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E-module development using problem-based learning approach to learn data processing in training students' critical thinking

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Abstract

The research conducted on data processing material in mathematics subjects at the elementary school level identified issues related to the low critical thinking skills of students. The study aimed to create e-modules based on the Problem Based Learning (PBL) model to enhance the critical thinking skills of grade VI students, ensuring validity, practicality, and effectiveness. This research uses the R&D method with the ADDIE model. The validity of the e-module is obtained from expert validation followed by two trials to obtain practicality, and effectiveness obtained from the test. The validity test of the e-module product obtained an average percentage of 92.56%, categorized as very valid. The practicality test obtained an average percentage of 90.39% categorized as very practical and the effectiveness results through normality gain obtained a percentage of 76.33% categorized as effective. Thus, the e-module product is declared valid, practical, and effective and affects critical thinking skills and improvement in learning outcomes. However, the study's limitation lies in the focus on data processing material, separate from thematic learning, suggesting future research should emphasize real-life problems and diverse content to maintain student engagement, alongside schools providing reliable internet access for teaching materials.
Keywords: E-module; Mathematics; Data Processing; Critical Thinking Skills.

INTRODUCTION

Mathematics has an essential role in everyday life. Yuniawatika (2018), revealed that mathematics has many contributions in various lives. Mathematics is needed by students to have the capability to address challenges that arise in one's life (Azizah et al., 2018). Therefore, at every level of education students must learn mathematics. Mathematics is among the subjects that are essential to be taught at the elementary school level. One of the objectives of mathematics is to equip students with critical thinking skills in solving problems in everyday life (Anugraheni, 2019). By thinking critically, students are expected to possess the

skills to resolve issues both in the learning process and when facing problems in real-world situations.

One of the math materials at the elementary school level is data processing material. This data processing material is taught in grade VI elementary school. According to Uenah et al. (2022), a problem was obtained related to student difficulties in discussing class VI data management material. In this material there are still difficulties experienced by students, causing student learning outcomes in this material to be low, especially in grade VI. This is reinforced by the statement Himawan (2014), a problem was obtained related to student difficulties in discussing class VI data management material. In this material there are still difficulties experienced by students, causing student learning outcomes in this material to be low, especially in grade VI. This is reinforced by the statement Yusuf (2021), also stated that in the material for collecting and reading data, on average only 6 out of 17 grade VI students reached the standard of learning completeness . These problems occur because students experience problems such as not being able to process information, difficulty analyzing the results of data processing, presenting data in tables and diagrams (Priyantini et al., 2022).

Problems with data processing material were also found at Sukorejo Islamic Elementary School in Blitar City. Based on interviews and observations with the VIA class teacher at Sukorejo Islamic Elementary School on September 22, 2022, it is known that student learning outcomes on data processing material are still low. This is because students have difficulty in reading data as a result students have difficulty when finding the average of a data. Another problem experienced by students is that when they get problems in the form of story problems, students have difficulty analyzing and understanding the meaning of the problem. Therefore, when the teacher modifies the structure of the narrative problem from the example that has been delivered, students face difficulties in solving it. This eventually resulted in low student learning outcomes.

The difficulties that students experience when solving problems are influenced by their skills in critical thinking. Critical thinking holds significant importance as students who master critical thinking skills have the ability to solve the problems they face (Kurniawati & Ekayanti, 2020). So, low critical thinking skills will cause low student learning results. This statement aligns with findings from conducted research by Maulida et al. (2019), that out of 23 students only 2 students were classified in the critical category and finally had an impact on the midterm test results where more than all students were not complete. Therefore, in conclusion possessing critical thinking skills in mathematics holds significant importance for students.

