JPPIPA 9(12) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Meta Analysis of the Effect Integrated Teaching Materials with Problem Based Learning Models on Students' Problem Solving Ability in Physics Learning

Asrizal[1*], Fatni Mufit[1], Riza Azriyanti[2], Utari Prisma Dewi[2], Nurhamdin Putra[2]

[1] Lecturer of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, Indonesia
[2] Magister of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, Indonesia

Received: June 19, 2023
Revised: November 20, 2023
Accepted: December 20, 2023
Published: December 31, 2023

Corresponding Author: Asrizal Asrizal
asrizal@fmipa.unp.ac.id

DOI: 10.29303/jppipa.v9i12.4368

Abstract: The purpose of this research is to combine, analyze, and conclude previous studies in order to obtain accurate results regarding the effect of integrated teaching materials using the Problem Based Learning (PBL) model on students' problem solving abilities in terms of the types of teaching materials, grade levels, and subject matter. The research method used is meta-analysis by reviewing 28 articles from national and international journals. The research results obtained included: overall the mean effect size of the PBL model integrated teaching materials on students' problem solving abilities was 0.858 which was in the high category. In terms of Teaching Materials, the largest mean effect size is 2.372 with the high category belonging to the E-module. Based on the class level, the largest mean effect size is owned by class XI, which is 0.990, which is in the high category. Based on the material unit, rotational dynamics has the largest mean effect size value of 2.522 which is included in the high category. From the results of this study, it can be concluded that in general teaching materials that are integrated with the PBL model can improve students' problem-solving abilities in learning physics. If viewed from the moderator variable, it can be concluded: First, the most effective teaching material is the e-module. Secondly, it is most effectively applied to class XI. Third, it is most effectively applied to rotational dynamics material

Keywords: PBL; Physics; Problem Solving Ability; Teaching materials

Introduction

Improving the quality of education is carried out by improving the curriculum from time to time, namely the Education Unit Level Curriculum to become the 2013 curriculum and refined again to become the 2013 revision of the 2017 curriculum. This is in line with the demands and challenges of 21st century skills. Aji (2019) says that 21st century learning is simply interpreted as learning that provides 21st century skills to students, namely 4C skills which include communication, collaboration, critical thinking and Problem Solving, Creativity and innovation. One of the characteristics of learning in the 21st century is that learning requires students to have problem-solving skills.

The existing reality has not met the desired expectations. According to research previously conducted by Diana and Makiyah (2021), students' problem-solving skills are still low, this is due to the fact that physics learning in class is more analytical in nature. In addition, research conducted by Noviatika (2019) states that students' problem-solving abilities are still relatively low. The lack of students' problem-solving abilities is suspected to be caused by students' understanding of physics concepts that are still lacking. The teacher only emphasizes learning that allows students to have the ability to answer questions without understanding the material. The teacher also places more emphasis on students memorizing concepts, especially various practical formulas that students can

How to Cite:
Asrizal, Mufit, F., Azriyanti, R., Dewi, U. P., & Putra, N. (2023). Meta Analysis of the Effect Integrated Teaching Materials with Problem Based Learning Models on Students' Problem Solving Ability in Physics Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 1323–1334. https://doi.org/10.29303/jppipa.v9i12.4368

use in answering exam questions without seeing the real benefits of the material being taught in real life. With this in mind, students will increasingly think that learning physics is difficult to understand and has no meaning for their lives. All of that ultimately resulted in the low problem-solving ability of students' Physics Learning.

The Problem Based Learning (PBL) learning model is a learning model that can be used to improve students' physics problem solving abilities. The Problem Based Learning (PBL) learning model is a learning model in which real problems form the basis of the process of delivering material in the learning process so that students can be independent, increase student confidence and construct their own knowledge (Lestari & Yudhanegara, 2015). This problem-based learning is a tool that can be used by physics teachers to help students discover physics concepts and simultaneously improve students' physics problem-solving skills. In addition, the PBL model helps improve the development of lifelong learning skills in an open, reflective, critical, and active learning mindset. PBL is supported in many ways by theories in learning science ranging from constructivism and cognition to problem solving (Sinaga, 2018). Learning introduces students to real-world problems and is encouraged to explore them which is especially designed for students to develop students' thinking, problem-solving and intellectual skills, learn the role of adults by experiencing them through simulated real situations, and become independent learners (Arends, 2013).

