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Development of a Problem-Based Learning E-Module to Enhance Mathematical Literacy Skills through Data Presentation

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Abstract

This study discusses the low mathematical literacy skills of students at Junior High School IT Al-Izzah Sorong City, particularly in the area of data presentation. The causes are attributed to ineffective conventional teaching methods and inadequate teaching materials. The research aims to develop a Problem-Based Learning (PBL) e-module to enhance mathematical literacy skills. Through the Research and Development (R&D) approach using the ADDIE model, the study produced an e-module validated for both media and content. Students' response to the e-module was highly positive, indicating a high level of comfort. Analysis showed that the PBL-based e-module effectively improves students' mathematical literacy skills. Despite limitations in access to Android devices, it did not hinder the learning process.

Keywords: e-module, problem-based learning, mathematical literacy skills

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INTRODUCTION

The 21st century education in Indonesia emphasizes developing students' potential in solving real life problems (Muthy & Pujiastuti, 2020; Sukmayadi & Yahya, 2020; Sembiring, 2013). Mathematical literacy, which involves the ability to think and reason in mathematics, is very important in the mathematics learning process (Stacey, 2015). However, several studies show the low level of students' mathematical literacy skills (Fatwa et al., 2019; Kusumawardani et al., 2018; Simarmata et al., 2020).

At the Junior High School IT AL-Izzah, Sorong City, especially in data presentation material, students experience difficulties in identifying and solving mathematical contextual problems (Rahmat, et al., 2020). The results of observations and interviews show that there are many students' mistakes in understanding and applying mathematical concepts in real situations. This results in students not achieving mathematical literacy indicators (Wardono, 2018). In conclusion, mathematical literacy is an important aspect in mathematics education but more efforts are needed to improve its understanding and application in everyday life situations. Following figure is the result when the researcher conducted an initial test on students by providing contextual problems to see the achievement of mathematical literacy indicators with test results as presented in Figure 1.

Based on the data in Figure 1, students at Junior High School IT Al-Izzah, Sorong City showed a low average score in question number 1 (15 out of 50) and question number 2 (7 out of 50), which resulted in only 22% of students achieving minimum completion in mathematical literacy (score 70). The results of interviews with students

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show that low mathematical literacy skills are caused by the use of conventional learning models which only rely on recording material and the lack of opportunities for students to solve problems independently.

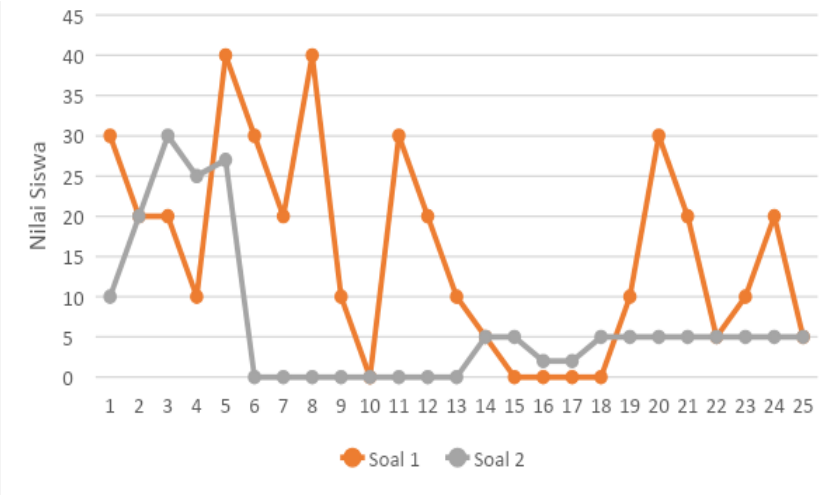

Figure 1. Recapitulation of Student Score

Therefore, a learning approach that is oriented to contextual problems is needed, such as Problem-Based Learning (PBL) (Suci & Taufina, 2020). Research shows that PBL has a positive influence on students' mathematical literacy skills (Agustin & Mayasari, 2022; Firdaus et al., 2021; Pamungkas & Franita, 2019; Pratiwi & Ramdhani, 2017). Apart from that, it is also necessary to improve independent and varied learning resources as well as learning books that are more focused and support learning (Turnip & Karyono, 2021; Maryam et al., 2019). In supporting the interview results, the researcher provided a needs analysis questionnaire which can be seen in Figure 2.

