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DEVELOPMENT OF MATHEMATICS E-COMIC MEDIA BASED ON PROBLEM BASED LEARNING TO IMPROVE THE PROBLEM SOLVING ABILITY AND LEARNING INTEREST OF STUDENTS OF MUHAMMADIYAH PRIVATE JUNIOR HIGH SCHOOL 16 LUBUK PAKAM

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ABSTRACT

This research intends to (1) create valid, practical, and successful PBL-based E-Comics media; (2) evaluating Problem-Based Learning-based E-Comics media for problem-solving improvement; (3) examining student enthusiasm in learning with Problem-Based Learning e-comics medium. This study follows the ADDIE model—analysis, design, development, implementation, and evaluation. This study included SMP Muhammadiyah 16 Lubuk Pakam seventh-graders. RPP, LKPD, problem-solving ability exam, and student learning interest questionnaire are used to create e-comic media. The results showed that (1) Media E-Comics based Problem Based Learning (PBL) to improve problem-solving skills and interest in learning met valid criteria with a score of 4.69; (2) The practical criteria in the second practical test included observation of learning using E-Comics media with a score of 88.15%, teacher response of 87.94%, and student response of 90.75%; and (3) E-Comics media meets effectiveness criteria; (i) Problem-solving skills in the effectiveness test I rose by 0.68 with a medium category at pretest and posttest. Comparing posttest I and II values showed that test II was more effective with N-gain 0.43 in the medium category; (ii) increased student interest in learning effectiveness test I with an average of 96.87%, with 8 excellent, 23 good, and 1 sufficient students. effectiveness test II followed with an average of 100%, with 17 excellent and 15 good students.

Keywords: E-Comic Media, Problem Based Learning, Problem Solving Ability, Student Learning Interest

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PRELIMINARY

The development of science and technology has become increasingly sophisticated over time, growing very rapidly and causing many changes in human life. One of the most visible things about The discipline of education is the site of technological and informational advancements, of course education must follow current developments. The objectives of mathematics learning based on the Ministry of Education and Culture 2013

are improving intellectual abilities (high level thinking), solving problems systematically, getting high learning outcomes, training in expressing ideas, and developing the characteristics of students (Susriyati & Yurida, 2019). Along with the development of science and technology, models and teaching materials used to support learning activities have also developed.

One of the many crucial variables that help pupils learn mathematics is the use of multiple sources and learning media in the classroom. Slameto (2006) Learning media is the most critical element of the educational system. The use of media in the teaching and learning process serves two critical functions: (1) as a teaching aid, also referred to as dependent media, due to its effectiveness; and (2) as a learning resource that is utilized independently by participants, also known as independent media (Citradevi, 2023). Senior teachers at SMP Muhammadiyah 16 struggle with media study, a teacher remarked. YouTube is the only interactive media young teachers have used. School apparently did not teach appealing media creation. Learning requires learning media. Benny (2010) said lower grades, like class VII, cannot reason abstractly and need real-life examples. Media helps teachers explain and boost pupils' talents and study enthusiasm. Media captivates kids with intriguing surroundings. E-comic presentations. Comics help with math. Comics are familiar to kids, making them great learning tools. The study targets 11-13-year-old class VII kids. Class VII kids enjoy elementary school, therefore comics appeal. Visual, funny, clever, and engaging topics make SMP Muhammadiyah 16 Lubuk Pakam class VII pupils happy and engaged. Mathematics and reading comprehension improve with comics.

Math comics' appealing design engages kids. Learning motivation helps engage kids in problem-solving. In problem-based learning (PBL), students tackle issues and use arithmetic to answer them. Problem-based learning requires student participation to establish a student-centered environment. Nailis Sakinah found that comic media can be used to teach two-variable linear equation systems. Comics can motivate students to learn. (Sakinah & Hendriana, 2022). Three further studies Cholidah et al (2024), Jannah & Zuliana (2014), developed comic media based on Problem Based Learning with diverse capacities and found it legitimate, practical, and effective. This research reveals that Problem Based Learning (PBL) achieves optimal learning goals. According to Isrok'atun and Rosmala, Problem-Based Learning (PBM) or PBL focuses on students' learning problems (Sopiah, 2019). Concepts begin with problems. The problems chosen are from students' daily experiences to help them understand the content. Cholidah et al.'s research Problem-Based Learning optimises student activity by organising all class activities at each

stage to teach higher-level thinking and personality development through common situations Cholidah et al (2024). Indonesian students' problem-solving skills are low. PISA scores show this. OECD gives math test. Mathematics proficiency is below OECD standards for 71% of students. This shows many Indonesian kids struggle with math. According to a classroom action research by Jannah & Zuliana (2014), in cycle I and cycle II, students' problem-solving skills are still low. The research continued to cycle III with an average value of 83.3 because the 75.4 increase in this cycle stage was only 12.1. The cycle II-III rise was 7.9. Since pupils' problem-solving skills are constantly improved, they will improve (Jannah & Zuliana, 2014).