PBL is an innovation in learning because in PBL students' thinking abilities are truly optimized through a systematic process of group or team work, so that students can empower, hone, test, and develop their thinking skills on an ongoing basis. PBL helps promote the development of lifelong learning skills in an open, reflective, critical, and active learning mindset. PBL is supported in many ways by theories in learning science ranging from constructivism and cognition to problem solving (Sinaga, 2018). Learning introduces students to real-world problems and is encouraged to explore them which is especially designed for students to develop students' thinking, problem-solving and intellectual skills, learn the role of adults by experiencing them through simulated real situations, and become independent learners (Arends, 2013).

Problem solving is a skill that includes the ability to seek information, analyze situations and identify problems with the aim of generating alternatives so that decisions can be taken to achieve goals (Shoimin, 2016). The ability to solve problems that are owned will equip students to face real problems and this PBL learning process makes students actively involved in learning. Problems in Problem Based Learning (PBL) use real (authentic) problems that are unstructured and open in nature as a context for students to develop problem-solving skills and critical thinking while forming new knowledge (Fathurrohman, 2015). Some of the results of research discussing the Problem Based Learning (PBL) model at the school level, the overall results of the several studies indicate that the Problem Based Learning (PBL) model has an effect on increasing students' Physics Learning problem solving abilities.

Based on the explanation above, this study aims to see how much influence the Integrated Teaching Materials Problem Based Learning Model has on Students' Problem Solving Ability in Physics Learning in terms of the type of teaching materials, grade levels, and subject matter on students' solving abilities.

Method

The research method used is quantitative meta-analysis. It uses effect size calculations from several articles that have been collected. According to Glass, et al (1981) meta-analysis means quantitative analysis and uses a large amount of data and applies statistical methods by practicing them to organize a number of issues from large samples whose use is to complement other purposes. According to Cohen (1988), effect size is a measure of the quantity of a research result to determine correlations or differences between research variables

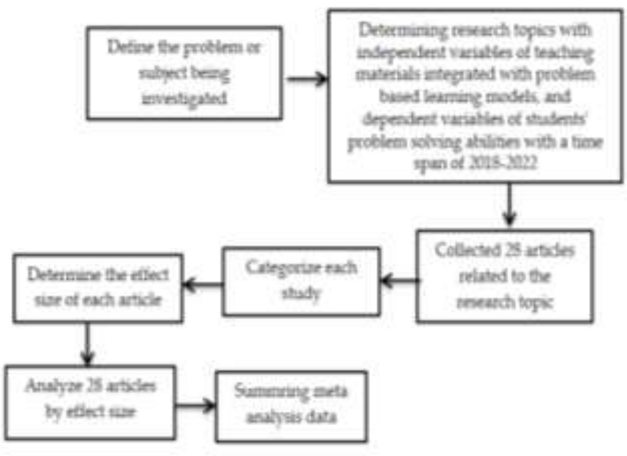

Figure 1. Research Flow

The data collected is secondary data, derived from articles published in SINTA accredited national and international journals which describe previous research. The articles that have been collected are related to the effect of the problem-based learning model on students' problem-solving abilities in physics learning. As research subjects, 28 national and international journal articles published between 2018 - 2022 were used. The research flow can be seen in Figure 1.

The procedure for conducting meta-analysis in this study was adapted to the procedure proposed by David B. Wilson and George A Kelly, namely: first, determine the problem or topic to be analyzed. The problem to be analyzed in this study is the effect of Problem Based Learning on students' Physics problem-solving abilities. Second, etermine the period of the research study that will be used as a source. Third, earch for reports according to the problem to be analyzed. Fourth, Read and understand journal titles and abstracts to ensure their suitability with the questions you want to analyze. Five, focus each study on research questions and methods. Six, categorize each study. Seven, compare all findings according to category 8. Analyze research findings and draw conclusions. Effect size measurement uses the following statistics:

Table 1. How to Determine the Effect Size

Statistics		Formula
Average in one group	$ES = \frac{\bar{x}_{post} - \bar{x}_{pre}}{SD_{pre}}$	Fr-1
Average in each group	$ES = \frac{\bar{x}_{eksperimen} - \bar{x}_{kontrol}}{s_{kontrol}}$	Fr-2
Average in each group	$ES = \frac{(\bar{x}_{post} - \bar{x}_{pre})_E - (\bar{x}_{post} - \bar{x}_{pre})_C}{\frac{SD_{preC} + SD_{preE} + SD_{postC}}{3}}$	Fr-3
t-test	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$	Fr-4
Chi-Square	$ES = \frac{2r}{\sqrt{1-r^2}}; r = \sqrt{\frac{x^2}{n}}$	Fr-5
P-value	CMA (Comprehensive Meta Analisis Software)	Fr-6

