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THE EFFECTIVENESS OF THE HEAT AND ITS TRANSFER E-MODULE BASED ON PROBLEM-BASED LEARNING TO IMPROVE STUDENTS' PROBLEM-SOLVING SKILLS

Euis Puspitasari[1], Baskoro Adi Prayitno[1], Lina Mahardiani[1]
[1] Science Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Jawa Tengah, Indonesia

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ABSTRACT

The purpose of this study is to analyze the effectiveness of the e-modul of heat and its transfer based on Problem Based Learning (PBL) to improve the problem-solving skills of junior high school students who still have low skills. The research method used was quasi-experimental with a nonequivalent pretest-posttest control group design. The population used was seventh grade students at SMPN 2 Purwosari Bojonegoro. The sampling technique used was cluster random sampling. The research sample consisted of classes VIIA, VIIB, and VIIC with a total of 96 students.The research instrument was form of a problem-solving skills test consisting of 5 description questions. The sampling technique uses random sampling in which. The data analysis technique was used ANCOVA test and N-Gain score analysis. The ANCOVA results test is obtained a significance value of 0.000<0.05. This data shows that the use of e-modules has a significant influence on students' problem-solving skills. Based on the N-Gain score, were clearly showed that the use of e-modules provided higher improvement in problem-solving skills than the PPT in experiment class in the control class. The e-module class obtained a score of 0.31 (Identify), 0.52 (Define), 0.56 (Explore Strategies), 0.71 (Anticipate), and 0.76 (Look Back). Three indicators were in the medium category, and two indicators were in the high category. In contrast, control class reaches the low to medium category, and the control class is mostly in the low category. Based on this data, it can be concluded that the use of the heat and its transfer e-module based on PBL has proven to be effective in improving the problem-solving skills of junior high school students and helping students better understand concepts, as well as training them to think critically and reflectively.

Corresponding Author:
Baskoro Adi Prayitno
Science Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Jawa Tengah, Indonesia
Email: baskoroap@fkip.uns.ac.id

1. INTRODUCTION

The 21st century is an era of rapid change in various fields, including education. Education in this era demands a transformation of the curriculum that is oriented towards mastery of technology and high-level thinking skills. Generation Z and Alpha as students today are digital natives who are used to and comfortable with technology (Seibert, 2021; Widya et al., 2019). Therefore, the integration of technology in learning is a necessity to facilitate the development of

21st century skills, such as communication, critical thinking, creativity, and collaboration (Suarsana et al., 2013). The use of technology in education has been proven to improve the quality of learning (Wijayanti & Ghofur, 2021). Teachers can use digital media to present more interesting and interactive learning. Technology-based learning innovations, such as digital modules, animated videos, and interactive applications can support increased motivation and understanding of learners (Buchori & Rahmawati, 2017). In this context, ICT-based teaching materials can play as an effective alternative learning solution (Maharani, 2017). According to Utami (2017) Learning media is considered high quality if it meets three standard assessment criteria, namely validity, practicality, and effectiveness.

One of the recommended models for practicing problem-solving skills is PBL. PBL encourages students to think critically through solving real problems in their lives (Joshi et al., 2020). PBL also emphasizes group work, discussion, and investigation, thereby increasing understanding and collaboration between students (Wyness & Dalton, 2018). In its implementation, PBL is in harmony with a contextual approach that allows learners to understand the material through experiences and situations that are relevant to their lives (Ngaderi & Wahyuni, 2021). Based on interviews with several science teachers at one of public junior high school at, Bojonegoro, it is known that teachers do not use technology as a learning medium, and do not integrate online learning platforms into learning because they have not received adequate training. The implementation of the PBL learning model to train problem-solving skills has not been widely done, teachers tend to use conventional learning methods, namely lectures, so that it does not involve student interaction. The material of heat and its transfer was chosen because it was considered difficult for students to understand. The teacher stated that concepts such as heat energy change, conduction, convection, and radiation are abstract and difficult to convey only through media such as PowerPoint slides. The teacher also said that the achievement of students' learning outcomes is still low, the average class is only 46% of students who achieve grades above the criteria of completeness of learning objectives (KKTP).

