

Development of Problem-Based Learning (PBL) based mathematics comic media using Pixton to improve students' mathematical problem-solving skills in class VIII junior high school

M. Afifuddin Khotibul Umam^{1*}, Dewi Iriani², Novferma³

^{1,2,3} Department of Mathematics Education, Jambi University, Jambi, Indonesia

*Correspondence: afifm4402@gmail.com

Abstract

Tujuan penelitian ini adalah untuk mengetahui kualitas komik matematika berbasis Problem Based Learning (PBL) menggunakan Pixton untuk meningkatkan kemampuan pemecahan masalah matematis siswa kelas VIII SMP. Penelitian ini menggunakan metodologi penelitian dan pengembangan (R&D) dengan menggunakan model pengembangan ADDIE. Subjek penelitian ini adalah Dosen Pendidikan Matematika Universitas Jambi sebagai tim ahli yang terdiri dari ahli materi dan ahli media, guru matematika kelas VIII SMPN 18 Kota Jambi pada uji coba perorangan, 9 siswa kelas VIII G pada uji coba kelompok kecil, dan seluruh siswa kelas VIII H yang berjumlah 28 siswa pada uji coba kelompok besar. Hasil produk yang didapatkan dari penelitian ini yaitu memenuhi kriteria valid, diperoleh rata-rata skor 4,79 yakni memenuhi kriteria "Sangat Baik" termasuk dalam interval $X > \bar{X}_1 + 1,8 \times Sb_1$. Produk memenuhi kriteria "Sangat Praktis", yaitu berdasarkan hasil penilaian guru matematika dengan rata-rata skor 4,77 memenuhi kategori "Sangat Baik", dan hasil penilaian siswa dengan rata-rata skor 4,90 memenuhi kategori "Sangat Baik". Produk memenuhi kriteria "Cukup Efektif", hasil penilaian oleh siswa satu kelas dengan rata-rata skor 4,67 memenuhi kategori "Sangat Baik" dan perhitungan nilai gain pada peningkatan kemampuan pemecahan masalah matematis siswa yakni 0,72 termasuk kategori "Sedang" dengan persentase 72% termasuk ke dalam kategori "Cukup Efektif". Berdasarkan penelitian, dapat disimpulkan bahwa media komik matematika dapat digunakan untuk proses pembelajaran karena telah memenuhi kriteria kevalidan, kepraktisan, dan keefektifan.

The purpose of this study was to determine the quality of Problem-Based Learning (PBL)-based mathematics comics using Pixton to improve students' mathematical problem-solving skills in JHS class VIII. This research uses research and development (R&D) methodology using the ADDIE

development model. The subjects of this study were Mathematics Education Lecturers of Jambi University as an expert team consisting of material experts and media experts, grade VIII mathematics teachers of JHS 18 Jambi City in individual trials, 9 grade VIII G students in small group trials, and all grade VIII H students totaling 28 students in large group trials. The product results obtained from this study met the valid criteria and obtained an average score of 4.79, namely meeting the criteria of "Very Good" included in the intervals $X > \bar{X}_1 + 1,8 \times Sb_i$. The product meets the criteria of "Very Practical", which is based on the assessment results of mathematics teachers with an average score of 4.77 meets the "Very Good" category, and the assessment results of students with an average score of 4.90 meet the "Very Good" category. The product meets the criteria of "Moderately Effective", the calculation of the gain value on improving students' mathematical problem-solving ability is 0.72 including the "Moderate" category with a percentage of 72% the "Moderately Effective" category Based on research, it can be concluded that mathematical comic media can be used for the learning process because it has met the criteria of validity, practicality, and effectiveness.

