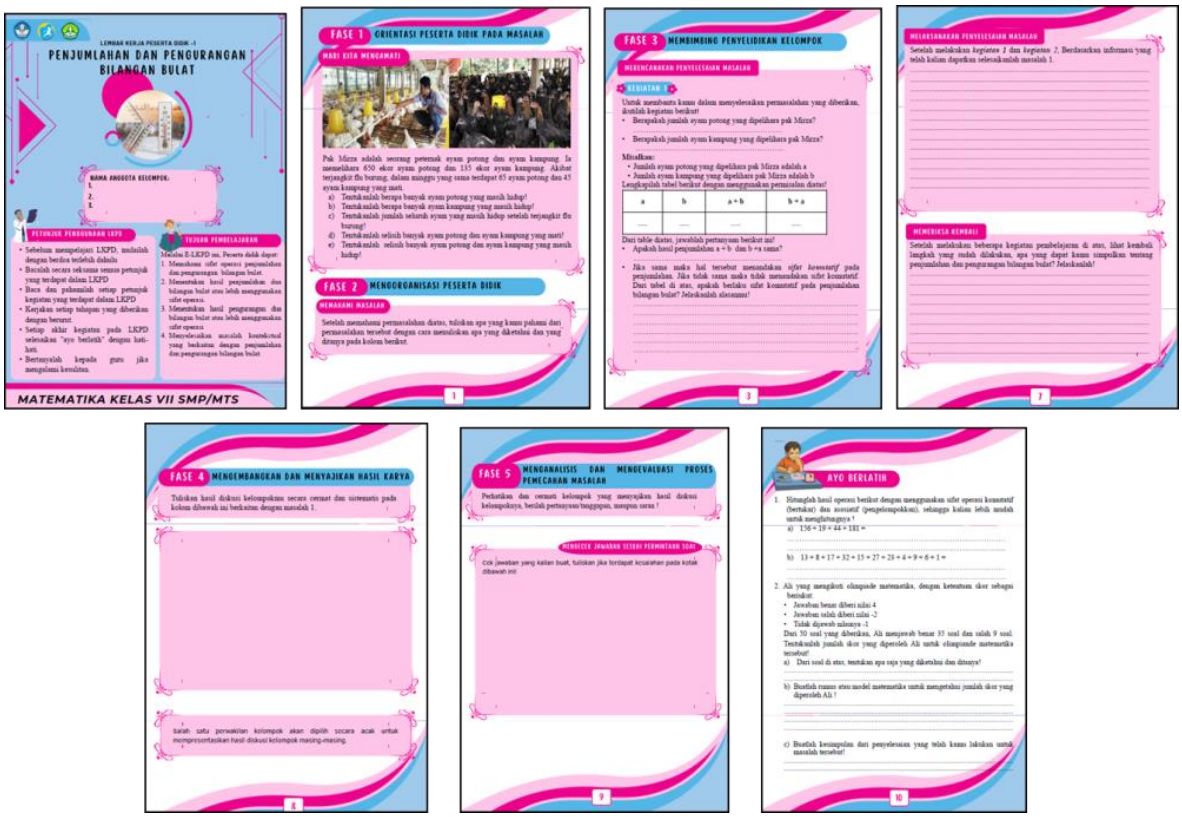

Figure 1. Initial Design

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Develop

At this stage an *expert review* is carried out where the e-worksheets of whole numbers and fractions that have been designed are validated by three validators. The following in Table 6 are the results of the validation

Table 6. E-Worksheets Validation Results

Aspect	Indicator	Average percentage				Average	Description
		1	2	3	4		
Face Validity	Presentation feasibility	91,67	89,58	87,50	91,67	90,11	Very Valid
	Graphical feasibility	80	80	85,00	86,67	82,92	Very Valid
	Accuracy of word choice and language used	78,33	81,67	80	86,67	81,67	Very Valid
Conten Validity	The suitability of e-worksheets with the material	87,5	84,37	87,5	88,54	86,98	Very Valid
Construct Validity	The suitability of e-worksheets with the steps of PBL model	84,72	84,72	84,72	91,67	86,46	Very Valid
	Conformity of e-worksheets with MPSS	87,5	89,58	89,58	91,67	89,58	Very Valid
	Overall average	84,95	84,99	85,72	89,48	86,28	Very Valid