Based on the results of a questionnaire respond of 32 junior high school students in Bojonegoro Regency, as many as 72% of students stated that they had difficulty understanding the heat material and its transfer. The causes include difficulty understanding concepts, scientific terms, and the use of formulas. Students stated that only 22% of teachers applied the PBL model. In addition, 63% of students considered the learning media used to be less attractive because teachers only used Powerpoint media. As many as 25% of students assessed that the assignments given by teachers lacked training in problem-solving skills because they were limited to multiple-choice questions and short descriptions. Previous studies have shown that the PBL learning model is effective for training problem solving, and e-modules provide a flexible learning medium. However, there is a clear research gap, namely the lack of sufficient empirical evidence to specifically test the effectiveness of integrating these two things—namely, heat and its transfer electronic modules based on PBL to improve students' problem-solving skills. Previous studies tend to test PBL or e-modules separately, or test them at different levels of education or on different materials. Therefore, this study is important because it aims to fill this gap by testing the impact of a very specific learning media design, namely e-modules whose structure is based on the phases of PBL. Its main contribution is to provide new empirical evidence regarding the synergy between technology (e-modules) and PBL to measurably and directly improve the problem-solving skills of junior high school students, not just cognitive learning outcomes or ordinary attitudes. By

testing this detailed design, this study ensures that the results obtained truly originate from the use of appropriately designed learning media, making it unique and relevant.

This condition shows the need for the development of effective learning media that is able to increase student involvement, stimulate critical thinking, and improve problem-solving skills. Therefore, this study aims to test the effectiveness of the heat and its transfer e-module based on PBL to improve the problem-solving skills of junior high school students. It is esensial because the results of this research can provide new insights for educators in optimizing the use of e-modules to improve problem-solving skills and can contribute to the development of more effective and attractive teaching methods in schools.

2. METHOD

a. Effectiveness Test Design

The design used was a quasi-experimental design with a control group involving unequal pre-tests and post-tests (Sugiyono, 2015). The quasi-experimental method was chosen because it is the most realistic and practical method for testing the effectiveness of PBL-based e-modules in a school environment. This method was chosen due to the limitations of randomizing students into experimental and control groups, which was not feasible in schools. By using existing classes (Non-Equivalent Control Group design), this study was able to test the impact of the intervention directly, so that the results obtained had high external validity and were relevant for application in other schools. Although the groups were not initially randomized, the use of a pre-test will help researchers control for differences in students' initial abilities, ensuring that significant differences in post-test scores are truly due to the effect of using the PBL e-module, rather than other external factors in the Table 1.

Table 1. Research Design

Group	Pretest	Variabel	Postest
Control	Y_1	X_0	Y_2
Treatment 1	Y_1	X_1	X_1Y_2
Treatment 2	Y_1	X_2	X_2Y_2

When Table 1 Y_1 is pre-test score, X_0 is application of heat transfer media and its transfer based on lectures, X_1 is PPT media application, X_2 is E-module deployment, Y_2 is postest value of the control class, X_1Y_2 is postest value of PPT deployment class, X_2Y_2 is postest value of the e-module deployment class.

b. Subjects of Effectiveness Testing

The population used was seventh-grade students at SMPN 2 Purwosari Bojonegoro. The sampling technique used was cluster random sampling. The research sample consisted of classes VIIA, VIIB, and VIIC with a total of 96 students. For sampling, a random sampling method was used, in which each individual had an equal chance of being selected (Sugiyanto, 2017).

c. Data Types and Collection Instruments

The data collection techniques used in testing the effectiveness of this study include two main categories, namely test techniques and non-test techniques. The test technique was carried out by giving students a written test in the form of a long essay. This test consisted of five cognitive questions with a maximum score of 20, which were specifically designed to measure students' problem-solving abilities in accordance with the predetermined aspects and indicators. Meanwhile, non-test techniques were used to supplement the main data. These non-test techniques were carried out through qualitative data collection, review of relevant documents, and collection of other research evidence.