Drawing from the outcomes of interviews with teachers of class VIA Sukorejo Islamic Elementary School, it is known that until now, only textbooks and student worksheets have been used by teachers during learning activities for data processing materials. The material will usually be explained first by the teacher in front of the class, then the teacher tells students to work on assignments from textbooks or student worksheets either independently or in groups. This makes the learning process tend to be passive and involves less student participation. The use

of textbooks and worksheets that do not present the connection between material and real life makes it difficult for students to comprehend concepts. The lack of teaching resources supporting the learning process results in low student skills in critical thinking. Whereas for students it holds significance to possess critical thinking skills in order to resolve issues in real situations in life. Moreover, to low critical thinking skills, the absence of creative and interesting teaching resources in supporting the process of acquiring knowledge also affects low learning outcomes. Furthermore, from the interview, it is known that the teaching resources utilized by teachers and students in class VIA are still in the format of conventional teaching resources. Teaching materials that have not been integrated with this technology make learning feel monotonous and cause students to feel bored. Prastowo (2015), argues that when educators only focus on using conventional teaching materials without the presence of creativity to develop innovative learning, the quality of learning will decrease. Therefore, teachers expect the existence of educational innovations capable of aiding teachers to produce technology-based learning activities and support students to actively participate and train skills in critical thinking.

Teaching materials are teacher support when delivering resources to students throughout their learning activities. Teaching materials function to achieve learning objectives and competencies after students learn a material (Rosilia et al., 2020). One shape of teaching material is modules. Acquiring knowledge experiences that are planned and made to fulfill certain objectives and are prepared as a whole and systematically are called modules (Sili et al., 2018). Along with technological developments, the presentation of modules is not only printed but also in electronic form such as e-modules. The module contains learning objectives, learning materials or substances, and assessment activities (Setyawati, 2022). E-modules contain various materials that are designed sequentially, interestingly, and in accordance with competencies as well as desires (Ramadanti et al., 2021). The utilization of e-modules as a support for teachers and students within the context of education and learning activities can train students critical thinking skills. This statement is reinforced by Nikita et al. (2018), where the average score from the pretest to posttest has shown an increase. Accompanied by increased skills in critical thinking, student learning outcomes also increase. E-modules are also more practical because they can be accessed at any time. Alongside teaching resources, careful selection of choice models can enhance student learning results (Pramana et al., 2020).

Forms of learning approaches one of them is the Problem Based Learning (PBL) model. With the PBL approaches, knowledge can be built by students independently and train skills in problem-solving (Novianti et al., 2020). According to research Cahyani et al. (2021), revealed that students' critical thinking skills have the potential to be trained through the implementation of the PBL learning approach. Furthermore, learning activities with problem solving will allow students to train their abilities in critical thinking. This is strengthened by the statement Rahayu et al. (2017), that with the execution of the PBL model, students' critical thinking skills and learning achievement will increase. There are 5 phase in

the PBL learning model, namely: 1) students are oriented to the problem, 2) Arranging students for learning, 3) providing guidance to individuals or groups experiences 4) fostering and producing work, 5) analyzing and assessing ways of resolving problems (Afridiani et al., 2020).

E-modules based on the PBL model as an innovative teaching material are designed by introducing practical, real-world issues that are adapted to the PBL stages enabling them to provide meaningful learning and train critical thinking skills. This is confirmed by meta-analysis conducted by Suharyat et al. (2023), that the utilization of e-modules based on PBL has high effectiveness to train students critical thinking skills. Furthermore, studies from Sujanem et al. (2022), also explained that the application of PBL-based e-modules has a significant impact on students' critical thinking skills. Several prior studies pertaining to the development of teaching materials include research from Noorruwaida et al. (2022), developing science e-modules based on authentic learning to enhance critical thinking skills of middle school students, Nia et al. (2022), developed a PBL approach for environmental conservation e-module to improve critical thinking skills of junior high school students, Turahmah et al. (2022), developed PBL- based e-modules in science learning to enhance critical thinking skills among middle school students, Ramadanti et al. (2021), developed an e-module grounded in PBL for teaching data presentation concepts to middle school students. Another research by Rahmawati (2019), developed PBL-based e-modules in history learning to enhance high school students' critical thinking skills. The novelty of this development research is to create technology-integrated teaching resources based on the PBL model in elementary school mathematics learning, especially data processing material in class VI that has suitable learning activities with syntax or stages in the PBL learning model, starting from problem presenting problems so that they can train students' critical thinking skills and includes content such as images, learning videos, google forms, and worksheets that can be accessed by the internet.