(Becker & Park, 2011)

Effect sizes are then characterized using the following criteria after being calculated using the appropriate formula:

Table 2. Effect Size Criteria

ES	Category
0 ≤ ES ≤ 0.2	Low
0.2 ≤ ES ≤ 0.8	Medium
ES ≥ 0.8	high

(Cohen, 1988)

Result and Discussion

The Effect of PBL Model Integrated Teaching Materials on Students' Problem-Solving Ability in Physics Learning

The data examined in this study are 28 articles, both national and international articles. From the articles that have been analyzed, the results of this study are grouped into 3 moderator variables, namely based on teaching materials, based on class levels, and based on material units. The following is the overall calculation of the 28 articles on the effect of the PBL model integrated teaching materials on students' problem-solving abilities in physics learning as shown in table 3.

Based on the heterogeneity test, it is found that Q > df, then the estimation of the variance between articles is quite large and the data is heterogeneous. The heterogeneity value of the article data is 90.58%, indicating that there is a population difference between articles of 90.58%.

Based on the results of the heterogeneity testing that has been done, it is known that the random effect model is suitable for calculating the size of the summary effect size of the effect of the integrated teaching materials of the PBL model on students' problem-solving abilities in physics learning. Furthermore, the calculation of the summary effect size of the effect of the PBL model integrated teaching materials on students' problem solving abilities in physics learning by conducting hypothesis testing, the results of the hypothesis testing can be seen in Table 4.

Based on the results of hypothesis calculations on students' problem-solving abilities in physics learning, it was found that from the 28 articles used, it was shown that the integrated teaching materials with the problem-based learning (PBL) model had a significant effect. The results of the weighted summary effect size obtained were 0.781 indicating that the integrated teaching materials problem based learning (PBL) models were in the very high category with confidence intervals below 0.149 and above 1.072. The results of hypothesis testing also show that the p value <α, which shows that the hypothesis testing H_0 is rejected. The results of H_0 were rejected indicating that as many as 28 similar articles stated that the PBL model integrated teaching materials had an influence on students' problem solving abilities in physics learning. This is in line with research that has been conducted (Astuti & Slameto, 2018) where there is an effect of the Problem Based Learning model on students' problem solving abilities. And also (Yunarni, 2018) the use of the Problem Based Learning model can improve students' problem solving abilities. Aji et al., (2017) also stated that teaching materials in the form of integrated modules of problem-based learning models can improve students' problem-solving abilities in learning physics on the subject of rotational equilibrium and dynamics. Product development in the form of problem-based learning model-based learning tools has proven to be very valid, reliable, very practical and quite effective in improving students' physics problem-solving abilities, especially on dynamic fluid topics (Widiawati et al., 2022). There are also those who apply a problem-based learning model assisted by electronic books on magnetic field material where the results are effective in improving students' problem solving abilities (Prahani et al., 2022).

Table 3. Testing the heterogeneity of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning

Article Code	Effect Size Yi	Q	df	I^2
A1	0.694			
A2	2.629			
A3	0.028			
A4	0.199			
A5	1.460			
A6	0.312			
A7	1.086			
A7	1.086			
A8	0.108			
A9	0.162			
A10	0.093			
A11	1.067			
A12	0.887			
A13	1.184			
A14	0.117	286.697	27	90.58
A15	0.081			
A16	0.044			
A17	0.020			
A18	0.002			
A19	4.613			
A20	0.871			
A21	1.908			
A22	0.137			
A23	0.048			
A24	4.174			
A25	0.858			
A26	0.079			
A27	0.571			
A28	0.579			

Table 4. Testing the hypothesis of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning

Article Code	Effect Size Yi	ES Average	M	SEM	LLM	ULM	Z	p-value
A1	0.694							
A2	2.629							
A3	0.028							
A4	0.199							
A5	1.460	0.858	0.781	0.149	0.490	1.072	5.259	0.000
A6	0.312							
A7	1.086							
A8	0.108							
A9	0.162							
A10	0.093							

Article Code	Effect Size Yi	ES Average	M	SEM	LLM	ULM	Z	p-value
A11	1.067							
A12	0.887							
A13	1.184							
A14	0.117							
A15	0.081							
A16	0.044							
A17	0.020							
A18	0.002							
A19	4.613							
A20	0.871							
A21	1.908							
A22	0.137							
A23	0.048							
A24	4.174							
A25	0.858							
A26	0.079							
A27	0.571							
A28	0.579							

The effect of integrated PBL model teaching materials on students' problem-solving abilities in physics learning based on Teaching Materials

The next result of this study is seen based on teaching materials. The summary effect size value of the effect of integrated problem based learning (PBL) model teaching materials on students' problem-solving abilities in learning physics based on teaching materials was obtained through the initial stage, namely testing the heterogeneity of each teaching material. Testing the heterogeneity of the effect of the problem based learning (PBL) model integrated teaching materials on students' problem-solving abilities in physics learning based on teaching materials can be seen in Table 5.