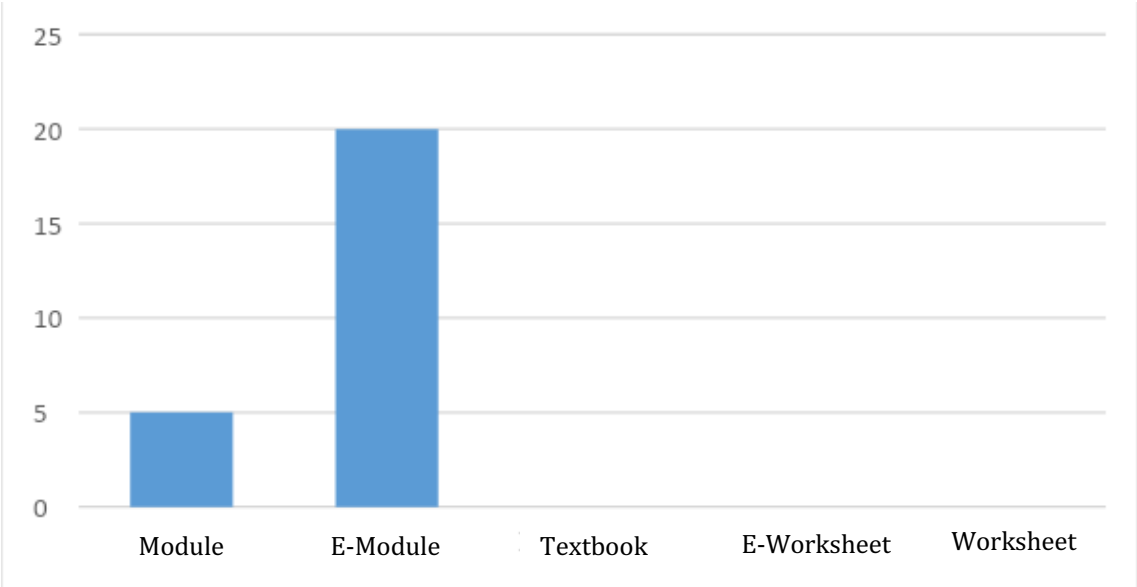

Figure 2. Results of analysis of e-module needs at Junior High School IT Al-Izzah Sorong City

Figure 2 shows that the majority of students (95%) choose e-module as their teaching materials, while only 5% choose module. No students choose e-worksheet or worksheet, because they already had the teaching materials. This indicates that e-modules are attractive to students, especially because the use of cellphones is preferred in everyday life.

By integrating Android into the learning process, e-modules can be a solution to encourage students to be more active in learning, especially in solving contextual problems. Based on this, the research aims to to develop a Problem-Based Learning (PBL) e-module to enhance mathematical literacy skills through contextual problems and teaching materials that support learning. This shows that a learning model that encourages students to solve contextual problems is really needed so that students can be active in learning and improve their mathematical literacy skills.

RESEARCH METHOD

This research uses the ADDIE model in developing mathematics e-modules with a PBL approach to increase mathematical literacy. The research stages include needs analysis of the curriculum, materials, student characteristics, learning conditions and situations. Based on this analysis, the e-module was prepared with a focus on increasing mathematical literacy for class VII junior high school students. The design, development, implementation and evaluation stages are carried out systematically to ensure product validity, practicality and effectiveness (Azka, et al., 2019).

The research was conducted at Junior High School IT Al-Izzah, Sorong City, involving 25 class VII students as subjects. Data was obtained in quantitative and qualitative form. Quantitative data is taken from suggestions from media experts, material experts, and student responses to assess the feasibility of the e-module.