Problem-Based Learning (PBL) emphasises critical thinking when solving learning difficulties.Ejin found a positive correlation between the Problem-Based Learning (PBL) model and students' math comprehension and critical thinking, and Wasonowati found an increase in activity and results. Budiarti found that e-comics increased inductor circuit chemistry student learning (Puteri, 2023). PBL using E-comics was chosen to improve class VII students' set operations. E-comics and PBL were chosen to improve student learning because they promote active and critical thinking when solving content-related problems. PBL-based E-comics media can improve students' problem-solving skills and love for learning, which affects their learning perspectives. They won't care until learning intrigues them. Passion for learning improves comprehension. Motivated math students succeed. Wetherington (2013) writes in "Educational Psychology" translated by Muhammad Bukhori that "interests can be divided into two, namely primitive interests and cultural interests." Witherrington defines interest as recognizing a person, thing, problem, or circumstance as relevant (Novembianto, 2019).

After interviewing mathematics study teachers at Muhammadiyah 16 Lubuk Pakam Private Middle School, the teacher said the teachers didn't use good and fascinating media because they didn't know how to build and create learning media. This is why math teachers don't design learning media. Designing learning material is important because it makes learning more engaging and improves quality. Based on the description of the problem above, it is interesting to carry out research aimed at producing E-Comic mathematics teaching materials on set material with the title "Development of Mathematics E-Comic Media Based On Problem Based Learning To Improve The Problem Solving Ability And Learning Interest of Students of Muhammadiyah Private Junior High School 16 Lubuk Pakam".

METHODS

R&D is used in this study. Product development and effectiveness assessment use development research (Sugiyono, 2017). This development study uses ADDIE. ADDIE refers to Analysis, Design, Development, Implementation, and Evaluation. The study includes 2023/2024 SMP Muhammadiyah-16 Lubuk Pakam class VII pupils. E-Comics media integrates Problem-Based Learning (PBL) into association processes to develop students' problem-solving skills.