Based on Table 6 obtained the average percentage of the assessment given by the three validators for the four e-worksheets is 86.28%. From the results of the average percentage, it can be concluded that the four e-worksheets have a very valid status. The suggestions and revisions from the validators are regarding errors in writing, such as not combining uppercase and lowercase letters in one sentence, improper use of punctuation, use of images that must be relevant to everyday life, use of ambiguous words, and errors in writing fraction symbols. After being revised according to the validator's suggestions.

Furthermore, a *one-to-one evaluation* was conducted in class VII with the subject of 3 students with different cognitive abilities, namely 1 person with low ability, 1 person with medium ability, and 1 person with high ability. The purpose of this stage is to test the readability of the e-worksheets. The results showed that there were no words or sentences that needed to be revised The following in Table 7 are the results *small group*.

Table 7. Small Group Trial Results

Aspect	Average Percentage of e-worksheets to				Average	Description
	1	2	3	4		
Presentation of e-worksheets	84	84,67	85,33	82	84,00	Very Practical
Ease of use of e-worksheets	82,67	85	84,67	86	84,59	Very Practical
Readability of e-worksheets	80	85,33	86,67	86,67	84,67	Very Practical
Time in using e-worksheets	76,67	80	83,33	83,33	80,83	Very Practical
Average	80,84	83,75	85	84,50	83,52	Very Practical

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Based on Table 7, it is found that the overall average assessment of the student's response questionnaire on the practicality of e-worksheets is 83.52, meaning that the e-worksheets developed includes the criteria "very practical" used by students. This is in line with the opinion of Akbar (2013), that e-worksheets will be said to be practical if the average results of the learner response questionnaire are in the interval 70.01%-100% and in the practical or very practical category. Rechecking of the developed learning e-worksheets was carried out again to find out whether there were still errors in typing or ambiguous words so that the developed e-worksheets were effective and practical to use. The e-worksheets was revised at *the small group trial* stage, and then tested in *the field test* to see the practicality and effectiveness of the learning products developed.

The field test was conducted of seventh-grade students of a junior high school in Rokan Hulu, Riau, Indonesia. At the beginning of learning, a *pretest* was given to determine the initial ability of students' mathematical problem-solving. Furthermore, students in the learning process used e-worksheets based on PBL for four meetings. The activities carried out before the implementation of learning are students working on questions for the pretest. The pretest is carried out to determine the mathematical problem-solving skills of students before learning using PBL-based e-worksheets. After learning using PBL-based e-worksheets. Students are given a response questionnaire to determine the practicality of e-worksheets for each meeting. The last step after the four meetings are completed, then students work on the posttest questions. This test aims to assess the quality of the e-worksheets used in terms of effectiveness.

At each meeting, the researcher distributed e-worksheets and response questionnaires to each student. Then at the end of learning, a *posttest* was given to test the improvement of students' mathematical problem-solving skills. The results of the students' response questionnaire to the practicality of e-worksheets in the field test can be seen in Table 8.

Table 8. *Field Test* Results

Aspect	Average Percentage of E-Worksheets to				Average	Description
	1	2	3	4		
Presentation of e-worksheets	82,72	83,04	81,6	82,56	82,48	Very Practical
Ease of use of e-worksheets	82,6	82,8	83,6	81,4	82,60	Very Practical
Readability of e-worksheets	82,4	85,07	81,33	82,93	82,93	Very Practical
Time in using e-worksheets	83,2	82,4	81,6	83,2	82,60	Very Practical
Average	82,73	83,33	82,03	82,52	82,65	Very Practical

Based on Table 8, the overall average assessment of the student's response questionnaire on the practicality of e-worksheets is 82.65, meaning that the e-worksheets developed is "very practical" to be used by students.