The aim of this research and development aims to develop teaching resources e-modules of data processing material based on PBL model to train critical thinking skills of grade VI elementary school students that are valid in accordance on resources experts, design experts and teachers, practical according to teachers and students and effective to use in learning activities. The development of the e-module will be used as a support for the process of active learning activities, presenting problems in accordance with the stages of PBL and training students' skills in critical thinking.

Based on this study, research will be carried out on the development of e- modules that contain learning data processing material for grade VI elementary school students. The e-module development will be used as a support for the learning activity process and train students' skills in critical thinking.

METHODS

The method utilized is the research and development (R&D) method. Salim & Haidir (2019), states that a series of processes or stages in developing new products and complementing existing ones, where the results can be taken into account, is called R&D. One of the development models is used in this study. The development model applied in this research and development is the ADDIE model which includes Analyze, Design, Development, Implementation, and Evaluation (Cahyadi, 2019). The ADDIE model is suitable for use in developing teaching materials because it has simple stages, but includes product testing and revision (Mulyatiningsih, 2016). The stages of the ADDIE model are described in the following scheme.

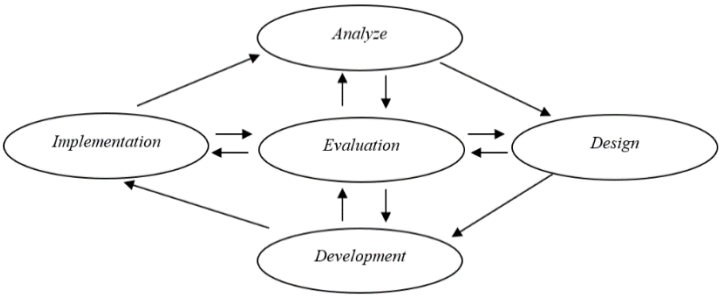

Figure 1. Stages of the ADDIE model (Ardiansyah et al. 2021)

In the utilizing e-module instructional materials in schools, the One Group Pretest Posttest Design research model is used. In this model, the research subject group will carry out a pretest which is then given treatment and carried out a posttest after treatment with the same measurements. The population and research subjects were carried out by all 6th grade students of Sukorejo Islamic Elementary School totaling 19 students. The methods for data collection applied consisted of observation, interviews, tests and questionnaires. The research instruments used include needs analysis questionnaire instruments, material expert validation questionnaires, design experts, teacher validation, teacher and student's user response questionnaires and test instruments. The assessment instrument is in the format of critical thinking skills analysis questions given to strengthen the teacher's argument pertaining to the low critical thinking skills and 10 questions.

The types of data analysis techniques used consist of both quantitative and qualitative data analysis. Quantitative data analysis was utilized for process needs analysis questionnaire data, critical thinking skills analysis, material expert validation questionnaire, design expert validation, and user validation, practicality questionnaire, and product effectiveness analysis. The data from the needs analysis questionnaire and student responses used a Guttman scale. While the data from the expert and user validation questionnaires use a Likert scale. The data from the critical thinking skills analysis test used the scoring criteria modified from Karim and Normaya (2015) on Table 3. Then the percentage value is sought using the formula from Rizky (2014) which was then categorized from Karim and Normaya

(2015) on Table 4. Furthermore, the pretest and posttest results were processed using gain normality.

The outcomes yielded by the collected data from the validation questionnaires of material experts, design experts, teachers, and user response questionnaires were calculated using the equation according to NF et al. (2022) on the Table 1 and Table 2 and categorized as follows.

Table 1. Criteria for categorized of validity

Achievement Rate (%)	Category
81 – 100	Very valid
61 – 80	Valid
41 – 60	Valid enough
21 – 40	Invalid
0 – 20	Very Invalid

Table 2. Practicality categorization criteria

Achievement Rate (%)	Category
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Practical enough
21 – 40	Less Practical
0 – 20	Not practical

Based on the categorization in Table 2, the e-module data processing material based on the PBL model to train critical thinking skills is declared valid or feasible to use if the percentage of validity test results is> 60%. If the validity test results are ≤ 60%, then improvements are made based on suggestions and criticisms from experts and teachers to achieve the expected degree of validity. As for the categorization in Table 3, the e-module of data processing material based on the PBL model to train critical thinking skills is declared practical if the percentage of test results is > 60%. If the test results are ≤ 60%, then improvements are made based on student suggestions, to attain the anticipated standard of practicality.