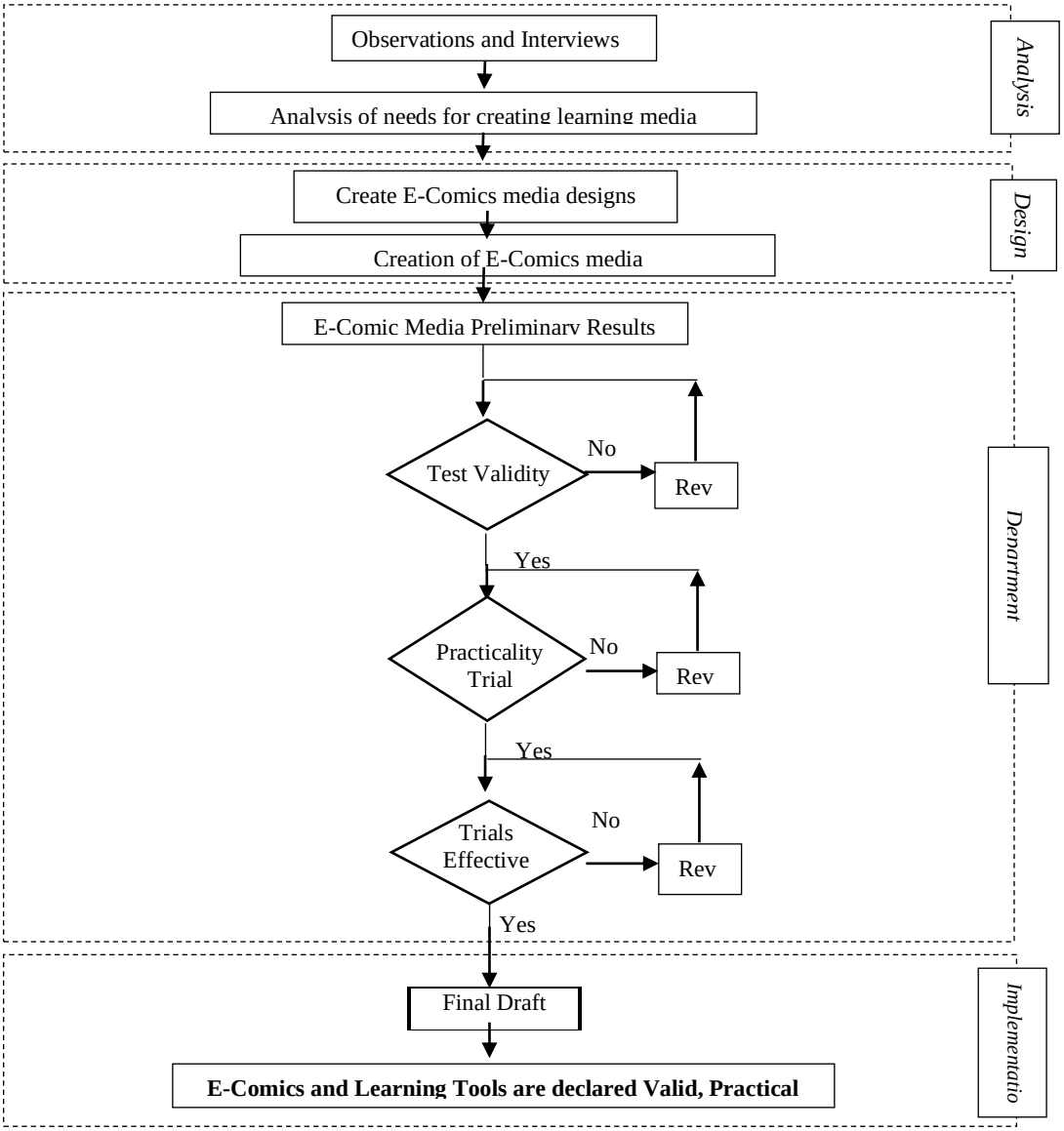

Figure 1. Procedure For Developing PBL-Based E-Comics Media (Thiagarajan et al., 1974)

Instruments

To measure the validity, practicality and effectiveness of mathematics learning media, a research instrument was prepared and developed (Brata, 2013). The instruments developed in this research are described as follows:

(1) Validity Instrument for E-Comics Learning Media

Sehas not been tested in the field, evaluation of the learning media developed is needed. Expert validation is an activity of collecting data or information from experts in their field to determine whether or not the media being developed is valid to achieve the expected goals. Determining the level of validity of the Problem Based Learning model learning media, as in table 1 below:

Table 1. Interpretation Criteria for Media and Material Expert Validator Assessments

No.	Score Range	Criteria
1.	0.00 < K 0.20≤	Totally Not Worth It
2.	0.20 < K 0.40≤	Not Worth It
3.	0.40 < K 0.60≤	Decent Enough
4.	0.60 < K 0.80≤	Worthy
5.	0.80 < K 1.00≤	Very Worth It

(Ernawati & Sukardiyono, 2017)

(2) Instruments Students' Problem Solving Abilities

This validation instrument aims to see the content validity of the test questions on students' problem solving abilities. Then the student test results are classified based on their ability to determine student mastery of the material that has been presented with the following references:

Table 2. Classification of Student Learning Mastery

No.	Value Interval	Information
1.	0 < NKBK 54≤	Very low
2.	54 < NKBK 65≤	Low
3.	65 < NKBK 79≤	Currently
4.	79 < NKBK 89≤	Tall
5.	89 < NKBK 100 ≤	Very high

Information: NKBK is the Critical Thinking Ability Value (Arifin, 2011)

(3) Validity Instrument for E-Comics Learning Media

Sehas not been tested in the field, evaluation of the learning media developed is needed. Determining the level of validity of the Problem Based Learning model learning media, as in table 3 below:

Table 3. Interpretation Criteria for Media and Material Expert Validator Assessments

No.	Score Range	Criteria
1.	0.00 < K 0.20≤	Totally Not Worth It
2.	0.20 < K 0.40≤	Not Worth It
3.	0.40 < K 0.60≤	Decent Enough
4.	0.60 < K 0.80≤	Worthy
5.	0.80 < K 1.00≤	Very Worth It

(Ernawati & Sukardiyono, 2017)