Then at the end of the learning, a *posttest* was given with 6 questions about the description of the mathematical problem-solving skills test. The mathematical problem-solving skills test was

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conducted once at the beginning before the learning activity began which is called the pre-test and once at the end of the learning after carrying out four meetings of teaching and learning activities using PBL-based e-worksheets called the post-test. Giving pre-test and post-test aims to determine the improvement of students' problem-solving skills obtained by students after being given learning treatment. This is explained in Table 9.

Table 9. Effectiveness Analysis of E- Student Worksheets

MPSS Test Results			**N-Gain**
MPSS Test Results	*Pretest*	*Posttest*	
Highest score	85	97	
Lowest score	38	48	
Average score	56.44	74.92	
Average Test Score for Each Indicator			0,456
Understanding the problem	69,33	89,56	
Devising a plan	57,67	72,67	
Currying out the plan	52,00	71,11	
Looking back	43,00	61,67	

Based on Table 9, the average MPSS test results in the pretest 56.44 met the criteria of less and the posttest value reached 74.92 with good criteria. The average posttest of each indicator of mathematical problem-solving skills, namely the stage of understanding the problem reached 89.56, the stage of developing a solution plan reached 72.67, the stage of completing the solution plan reached 71.11, and the stage of checking back reached 61.67.

Based on the criteria for classifying mathematical problem-solving skills, it can be concluded that the stage of understanding the problem has fulfilled the excellent category, meaning that students can understand the problem, which is indicated by writing the known and asked questions correctly. The stage of preparing a solution plan reaches the good category meets the good category, meaning that students can identify relationships between statements, questions, and concepts given in the problem, which is indicated by making the right mathematical model and giving the right explanation. The stage of completing the solution plan reaches the good category, meaning that students can use the right strategy in solving the problem, and complete and correct in performing calculations. The stage of checking back on average meets the good category, meaning that some students have been able to draw conclusions and check back appropriately. Based on the criteria for classifying the average final test of mathematical problem-solving skills as a whole meets the good classification.

Average N-Gain to see the increase in students' mathematical problem-solving skills scores before and after using e-worksheets with the PBL model. Based on Table 6, the average pretest

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score of the MPSS question is 56.44 and the posttest score of the MPSS question is 74.92 so that to determine the magnitude of the MPSS increase is calculated using N-Gain. Based on the calculations in Table 6, the N-Gain score obtained from the comparison of the average pretest and posttest scores of mathematical problem-solving skills in using e-worksheets based on the PBL model is 0.456 in the "medium" category. The increase in the average post-test score shows that in general e-worksheets with the PBL model can effectively improve students' MPSS after students use e-worksheets in learning.

The indicator of the success of effective treatment is whether the learning outcomes after treatment are better than before treatment. Based on the results of the analysis, it can be concluded that the e-worksheets based on the PBL model on whole numbers and fractions can improve students' MPSS. The learning assisted students worksheets that integrated the internet can increase students' performance in mathematical abilities and skills in general (Riwayati & Destania, 2019). Other research also show that electronic material source like e-module also able to attract student interest. It can be an innovative solution in improving the quality of mathematics learning in the digital era (Hamid & Rahmawati, 2024).

Dissemination

E-worksheets packaging is done by printing an implementation guide book which is then distributed so that it can be absorbed or understood by others and disseminated to teachers for use in the classroom.

CONCLUSION

The development research conducted has produced a product in the form of e-worksheets based on the PBL model on whole numbers and fractions for junior high school students that is valid, practical, and effective. However, the suggestions that the researcher wants to give related to the development research are that the next researcher chooses a representative trial location so that the e-worksheets components can be realized properly and in this development research, the researcher limits the learning devices developed for validation, namely only e-worksheets. The researcher suggests following up on this research in order to develop complete learning devices (syllabus, lesson plan, and e-worksheets) for integers and fractions.

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