The acquisition of data from the outcomes of the analysis of critical thinking skills is carried out modified scoring from Facione in Karim and Normaya (2015) on the to determine whether someone can be said to be thinking critically (Formula 1). Then the percentage value is sought using the formula from Rizky (2014) which is then categorized as follows.

Table 3. Scoring guidelines for students' critical thinking skills

Indicator	Description	Score
Interpretation	Write both known and questioned correctly	2
	Write known and questioned but not yet correct	1
	Did not write the known or questioned correctly	0
Analysis	Write down what must be done to solve the problem (making mathematical models, memorization, determining formulas, etc.) appropriately	2
	Write down what must be done to solve the problem (making mathematical models, modeling, determining formulas, etc.) but not yet correct	1
	Did not write what must be done to solve the problem (making mathematical models, modeling, determining formulas, etc.) correctly	0
Evaluation	Use ways, steps, or strategies in solving problems appropriately	2
	Uses ways, steps, or strategies in solving problems but not yet precise	1
	Does not use methods, steps, or strategies in solving problems appropriately	0
Inference	Draw conclusions appropriately	2
	Making conclusions but not yet correct	1
	Did not make a proper conclusion	0

$$NP = \frac{R}{SM} \; x \; 100\% \qquad (1)$$

Description:
NP = Percentage value
R = Student score from each indicator
SM = Maximum score of each indicator

Table 4. Category Percentage of Critical Thinking Skills

Value Interval (%)	Category	Analysis Result
$81{,}25 < X \leq 100$	Very High	Students' critical thinking skills are very high
$71{,}50 < X \leq 81{,}25$	High	Students' critical thinking skills are high
$62{,}50 < X \leq 71{,}50$	Medium	Critical thinking skills of moderate students
$43{,}75 < X \leq 62{,}50$	Low	Students' critical thinking skills are low
$0 < X \leq 43{,}75$	Very Low	Students' critical thinking skills are very low

Based on the categorization in table 4, the outcomes of the analysis of students critical thinking skills are low if the percentage results are in the interval $43.75 < X \leq 62.50$ and very low if the percentage results are in the interval $0 < X \leq 43.75$.

The data obtained from the outcomes of both the pretest and posttest results were processed with the normality gain equation. The outcomes of the calculation of each students n-gain score as an increase in learning outcomes are averaged and then categorized in the normality gain criteria, specifically the n-gain>0.7, including the high category, 0.3≤n- gain≤0.7, the moderate category, and n-gain<0.3, the low category (Mapilindo et al., 2021). After knowing the n-gain category, it is then transformed into a percentage format where if the percentage result of normality gain> 76%, then the application of e- modules in learning is said to be effective in learning.

The effectiveness of e-modules is known by analyzing pretest and posttest results with normality gain using the equation and categorized according to Mapilindo et al. (2021) on the Table 5, the effectiveness of e-modules is known by analyzing pretest and posttest results with normality gain using the equation and categorized (Maulidah, 2022) on Table 6 with formula (2).

$$N\text{-}Gain = \frac{S_{post} - S_{pre}}{100 - S_{pre}} \quad (2)$$

Description

N-Gain = gain normality test value

$Spost$ = post-test score

$Spre$ = pre-test score

Table 5. Gain Normality Criteria

Limitations	Criteria
0.7 ≤ N-gain ≤ 1	High
0.3≤N-gain≤0.7	Medium
N-gain<0.3	Low

Table 6. Normality Gain Interpretation Criteria with Percentage

Percentage (%)	Category
>76	Effective
56-75	Effective Enough
40-55	Less Effective
<40	Ineffective

In accordance with the normality gain criteria in table 5, it is evident that the n-gain score of 0.7 ≤ N-gain ≤ 1 is categorized as high. Furthermore, in table 6, the application of e-modules in learning is said to be effective if the average percentage of n-gain score is more than 76%. If the result of the normality gain percentage is <76%, it is necessary to make improvements so that it can achieve the expected goals. Qualitative data presented in the format of interview outcomes and recommendations or feedback by experts. Qualitative data analysis was conducted

through analyzing the outcomes of teacher interviews and input from experts and teachers descriptively. Analysis of the findings from teacher interviews was carried out to find out the problems during learning in class VIA Sukorejo Islamic Elementary School, Blitar City. Analysis of the results of suggestions and input from experts and users is used as material for revising the e-module product being developed.