Based on the results of the heterogeneity test, it can be seen that there are 4 teaching materials integrated with the PBL model on students' problem-solving abilities in physics learning which show a value of Q > df, so the estimation of the variance between articles is quite large and heterogeneous. The model that is suitable for calculating the size of the summary effect on the four teaching materials is the random effects model. The heterogeneity value of the articles in each teaching material, namely the heterogeneity value of Student worksheet was 90.33%, textbooks were 54.75%, modules were 74.52 and E-modules were 97.86%. This heterogeneity value indicates that there are population differences between articles in each teaching material.

The next stage is testing the hypothesis of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning based on teaching materials. Calculation of the hypothesis based on teaching materials can be seen in Table 6.

Table 5. Testing the heterogeneity of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning based on teaching materials

Teaching materials	Article Code	Effect Size Yi	Q	df	I^2
Student worksheet	A1	0.694	144.728	14	90.33
	A2	2.629			
	A3	0.028			
	A5	1.460			
	A6	0.312			
	A7	1.086			
	A8	0.108			
	A9	0.162			
	A10	0.093			
	A12	0.887			
	A14	0.117			
	A16	0.044			
	A21	1.908			

	A22	0.137			
	A23	0.048			
Book	A4	0.199	6.629	3	54.75
	A11	1.067			
	A25	0.858			
	A28	0.579			
Module	A20	0.871	3.924	1	74.52
	A26	0.079			
E-Module	A24	4.174	46.741	1	97.86
	A27	0.571			

Table 6. Testing the hypothesis of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning based on teaching materials

Teaching materials	Article Code	Effect Size Yi*	ES Average	M	SEM	LLM	ULM	Z	p-value
Student worksheet	A1	0.694	0.647	0.635	0.185	0.272	0.998	3.431	0.000
	A2	2.629							
	A3	0.028							
	A5	1.460							
	A6	0.312							
	A7	1.086							
	A8	0.108							
	A9	0.162							
	A10	0.093							
	A12	0.887							
	A14	0.117							
	A16	0.044							
	A21	1.908							
	A22	0.137							
	A23	0.048							
Book	A4	0.199	0.676	0.684	0.185	0.321	1.047	3.691	0.000
	A11	1.067							
	A25	0.858							
	A28	0.579							
Module	A20	0.871	0.475	0.442	0.395	-0.332	1.216	1.120	0.131
	A26	0.079							
E-Module	A24	4.174	2.372	2.352	1.802	-1.179	5.883	1.306	0.096
	A27	0.571							

Based on the results of testing the hypothesis on each teaching material, it shows that the four teaching materials have an influence on students' problem-solving abilities in physics learning. Effect size for each teaching material, namely on student worksheets (LKS) the heterogeneity value is 0.647% in the medium category, 0.676% in textbooks is also in the moderate category, and modules are also in the medium category with an effect size of 0.475% while in the E-module of 2,372% in the high category. The results of testing the hypothesis on the four teaching materials show that the value of $p < \alpha$, which shows that the hypothesis testing H0 is rejected. So that it is obtained that the teaching materials that have the greatest summary effect size have an influence on solving student problems in physics learning, namely in the E-module. This is in accordance with the opinion (Zhafirah & Rery, 2021) E-modules based on Problem Based Learning (PBL) on hydrocarbon material are stated to be effective in increasing students' problem solving abilities. Ajri & Diyana (2023) developed a problem-based learning-based e-module assisted by liveworksheets for dynamic fluid material that is feasible in improving students' problem solving skills. In line with Gita et al., (2022) which stated that e-modules based on problem based learning are feasible and effective for improving students' problem solving skills. In addition, products in the form of electronic science modules based on problem based learning models and guided discovery learning are declared feasible to be applied to improve students' critical thinking skills and problem solving (Suryaningtyas et al., 2019). Then, Astra et al., (2020) stated that students' higher-order thinking skills in gas kinetic theory material can be improved by using teaching materials in the form of electronic modules using creative problem solving models which are equipped with Higher Order Thinking Skills (HOTS) questions.