Keywords: Mathematics Comics, Pixton, Problem-Based Learning, Mathematical Problem-Solving Ability

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INTRODUCTION

Mathematics is the dominant field as well as playing an important role in the development of science and technology. Thus, it is about understanding and creating future technologies, you have to understand them early on. Learning maths is very important for students because it helps them solve everyday problems (Putra & Yulita, 2019; Kusmanto et al., 2014, Tiwow et al., 2022, Sulistyawati et al., 2021). But some students don't like maths because they see it as a subject that requires higher-order thinking. and makes it difficult to access mathematical concepts and symbols unknown to him (Rohati et al., 2018)

During the Mathematics learning process, students will be faced with problems that require them to solve problems. A math problem often contains situations that

encourage students to solve a problem. However, many students don't know what to do. In the context of mathematics learning, we need to strengthen the ability to integrate information, draw conclusions, and generalize reinforcement to aspects that strengthen the ability to solve mathematical problems (Nalurita et al., 2019). If Budinurani & Jusra (2020) one faces a problem and strives to find a solution, the ability to solve the problem will follow a purposeful process, because when overcoming a problem, one not only learns how to use the knowledge and principles they have to create and build strategies to find solutions and answers, as well as find new ways of thinking.

To be able to read a story, present a mathematical model, plan calculations based on models, and perform calculations with various problems, is very closely related to his ability to solve problems. Nevertheless, the importance of the ability to solve mathematical problems is not in line with the existing situation in the field (Anisa, 2014).

This is due to general problems related to students' low ability to master mathematics learning materials. Evidenced by the results of the TIMSS (Trend in International Mathematics and Science Study) that Indonesia is no longer in the category of 39 East Asian Countries regarding the country's achievements in Mathematics and Science in 2019 until now, namely in 2023, where the top rank is achieved by Singapore with a score of 616 (TIMSS, 2019). Indonesia was included in the country category in the last TIMSS in 2015 (TIMSS, 2015). Results from the Programme for International Study of Achievement (PISA), published by the Organisation for Economic Co-operation and Development (OECD) in 2022, show that Indonesian students scored an average of 366 in mathematics, below the OECD average of 472 (OECD, 2023).

This is evidenced by tests of mathematical problem-solving skills on the topic of two-variable linear equations, many students answer directly and not systematically according to procedures or steps in answering SPLDV questions, such as Figure 1. Many students' answers are still wrong and the answers they write only write what is known from the problem. Many of the students' answers were answered directly without a clear flow, so suddenly results appeared that were unknown where they came from. The answers from each student also varied the results, most students got incorrect results.

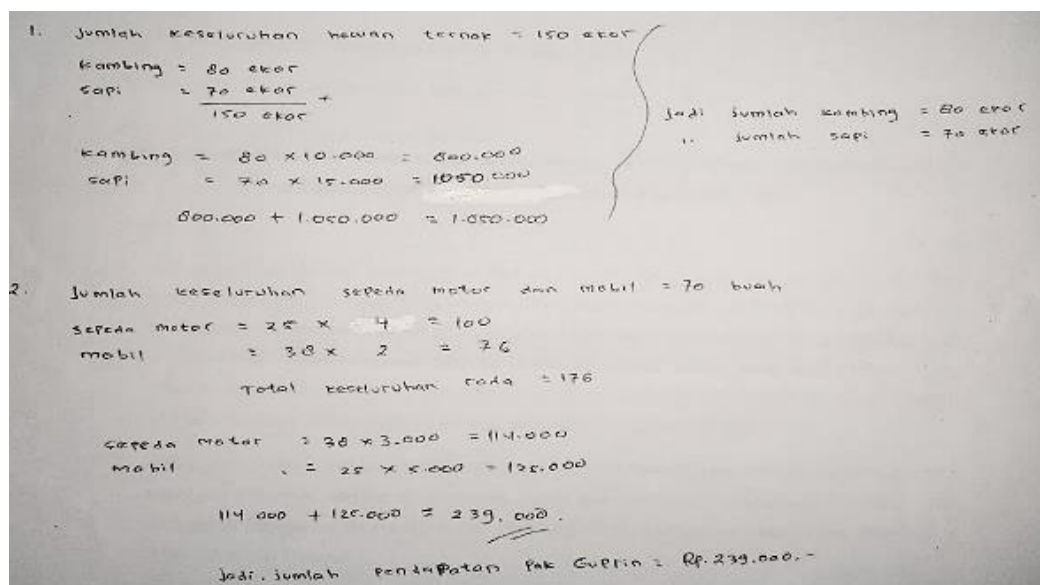


Figure 1. Student answer sheet.