RESULT AND DISCUSSION

The outcome generated from this study materializes as e-module teaching materials for data processing material based on the PBL model through the ADDIE development stage, specifically analysis, design, development, implementation and evaluation. At the analysis step, interviews were conducted with VIA class teachers, VIA class students filled out a needs analysis questionnaire in order to ascertain the conditions of students and problems in the learning activity process. The outcomes of interviews with teachers include 1) Student difficulties in math subjects, 2) Many difficulties are encountered in data processing material, 3) Lack of accuracy in calculating so that the final result is wrong, 4) Students lack understanding of concepts so that they cannot answer problems that are different from those exemplified, especially story problems, 5) Class VIA uses the 2013 curriculum, 6) The 2013 curriculum mathematics package book and student worksheets book are learning resources used in mathematics learning activities, 7) In the learning process, the methods used are lectures, memorization, and assignments, 8) Learning has used technology such as smartphones, LCDs, the internet, 9) Students like learning that utilizes the internet, 10) Support teaching materials that utilize technology because students are more interested and enthusiastic, 11) The majority of students have low skills in critical thinking so that they are less quick to absorb material and have difficulty solving a problem. This is reinforced by the outcomes of the requirements questionnaire analysis which indicates a percentage of 86.58% with the level of need being in the category of most needs (Wati et al., 2020). Thus, it was concluded that teachers and students of class VIA Sukorejo Islamic Elementary School, Blitar City need innovative teaching materials, which can support learning activities, especially in data processing material.

To strengthen the results of interviews related to students' low critical thinking skills, tests were conducted on all students of class VIA Sukorejo Islamic Elementary School. This study uses a test, namely a written test in the format of evaluation questions to determine critical thinking skills from student answers. The outcomes of the student critical thinking skills test can be presented as follows.

has been prepared in the Microsoft Word and Canva programs is then realized into a finished product by utilizing the Heyzine.com website. In product development, learning videos from Youtube that have been stored on Google Drive, E-LKPD from a live worksheet, problems and evaluation questions through Google Form. Next, enter the content in the design that has been made with Microsoft Word and then change the format to PDF. The PDF is then uploaded to the heyzine.com website to provide a flipbook display so that students are interested in learning using e-modules with smartphones.

Product development and e-module product results are presented in Figure 2 and Figure 3 presents the problem at the problem orientation stage accompanied by image content and continued with activity instructions at each stage of PBL. students do problem solving with PBL stages through the google form link located at the bottom. For the google form display can be seen in Figure 4.