Data analysis technique

The aim of data analysis in this research is to answer the validity and effectiveness of the learning media being developed (Mulyatiningsih & Ahmad, 2014). In detail, the data analysis in this research is as follows:

(1) Data Analysis of the Validity of E-Comic Learning Media

Determine the Va value or total average value from the average value for all aspects using the formula:

(i) $V_a = \frac{\sum_{i=1}^{n} A_1}{n}$ (Abdullah & Sutanto, 2016)

Information : Va : total average value for all aspects; Ai : average value for the ith aspect; n : number of aspects

(2) Data Analysis for the Practicality of E-Comic Learning Media

This analysis was carried out to see whether the learning media that had been developed was practically used in learning. The following is a description of the analysis. Media Implementation The scores obtained are categorized into a percentage of overall implementation using the following formula :

(ii) $k = \frac{the\ average\ score\ is\ obtained}{maximum\ average\ score} \times 100\%$

(3) Analysis of Teacher and Student Response Data

To determine the achievement of learning objectives in terms of student responses, if the number of students who give positive responses is greater than or equal to 80% of the number of subjects studied for each trial. The percentage of student responses is calculated using the formula:

(iii) $PRS = \frac{\sum A}{\sum B} x\ 100\%$ (Arikunto, 2011)

Information : PRS : Percentage of students who gave positive responses to each category asked; $\sum A$: proportion of students who gave a positive response*;* $\sum B$: number of students who were respondents

(4) Analysis of Student Learning Interests

A positive response means that students state that they feel happy, new, interested and interested in the learning components and activities in implementing the Problem Based Learning model. The percentage of student responses is calculated using the formula:

(iv) $PRS = \frac{\sum A}{\sum B} x\ 100\%$ (Arikunto, 2011)

Information : PRS : Percentage of students who gave positive responses to each category asked; $\sum A$= proportion of students who gave a positive response*;* $\sum B$: number of students who were respondents.

Analysis of the Validity and Reliability of Question Items

(1) Validity of Test Items

Validity concerns the accuracy of the measuring instrument in mastering the concept being measured so that it actually measures what it should measure.This alignment can be interpreted as correlation, so that to determine the validity of the test items it is calculated using the product moment correlation formula proposed by Pearson, namely:

(v) $r_{xy} = \frac{N\sum XY-(\sum X)(\sum Y)}{\sqrt{\{N\sum X^2-(\sum X)^2\}\{N\sum Y\}-\{(\sum Y)^2\}}}$ (Arikunto, 2011)

Information : r_{xy} : test correlation coefficient; N : number of research respondents; $\sum X$: total item score; $\sum Y$: total score.

Then, to find out the significance of the correlation obtained, it was tested using the t-test:

(vi) $t_{hit} = r_{xy}\sqrt{\frac{N-2}{1-(r_{xy})^2}}$

Information : t_{hit}= different power of the t test; N : number of subjects; r_{xy}: correlation coefficient

To determine whether a test item is valid or not, tcount needs to be compared with ttable. Meanwhile, to determine ttable, a product moment correlation table is needed by looking at df = N – 2 and a significance level of 5% or 0.05 with the interpretation that t-count ≥ t-table means the correlation is significant.

(2) Reliability of Test Instruments

To calculate test reliability, Arikunto (2011) suggests that the reliability coefficient of essay tests can use the Alpha formula, as follows:

(vii) $r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_t^2}{\sigma_i^2}\right)$

Information : r_{11}: the reliability sought; $\sum \sigma_t^2$: the amount of variance in the scores for each item; σ_i^2: total variance; n : number of questions. In this research, test items are said to be reliable if they have at least sufficient reliability.

(3) Data Analysis Improves Problem Solving Ability

The test results were analysed to measure pupils' problem-solving improvement. Comparisons of student test scores before and after treatment with the learning media are made. N-gain formula calculates pre- and post-learning growth (Hake, 1999):

(viii) $N\ gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$

With the gain index criteria as in table below:

Table 4. Normalized Gain Score Criteria

Gain Score	Interpretation
$g > 0.7$	Tall
$0.3 < g \leq 0.7$	Currently
$g \leq 0.3$	Low

(Hake, 1999)

(4) Data Analysis on Increasing Student Interest in Learning

The statements used in the student interest in learning instrument are prepared based on a Likert scale. The results of measuring student interest in learning are in the form of scores or numbersThe completed instrument is searched for the overall score, so that each student has a score. Next, look for the average overall score of students in one class and the standard deviation. The categorization of calculation results is seen from table 5.