Based on observations and interviews with one of the mathematics teachers, several things support the improvement in mathematics learning of grade VIII students of SMPN 18 Jambi. First, learning methods that are still conventional, so that it negatively affect their problem-solving ability in mathematics because it does not require them to actively participate in the learning process, especially in problem-solving, or relate it to everyday life.

Second, the results of interviews have also been conducted with grade VIII mathematics teachers, where he explained that students do not play an active role when learning, learning methods change in each class, sometimes using group discussion methods and sometimes conventional methods with tasks done individually. He also explained that there is no availability of learning media that supports learning, only certain materials are available for learning media such as building space using concrete media cubes, blocks, and prisms made of 3-dimensional glass, then for other materials, there are no learning media available.

Another learning tool that can help students learn is comics. This is because comics have interesting illustrations. The illustrations stimulate the students' imagination and they love it, the comic challenges its readers to not just stop at one page but read the entire book. Comics is a learning resource for students that is educational, not only displays interesting pictures but also includes stories that are relevant to the

subject and adapted to students' daily lives (Syahmita et al., 2020; Budinurani & Jusra, 2020).

For creating and designing math comics, there are many apps available, including Photoshop, CorelDraw, Manga Studio, Canva, and Pixton. In this study, the authors chose to use the Pixton application. Pixton is a web application designed to create comics online, all Internet users can use it as a means of entertainment and learning (Nurmala & Wiratsiwi, 2022). Comics using Pixton as a learning medium with the latest technology will make students' curiosity and interest in learning mathematics increase. The desire of students to learn mathematics will lead to interest in being able to solve problems commonly called Problem Solving.

The Problem-Based Learning (PBL) model is a learning approach that can help students solve problems and find solutions to mathematical problems (Pratiwi & Musdi, 2021). PBL is a learning approach in which students use scientific measures to actively participate in the problem-solving process. PBL also increases students' enthusiasm and provides them with the knowledge and skills necessary to solve problems (Syamsidah & Suryani, 2018). The PBL approach emphasizes the use of problems related to everyday life as a basis for students to acquire knowledge and concepts through the development of problem-solving and critical-thinking skills (Asriningtyas et al., 2018).

Based on the problems that have been described, researchers develop mathematical comic learning media that can help students in learning. Therefore, researchers conducted a study entitled "Development of Problem-Based Learning (PBL) Based Mathematics Comic Media using Pixton to Improve Students' Mathematical Problem-Solving Skills in Class VIII Junior High School SPLDV Material".

METHODS

This research is a type of research and development or Research and Development (R&D) using the ADDIE Model. According to the ADDIE Model (Branch, 2009), it proved to be appropriate and efficient as applied to the process of instructional product development and educational research. Consisting of five stages of development, this model provides a clear and organized structure, namely: Analysis, Design, Development, Implementation, and Evaluation.

The subjects of this study were Mathematics Education Lecturers of Jambi

University as an expert team consisting of material experts and media experts, grade VIII mathematics teachers of SMPN 18 Jambi City in individual trials (teachers), 9 grade VIII G students in small group trials, and all grade VIII H students totaling 28 students in large group trials or field trials.

Good quality learning products if they meet certain criteria. The quality of the product developed must meet validity, practicality, and effective criteria (Nieveen, 2010).