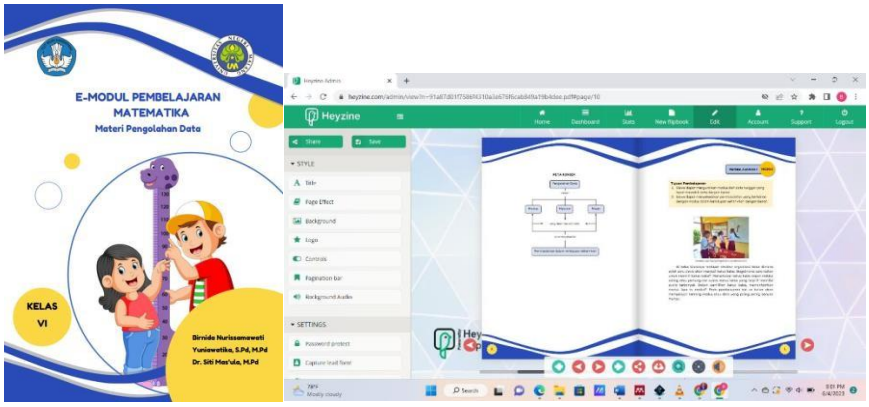

Figure 2. Cover design and e-module products on the heyzine.com website

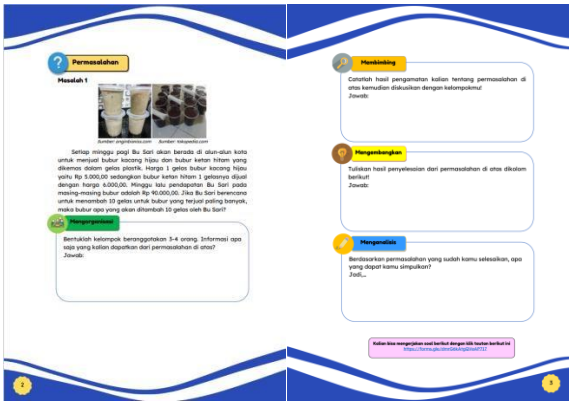

Figure 3. Image content at problem orientation stage

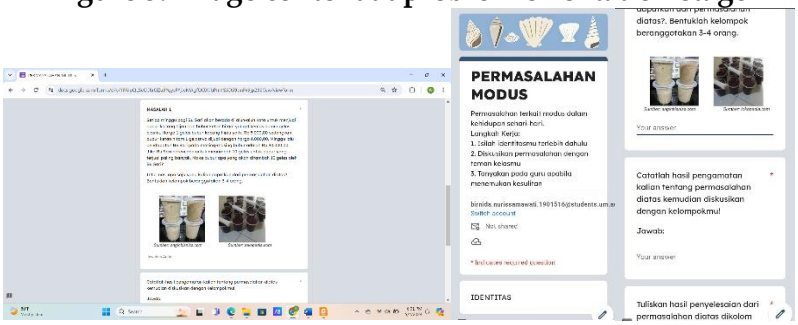

Figure 4. Google form view via laptop and smartphone

The development of e-modules of PBL-based data processing material to draw critical thinking skills of sixth-grade elementary school students was carried out in line with the necessities and traits of students. The readiness of e-modules is in accordance with the 2013 curriculum and utilizes smartphones as a medium. The e-module product is supported by pictures or illustrations, learning videos, and e-lkpd. E-modules are developed by utilizing heyzine.com so that the display is in the format of a flipbook. E-modules are extracted into html links to make it easier for

users without requiring a lot of storage space (Kumalasari et al., 2023). Link *e-modul*: https://heyzine.com/flip-book/01cc7e801b.html
The finished product was then validated. The PBL-based data processing material e-module to train critical thinking skills of grade VI elementary school students was validated by 3 validators, specifically material experts, design experts, and teachers as users. A recapitulation of the results of validation of the experts can be presented in Table 7.

Table 7. Recapitulation of Validation Results

No.	Validator	Validation Value	Category
1.	Material Expert	87, 32%	Very valid
2.	Design Expert	93, 75%	Very valid
3.	Teacher	96,63%	Very valid
	Average	**92, 56%**	**Very valid**

Based on the recapitulation table above, the percentage result is 92.56%, therefore it can be deduced that the e-module of data processing material built upon the PBL model to train critical thinking skills falls within a very valid category after revision based on expert suggestions. There are inputs provided by experts including the addition of an assessment rubric for evaluation questions as a reference for teachers in assessing, PBL stages are not only in the form of icons in learning activities but written information on the stages, rechecking related access links on the e-module, a series of activities arranged sequentially according to the PBL stages, each activity needs an explanation that directs students to the concepts learned, adding pictures or illustrations to some story problems and icon instructions on the e-module are adjusted to the display on the heyzine.com website.
The developed e-module product and tested for validity and revision shows a percentage of 92.56% with a very valid category. Although the value is quite high, it has not yet reached the maximum score. This implies that the e-module product has been created with the viability of content or content, presentation, PBL model, contextualization, cover and content appearance, as well as excellent language feasibility but the PBL model still needs a little improvement. According to the validator, the series of learning activities must be arranged sequentially according to the PBL stages. This reflects that the development of teaching materials should be organized systematically to achieve learning objectives. This is in line with the statement of Arum and Wahyudi (2016), that teaching materials are presented in a systematic way to achieve the objectives and competencies to be achieved. The e-module product is also developed with a simple design without reducing the attractiveness of the e-module, able to make students interested in learning. In line with the opinion of Winatha et al. (2018), students' interest and involvement in learning can be triggered by e-modules because of the attractive and simple design. Furthermore, e-module product development uses language that is accessible and comprehensible for students, proper grammar, spelling and sentence structure, and uses effective sentences and standardized terms. This is supported by the opinion of Sujiono and Widiyatmoko (2014), that module development must use Indonesian