Table 5. Categorization of students' learning interests

Value Interval	Category
76-100	Very good
51-75	Good
26-50	Pretty good
0-25	Not good

(Arikunto, 2011)

RESULTS AND DISCUSSION

The following is a summary of the data analysis and research results that were acquired during each development stage:

E-Comics Media Development Results

This study produced an e-comic on association operations for class VII junior high pupils. There were five stages to this research design: analysis, design, development, implementation, and assessment.

(1) Analysis

Analysts evaluate learning media demand, feasibility, and needs. This study examines student personality, curriculum, and needs. An analysis of this work follows: (a) Assessment of student needs; (b) Character Analysis of Students; (c) Curriculum-analysis; (d) Set Learning Goals.

(2) Development

Pre-construction inspection.Proof is needed to find media design mistakes. Three UNIMED math professors and two junior high teachers concurred. Research and e-comics need clearance. Experts will evaluate media, RPP, LKPD, problem-solving, and student learning interest questionnaire apps. Evaluation of research tools. Validators suggest research instrument improvements. Test efficacy, relevance, and validity are proved. Next, examine research instrument data.

(a) Validity test

Expert validation results serve as a foundation for the enhancement and revision of educational media and instruments. Validation: (1) Learning Media; (2) RPP; (3) LKPD; (4) Problem Solving Ability Test; (5) Student Learning Interest Questionnaire. The validation results from experts are illustrated in the subsequent table:

Table 6.Validation Results

No.	Appraised device	Average total validation value	Validation Level
1.	Instructional Media	4.69	Valid
2.	lesson plans	4.62	Valid
3.	LKPD	4.73	Valid
4.	Problem Solving Ability Test	4.46	Valid
5.	Student Learning Interest Questionnaire	4.46	Valid

(4) Implemented and evaluated

True, realistic, and effective e-comic learning tools. Media result from execution. All learning technologies were assessed. Testing findings must meet research success criteria to end study. Failure to achieve trial success requirements will change each phase. After media training, the researcher corrected incomplete assessments. This study contained two trials, I and II. One e-comics-based problem-based learning endeavour failed practicality and efficacy.

Analysis of Learning Implementation Observation Results

This study measures students' problem-solving and learning motivation with a learning implementation observation sheet. Learning implementation grades of "well implemented" ($80 \leq k < 90$) imply useful media. Methods and social systems for management reaction. Trial Problem-based learning-based e-comic medium practicality assessment showed 78.89 learning implementation. Therefore, the learning process met criteria from the first to third meeting. Experiment II averaged 88.15 for problem-based learning-based e-comic medium. Final trial II's learning implementation fulfilled standards.

Analysis of Teacher Response Results and Student Responses

All teachers received a viability survey for e-comic media. Muhammadiyah Middle School has 17 teachers. All professors rate e-comic creations. The 17 instructors who completed the distributed teacher response questionnaire reported:

Table 7. Results of Teacher Response Questionnaire on Practicality Test

No.	Questions	Score Percentage
1	The attractiveness of the E-Comics display for students to learn	85.62%
2	Clarity of writing in the media	83.75%
3	Grammar and arranging sentences in the media to be understood by students	82.50%
4	Suitability of material in the media with the main material in Basic Competencies (KD)	85.62%
5	Suitability of the material presented in the media with the learning objectives to be achieved	85.00%
6	Presentation of images on attractive media	83.75%
7	The ability of media to improve students' problem solving abilities	89.37%
8	Flexibility in using media in learning	87.5%
9	Ease of media to understand the material presented	91.87%
10	The ability of media to increase students' knowledge	90.62%
	Overall Average	86.56%

E-comic media may make learning easier and more enjoyable, say 88.16% of teachers. This suggests teachers think e-comic mediums boost learning. After class, thirty-two class VII students at SMP Muhammdiayah 16 Lubuk Pakam completed a problem-based learning questionnaire about e-comic media reactions. Positive responses have 80% or more students agreeing. The table below shows thirty-two students' problem-based learning model questionnaire responses:

Table 8. Results of Student Response Questionnaire Practicality Test Trial I

No	Statement	Score Percentage
1	More motivated to learn	83.12%
2	The material is easy to understand	83.13%
3	Provide students with opportunities to learn independently	86.88%
4	Learning can foster students' interest in learning	81.87%
5	Learning encourages student activity in learning	85.6%
6	Attractive media design (cover and layout)	89.38%
7	Font suitability (type and size)	93.12%
8	Ease of language used	90%
9	Image suitability	87.5%
10	Matching color combinations	86.25%
	Overall Average	86.69%

According to the analysis of student response questionnaires, the average percentage of student responses to each aspect of student responses was 87.63%, which is the average percentage of total student responses on the practicality test.