Likert Scale Analysis

The validated data collection was used to determine the validity of the research using questionnaires obtained from material experts, media experts, mathematics teachers, and students, practicality, and effectiveness of the results of this learning support activity. Information on validation results can be seen in Table 1.

Table 1. Assessment Score Criteria

Ranking	Score
Very good	5
Good	4
Just	3
Not good /appropriate	2
Very not good /appropriate	1

The average is calculated using the following formula (1):

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \tag{1}$$

After getting the average of the given scores, then convert the average value qualitatively.

Table 2. Convert quantitative to qualitative data (Widoyoko, 2012)

Interval	Value	Criteria
$X > \bar{X}_i + 1,8 \times Sb_i$	A	Excellent
$\bar{X}_i + 0,6 \times Sb_i < X < \bar{X}_i + 1,8 \times Sb_i$	B	Good
$\bar{X}_i - 0,6 \times Sb_i < X \leq \bar{X}_i + 0,6 \times Sb_i$	C	Good Enough
$\bar{X}_i + 1,8 \times Sb_i < X \leq \bar{X}_i - 0,6 \times Sb_i$	D	Unkind
$X \leq \bar{X}_i - 1,8 \times Sb_i$	E	Very Unkind

The table above shows the conversion of quantitative to qualitative data shows that only reliable and unreliable data are required to obtain reliable data as shown in Table 3.

Table 3. Media Validity Qualification

Interval	Criteria
$X > \bar{X}_1 + 0,6 \times S_{b_1}$	Valid/Practical/effective
$X \leq \bar{X}_1 + 0,6 \times S_{b_1}$	Invalid/ Impractical/ ineffective

Analysis of students' Mathematical Problem Solving Abilities

Second, students' ability to solve math problems is assessed by calculating their grades. Using the formula:

$$Value = \frac{Student\ Score}{Maximum\ Score} \times 100 \quad (2)$$

Furthermore, to measure the magnitude of the category of students' mathematical problem-solving abilities, namely Table 4.

Table 4. Mathematical Problem Solving Ability Score Criteria (Yustiara et al., 2021)

Score Range	Category
$80 \leq score < 100$	Very high
$60 \leq score < 80$	High
$40 \leq score < 60$	Keep
$20 \leq score < 40$	Low
$0 \leq score < 20$	Very low

The N-Gain test (N-Gain) is used to assess the improvement of math problem-solving skills in schoolchildren who follow certain therapies. Calculating the N-Gain score to evaluate the level of improvement in students' mathematical solving ability can be described by the following formula:

$$(g) = \frac{(Sp_{post}) - (Sp_{pre})}{(Nilai\ ideal) - (Sp_{pre})} \quad (3)$$

Table 5. Criteria for Improving mathematical problem-solving ability

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
> 76	Effective

Furthermore, to measure the percentage if categorized into the interpretation of the effectiveness of the N-Gain Score, students' mathematical problem-solving abilities are in Table 5 and Table 6.

Table 6. N-Gain Score Effectiveness Criteria (Santi et al., 2023)

Interval	Criteria
$g > 0,7$	Height
$0,3 \leq g \leq 0,7$	Medium
$g \leq 0,3$	Low

RESULT AND DISCUSSION

The results of this study include the development of PBL-based mathematics comics to improve students' mathematical problem-solving skills involving several aspects, including (1) instrument assessment by instrument experts, design experts, and mathematics comic material experts, (2) assessment of media practicality by mathematics teachers on the use of mathematics comics, (3) assessment of practicality by students in using mathematical comics, (4) assessment of the effectiveness of Mathematics comics by students, (5) evaluation of the results of tests of mathematical problem-solving ability by students. after participating in learning activities with PBL-based math comics. Analysis, design, development, and evaluation are the steps included in the ADDIE model when developing this mathematical comic.