language in accordance with Indonesian grammar rules and refer to the enhanced EYD.

Next, at the implementation stage, large-scale trial activities were carried out. While the small-scale trial took place at the development stage. The small- scale trial was conducted with class VIB totaling 5 students, while the extensive trial was conducted with all students in the VIA class totaling 19 students. Small-scale trials were conducted to determine access to links on the product, readability of writing, delivery of content, and test the practicality of the product. The large- scale trial was undertaken to test the practicality and effectiveness of the e-module. The collected data was subsequently used to assess the practicality and validity of the e- module product development. The recapitulation of the outcomes of the practicality of the e-module product developed (Table 8).

Table 8. Recapitulation of practicality score

No.	Test Phase	Practicality Score	Category
1.	Small Scale Trial	90%	Very practical
2.	Large Scale Trial	90,78%	Very practical
	Average	**90,39%**	**Very practical**

According to the table above, it can be observed that the average practicality value obtained from the small-scale trial and large-scale trial is 90.39%, which is very practical, which is obtained after making revisions based on teacher and student suggestions. There are suggestions given by students, namely ensuring that the links on the product can be accessed. In addition, it was also found that one student had problems using the e-module. This is because the student's smartphone screen is not suitable so it is difficult when opening the e-module. The practicality of the e-module reached a percentage of 90.39% after the revision, which can be categorized as very practical. The achievement of the percentage value is quite high, but it has not reached the maximum score. This means that the e-module can be utilized at any location and time by students, but it must be ensured that the links included within the e-module are accessible. Part of the evaluation of the practicality of teaching resources is the ease of use. This is in line with Sangka & Yasa (2022), who used the user-friendliness aspect in the e-module practicality test. E-modules received positive affirmation because with e-modules learning becomes less boring, more enthusiastic, and happy. Furthermore, the utilization of e-modules is very practical because it can be used anywhere and anytime. This is in line with the E-module is practical to carry around because it can be accessed with a smartphone and the file size is small so that students can access it anywhere and anytime (Muzijah et al., 2020).

The next phase is the evaluation which is conducted at the end of each research phase. At the analysis stage, problem evaluation is performed to determine development products that match the outcomes of the needs analysis. At the design stage, an evaluation is carried out, namely the design, content of e- module products, validation instruments, and evaluation instruments according to the suggestions of the supervisor. At the development phase, an evaluation was

conducted using input provided by material experts, design experts and users. At the implementation stage, an evaluation is conducted based on input from students. At the evaluation stage as the final stage in research and development, the developed product is reviewed to reduce the errors and shortcomings of the developed product at the previous stage. The final result obtained from this development activity is that the PBL model-based data processing e-module product to train critical thinking skills for grade VI elementary school is very valid and very practical to use. Next, to assess the efficiency of the e-module products in learning, pretests and posttests were conducted. The results of students' pretests and posttests were used to determine the normality gain score. After knowing the normality gain score of each student, the normality gain test was carried out. This test is used to determine the effectiveness of the treatment given. The following are the normality gain results from students' pretest and posttest scores (Table 9).