(b) Effectiveness Test

E-comic media that is based on problem-based learning is considered effective if (1) at least 85% of the students who take the test have moderate problem-solving abilities. (2) attainment of learning objectives. (3) Students' enthusiasm for learning when it is classified as positive. (4) The learning media and learning activities were met with a positive response from a minimum of 80% of the students in the subjects studied (for each test).

(1) Problem Solving Ability Test Analysis Results

In this investigation, students' proficiency in problem-solving is assessed through the administration of a problem-solving aptitude test. Table 9 illustrates the results of the problem-solving aptitude test.:

Table 9. Description of the Results of the Problem Solving Ability Test Effectiveness of trial I

Information	Pretest Problem solving skills	Posttest Problem solving skills
The highest score	87.50	93.75
Lowest Value	54.17	66.67
Average	72.14	77.95

(2) Achievement of Learning Goals

Learning objectives were analyzed to determine the proportion of learning objectives completed for each posttest item on problem-solving ability. Successfully meeting effectiveness test problem-solving posttest learning objectives The efficacy test I for students' problem-solving abilities showed that the learning objectives were met at 86.67%, 87.42%, and 87.42% in the first, second, and third meetings. Figure 3 shows 85.83% achievement of learning objectives for students' problem-solving abilities in effectiveness test I:

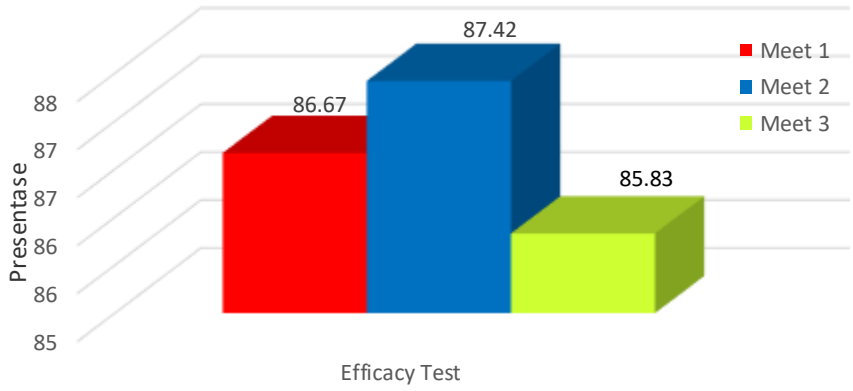

Figure 2. Diagram of Achievement of Learning Objectives for Problem Solving Ability in Effectiveness Test I

Figure 2 shows that all question items matched learning objectives. Trial I's effectiveness test findings show that learning objectives were met with a posttest score of ≥ 85% of the maximum score, meeting the requirements for accomplishing learning objectives. Problem-solving skill was found for all questions.These are efficacy test II results.

(3) Problem Solving Ability Test Analysis Results

Utilizing a problem-solving ability assessment, this investigation evaluates students' proficiency in problem-solving. Table 10 illustrates the results of the problem-solving aptitude test:

Table 10. Description of Test II Problem Solving Ability Results

Information	*Posttest I*Problem solving skills	*Posttest II*Problem solving skills
The highest score	66.67	97.92
Lowest Value	77.95	72.92
Average	77.99	87.17

Based on table 7, it shows that the average problem solving ability in posttest I results was 66.67 and posttest II was 87.17.

(4) Analysis of Problem Solving Ability Test Improvement

The N-Gain formula in effectiveness tests I and II shows problem-solving improvement. The pretest, posttest I, and posttest II problem-solving scores confirm this. Problem-solving N-Gain results are in Table 11:

Table 11. Summary of N-Gain Results Problem Solving Ability Effectiveness Test I on Pretest and Posttest I

N-Gain	Interpretation	The number of students
$g > 0.7$	Tall	0
$0.3 < g \leq 0.7$	Currently	32
$g \leq 0.3$	Low	0

According to Table 8, there were 32 pupils that achieved an N-Gain score between $0.3 < g \leq 0.7$, falling into the medium category. The average score achieved in the effectiveness test was 0.68, placing it in the medium category.