The analysis phase includes initial observation in the school under study, with activities such as needs, making educational goals, analyzing student characteristics, evaluating programs, finding resources, and planning work. Needs analysis was conducted through interviews with a teacher and 4 students to identify needs in making effective learning media. This includes the material, media, and animations used, and ensures that learning media can summarize all subject matter, provide practice questions, and provide effective feedback.

The design phase includes the initial design of mathematical comics, Then it was refined and improved. The comic display planning applied at the design stage is as Table 7.

Table 7. Math Comics Display

No.	Visual	Keterangan
1	Comic Cover	Contains the title of the comic and the creator of the comic.
2	Opening page	The opening page of the comic contains the title, material, semester, and pictures of comic characters to make it more interesting.
3	Author Bio Page	Contains personal data of the author and supervisor

4	Core components page	Contains Learning Outcomes and Learning Objectives
5	Table of Contents of the Story	Contains a list of stories from each chapter that will be studied in the medium of mathematics comics
6	Character introduction page	Contains introductions of characters in math comics (in each chapter)
7	Splash page	Contains introductions of characters in math comics (in each chapter)
<hr/>		
	Contents Page	
	Chapter	

On the other hand, the development stage includes the validation of research tools and product quality checks, such as checking mathematical validity, practicality, and effectiveness.

Several validators, including equipment, materials, and design experts, perform product validation tests to find flaws or weaknesses. Furthermore, feedback and recommendations from validators are used as a basis for making improvements. Once deemed suitable for use in research, the next step is to test its practicality. A mathematics teacher at SMPN 18 Jambi class VIII conducted individual exams and nine selected students participated in small group exams from class VIII G SMPN 18 Jambi City. After individual and group testing and product modification are carried out, the next step is to test the effectiveness of the implementation stage, which is to implement mathematics comic books in classroom learning with grade VIII H students of SMPN 18 Jambi. This activity was carried out for four meetings, which were followed by an assessment of students' mathematical abilities. The results of the quality assessment conducted by verifiers based on validation questionnaires on the practicality and effectiveness of problem-based learning mathematics comics are presented in Table 8.

Material experts and design experts use material and design validation questionnaires to assess the validity of comic media. However, before the questionnaire was given to material and media experts, the instrument expert checked the instrumentation of the two questionnaires. Once the instrumentation is examined, the questionnaire can be used in research.

After the material expert validator and design expert assign a grade to the problem-based math comic, the validator makes a comment that serves as a reference for the development of the problem-based math comic. The products that have been


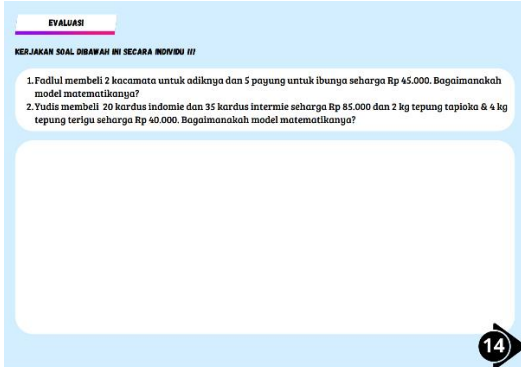
developed have been updated by researchers. Table 8 shows improvements to mathematical comics based on the recommendations of material experts.

Table 8. Quality Assessment Results of Mathematics Comics

No	Quality Aspects of Math Comics	Total Assessment Score	Maximum Score	Criterion
1	Material Validation Questionnaire Results	81	85	Excellent
2	Results of the Design Validation Questionnaire	82	85	Excellent
3	Results of Practicality Questionnaire by Teachers	86	90	Excellent
4	Results of Practicality Questionnaire by Students	397	405	Excellent
5	Results of Effectiveness Questionnaire by Students	1.177	1.260	Excellent

By the recommendations received, researchers have improved problem-based mathematical comics. The goal is that the products developed are of good quality and can be seen as teaching materials that are worthy of use in research. Details of improvements to problem-based math learning comics are presented in Table 9, which contains suggestions submitted by design experts. Then Table 10 shows the improvement based on suggestions and input from media experts.