Meanwhile, qualitative data was obtained from validation results from media experts, material experts, and student responses through sentence statements. In data collection techniques and instruments, there are two data collection techniques used: test and non-test. Non-test techniques include validation of e-modules by a team of material and media experts through questionnaire instruments, as well as practicality assessments by students through student response questionnaires. Meanwhile, the test technique involves a pretest and posttest to measure the effectiveness of using e-modules and students' mathematical literacy abilities. Data collection instruments include validation sheets from material and media experts, as well as pretest and posttest questions to measure students' mathematical literacy abilities. The assessment sheet is used as a basis for revising the e-module.

Data analysis techniques for measuring the validity of e-modules quantitative and qualitative analysis used to ensure product validity. Descriptive statistical analysis used to measure the validity and practicality of the product. Parametric analysis (Paired Sample t-Test) is used to evaluate the achievement of mathematical literacy skills. N-Gain Score Test is used to measure the effectiveness of the teaching materials being developed. An explanation regarding these criteria is shown in Table 1.

Validity of e-modules in validity analysis aims to obtain valid qualifications from the learning tools developed e-module is said to be valid when the average score of the validity assessment meets the minimum criteria "**valid**".

Table 1. Multimedia validity categories

No	Average Score	Categories
1	Va= 5	Very Valid
2	4 ≤ Va < 5	Valid
3	3 ≤ Va < 4	Moderately Valid
4	2 ≤ Va < 3	Less Valid
5	1 ≤ Va < 2	Not Valid

Source: Arsal (2019)

The Practicality of E-Modules includes the Assessment Method, which is a student response questionnaire used to evaluate the practicality of e-modules based on four aspects: suitability to the PBL approach, interest, presentation material, and language use. Assessment Classification is a calculated assessment and the practical value is determined based on the practical criteria listed in Table 2.

Table 2. Practical categories

No	Average Score	Categories
1	80% ≤ x ≤ 100%	Very Practical
2	60% ≤ x < 80%	Practical
3	40% ≤ x < 60%	Moderately Practical
4	20% ≤ x < 40%	Not Practical
5	0% ≤ x < 20%	Very Not Practical

Source: Riduwan (2010)

E-Module effectiveness analysis includes descriptive analysis determining the maximum and minimum values from the pre-test and post-test results. Normality Test by checking the distribution of pre-test and post-test data using the Kolmogorov-Smirnov test and the Shapiro-Wilk test at a significance level of 0 .05, Paired Sample t-Test tested the improvement between pre-test and post-test using SPSS version 22, with a Sig value. (2-tailed) < 0.005 indicates an increase and N-Gain score test measuring the effectiveness of e-modules in improving mathematical literacy skills using a specified formula.

$$N - Gain = \frac{\bar{x}_{post} - \bar{x}_{pre}}{\bar{x}_{max} - \bar{x}_{pre}}$$

Note:
$\bar{x}_{post}$ = Average Post-test score
$\bar{x}_{pre}$ = Average Pre-test score

Table 3. Categorization of N-Gain effectiveness

N-Gain Score	Categories
0,7 < N-Gain	High
0,3 ≤ N-Gain ≤ 0,7	Moderate
N-Gain < 0,3	Low

Source: Riduwan (2010)

RESULTS AND DISCUSSION

This research uses the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model. The first stage is the analysis stage including: Analysis of the Curriculum and Materials of Junior High School IT Al-Izzah Sorong City using the K-13 curriculum. Data presentation materials include tables, bar charts and line charts. Analysis of conditions and situations where teachers still use conventional learning strategies without discussion or student cooperation. Students have difficulty solving questions without guidance. The lack of practical teaching materials makes some students less than optimal in learning. Student preferences where students prefer learning using technology such as Android and computers.

Based on this analysis, the researcher decided to develop a PBL-based e-module with 5 stages, namely problem orientation, organization in learning, individual/group guidance and investigation, development and presentation of results, and analysis and evaluation of the problem solving process. To find out the characteristics of students, researchers conducted interviews and written tests related to data presentation material to assess mathematical literacy abilities. The results of the interviews showed that students had difficulty solving contextual problems, creating mathematical models, creating problem-solving steps, determining appropriate formulas, and evaluating their work results. The written test shows that students' mathematical literacy skills are still low. . From the results of the test, it can be seen that students' mathematical literacy skills are still relatively low, this can be seen in Figure 3.

