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Development of Problem Solving Based E-Modules Assisted by Flipbook in Physics Learning for Middle School Students

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Abstract: This research aims to create a problem-solving e-module supplemented by a flipbook, for physics education targeting junior high school students. This study employed the research and development (R&D) method utilizing the ADDIE model, encompassing the phases of analysis, design, development, implementation, and evaluation. The research methodologies encompassed observation, interviews, questionnaires, and pre-tests and post-tests. This research employed a data analysis technique that incorporates quantitative and qualitative descriptive analysis, utilizing the Aiken V index for data evaluation. The findings of this study demonstrated that the created e-module possesses a high feasibility level, evidenced by an average validation score of 0.83, classified as very valid. The deployment of the e-module among 28 seventh-grade students in class VII C at SMP Negeri 6 Pontianak yielded an effect size of 3.02, categorizing it as very effective, while the assessment of students' problem-solving abilities revealed an average N-Gain value of 0.53, indicating a modest level of improvement. The teacher's reaction rate was 97%, while the pupils' response rate during the field trial was 86%, both classified as exceptionally high. The results demonstrate that the problem-solving-based e-module, supplemented by a flipbook, is an excellent physics learning medium for enhancing problem-solving skills related to the theme of matter and its transformations.

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Introduction

Natural Science Education (IPA) is crucial to raising the standard of education in Indonesia, particularly in terms of turning out high-caliber students. Critical thinking, creativity, logical reasoning, and initiative in tackling societal concerns resulting from scientific and technological advancements are all expected of students. Thus, improving students' scientific knowledge is essential to preparing them for a world that is becoming more reliant on information technology. Science is a methodical process of discovery as well as the mastery of facts and ideas (Marhento, 2020).

One of the natural sciences, physics examines the characteristics and occurrences of the natural world and is essential to the advancement of knowledge and technology (Aththibby, 2015). In the education curriculum, physics is taught from elementary to secondary school levels with the aim of not only providing knowledge but also encouraging students' thinking abilities in solving everyday problems (Kemendikbud, 2014). However, many students find physics difficult due to the complexity of the formulas and calculations involved, resulting in a lack of interest and enthusiasm (Muizzuddin, 2019).

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According to the idea of the independent curriculum, which seeks to develop the potential of both teachers and students, physics teachers must be more creative in their approach. (Kemdikbud,2022). This innovative learning aims to develop 21st-century skills, including problem-solving skills (Adinia et al., 2022). According to Jannah (2017), problem-solving is a mental process that involves gathering data and information to find the right solution. However, low problem-solving skills are often caused by monotonous teaching methods and a lack of practice in real contexts (Sulastri & Pertiwi, 2020). Hamid et al. (2017) found that by promoting active participation in problem-solving and developing critical thinking abilities, the use of problem-solving-based learning modules effectively improves students' learning results.

SMP Negeri Pontianak's observation results demonstrate that scientific instruction is still subpar. Since printed modules typically lack thorough explanations and content summaries that support independent concept understanding, their usage as instructional materials has not fully satisfied students' learning demands. Furthermore, the findings of the interviews conducted with the science instructors at SMP Negeri Pontianak showed that the current teaching methodology is still restricted and consists solely of cursory inquiries that are not accompanied by instructional resources intended to foster problem-solving abilities. Students struggle to solve physics issues as a result, which indicates that they have poor problem-solving skills. Particularly when it comes to the subject and its modifications, students frequently struggle to solve the issues assigned and are reluctant to look for solutions on their own. Because the notions of physical and chemical processes involved are abstract and complex, requiring a deep understanding to resolve, this content is frequently regarded as difficult and less interesting to pupils. Only 70% of students have finished the summative exam on the subject matter and its changes over the last two years, according to learning outcome data, and the other 30% have not yet attained mastery.

Given the challenges above, there has to be more effective, creative, and innovative educational material development to use technology to create and distribute engaging media for students (Kumalasari et al., 2023). Lestari & Rahman (2022) study develops an interactive problem-solving module for IPA instruction at SMP, indicating that it significantly increases students' conceptual understanding and motivation to learn. Boresome teaching materials cause students' ability to solve problems to suffer due to a lack of interaction, which makes it difficult for them to understand the course material and makes the learning process difficult (Ainy et al., 2024). In light of this, the use of technology in education is extremely relevant. Munir (2012) notes that many educational institutions are using the Internet to improve educational services and the effectiveness and efficiency of the teaching and learning process. One innovative solution is the development of E-Modul as a teaching tool. E-Modul is designed using a structural approach that emphasizes problem-solving and understanding so that learning objectives can be clearly and effectively stated.