Table 9. Revision of Math Comics based on suggestions and input by subject matter experts

The appearance of math comics before improvements were made	The appearance of mathematics comics after improvements
The practice questions in each chapter in the evaluation section have not met the indicators of mathematical problem-solving	Practice questions in each chapter in the evaluation section Have met the indicators of mathematical problem solving
	

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Table 10. Revision of Mathematical Comics based on suggestions and input by media experts

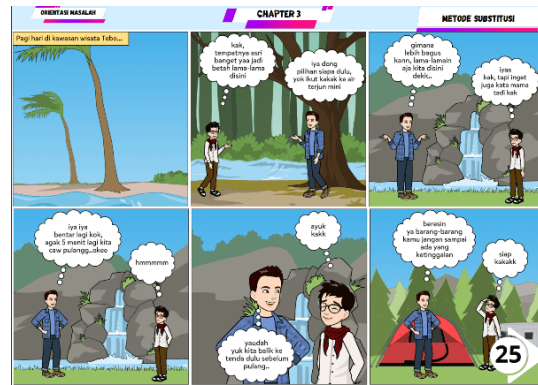
No	The appearance of math comics before improvements were made	The appearance of mathematics comics after improvements
1	Consider the size of the comic, if it is too big or less attractive 21×30 cm is equivalent to A4 size.	Size to 21 x 15 cm
2	Fix the cover to make it more attractive	Cover after revision
3	The storyline of each chapter is less diverse so that readers are not monotonous	The storyline of each chapter has been varied so that readers are not monotonous

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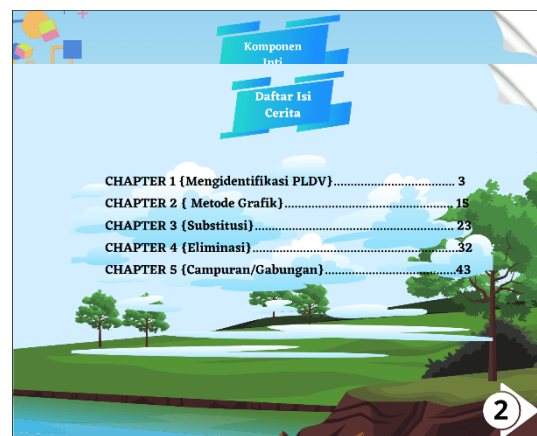
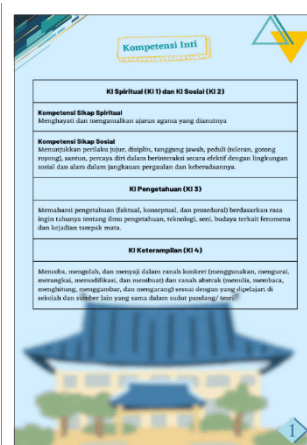
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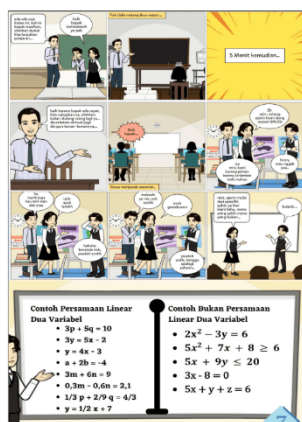
4 Backgrounds and fonts are less readable, clear, and less