Table 9. Recapitulation of Gain Normality Results

No.	N	Average N-Gain Score	Average N-Gain Score Percent	Category
1	19	0.76	76.33	Effective

It is evident from the table above, the n-gain score shows an average of 0.76 with a high category. Furthermore, the average percentage of n-gain score reached 76.33%, which shows that the application of e- modules in learning is said to be effective.
The use of e-modules on data processing material based on the Problem Based Learning (PBL) model to train critical thinking skills of grade VI students is effective in the learning activities as evidenced by evaluation of learning outcomes by analyzing pretest and posttest scores. The improved learning results cannot be divided from the presence of learning activities in the e-module that uses the stages of PBL which is able to effectively cultivate students' critical thinking skills in problem solving. The PBL model is a learning approach that focuses on issues to train students critical thinking skills. This statement is strengthened by the opinion of Novianti et al. (2020), that PBL is referred to as a learning model where students are upskill to compile their understanding independently and develop skills in problem solving. Haryanti (2017), also revealed that the PBL model can familiarize students to develop their critical thinking skills. Referring to this opinion, the developed e-module contains PBL stages where at the beginning of the activity a problem related to everyday life is presented. In the settlement process, knowledge is built by students themselves so that learning becomes more meaningful. This statement aligns with the opinion of Zhafirah et al. (2021), the PBL model has advantages, namely simplifying the comprehension of concepts for students because knowledge is built from students themselves through solving problems related to real life so that they get benefits from learning. In addition, through problem solving activities, students can train their critical thinking skills. This aligns with the study of Sujiono and Widiyatmoko (2014), the use of PBL model in the module is effective in training students' critical thinking skills.

This e-module teaching material based on the PBL model has advantages and disadvantages including the PBL-based e-module product is a product developed utilizing the use of smartphones which elicits enthusiasm and interest from students with using e-modules in learning. This is evidenced during the small-scale and large- scale experiments, students were enthusiastic and excited when they received the e-module link and accessed it. The e-module product can also be downloaded for free and opened repeatedly in PDF form. In addition, e-modules do not require large storage space, because they do not require applications that need to be downloaded, but e-modules are accessed through the heyzine.com website. The e-module product has an attractive flipbook display with a combination of colors that students like. The activities in the e-module are accompanied by pictures and videos at the end of each learning activity thus preventing students from becoming bored in using the e-module. The instructions on the e-module are also clear, simplifying the utilization of the e-module for students. Furthermore, the activities in the e-modules use the PBL model which includes orienting students to the problem, organizing, developing, and analyzing. In addition, the content in the e-module is designed to train students' critical thinking skills.

The PBL model-based data processing material e-module has shortcomings. The disadvantages of this e-module product are that the content within the e-module is only limited to data processing material in class VI with KD Permendikbud No.37 of 2018 so that if it is used in data processing material with a different KD it cannot. The use of this e-module must be within a stable internet range, so if it is not within a good internet range, there will be problems accessing the e-module or doing learning activities in the e-module.

CONCLUSION

The research and development that has been carried out produces an e-module product for data processing based on the Problem Based Learning (PBL) model to train critical thinking skills of grade VI students. Based on the results of the validity of the e-module product, it shows a validity value with an average of 92.56% which falls into the highly valid category. The results of the e-module practicality test resulted in a percentage of 90.39% with a very practical category. The outcomes of effectiveness through normality gain resulted in an average n-gain score of 0.76 with a high category and the average percentage of n-gain scores reached 76.33% with an effective category. Thus, it can be stated that the e-module product is very valid according to material experts, design experts and teachers. The e-module is also very practical according to teachers and students and effective to use in the learning process and train students' critical thinking skills.

The limitation of this research is that the model used to develop e-modules for sixth grade elementary students is a PBL model with a focus on data processing material and separate from thematic learning. Based on the results of this study obtained, it is suggested the development of e-module teaching materials for data processing materials based on the PBL model to train critical thinking skills, needs to pay attention to the problems chosen so that they are related to real situations or students' daily lives. In addition, it is necessary to add varied content to the e-

module teaching materials that can be developed according to the developer's ability with a note that it still adapts to the material raised. With this, it is expected that students will not be bored, excited, and actively participate in learning activities. In addition, to ensure that learning activities run well, schools should provide a smooth internet network so that there are no obstacles in accessing the links in the teaching materials. This research is not perfect because it has shortcomings, namely its use must be within the reach of the internet. So that for further research and development can modify the product better than the one produced.

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