Based on the conditions mentioned above, the purpose of this study is to develop an electronic module based on problem-solving in physical education, with an emphasis on improving students' conceptual knowledge and ability to solve problems. This e-module differs from previous research because it incorporates the following problem-solving techniques described by Heller (1992): 1) visualize the problem; 2) describe the problem; 3) plan a solution; 4) execute the plan; and 5) check and evaluate.

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Research Method

This study employed the Research and Development (R&D) method, specifically the ADDIE model. This model, as articulated by Branch (2009), comprises five stages: the analysis stage, which assesses the learning process's needs to identify appropriate problems, solutions, and learner competencies; the design stage, which entails the creation of the E-Module and the specification of competencies, methods, teaching materials, and learning strategies; the development stage, which focuses on producing programs and teaching materials for the learning initiative; the implementation stage, which tests and applies the teaching materials within the educational process; and the evaluation stage, which assesses the effectiveness of the created and implemented teaching materials. This method employed a qualitative approach to assess needs and a quantitative way to evaluate the validity and efficacy of the generated E-Module.

This study's method combines a qualitative and quantitative approach. Through interviews and evaluations in the form of validators' comments and recommendations about the caliber of the created educational materials, the qualitative method gathers data. Additionally, the quantitative methodology collected data from the implementation of educational media for both educators and students, as well as from the responses of questionnaires completed by subject matter experts, media specialists, and language authorities, yielding numerical outcomes. Data was collected using surveys targeting student replies, educator feedback, and expert validation. The questionnaire was administered via a 4-point Likert scale checklist.

Tabel 1. Likert Scale Criteria

Score	Category
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

Sumber: Sugiyono (2019)

The Aiken V Index is then used to assess the data collected from the validators, and the average score is determined using the following formula:

$$V = \frac{\Sigma s}{[N(c-1)]} \; ; s = r - l_o$$

Description:

V = rater agreement index
l_o = lowest validation rating score
c = highest validation rating score
R = score given by the evaluator
N = number of ratings

The final score determines the category of validation for electronic teaching modules; a module is deemed legitimate if the V index $> 0{,}60 > 0{,}60$ (Riduwan, 2016).

Tabel 2. Validation Questionnaire Interpretation

Percentage	Category
$0{,}80 < V \leq\leq 1{,}00$	Very High
$0{,}60 < V \leq\leq 0{,}80$	High
$0{,}40 < V \leq\leq 0{,}60$	Moderate
$0{,}20 < V \leq\leq 0{,}40$	Low
$0{,}00 < V \leq\leq 0{,}20$	Very Low

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Before doing the *N-gain* and *effect size* analysis to assess the efficacy of the e-module, the pre-test and post-test data underwent normality testing via the *Shapiro-Wilk test* to verify data distribution. If the p-value is less than 0.05, the data are deemed non-normal, prompting the execution of a non-parametric test, namely the Wilcoxon test, to assess if a significant change exists between the pre-test and post-test findings within the same group. It is implemented to guarantee that the utilization of problem-solving-based e-modules influences students' problem-solving abilities. The *Wilcoxon test* revealed substantial differences despite the data's non-normal distribution. Following the acquisition of substantial results, the extent of the influence of utilizing the e-module can be assessed by the calculation of effect size. The magnitude of effectiveness is calculated using the equation proposed by Cohen and accepted by Glass, written as follows.

$$ES = \frac{\bar{Y}_E - \bar{Y}_C}{s_c}$$

Source: Edy (2011)

Description:
ES : Effect size
ES
$\bar{Y}_E$: average *post-test* score
$\bar{Y}_E$
$\bar{Y}_C$: average *pre-test* score
$\bar{Y}_C$
S_c : *pre-test* standard deviation
S_c

Tabel 3. *Effect Size* level interpretation

Interval	Category
0,20 ≥≥ ES ≤≤ 0,50	High
0,50 ≥≥ ES ≤≤ 0,80	Moderate
ES ≥≥ 0,80	Low

Source: Cohen (2017)

After conducting an effect size analysis, the average normalized gain score will be calculated to determine how much students' problem-solving abilities have improved utilizing the e-module at each stage of the Heller strategy. The following equation uses Hake's (1999) equation to determine the normalized gain score (g) and categorization.

$$N\ Gain = \frac{Posttes - Pretest}{Skor\ Ideal - Pretest}$$

According to the calculation results using the formula above, the category of improvement in problem-solving skills can be said to have increased if the interpretation reaches 0,30.