Table 12. Summary of N-Gain Results Problem Solving Ability Effectiveness Test II on Posttest I and Posttest II

N-Gain	Interpretation	The number of students
$g > 0.7$	Tall	2
$0.3 < g \leq 0.7$	Currently	30
$g \leq 0.3$	Low	0

Posttest II improved students' mass issue-solving skills, with N-Gain scores from 0.3 to 0.7 and 32 small increases.

The pretest results indicate that the low category is the most prevalent level of mastery of problem solving abilities, while the high category is the most prevalent level of mastery of problem solving abilities in the posttest I and posttest II results, as illustrated in Table 10. Additionally, the results of the classical success in problem-solving abilities in the effectiveness examination are presented in Table 13 below:

Table 13. Level of Mastery of Test Solving Ability II

Categories	Pretest		Posttest I		Posttest II	
	The number of students	Percentage	The number of students	Percentage	The number of students	Percentage
Complete	16	50%	22	68.75%	32	100%
Not Completed	16	50%	10	31.25%	0	0%
Amount	32	100%	32	100%	32	100%

Increasing student interest in learning

The attachment contains the outcomes of the student interest in learning questionnaire in effectiveness tests I and II. Students' interest in learning increased during effectiveness assessments I and II. The results of the student interest in learning questionnaire are illustrated Figure 3:

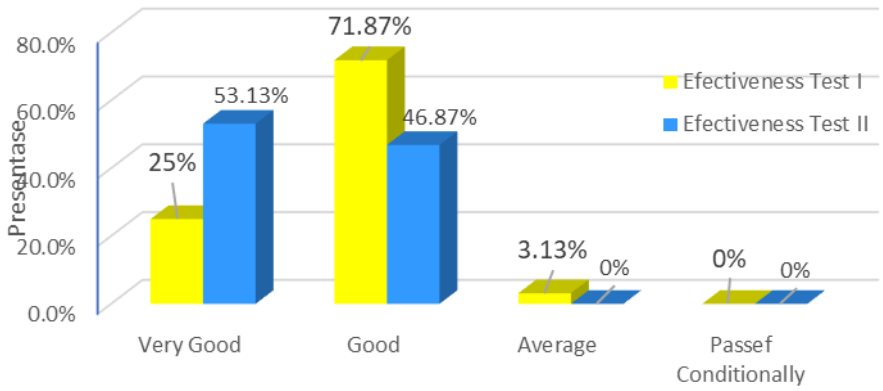

Figure 3. Results of Increased Interest in Learning Students

Based on Table 10 and Figure 3 it is found that the most dominant level of student inter est in learning ability in the effectiveness test I is the good category, which indicates that students in the effectiveness test have high interest in learning. Overall, from the results of data analysis, effectiveness test I was 81.31%, and effectiveness test II was

89.06%. This resulted in an increase of 7.75%. It can be concluded that e-comic media based on problem based learning is able to increase students' learning interest abilities.

CONCLUSION

Study analysis and discussion offer numerous findings: (1) create valid, practical, and successful PBL-based E-Comics media; (2) evaluating Problem-Based Learning-based E-Comics media for problem-solving improvement; (3) examining student enthusiasm in learning with Problem-Based Learning e-comics medium. This study follows the ADDIE model—analysis, design, development, implementation, and evaluation. This study included SMP Muhammadiyah 16 Lubuk Pakam seventh-graders. RPP, LKPD, problem-solving ability exam, and student learning interest questionnaire are used to create e-comic media. The results showed that (1) Media E-Comics based Problem Based Learning (PBL) to improve problem-solving skills and interest in learning met valid criteria with a score of 4.69; (2) The practical criteria in the second practical test included observation of learning using E-Comics media with a score of 88.15%, teacher response of 87.94%, and student response of 90.75%; and (3) E-Comics media meets effectiveness criteria; (i) Problem-solving skills in the effectiveness test I rose by 0.68 with a medium category at pretest and posttest. Comparing posttest I and II values showed that test II was more effective with N-gain 0.43 in the medium category; (ii) increased student interest in learning effectiveness test I with an average of 96.87%, with 8 excellent, 23 good, and 1 sufficient students. effectiveness test II followed with an average of 100%, with 17 excellent and 15 good students.

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