Testing the heterogeneity of the effect of integrated PBL model teaching materials on students' problem-solving abilities in physics learning based on class level

The third result is in the study of the effect of problem based learning (PBL) model integrated teaching materials on students' problem-solving abilities in physics learning, which is based on class level. Heterogeneity testing based on class level can be seen in table 7.

Table 7. Testing the heterogeneity of the effect of integrated PBL model teaching materials on students' problem-solving abilities in physics learning based on class level

Class	Article Code	Effect Size Yi	Q	df	I^2
X	A2	2.629	181.538	18	90.085
	A4	0.199			
	A5	1.460			
	A6	0.312			
	A7	1.086			
	A8	0.108			
	A10	0.093			
	A11	1.067			
	A13	1.184			
	A14	0.117			
	A15	0.081			
	A16	0.044			
	A17	0.020			
	A19	4.613			
	A22	0.137			
	A23	0.048			
	A25	0.858			
	A27	0.571			
	A28	0.579			
XI	A1	0.694	103.531	7	93.239
	A3	0.028			
	A9	0.162			
	A18	0.002			
	A20	0.871			
	A21	1.908			
	A24	4.174			
	A26	0.079			

Based on the results obtained in Table 6, it is known that only 2 classes were tested for heterogeneity, because these 2 classes have different populations, namely in class X and XI. Meanwhile, in class XII heterogeneity testing was not carried out because the population was the same.

Based on the results of the heterogeneity test in the 2 classes, it was found that it showed a value of Q> df, so the estimation of the variance between articles was quite large and the data was heterogeneous. In class X it is 90.085% and 93.239% in class XI. So it can be seen that there are differences in population between articles at each class level. Next is testing the hypothesis of the effect of the problem-based learning (PBL) model integrated teaching materials on students' problem-solving abilities in physics learning, which is based on class level. Hypothesis calculation based on class level can be seen in Table 8.

Table 8. Testing the hypothesis of the effect of the PBL model integrated teaching materials on students' problem-solving abilities in physics learning based on class level

Class	Article Code	Effect Size Yi	ES Average	M	SEM	LLM	ULM	Z	p-value
	A2	2.629							
	A4	0.199							
	A5	1.460							
	A6	0.312							
	A7	1.086							
	A8	0.108							
	A10	0.093							
	A11	1.067							
	A13	1.184							
X	A14	0.117	0.800	0.718	0.169	0.387	1.050	4.246	0.000
	A15	0.081							
	A16	0.044							
	A17	0.020							
	A19	4.613							
	A22	0.137							
	A23	0.048							
	A25	0.858							
	A27	0.571							
	A28	0.579							
	A1	0.694							
	A3	0.028							
	A9	0.162							
	A18	0.002							
XI	A20	0.871	0.990	0.936	0.362	0.227	1.646	2.588	0.005
	A21	1.908							
	A24	4.174							
	A26	0.079							

Based on the results of testing the hypothesis at the class level, it was found that the 2 existing classes showed the effect of integrated teaching materials with problem based learning (PBL) models on students' problem solving abilities in physics learning. The results of the calculation of the effect size show that the effect size for class X is 0.800% and 0.990% for class XI with the high category. The result of testing the hypothesis is that the p value <α, then testing the hypothesis H0 is rejected. So it was found that teaching materials that have the greatest summary effect size have an influence on solving student problems in physics learning, namely in class XI. This is in line with the opinion (Mahmudah, 2020) There is a significant influence from the use of the Problem Based Learning model on the problem-solving abilities of class XI students. Diana & Makiyah (2021) also stated that student worksheets (LKPD) based on Problem Based Learning (PBL) could optimize the problem solving skills of class XI students on the topic of double slit interference. A study said that teaching materials based on Problem Based Learning proved to be valid and practically applied to class XI on Elasticity and Hooke's Law (Harefa & Gumay, 2020). Research conducted by Suwandi et al., (2021) where he developed a problem-based learning model set with a multiple intelligences approach, the results of which were effectively used in class XI in improving students' physics problem-solving skills. Other research also states that website-based static fluid and dynamic fluid e-books integrated with problem based learning (PBL) models are feasible and effective in improving the problem solving abilities of class XI students (Ramli et al., 2021).

Testing the heterogeneity of the effect of integrated PBL model teaching materials on students' problem-solving abilities in physics learning based on unit material

The final moderator variable from the study is related to the influence of integrated teaching materials in the problem based learning (PBL) model on students' problem-solving abilities in physics learning, namely based on unit material. Testing the hypothesis on the effect of integrated problem based learning (PBL) model teaching materials on students' problem-solving abilities in physics learning can be identified by first testing the heterogeneity of the learning model media used. Heterogeneous testing based on material units can be seen in Table 9.