Tabel 4. *N-gain* level interpretation

Interval	Category
g > 0,70	High
0,30 ≤≤ g ≥≥ 0,70	Moderate

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g < 0,30	Low

The subsequent provisions were incorporated in the evaluation of responses from educators and students concerning the problem-solving based e-module developed with a Likert scale, following assessment by N-gain to determine the enhancement in problem-solving skills:

Tabel 5. Likert Scale Response Criteria

Scor	Category
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

Source: Sugiyono (2019)

The following formula is used to assess the questionnaire replies on a scale of (0-100) in order to determine the final result:

$$P_{total} = \frac{\sum P}{n}$$

Description:

P_{total} : Total Respon Percentage
$\sum P \sum P$: Score Percentage Total
n : Number of Items/Questions

The numerical scores are interpreted into a category based on the final findings. Based on the final result, the electronic teaching module can be deemed practical if the percentage meets the validation category > 60.

Tabel 6. Questionnaire Response Interpretation

Percentage Assesmen	Interpretation
0-20%	Very Low
21-40%	Low
41-60%	Moderate
61-80%	High
81-100%	Very High

Source: Riduwan (2010)

Results and Discussion

The research and development (R&D) process, following the phases of the ADDIE model analysis, design, development, implementation, and evaluation resulted in the creation of an electronic teaching module (e-module) focused on problem-solving for the topic of matter and its changes in seventh-grade physics education. The first phase in developing the ADDIE model is the analysis stage. At this point, 28 pupils in class VII C were given questionnaires in order to perform a needs analysis. According to the requirements analysis, the only printed materials used in physics lessons were those given by the school and the LKS books that each student primarily owned. Examples of issues are not yet included in the printed book, whether they are queries pertaining to systematic.

This needs analysis aims to identify existing teaching materials and determine the essential components that must be integrated into the new learning module to make it more relevant to the needs of the students and in accordance with the curriculum requirements (Wati et al., 2020). Additionally, data was obtained on students' difficulties in solving questions on the topic of matter and its changes using the Heller problem-solving strategy.

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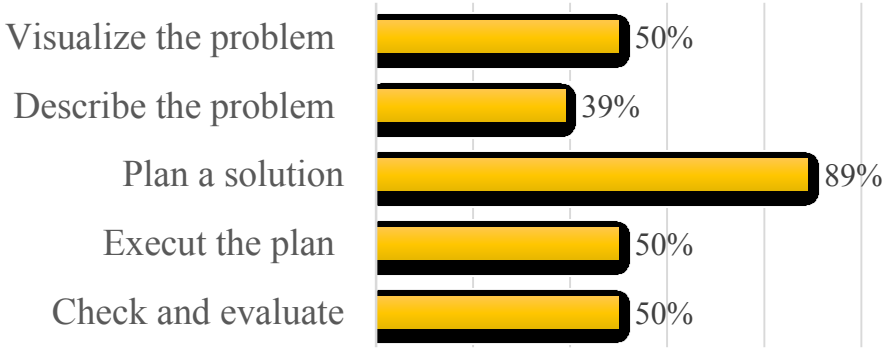

Figure 1. Diagram of students' difficulties in solving physics problems

Based on the needs analysis, it was found that 50% of the 28 students had difficulty visualizing the problems in physical form. As many as 39% of the students had difficulty gathering information to solve the problems. Additionally, 89% of the students had difficulty planning solutions to the problems, 50% had difficulty using the solutions to solve the problems, and 50% had difficulty concluding the results of the problem-solving.

The design phase is the second stage in the development of the ADDIE model. In this phase, media design and planning were carried out. The design begins with the creation of storyboards and media design (Legina & Sari, 2022). By incorporating different media assets, like images, font selections, videos, and interactive links that suit learning goals, graphic design platforms like Canva make the process of building e-modules easier. Once all of the information has been put together, the e-module is imported into Canva's Heyzine tool and transformed into a flipbook format, which makes it appear like a real book that can be opened online. With its presentation of real-world problems and integrated problem-solving questions, this module design is likewise based on Heller's approach to problem-solving. The alignment between the e-module's problem-solving stages and the way real-world situations are presented is also part of the evaluation at this point. The e-module design is improved or refined to increase its effectiveness using the input gathered from this assessment (Nial et al., 2021).