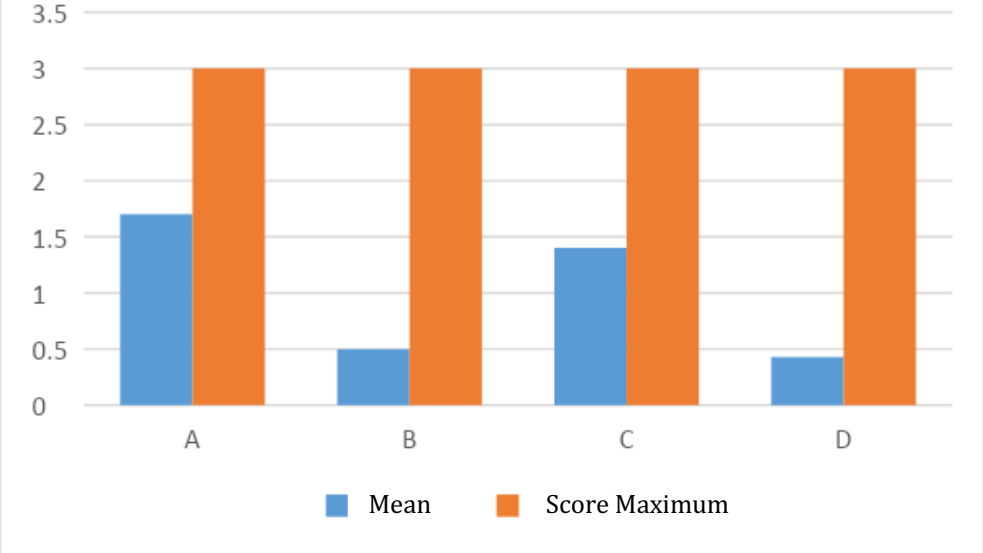

Figure 3. The percentage of test results based on mathematical literacy indicators

Note:
A = Create a mathematical model of the problem
B = Writing problem solving steps
C = Determine the correct formula for the problem
D = Evaluate work in writing

Based on tests, students' mathematical literacy skills are still low due to lack of practice with questions that test mathematical literacy. Lack of supporting teaching materials is also a factor causing low mathematical literacy skills. However, students' interest in using Android can be an encouragement for teachers to create more practical

and interesting teaching materials. Therefore, researchers aim to develop problem-based learning-based data presentation e-modules to improve students' mathematical literacy skills.

Analysis of the lesson plan includes setting development goals: the development goal is to create a learning atmosphere with a problem-based learning model that focuses on students' mathematical literacy skills and enriches the learning process with the use of Android. Preparing the e-module design is designed using PBL stages which have been proven effective in improving mathematical literacy skills. E-module design includes problem orientation activities, organizing students, guidance on investigations, presentation of results and evaluation. Compiling validation instruments and carrying out validation: prepare e-module validation instruments by media and material experts, as well as student response sheets. Validation is carried out to ensure that the e-module created is valid. Testing the validity of the E-Module is assessed based on validation results by a team of media and material experts. While the implementation where an e-module was implemented at Junior High School IT Al-Izzah, Sorong City in one class of class VII students in the even semester of the 2021/2022 academic year. Testing the practicality and effectiveness of the e-module is evaluated through student response sheets, while effectiveness is assessed through pretest and posttest results using a mathematical literacy test. The learning process is evaluated and improved based on problems identified during implementation in the classroom.