Table 9. Testing the heterogeneity of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning based on material units

Material Units	Article Code	Effect Size Yi	Q	df	I^2
Static Fluids	A3	0.028	9.265	1	89.207
	A11	1.067			
Momentum and Impulse	A4	0.199	69.499	4	94.245
	A5	1.460			
	A6	0.312			
	A16	0.044			
	A19	4.613			
Simple Harmonic Vibration	A10	0.093	11.120	1	91.007
	A13	1.184			
Rotation dynamics	A20	0.871	34.561	1	97.107
	A24	4.174			
Parabolic Motion	A21	1.908	7.922	1	87.377
	A25	0.858			

Based on the results obtained in Table 9, it is known that only 5 material units were tested for heterogeneity, because only 6 of these material units had different populations. The 6 material units tested for heterogeneity were Static Fluid, Momentum and Impulse, Simple Harmonic Vibration, Rotational Dynamics and Parabolic Motion material. Meanwhile, the other 5 learning material units were not tested for heterogeneity because the populations were the same.

The results of heterogeneity testing on learning material units showed that Static Fluid, Momentum and Impulse, Simple Harmonic Vibration, Rotational Dynamics and Parabolic Motion material showed a value of Q > df, so the estimation of the variance between articles was quite large and the data was heterogeneous. The model that is suitable for calculating summary effect sizes on Static Fluid, Momentum and Impulse, Simple Harmonic Vibration, Rotational Dynamics and Parabolic Motion material is the random effect model.

Next is testing the hypothesis of the effect of integrated teaching materials on the problem based learning (PBL) model on students' problem-solving abilities in physics learning. Hypothesis calculations based on material units can be seen in Table 10.

Based on the results of testing the hypothesis contained in the 5 material units it is known that the results of the effect size on the material unit Static Fluid and Simple Harmonic Vibration are in the Moderate category with effect sizes of 0.548% and 0.639%, while in the material Momentum and Impulse are 1.326%, Rotational Dynamics are 2.522%, Parabolic Motion 1.383% is in the high category. Testing the hypothesis on the material unit shows that the p value <α, then the HO hypothesis testing is rejected. So that the test results indicate that there is an influence of integrated PBL model teaching materials on students' problem-solving abilities in physics learning based on material units. So that it is obtained that teaching materials that have the greatest summary effect size have an influence on solving student problems in learning physics, namely in the material of rotational dynamics. This is in accordance with (Wisic & Makiyah, 2021) with the results of his research, namely that there are differences in the level of effectiveness of using Problem Based Learning-based learning modules on students' problem solving abilities in rotational dynamics material. Other research also states that problem-based learning (PBL) oriented student worksheets (LKPD) have proven to be very valid and very practical to apply to rotational dynamics and rigid body equilibrium material (Novia et al., 2021). Sandi & Bachri (2020) research also produced an E-Module material on rotation dynamics that is effectively used in learning activities.

Table 10. Hypothesis testing of the effect of integrated teaching materials on the PBL model on students' problem-solving abilities in physics learning based on material units

Material Units	Article Code	Effect Size Yi	ES Average	M	SEM	LLM	ULM	Z	p-value
Static Fluids	A3	0.028	0.548	0.547	0.520	-0.472	1.566	1.052	0.146
	A11	1.067							
Momentum and Impulse	A4	0.199	1.326	1.174	0.477	0.240	2.108	2.464	0.007
	A5	1.460							
	A6	0.312							
	A16	0.044							
	A19	4.613							
Simple Harmonic Vibration	A10	0.093	0.639	0.617	0.545	-0.451	1.686	1.132	0.129
	A13	1.184							
Rotation dynamics	A20	0.871	2.522	2.507	1.651	-0.730	5.743	1.518	0.065
	A24	4.174							
Parabolic Motion	A21	1.908	1.383	1.374	0.525	0.344	2.403	2.616	0.004
	A25	0.858							

Conclusion

Based on the data and research results, it can be concluded that the PBL model integrated teaching materials can have an influence on students' problem-solving abilities in physics learning. If viewed from the moderator variable, the following conclusions can be drawn: First, based on the teaching materials used, the PBL model integrated teaching materials have an influence on students' problem-solving abilities in physics learning, especially in E-modules with an effect size of 2.372% in the high category. Second, based on the class level, the PBL model integrated teaching material has an influence on students' problem solving abilities in physics learning in class XI with an effect size of 0.990% in the high category. Third, based on the unit of material used, the PBL model integrated teaching material has an influence on students' problem-solving abilities in physics learning, especially the rotation dynamics material with an effect size of 2.522% in the high category.