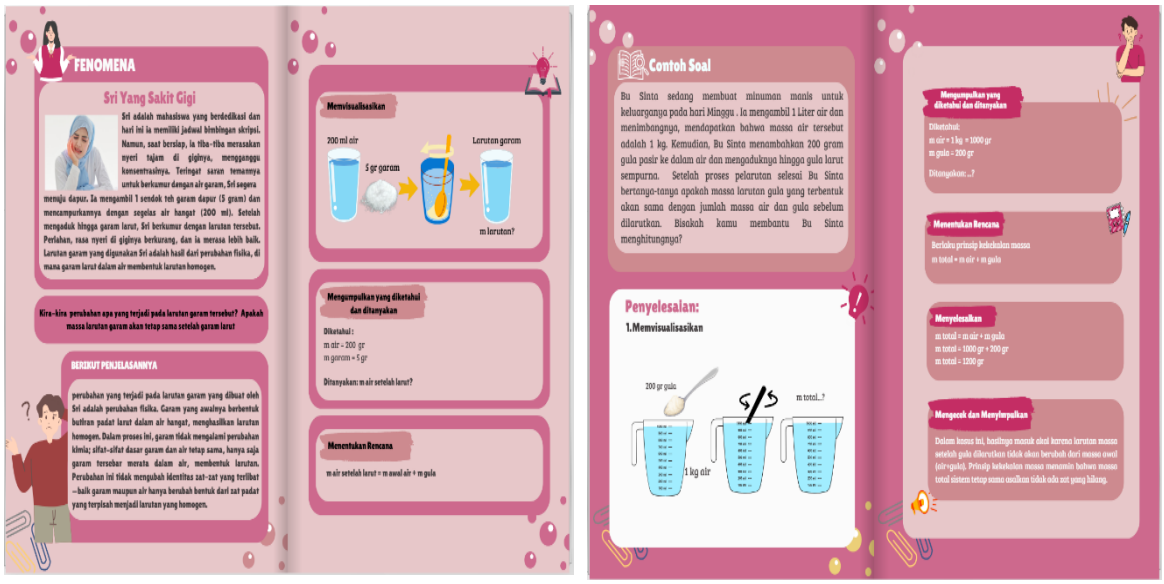

Figure 2. Example of a problem solving based e-module display assisted by a flipbook

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The third step in the ADDIE model's development is the development stage. At this point, an e-module on matter and its modifications that is centered around problem-solving is created. Experts validate the e-module after it is developed based on the original design during the design stage. (language, media, and material). At this stage, there are inputs in the form of comments and suggestions from validators, especially regarding the everyday problem segments in the e-module. It is advised that the font color be changed to make it more pleasant for pupils to read because it is thought to be too contrasting. The e-module's audio was also evaluated by the validator as being too low, requiring a volume adjustment or improvement in audio quality to guarantee that the learners could understand the content. According to research (Sa'diyah, 2021) e-modules with a variety of colors and supplementary materials like audio and video make learning more fun and simpler for students to comprehend.

Tabel 7. Results of Subject Matter Expert Validation

Validation Aspect	Value V	Category
Content	0,81	Very High
Presentation	0,87	Very High
Average	**0,84**	**Very High**

Two factors are considered in the assessment, based on the validation calculation findings from the material expert mentioned above. At 0.81, the content component was categorized as very high, and at 0.87, the presentation component was likewise classified as very high. Consequently, the expert material validators' average score of 0.84, which is classified as very high, was reached. The e-module's content is judged appropriate for use in instruction based on these findings.

Tabel 8. Results of Media Expert Validation

Validation Aspect	Value V	Category
Graphics	0,78	High
Presentation	0,83	Very High
Average	**0,80**	**Very High**

The assessment obtained from the media expert validators above includes two aspects used in the evaluation. In the graphic aspect, it received a score of 0.78, which falls into the high category, while in the presentation aspect, it received a score of 0.83, which falls into the very high category. Overall, the average validation score from media experts is 0.80, which falls into the very high category. Thus, the media used in the e-module is deemed suitable for implementation in learning.