d. Data Analysis Techniques

1) Normalized Gain (N-Gain) Test

N-Gain is the difference between the post-test and pre-test scores used to show the improvement in students' problem-solving skills after learning. The use of N-Gain aims to obtain a more objective picture of the effectiveness of learning, thereby minimizing potential bias in drawing conclusions from the research results. The N-Gain test formula is:

$$G = \frac{\text{Spost}-\text{Spre}}{\text{Smaks}-\text{Spre}} \quad (1)$$

When, g is N-gain, Spre is Rather pre-test, Spost is Post-test score, Smax is Maximum score of questions. The results of the N-gain calculation are then categorized in the criteria in Table 2 as follows (Guntara, 2021):

Table 2. N-Gain Assessment Criteria

Value	Criterion
g ≥ 0,7	Tall
0.3 ≤ g < 0.7	Keep
g < 0,3 g	Low

2) Ancova Test

This data analysis technique uses covariate analysis (Ancova) with the help of SPSS 25. This test uses pretest values as covariates and uses a significance level of 0.05. This test uses normality and homogeneity tests as prerequisites.

a) Normality Test

This test uses the Shaphiro-Wilk model in SPSS 25 to determine the distribution of the sample used. The test is conducted using a p-value of 0.05. The data is considered to have a normal distribution if the significant value found is greater than 0.05.

b) Homogeneity Test

This test uses the Levene test in SPSS 25 to determine whether the population is homogeneous or not. This test uses a p-value of 0.05. The data is considered homogeneous if the significant value found is greater than 0.05.

3. RESULTS AND DISCUSSION

A. N-Gain Test Results

Learning using the heat e-module and its transfer based on Problem Based Learning (PBL), a posttest was carried out to measure the improvement of students' problem-solving skills after being given an e-module in learning. The improvement of students' problem-solving skills is measured from the results of the pretest and posttest. The result of the N-Gain value of each indicator is as shown in Table 3.

Table 3 Results of N-Gain problem-solving skills in extensive trials

Measured aspects	Indicators	N-Gain		
		Control Class	PPT Class	Class E-module
Identify the problem	Developing/analyzing problems	0,15	0,16	0,31
Defining the Problem	Formulating the problem.	0,16	0,14	0,52
Find Alternative Solutions	Search for a variety Alternative Problem Solvers	0,20	0,17	0,56
Choosing an alternative solution (best)	Deciding on the most appropriate solution	0,29	0,37	0,71
Review and evaluate its impact.	Review/re-correct troubleshooting methods.	0,38	0,43	0,76
Average N-Gain		0,24	0,26	0,57
N-Gain Criteria		Low	Low	Keep

Based Table 3 on the N-Gain data presented, it is clear that the difference in effectiveness between the three learning methods in improving students' problem-solving skills is clearly visible. The control class with an average N-Gain of 0.24 and the PPT class with an average of 0.26, both were in the low category. This figure shows that conventional learning methods (control) and the use of Power Point presentation media (PPT) are only able to provide minimal and insignificant improvement in learning outcomes. This is understandable because both methods tend to be teacher-centered, where learners tend to be passive and less involved in the problem-solving process. In contrast, the e-module implementation class showed much superior results with an

average N-Gain of 0.57, which falls into the Medium category. This significant increase was seen to be consistent in each indicator, even reaching the high category, namely 0.71 in the aspect of choosing alternative solutions and 0.76 in the aspect of reviewing. This proves that e-modules are the most effective media because of their interactive and student-centered nature. Learners are encouraged to actively identify problems, find solutions, and evaluate their own processes, which ultimately significantly improves their higher-level thinking skills.

Thus, it can be concluded that the caloric e-module and its transfer based on Problem Based Learning (PBL), is the best choice of learning media and is feasible to develop students' problem-solving skills compared to other methods tested characterized by a *moderate N-Gain* value.

B. Ancova Test Results

1) Ancova Prerequisite Test

a) The normality test using SPSS 25 was carried out on the pretest and posttest scores of students' problem-solving skills with the following results in Table 4.