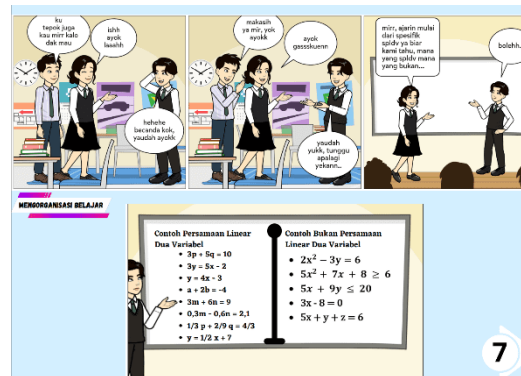
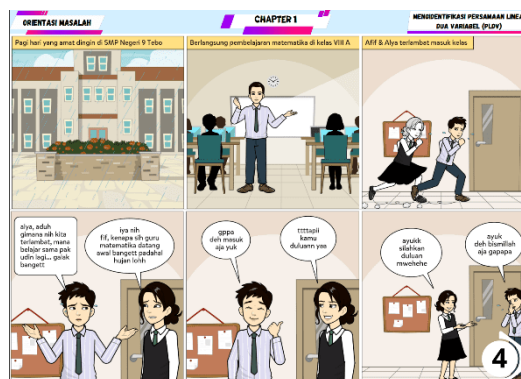
Backgrounds and fonts can be read clearly and attractively



5 PBL steps in each chapter do not yet exist



PBL steps in each chapter have been given



The Validity of Math Comics

The results of the validation assessment by material experts on PBL-based mathematics comics obtained a total score of 81 included in the interval $X > \bar{X}_l + 1,8 \times S_{b_l}$ of meeting the "Very Good" classification, while the results of the validation assessment by media experts on PBL-based mathematics comics obtained a total score of 82 included in the interval $X > \bar{X}_l + 1,8 \times S_{b_l}$ meeting the "Very Good" classification. Thus based on Table 3. Media validity qualification according to (Widoyoko, 2012) Meet $X > \bar{X}_l + 0,6 \times S_{b_l}$, that is $81 > 51 + 0,6 \times 11,3$; $81 > 57,78$ meet the "Valid" criteria for expert validation of the material and meet $X > \bar{X}_l + 0,6 \times S_{b_l}$, that is $82 > 51 + 0,6 \times 11,3$; $82 > 57,78$ meets the "Valid" criteria.

The Practicality of Math Comics

Individual experiments with the teacher and small groups of nine students were used to assess students' mathematical problem-solving abilities. There is no suggestion

or feedback from teachers in evaluating the usefulness of math comics based on problem-based learning. The practicality of mathematics comics is assessed using individual instruments (teachers) obtained the total result of a score of 86 is included in the interval $86 > \bar{X}_l + 1,8 \times Sb_i$ meeting the classification "Excellent". Thus based on Table 3. Media validity qualifications according to meet, namely; meet the "Practical" criteria for individual (teacher) validation. $86 > \bar{X}_l + 1,8 \times Sb_i$; $X > \bar{X}_l + 0,6 \times Sb_i$; $86 > 51 + 0,6 \times 1286 > 57,78$

The results of the practical assessment of mathematics comics are based on the results of the student practicality questionnaire or small group tests obtained a total score of 397 included in the interval meeting the classification "Very Good". Thus based on Table 3. Media practicality qualifications according to (Widoyoko, 2012) Meet $X > \bar{X}_l + 0,6 \times Sb_i$, that is $397 > 243 + 0,6 \times 54$; $397 > 275,4$ meet the "Practical" criteria for validation of student practicality.

The Effectiveness of Math Comics

Evaluation of effectiveness was done by analyzing student responses using effectiveness questionnaires, which were distributed during the large group test phase. In addition, assessment includes the results of students' ability to solve mathematical problems. All grade VIII H students at SMPN 18 Jambi City were involved in a large trial to evaluate the effectiveness of this math comic. Results of student evaluation of the effectiveness of mathematical comics using effectiveness questionnaires or the large group test obtained a total score of 1,177 included in the interval meeting the "Very Good" classification. Dengan demikian berdasarkan Tabel 3. Kualifikasi keefektifan media menurut (Widoyoko, 2012) memenuhi $X > \bar{X}_l + 0,6 \times Sb_i$, yaitu $1.177 > 756 + 0,6 \times 168$; $1.177 > 856,8$ memenuhi kriteria "Efektif" untuk validasi keefektifan ke siswa atau uji kelompok besar.