Tabel 9. Results of Language Expert Validation

Validation Aspect	Percentage	Category
Straightforward	0,83	Very High
Communicative	0,89	Very High
Language Rules	0,81	Very High
Terms and Symbol	0,89	Very High
Average	**0,85**	**Very High**

The feasibility evaluation conducted by language experts yielded scores of 0.83 for clarity, 0.81 for language rules, and 0.89 for communicative aspects, terminology, and symbols, all classified within the very high range. The e-module's language, receiving an average score of 0.85 from language experts' validation results, is classified as extremely high and is considered appropriate for educational implementation.

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Table 10. Total Feasibility Test Score by Expert Validators

Hasil Validasi	Persentase (%)	Kategori
Material validation	0,84	Very High
Media validation	0,80	Very High
Language validation	0,85	Very High
Average	**0,83**	**Very High**

It may be inferred from the overall findings of the expert validation of the created media that this flipbook-assisted problem-solving e-module is appropriate for use in the educational process. According to (Herawati & Muhtadi, 2018) & (Wahab et al., 2023) media can be used in the educational process if it has been proven feasible and is in the very high category.

Qualitative data in this study were obtained through critiques and suggestions provided by validators, which were systematically recorded. These notes serve as a reference to refine the e-module so that it can be implemented optimally. This process is in line with previous research findings, as reported by (Gogahu & Prasetyo, 2020) which indicate that feedback from validators plays a crucial role in improving the quality of learning media. Based on the suggestions and criticisms provided by the validators, several improvements have been made to enhance the quality of the e-module. Here are the improvements made by the researchers.

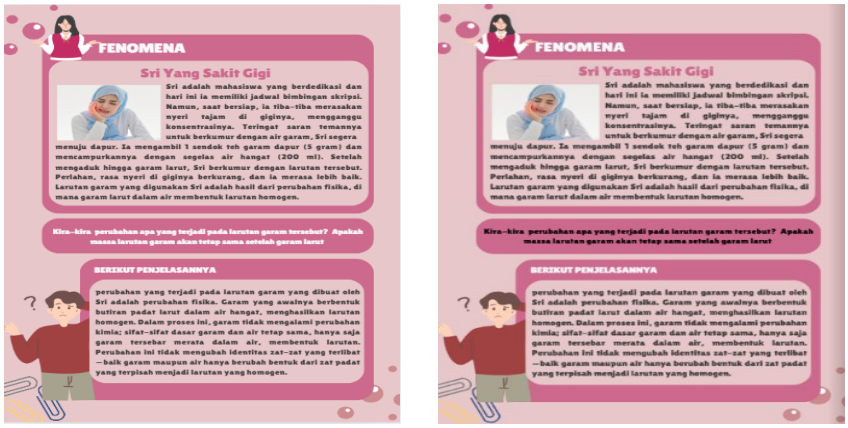

Figure 3. Problem-solving-based e-module assisted by flipbook before and after revision

Following their approval by subject, media, and language experts, small- and large-scale trials were conducted to ascertain how teachers and students responded to the created instructional materials. Ten students participated in the large-scale trial, compared to five in the small-scale one. According to the testing results, the created e-module can help students comprehend the content, particularly when it comes to the subject matter and its modifications. It suggests that the learning process has been well supported by the e-module's design. Moreover, the material's organized presentation helps to focus the learning process.

Implementation is the fourth phase of this study, during which the updated and verified product is put through additional testing. To gauge the students' starting proficiency, a pre-test including five essay questions regarding the substance's composition and its changes was given to the 28 students in class VII C at SMP Negeri 6 Pontianak. Following a pre-test, the learning activities on matter and its modifications were carried out using an e-module that focused on problem-solving and was aided by a flipbook. Following the learning process, the students were required to finish a response questionnaire and a post-test. The efficacy of the e-module was then ascertained by analyzing the data from the pre-test and post-test.

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A normality test was conducted using the Shapiro-Wilk test in SPSS version 25 to determine the data distribution, after the examination of the pre-test and post-test results. The pre-test and post-test results had significance values of 0.004 and 0.356, respectively. The significance value of the pre-test data is below 0.05, indicating it is non-normally distributed. The Wilcoxon Test was employed to determine if a significant difference exists between the pre-test and post-test results within the same group. The Asymp.Sig (2-tailed) value was 0.000 as per the Wilcoxon test. Since 0.000 < 0.05, it can be inferred that the pre-test and post-test results differ significantly, demonstrating the efficacy of the e-module.