Table 4 Normality Test Results

Value	Treatment	Shapiro-Wilk		
		Statistics	Df	Sig.
Pretest	No treatment	0.937	32	0.061
	PPT Based Problem Based Learning (PBL)	0.961	32	0.302
	Problem-based e-modules Based Learning (PBL)	0.935	32	0.054
Posttest	No treatment	0.937	32	0.060
	PPT Based Problem Based Learning (PBL)	0.972	32	0.561
	Problem-based e-modules Based Learning (PBL)	0.964	32	0.348

Based Table 4 on the results of the normality test, it can be found that all samples have a significance value of > 0.05 so that it can be concluded that all samples used in the study from the three groups are declared to have normal distribution.

b) Homogeneity Test Results

Homogeneity test results using SPSS 25 in the Table 5.

Table 5 Homogeneity Test Results

Living Statistic	df1	df2	Sig.
0.760	5	186	0.580

Based Table 5 on the results of the homogeneity test, it can be found that the sample used in this study has a significance value of 0.580 > 0.05, so it can be concluded that the data has a homogeneous variance. Based on the results of the Ancova prerequisite test with the normality test and the homogeneity test, the sample used in this study has a normal distribution and has a homogeneous variance so that this test can be continued with the Ancova test.

2) Ancova Test

The Ancova test was carried out with the value of problem-solving skills, the type of learning media used and the interaction between the two in the Table 6.

Table 6 Ancova Test Results

Source	Db	Mean Square	F	Sig.
Corrected models	3	5024.632	81.745	0.000
Intercept	1	5674.791	92.322	0.000
Pretest	1	7469.208	121.515	0.000
Treatment	2	2684.799	43.678	0.000
Error	92	61.468		
Total	96			
Corrected Total	95			

Based Table 6 on the Ancova test, it is known that the pretest score has a Sig value of 0.000 < 0.05, so it can be concluded that there is a significant influence of the pretest on the problem-solving skills of students. While the type of treatment has a Sig value of 0.000 < 0.05, it can be concluded that there is a significant difference in the student's problem-solving skills based on the treatment or it can be concluded that the type of treatment has a significant influence on the student's problem-solving skills.

3) LSD/BNT Test Results

Table 7 LSD/BNT Advanced Test Results

(I) CLASS	(J) CLASS	Mean Difference (I-J)	Sig.
No Treatment	PPT based Problem Based Learning (P B L)	6.95*	0.011
	E-module based Problem Based Learning (PBL)	-13.98*	0.000
Problem Based Learning (PBL) based PPT	N o T r e a t m e n t	6.95*	0.011
	Problem Based Learning (PBL) based e-modules	-7.03*	0.010

Problem Based Learning (PBL) based e-modules	No Treatment	13.98*	0.000
	Problem Based Learning (PBL) based PPT	7.03*	0.010

Based Table 7 on the results of the LSD/BNT follow-up test, it can be found that each treatment given has a significance value of <0.05 so that it can be concluded that each treatment has a real difference. Based on the results of the Ancova test, the results were obtained that there was a difference in the results of the students' problem-solving skills in several classes as evidenced by a Sig value of 0.000. The use of heat e-module media and its PBL-based transfer is the most significant media combination in improving students' problem-solving skills. This is evidenced by the value of problem-solving skills in the heat and displacement e-module experiment class based on PBL value of 90.32 which is the highest average compared to other classes. In addition, in the experimental class using PBL-based powerpoint, an average of 82.79 was obtained, and the last one, the control class without treatment, only got an average of 77.28.

Classes with the treatment of giving e-modules heat and their PBL-based transfers have the highest average because the use of e-modules has advantages, namely; 1) allowing students to learn independently; 2) increase learning resources; 3) enabling students to be 'literate' in technology as required in 21st century learning (Manzoor, Hussain, Ahmed, Iqbal, 2012). The features contained in the e-module can allow students to learn in class and also before and after class. The many features that can be used allow for an interactive learning atmosphere so that students can build concepts in learning. Learning with e-modules can create interaction between teachers and students, peseta didik and other students. The assignment in the form of LKPD on the heat e-module and its transfer is PBL-free which is integrated with biotechnology material (conventional biotechnology topic of making youghurt) and chemical change material (fermentation topic) is an innovation in the e-module developed. This assignment is an effort to improve students' problem-solving skills that meet the five indicators of problem-solving skills adjusted to the stages of PBL. Students can solve problems according to aspects of problem-solving skills.