Effectiveness assessment is also carried out by measuring the results of students' mathematical solving ability tests through pre-tests taken at the beginning of learning and post-tests taken at the end of the learning process Large group testing. Based on the results of testing students' mathematical solving skills before using math comics in learning, the average posttest score obtained was as large as the level of mathematical problem-solving ability category according to being included in the "Very Low" category.

The results of the students' mathematical problem-solving ability test after being treated with mathematical comics obtained an average posttest score of 75 with the category of the level of mathematical problem-solving ability according to being included in the "High" category. The result of calculating the gain value is 0.717% (Yustiara et al., 2021) (Yustiara et al., 2021) based on Table 6 included in the "Medium" criterion, if viewed from the percentage of effectiveness of the value achieved reached a percentage of 72%, then the criterion explains the effectiveness of the value achieved based on Table 5 classified as "Quite effective".

Table 11. N-Gain Serving

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NGain_Score	28	.40	1.00	.7184	.17826
NGain_Persen	28	40.00	100.00	71.8367	17.82576
Valid N (listwise)	28				

This research is related to several previous studies, such as Raffi Hidayat (2018) who uses Manga Studio V05 and Geogebra for Building Space material, and Siti Umi Maisyaroh (2018) and Ardy Irawan (2021) who also developed Problem Based Learning (PBL)-based mathematics comics but with different tools and materials. The advantages and novelties in this study include: (1) Use of Pixton: Provides a more attractive visual appearance and facilitates the comic design process compared to Manga Studio or CorelDRAW, (2) ADDIE Model: Provides a clear and structured development structure through the stages of analysis, design, development, implementation, and evaluation, (3) focus on Problem-Solving: Targeting the improvement of students' mathematical problem-solving skills with a PBL approach that interactive, (4) Comprehensive Trials: Involves individual, small group, and large group trials to ensure media effectiveness before full implementation in the classroom.

Thus, mathematics comics based on problem-based learning methods are effectively applied in learning and help improve students' ability to solve mathematical problems.

CONCLUSION

Based on the results and discussion, the mathematical comic media has fulfilled the aspects of validity, practicality, and effectiveness. Research conducted showed that

the total score for material review by material experts was 81, with a classification of "Excellent" meeting the "valid" criteria, the total media validation score by media experts is 82 with the classification "Very Good" meeting the "valid" criteria, the total practicality score by teachers or individuals is 86 with the classification "Very Good" meets the "practical" criteria, the total practicality score by students or small group trials is 397 with the classification "Very Good" meets the criteria "practical", the total effectiveness score by students or large group trials is 1,177 with the classification "Very Good" meets the criteria of "effective", while the gain value achieved in improving students' mathematical problem-solving ability reaches 72%, categorized as "moderately effective".

With the existence of this mathematics comic learning media, students can read comics while learning on SPLDV material and as a means of helping students understand the material, so that students are not monotonous in learning even students will be more interested in reading and learning and for teachers as an alternative learning media to be given to students when learning and as a reference to develop mathematics comic media. Due to limitations in this study, researchers suggest that further development be improved by using more up-to-date applications. This is expected to make comics and their contents more interesting for students to learn mathematics, while still paying attention to other abilities in learning mathematics.

Therefore, the conclusion is The use of PBL-based mathematics comics learning media to improve students' mathematical problem-solving skills in class VIII junior high school SPLDV material is suitable for use in learning because it meets quality standards that are considered valid, practical, and effective.

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CONFLICT OF INTEREST

We have no conflicts of interest to disclose.

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AUTHOR CONTRIBUTIONS

M. Afifuddin Khotibul Umam: Conceptualization, writing - original draft, writing - review & editing, and methodology;

Dewi Iriani, Novferma: Validation and supervision.

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