The effect size of the pre-test and post-test scores was calculated to determine the efficacy standards of the e-module. The effect size was calculated using the Microsoft Excel program. The computed effect size value of the e-module, categorized as large, was 3.02. Consequently, it is asserted that the developed e-module effectively improves students' proficiency in addressing issues related to matter and its transformations. Table 11 presents the N-gain-calculated outcomes of the students' problem-solving capabilities at each phase of the Heller approach.

Tabel 11. Results of the analysis of problem-solving skills at each step

Validasi Results	Pre-test	Post-test	N-Gain	Category
Visualize the problem	268	473	0,70	Moderate
Describe the problem	422	492	0,50	Moderate
Plan a solution	449	492	0,38	Moderate
Execute the plan	379	480	0,55	Moderate
Check and evaluate	344	457	0,52	Moderate
Average	**372,4**	**478,8**	**0,53**	**Moderate**

N-gain is also used to analyze the improvement in students' *problem-solving* skills for each problem-solving skill indicator (Gunawan et al., 2020). The lowest improvement was found in the indicator of planning solutions. The low improvement is caused by the habit of students who tend to memorize formulas, so in the pre-test and post-test, students answered by recalling the memorized formulas, and most students had already answered correctly in the pre-test. If we look at the average N-gain score, we obtain a value of 0.53, which falls into the moderate category. This indicates that the improvement in students' problem-solving skills at each step in the Heller problem-solving strategy falls into the moderate category.

Tabel 12. Teacher's response to the problem solving based e-module

Indicator	Percentage %	Criteria
Learning	100	Very High
Media	94	Very High
Average	**97**	**Very High**

Table 12 demonstrates that teachers' answers to this problem-solving e-module received 100% in the learning category, which is in the very high category, and 94% in the media area, which is also in the very high category. As a result, the aggregate evaluation derived from the teachers' answers yielded a 97% percentage, which is considered quite high.

Tabel 13. Student responses to problem solver-based e-modules

Indicator	Percentage %	Criteria
Material/Content	86	Very High
Language and Media	86	Very High
Average	**86**	**Very High**

Based on the assessment results of student responses to the e-module filled out by 28 students, a percentage of 86% was obtained for the content aspect and a percentage of 86% for the language and media aspect. The average score obtained from the student response

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questionnaire was 86% with a very high criterion, indicating that the e-module is very effective and suitable for supporting the learning process and enhancing students' problem-solving skills. Based on the results obtained from the above responses, at this stage, there is no evaluation or improvement. This indicates that the designed media is already in accordance with the needs of the learners. Penelitian Wati et al., (2020) emphasize that when teaching materials are well-designed and meet the needs of learners, the lack of necessity for evaluation becomes an indicator of successful implementation.

Evaluation is the last phase in the creation of the e-module. The research's conceptual ramifications show that the creation of *problem-based e-modules* greatly enhances students' ability to solve problems, especially when it comes to the subject of matter and its modifications. The e-module's efficacy in promoting the growth of students' analytical and applied skills is supported by systematic evaluation at every level of development, which guarantees that the content complies with the tenets of problem-based learning. From a practical standpoint, the findings of this study present a novel approach to teaching physics that is pertinent to the advancement of educational technology. Findings from the evaluation, such as the requirement for changes to the font color and audio volume, highlight how crucial design elements are to enhancing the e-module's usability and comfort. In the framework of 21st-century education, it is anticipated that the use of this e-module would improve students' problem-solving abilities through an engaging, efficient, and significant method.

Conclusion

The conclusion drawn from the results of this study is that the problem-solving-based e-module assisted by a flipbook, which has been developed, is declared valid, effective, and suitable for use as a learning medium with the following details: (1) the results of the validation analysis by experts in content, media, and language show an average score of 0.83 with a very high validity criterion. (2) the effectiveness results show an effect size value of 3.02 with a large category. (3) the analysis results of students' problem-solving skills at each step in the Heller problem-solving strategy show an average N-gain value of 0.53 with a moderate category. (4) the results of the responses from educators and students in the field test show a percentage value of 97% for educators and 86% for students with a very high category. Therefore, it can be concluded that the problem-solving-based e-module assisted by a flipbook helps the learning process of students in improving problem-solving skills on the topic of matter and its changes.

Recommendation

Recommendations that can be given for further research include developing e-modules as learning media for different subjects or materials, as well as providing training to educators on the use of interactive learning media. The aim is to facilitate educators in the learning process and to foster students' skills. As for teachers, they should enhance their creativity in using and providing learning media by practicing the creation of learning media.

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