The integration of problem-solving indicators in LKPD activities can build students' problem-solving skills at each stage. The innovation and novelty of the caloror e-module and its transfer based on Problem Based Learning (PBL) is the integration with conventional biotechnology of yoghurt making and the concept of chemical change (fermentation) which is integrated with five aspects of problem-solving skills. In the first stage of PBL, which is to orient students to problems, it is integrated with the Problem Solving aspect, namely identifying problems. The e-module introduces students to real situations in yogurt making, where students are faced with problems that arise, such as inappropriate yogurt consistency or lack of taste. Learners are trained to actively look into the factors that affect the results, such as temperature and fermentation time, so that they can identify problems in more depth. In the second stage of PBL, namely organizing students to learn, it is integrated with the Problem Solving aspect, namely Define Goals. The e-module provides guidance that helps learners formulate problems systematically, including questions that need to be asked to better understand the situation. Students can use mind mapping, to visualize problems and relationships between variables, so that formulating problems becomes clearer and more structured.

In the third stage of PBL, which is to guide individual and group investigations, it is

integrated with the Problem Solving aspect, namely Explore possible strategies. Students are encouraged to look for various alternatives in making yogurt, such as temperature variations, types of raw materials, or different fermentation techniques. The e-module provides links linked to youtube, live worksheets that allow students to be more creative in finding solutions. In the fourth PBL stage, which is developing and presenting the results of the work, it is integrated with the Problem Solving aspect, namely anticipate outcomes and act (implementing strategies). Students can rate each alternative based on specific criteria, such as effectiveness, cost, and time. Using the data collected from the experiments, learners learn to make evidence-based decisions, improving their analytical abilities in choosing the most efficient solutions.

In the fifth stage of PBL, which is to analyze and evaluate problem solving, it is integrated with the Problem Solving aspect, namely look back and learn. The e-module encourages learners to reflect after the experiment, discussing what worked and what didn't, as well as how the chosen solution affected the final result. Learners can also give each other feedback, which not only strengthens their understanding but also builds communication and collaboration skills. The results of the students' answers showed that the control class reflected relatively low results with an average score of 58.75, in the experimental class the use of PPT with an average score of 65.15, and in the experimental class the use of PBL-based e-modules with an average score of 80.00 showed the most positive contribution to the students' skills.

Based on the results of the N-Gain calculation, there was a significant increase in the average N-Gain score on each skill indicator. In the control class, the average overall N-Gain reached 0.24, indicating a relatively low improvement in understanding. In the experimental class with the administration of PPT, the average N-Gain increased slightly to 0.26, indicating an improvement in learning outcomes. However, the most noticeable improvement occurred in the experimental class with the provision of e-modules, where the average N-Gain increased significantly to 0.57 in the medium category. This improvement shows that learning methods or interventions applied using e-modules have a much higher effectiveness in improving students' problem-solving skills, compared to the other two groups. The N-Gain value of 0.57 is in the medium to high category, which indicates that most students have managed to master the material substantially.

The highest N-Gain value was 0.76 in the aspect of reviewing and evaluating its influence, showing that students experienced a very significant increase in understanding of this aspect after using the e-module. This number is in the high category (N-Gain > 0.7), which means that the learning material is absorbed effectively. The indicator that achieves the highest value is very likely to be influenced by the characteristics of the e-module itself. E-modules encourage students to anticipate or plan steps before working on a problem. Interactive features such as trigger questions and Google Form-based questions force learners to think critically and predict outcomes before attempting to answer. This is different from the conventional method where students only answer questions without thinking about strategies first. The increase in the value of this indicator is also very likely due to the self-reflection feature through Padlet and instant feedback from Google Forms. Students can immediately see the score and answer key, then evaluate their own mistakes, so that the learning process becomes more independent and effective. The interactive features in the e-module, such as triggering questions and automatic evaluations, specifically train learners' ability to plan and evaluate their thought processes.

Based on the data provided, the lowest N-Gain value in the e-module class was 0.31 on

the "identify problem" indicator. indicating that the e-module may be less effective in helping students understand basic concepts. The cause is the initial conceptual challenge where the material about heat and its displacement has many new terms and concepts that may be difficult for students to understand at first glance. Although the e-module provides a description of the material, the process of internalizing the basic concepts (identification and definition) still requires a more personal and in-depth understanding. Another cause is the lack of direct interaction to identify and define often reinforced through direct discussion or oral explanations from teachers. E-modules, which are self-contained, may not be able to completely replace the role of these interactions, especially in breaking down the initial confusion that often occurs.