The second stage is design. At the design stage, researchers designed a PBL-based e-module with a focus on data presentation material and the mathematical literacy skills of class VII students at Junior High School IT Al-Izzah, Sorong City. The e-module design follows PBL learning steps such as problem orientation, student organization, inquiry guidance, results presentation, and evaluation. Mathematical literacy indicators are included in the e-module with symbols that represent the steps in the problem solving process. The data presentation material is divided into basic competencies (KD) and competency achievement indicators (GPA) which are then explained in the e-module. Apart from that, the e-module also includes instructions for use, indicators of mathematical literacy, mind maps, activities and work steps, and assessments. Additional components such as a glossary, author's identity, and bibliography are also included in the e-module. After designing the initial design of the e-module with PBL-based data presentation material, the researcher prepared a validation instrument and lesson plan. Validation instruments for media refer to aspects of appropriateness of content, presentation and aggressiveness. This instrument was validated by a mathematics learning evaluation lecturer and declared suitable for use. Input and suggestions from experts are summarized in the instrument review sheet. Meanwhile, input and suggestions from experts on the instrument review sheet can be seen in Table 4.

Table 4. Media Experts' Suggestions

Expert	Suggestion	Note
Instrument Validator	Check again some of the written sentences/statements	Worth using with revisions

The preparation of material expert validation instruments involves aspects of appropriateness of content, language, presentation, and conformity with the PBL model and indicators of mathematical literacy. This instrument was validated by a mathematics learning evaluation lecturer and declared suitable for use in terms of

material. The results of the expert assessment of the instrument are available in the attached appendix. Meanwhile, input and suggestions are presented on the instrument review sheet in Table 5.

Table 5. Material Experts' Suggestions

Expert	Suggestion	Note
Instrument Validator	Added data presentation section	Worth using with revisions

The preparation of the student response questionnaire pays attention to suitability with the PBL learning model, interest, material, presentation and language. The questionnaire instrument was validated by a lecturer who teaches mathematics learning evaluation courses and was declared suitable for use as a student response instrument. The results of the expert assessment of the instrument can be found in the attached attachment. Meanwhile, input and suggestions from experts on the instrument review sheet can be seen in Table 6.

Table 6. Students' Responses Suggestions

Expert	Suggestion	Note
Instrument Validator	Add the PBL syntax content that students will work on.	Worth using with revisions

The pretest and posttest question instruments were prepared by taking into account students' mathematical literacy indicators, such as the ability to create mathematical models from contextual problems, solution steps, use of appropriate formulas, and written evaluation. After being prepared, the instrument was validated by two experts, namely mathematics learning evaluation lecturers. The validation results show that the instrument is suitable for use. Suggestions for improvements from validators can be found in the attached attachment.

Table 7. Suggestions for improvement pretest and posttest

Validator	Suggestion
Validator 1	1. Numbers 1 and 2 in the pretest are not ill-structured questions 2. Numbers 1 and 2 on the posttest are not ill-structured questions
Validator 2	Question number 2 does not show a line diagram and question number 4 is not clear

After validation, the researcher tested the reliability of the pretest and posttest question instruments on class VIII students. Reliability testing uses SPSS software. The reliability test results are attached in Table 8 and Table 9.

Table 8. Reliability Test Pretest Mathematical Literacy Ability

r-count	r-table	Correlation Note	Reliability Note
0,809	0,561	High correlation	Precise reliability

From table 8, r-count is 0.809 with N=10. This shows that the Cronbach's alpha reliability coefficient is 0.809 > 0.561. Therefore, it can be concluded that the pretest instrument has good reliability with high correlation.

Table 9. Reliability Test Posttest Mathematical Literacy Ability

r-count	r-table	Correlation Note	Reliability Note
0,804	0,561	High correlation	Precise reliability

From Table 9, rcount is 0.809 with N=10. This shows that the Cronbach's alpha reliability coefficient is 0.804 > 0.561. Therefore, it can be concluded that the posttest instrument has good reliability with high correlation.

The second stage is the development stage. Researchers developed e-modules using Microsoft Word 2010 and saved documents in PDF format. Next, using the Flip PDF Corporate Edition application, the project files are converted into HTML format, turning them into e-modules. Additional features were added to make the e-module more interactive, using the FAPA book extender application provided by Dr. Andriyani, M.Si. Book configs are adjusted to the needs of the e-module which was developed so that the results of the Flip PDF Corporate Edition publication can be read by the FAPA book extender application. The e-module developed can be accessed online or offline, and validated by material experts and media experts. Material expert validation was carried out by 3 validators who were Masters Lecturers in Mathematics Education at Ahmad Dahlan University and Mathematics Teachers at Junior High School IT Al-Izzah, Sorong City on January 6 2023. The following are comments from material experts which are summarized in Table 10.