Acknowledgments
Thank you to all the researchers whose articles we have reviewed and cited, Google Scholar and other sources who have provided articles relevant to this research, and the JPPIPA editorial board for providing this valuable opportunity to publish this article

Author Contributions
Author contributions include Riza Azriyanti, Utari Prisma Dewi, and Nurhamdin Putra: collecting data, analyzing data, writing original drafts, and so on; Asrizal and Fatni Mufit: focus on methodology and review writing.

Funding
This research was independently funded by researchers.

Conflicts of Interest
The authors declare no conflict of interest

References

Aji, S. D, Hudha, M. N & Rismawati, A. Y. (2017). Pengembangan Modul Pembelajaran Fisika Berbasis *Problem Based Learning* untuk Meningkatkan Kemampuan Pemecahan Masalah Fisika. *Science Education Journal, 1*(1), 36-51. https://doi.org/ 10.21070/sej.v1i1.830

Aji, M. Q. W. (2019). Mengembangkan kecakapan abad 21 mahasiswa melalui model pembelajaran inkuiri. *Teknodika, 17*(2). https://doi.org/10.20961/teknodika.v17i2.3 5281

Ajri, A. S., & Diyana, T. N. (2023). Pengembangan E-Modul berbasis problem based learning berbantuan liveworksheets untuk mengoptimalkan keterampilan pemecahan masalah. *Jurnal Kajian Pendidikan IPA*, *3*(2), 223-234. Retrieved from https://journal.uniga.ac.id/index.php/jkpi/article/view/2377/pdf

Astra, I. M., Raihanati, R., & Mujayanah, N. (2020). Development of electronic module using creative problem-solving model equipped with HOTS problems on the kinetic theory of gases material. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *6*(2), 181-194. https://doi.org/10.21009/1.06205

Astuti, P., & Slameto, (2018), Pengaruh Model Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematika Siswa Sekolah Dasar. *Jurnal Sekolah,* *2*(2). Retrieved from https://jurnal.unimed.ac.id/2012/index.php/js/article/view/9520/8737

Arends, R, I. (2013). *Learning To Teach Edisi Kesembilan*. Jakarta: Salemba Humanika.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(5), 23-37. Retrieved from https://www.jstem.org/jstem/index.php/JSTEM/article/download/1509/1394

Cohen, J. (1988). Set correlation and contingency tables. *Applied psychological measurement*, 12(4), 425-434. Retrieved from https://conservancy.umn.edu/bitstream/handle/11299/104317/1/v12n4p425.pdf

Diana, R., & Makiyah, Y. S. (2021). Efektivitas Lembar Kerja Peserta Didik (LKPD) Berbasis Model Problem Based Learning (PBL) untuk Meningkatkan Keterampilan Pemecahan Masalah pada Materi Interferensi celah Ganda. *Jurnal Pendidikan Fisika*, *10*(1), 48-54. https://doi.org/10.22611/jpf.v10i1.24763

Fathurrohman, M. (2015). *Model-Model Pembelajaran Inovatif.* Yogyakarta: Ar-Ruzz Media. Retrieved from http://staffnew.uny.ac.id/upload/132313272/pengabdian/model-model-pembelajaran.pdf

Gita, D. R., & Dewati, M. (2022). Pengembangan E-Modul Fisika Berbasis Problem Based Learning Untuk Meningkatkan Keterampilan Pemecahan Masalah Siswa. In *SINASIS (Seminar Nasional Sains)*, *3*(1). Retrieved from https://proceeding.unindra.ac.id/index.php/sinasis/article/view/6025/1580

Glass, G.V., McGaw B., & Smith, M.L. (1981). *Meta-Analysis in Social Research*. London: Sage Publications. Retrieved from https://www.jameslindlibrary.org/glass-gv-mcgaw-b-smith-ml-1981/

Harefa, D. P., & Gumay, O. P. U. (2021). Pengembangan buku ajar fisika berbasis problem based learning pada materi elastisitas dan hukum hooke. *Silampari Jurnal Pendidikan Ilmu Fisika*, *3*(1), 1-14. https://doi.org/10.31540/sjpif.v3i1. 1044

Lestari, K.E., & Yudhanegara, M. R. (2015). Penelitian Pendidikan Matematika (Panduan Prkatis Menyusun Skripsi, Tesis, dan Karya Ilmiah dengan Pendekatan Kuantitatif, Kualitatif, dan Kombinasi Disertai dengan Model Pembelajaran dan Kemampuan Matematis). Bandung: PT Refika Aditama.