Nevertheless, the increase from pretest scores to posttest scores on both indicators still shows progress. However, the improvement is not as strong as in other indicators such as "Anticipation" and "Review" which are directly supported by interactive features in the e-module (e.g., interactive questions and reflections). This shows that e-modules are superior in training high-level thinking skills (application and evaluation) than mastery of basic concepts which are often better achieved through face-to-face methods. A significant increase in the N-Gain score of 0.57 in classes that used e-modules shows that this intervention is much more effective than other methods, with a sharp jump of up to 0.76 in the aspects of reviewing and evaluating. This substantial improvement in problem-solving skills can be explained by the synergy between Problem-Based Learning (PBL) and integrated technology features. Theoretically, well-designed e-modules can reduce unnecessary cognitive load, allowing students to focus their mental capacity on the core problem-solving process. Interactive features, such as trigger questions and instant feedback from quizzes, effectively force students to engage in metacognition; they must plan their steps and reflect on their own mistakes, an action strongly associated with sustained problem-solving mastery (Jonassen, 2000). In addition, e-modules support independent learning because students can set the pace and repeat the material at their own speed. Although e-modules show weaknesses in the “identifying problems” indicator (N-Gain 0.31), which most likely still requires face-to-face interaction to overcome initial conceptual confusion, their strength is proven to be optimal in training higher-order thinking skills (HOTS), namely application, planning, and evaluation of solutions. However, the increase in scores from pre-test to post-test on both indicators still shows progress. However, this improvement was not as strong as on other indicators such as “Anticipation” and “Review,” which were directly supported by interactive features in the e-module (e.g., interactive questions and reflections). This shows that e-modules are superior in training higher-order thinking skills (application and evaluation) than in mastering basic concepts, which are often better achieved through face-to-face methods.

4. CONCLUSION

Based on the comes about of the think about, it can be concluded that the Issue Based Learning PBL)-based e-module on warm and its exchange demonstrated to be exceptionally compelling in progressing the problem-solving abilities of junior tall school understudies. This viability is illustrated by noteworthy Ancova test comes about and tall N-Gain scores within the exploratory lesson compared to the control course, particularly in problem-solving pointers. Hypothetically, these discoveries fortify the thought that the integration of innovation and problem-based learning models can altogether make strides learning results. Essentially, this

inquire about gives imaginative arrangements for instructors and und erstudies. For teachers, this e-module can be an effective alternative learning medium for teaching abstract material such as heat and its transfer. For students, the use of this e-module not only helps them understand concepts but also trains them to think critically and analytically through problem solving. Thus, this e-module can be an important reference for future curriculum and teaching method development.

REFERENCES

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers‘ conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7).

Azwar, S. (2015). *Reliabilitas dan validitas.* Yogyakarta: Pustaka Pelajar

Buchori, A., & Rahmawati, N. D. (2017). Development of Geometry e-modules with a Realistic Mathematics Approach in Elementary Schools. *Mathematics Education Study Program, University of PGRI Semarang*, *26*(1), 23–29.

Chain, S. E., & Evans, J. M. (1990). Sciencing an Involvement Approach to Elementary Science Methods. Colombus: Merril Publishing Company.

Chiappetta, E. L & Koballa, T. R., J. (2010). *Science Instruction in the Middle and Secondary Schools.* Boston:Allyn & Bacon.

Daud, D. (2024). Pengembangan E-LKPD interaktif berorientasi SETS dengan liveworksheet untuk meningkatkan minat dan hasil belajar siswa. *Open Journal Systems, 18*(9), https://binapatria.id/index.php/MBI/article/view/772

Dencik, A. (2019). *Multivariate Statistics: Analysis of ANOVA, MANOVA, ANCOVA, MANCOVA, Repeated Measures with Excel and SPSS Applications*. Rajawali Press.