Table 10. Experts' Comments

Validators	Comments
Validator 1	1. Symbols on student answer sheets should not be duplicated so as not to confuse students and according to function 2. Many of the e-module equipment does not contain the learning activities and glossary content
Validator 2	Fix the typo in the e-module
Validator 3	-

In Table 11 shows the e-module improvement process with an explanation of the changes and the reasons as follows: Choosing just one symbol for the answer key in the e-module for uniformity. Adding a problem-solving process and glossary to learning activities. Changing orientation activities according to PBL syntax and fixing typos by

changing the word "related" to "related" in the learning objectives. The results of material expert validation can be seen in Table 11.

Table 11. Material Expert Validation Results

Validators	Total Score	Categories
Validator 1	104	Valid
Validator 2	106	Valid
Validator 3	108	Valid
Mean Score	4,81	Valid

In the table it can be seen that the score from validator 1 is 104 in the very good category, the total score from material expert 2 is 106 in the very good category and the total score from material expert 3 is 108 in the very good category, as well as the average validation results of material experts ie 4,81 with the valid category.

Researchers carried out media expert validation by involving 3 validators, including 2 Mathematics Education Masters Lecturers from Ahmad Dahlan University and 1 Mathematics Teacher from Al-Izzah Junior High School IT, Sorong City, on November 20 2022. The following are comments from media experts regarding the e-module developed, which is contained in the Table 12 and Table 13.

Table 12. Media Experts' Comments

Validators	Comments
Validator 1	1. The size of the letters is still not suitable for teaching materials on the Android platform 2. Change the e-module background to make it more attractive 3. The location of students' answers is still not harmonious
Validator 2	4. Fix the typo 'penyelidikan' in the e-module 5. Replace the numbers in question number 4 because there are no number of family members who are in comas
Validator 3	-

Table 13. Media Expert Validation Results

Validators	Total Score	Categories
Validator 1	119	Good
Validator 2	106	Good
Validator 3	120	Good
Mean Score	4,6	Good

In Table 13 it can be seen that the score of validator 1 is 119 in the good category, the total score of validator 2 is 106 in the good category and the total score of validator 3 is 120 in the good category. The average total score of media expert validation is 4,6 and is in the valid category.

The fourth stage is the application/implementation stage. Researchers tested PBL-based e-module products to improve mathematical literacy skills. After the e-module is declared valid, the next stage is to test the practicality of the e-module by implementing it in small and large classes. Implementation begins with a trial in small classes, where 10 class VIII students at Junior High School IT Al-Izzah, Sorong City use e-module. -module and gave a positive response with 9 students achieving very good criteria and 1 student achieving good criteria, with a total response reaching 74%. The learning process is carried out using the PBL model. PBL stages include orientation to problems, organizing students to learn, guiding group investigations, developing and presenting work results, and evaluation. The practicality test continued with a large class, where 25 class VII students at Junior High School IT Al-Izzah, Sorong City used e-modules. The results show that 22 students are in the very good category and 3 students are in the good category, with an average response of 92.5% which shows that the e-module is very practical.

The final stage is the evaluation stage. Researchers identify deficiencies in the implementation of e-modules and make improvements to improve their quality. Evaluation is carried out with a pretest before implementing the PBL-based e-module, and a posttest after implementing the e-module. The pretest results showed that only 2 out of 25 students completed, with a completion percentage of 8%. After implementing the e-module, the posttest results showed a significant increase, with 22 students completing and the completion percentage reaching 88%. Statistical tests use the paired sample T-test with test normality was performed using Shapiro-Wilk (Afifah, E. P., Wahyudi, W., & Setiawan, Y., 2019). The results of the normality test can be presented in Table 14.