Dogru, M. (2008). The Application Of Problem Solving Method On Science Teacher Trainees On The Solution Of The Environmental Problems. *Journal Of Environmental & Science Education, 3*(1), 9–18.

Ghozali, I. (2018). *Multivariate Analysis Application with IBM SPSS 25 Program*. Publishing Agency of Diponegoro University.

Guntara, Y. (2021). Normalized Gain Measures of Treatment Effectiveness. *Sultan Ageng Tirtayasa University*, 1–3. https://doi.org/https://doi.org/10.13140/RG.2.2.2 7603.40482

Indonesia, F. (2022). *PISA 2022 Results*.

Joshi, A., Desai, P., & Tewari, P. (2020). Learning Analytics Framework for Measuring Students' Performance and Teachers' Involvement Through Problem Based Learning in Engineering Education. *Procedia Computer Science, 172*, 954–959.

Kepka BSKAP. (2024). *Number 032/H/KR/2024 concerning Learning Outcomes in Early Childhood Education, Primary Education Levels, and Secondary Education Levels in the Independent Curriculum*.

Maharani, A. (2017). Development Of Mathematics Teaching Materials Based On Macromedia Flash Real Number Operation Materials For Vocational High School Technology & Engineering. *Journal of Mathematical Theory and Research (THEOREM), 2*(1), 1–10.

Ngaderi, N., & Wahyuni, M. E. (2021). The Effectiveness of Contextual Approach on Students' Comprehension Ability. *Journal of Advanced Sciences and Mathematics Education*, *1*(1), 15–20.

Prasetya, A., Kartono, & Widodo, A. . (2012). IDEAL Problem Solving Model for Achieving Problem-Solving Skills in the Olympic Classroom. *Journal of Educational Sciences*, *41*(1), 1–6.

Puspita, R. A., & Hidayah, R. (2025). The Practicality of Problem-Based Learning Oriented E-Modules to Practice Students' Metacognitive Skills on React Rate Materials. *Journal of Chemistry, Physics and Biology Education*, *1*(3), 92–108.

Rahmadayanti, D., & Hartoyo, A. (2022). Portrait of the Independent Curriculum, the Form of Freedom of Learning in Elementary School. *Journal of Basic Education*, *6*(4), 7174–7187.

Santyadiputra, G. S., Purnomo, & Juniantari, M. (2023). ANCOVA is One Lane Using SPSS. *Accessed From: Https://Saindras.Github.Io/Posts/Ancova-Satu-Jalur-Menggunakan-Spss/*.

Seibert, S. A. (2021). Problem-Based Learning: A Strategy To Fostergeneration Z's Critical Thinking And Perseverance. *Teaching And Learning In Nursing*, *16*, 85–88.

Suarsana, I. M., Major, G. A. M., Mathematics, P., Mathematics, F., Science, D., & Nature, P. (2013). The Development Of Problem-Solving-Oriented E-Modules To Improve Students' Critical Thinking Skills. *Indonesian Journal of Education*, *2*(2).

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). Instructional Development for Training Teachers of Exceptional Children. *National Center for Improvement Educational System*.

Trna, J. (2012). Implementation Of Inquiry-Based Science Education In Science Teacher Training. *Journal Of Educational And Instructional Studies In The World*, *2*(4).

Utami, R. P. (2017). "The Importance of Learning Media Development in Teaching and Learning Process Activities." *Journal of Dharma Education Stkip Pgri Nganjuk*, *12*(2).

Widodo, C. s., & Jasmadi. (2021). *Guidelines for Compiling Competency-Based Teaching Materials*. PT Elex Media Komputindo.

Widya, Rifandi, R., & Laila Rahmi, Y. (2019). STEM Education to Fulfil the 21st Century Demand: A literature Review. *Journal of Physics: Conference Series*, *1317*(1).

Wijayanti, K., & Ghofur, M. A. (2021). Development of Bank e-module Learning Media and Android-Based Fayment System for Class X Students. . *Journal of Economic Education*, *14*(1).

Wyness, L., & Dalton, F. (2018). The Value Of Problem-Based Learning In Learning For Sustainability: Undergraduate Accounting Student Perspectives. *Journal Of Accounting Education*, *45*, 1–19.