Table 14. Test of Normality

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	.196	25	.014	.910	25	.031
Post-test	.198	25	.013	.929	25	.081

a. Lilliefors Significance Correction

On the results of the normality test using SPSS 22, the significance of the pretest and posttest results is greater than the decision making standard (0.05), indicating that the data is normally distributed. The independent sample T-test shows that students' mathematical literacy abilities after using PBL-based e-modules are higher than before, with a significance value (2-tailed) 0.000 < 0.05. The N-Gain test shows an average N-gain score of 0.5082, indicating an increase in the mathematical literacy skills of students in the moderate category after using the PBL-based e-module.

Based on development using the ADDIE model, the resulting e-module meets the validity criteria both in terms of material and media. The validity of material experts is examined in terms of content, language, presentation and PBL approach, while the validity of media experts is seen from fonts, layout, design and illustrations. The e-module was developed based on the characteristics of students with low mathematical literacy skills, as evidenced by the mathematical literacy indicators. This e-module helps students solve contextual problems with structured solution steps. With PBL content, this e-module provides real-world contextual problems and interesting interactive features, increasing students' interest in learning. The learning process with PBL-based e-modules was followed by student enthusiasm. Students are active in discussions and

study in groups, increasing enthusiasm for learning and overcoming boredom. The learning process becomes more conducive and enjoyable. Students are independent in solving contextual problems and indicators of mathematical literacy, supported by e-module features. Students' interest in learning increases along with a fun and independent learning process (Ariyani & Kristin, 2021; Suryandari, 2016; Nurkhasanah, et al., 2019; Husnidar, 2021). The practicality of this e-module is proven by the student questionnaire score of 4.65 (good category), and its effectiveness can be seen from the increase in students' mathematical literacy skills as shown by the posttest results. An N-gain of 0.50 indicates a moderate increase in mathematical literacy skills. These results are in accordance with the objectives of the e-module and show that good e-module design can improve student learning outcomes (Sumaryani, 2019; Sirate & Ramadhana, 2017).

CONCLUSION

Based on the problem formulation and the results of the research carried out, it can be concluded (1) E-module based development *Problem based learning* which was carried out at SMPIT Al-izzah, Sorong City for class VII students, resulting in teaching materials in the form of data presentation e-modules. E-module teaching materials were developed using the ADDIE method; (2) The needs analysis stage for creating an e-module is curriculum and material analysis, condition and situation analysis and student characteristics analysis; (3) At the design stage, the e-module was created in accordance with the needs analysis and the researchers designed a PBL-based data presentation e-module to improve mathematical literacy skills and created a validation instrument for media experts and material experts; (4) In general, the e-module developed shows a category that is suitable for use. This feasibility can be seen from the material aspect with a mean of 4.81 obtained in the valid category. Furthermore, from the media expert aspect, the average was 4.6 in the valid category; (5) The implementation of PBL-based data presentation e-modules in improving mathematical literacy skills has been effective, this can be seen from the provision *pretest* and *posttest* using mathematical literacy indicators. Giving *posttest* achieved 88% student completion so it can be said that the e-module is effective to use. Then the N-Gain value of the problem results *pretest* and *posttest* namely 0.5. This indicates that mathematical literacy skills are in the medium category, and are based on the results of obtaining sig scores. equal to 0.000 <0.05. It means H_0 rejected and accepted H_1 or it could be said that the average mathematical literacy ability before implementing the PBL-based data presentation e-module was different after using the PBL-based data presentation e-module in improving mathematical literacy skills; (6) The PBL-based data presentation e-module has also been said to be practical, this can be seen from the results of student responses to the application of the e-module that has been used. Student response results were at an average of 92.5% in the practical category.

DECLARATION

Author Contribution

All authors contribute in the research process, such as collecting the data, analyzing the data, and writing the manuscript. All authors approved the final manuscript.

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This research did not receive any funding.

Conflict of Interest

Both authors declare that they have no competing interests.

Ethics Declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Emerging Mathematics Education (IJEME) in maintaining high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

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