Mahmudah, W., & Tanjung, R. (2020). Pengaruh Model Problem Based Learning dalam Meningkatkan Kemampuan Pemecahan Masalah Siswa di MAN 3 Medan. *Jurnal Ikatan Alumni Fisika Universitas Negeri Medan*, *6*(3), 18-22. Retrieved from https://jurnal.unimed.ac.id/2012/index.php/jiaf/article/view/20143/pdf

Noviatika, Rindayu, Gunawan, and Joni Rokhmat. (2019). Pengaruh Model Pembelajaran Berbasis Masalah Berbantuan Mobile Pocket Book Fisika Terhadap Kemampuan Pemecahan Masalah Peserta Didik. *Jurnal Pendidika Fisika Dan Teknologi* 5(2), 240–46.

Novia, N., Husna, H., & Zulva, R. (2021). Pengembangan LKPD Dinamika Rotasi dan Kesetimbangan Benda Tegar Berorientasi Problem Based Learning. *Journal of Natural Science and Integration*, *4*(2), 214-221. http://dx.doi.org/10.24014/jnsi.v4i2.14428

Novita, N., Hidayati, H., & Masril, M. (2018). Pengaruh Penggunaan Modul Berorientasi Pendekatan Saintifik dalam Model Problem Based Learning (PBL) Terhadap Pembelajaran Fisika Kelas XI di SMAN 1 Bukittinggi. *Pillar of Physics Education*, *11*(2), 89-96. http://dx.doi.org/10.24036/2731171074

Prahani, B.K. , Rizki, I.A., Nisa, K., Citra, N.F., Alhusni, H.C., & Wibowo, F.C. (2022). Implementation of online problem-based learning assisted by digital book with 3D animations to improve student's physics problem-solving skills in magnetic field subject. *Journal of Technology and Science Education,* 12(2), 379-396. https://doi.org/10.3926/jotse.1590

Ramli, Z., & Serevina, V. (2021). E-Book Static Fluid and Dynamic Fluid Web-Based with a Problem-Based Learning Model to Improve Students Physics Problem-Solving Skills. In *Journal of Physics: Conference Series,* *2019*(1), 012001. https://doi.org/10.1088/1742-6596/2019/1/012001

Sandi, A. M., & Bachri, B. S. (2020). Pengembangan e-modul materi dinamika rotasi pada mata pelajaran fisika kelas xi di sma negeri 11 surabaya. *Jurnal*

Mahasiswa Teknologi Pendidikan, *10*(5). Retrieved from https://ejournal.unesa.ac.id/index.php/jmtp/article/view/32232

Shoimin, A. (2016). *68 Model Pembelajaran Inovatif dalam Kurikulum 2013*. Yogyakarta: Ar-ruzz Media.

Sinaga, Rafles, and Eidi Sihombing. 2019. "Pengaruh Model Problem Based Learning (Pbl) Terhadap Kemampuan Pemecahan Masalah Pada Materi Pokok Fluida Statis Di Sma Negeri 1 Silima Punggapungga." *INPAFI (Inovasi Pembelajaran Fisika)* 6(4). https://doi.org.10.24114/inpafi.v6i4.13368.

Suryaningtyas, A., Kimianti, F., & Prasetyo, Z. K. (2020). Developing science electronic module based on problem-based learning and guided discovery learning to increase critical thinking and problem-solving skills. In *International Conference on Educational Research and Innovation (ICERI 2019)*, 65-70. https://doi.org/10.2991/assehr.k.200204.013

Suwandi, A.F., Sahidu, H., & Gunada, I. W. (2021). Effectiveness of Problem-based Learning Model Devices with Multiple Intelligences Approach to Improve Learners' Physics Problem-Solving Skills. *Jurnal Penelitian Pendidikan IPA*, *7* (SpecialIssue), 238–243. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1064

Widiawati, R., Hikmawati, H., & Ardhuha, J. (2022). Pengembangan Perangkat Pembelajaran Berbasis Model Problem Based Learning untuk Meningkatkan Kemampuan Pemecahan Masalah Fisika Peserta Didik pada Materi Fluida Dinamis. *Jurnal Ilmiah Profesi Pendidikan*, *7*(3c), 1803-1810. https://doi.org/10.29303/jipp.v7i3c.857

Wisic, M. I., & Makiyah, Y. S. (2021). Efektivitas Modul Pembelajaran Berbasis Problem Based Learning terhadap Kemampuuan Pemecahan Masalah Siswa pada Materi Dinamika Rotasi. *ORBITA: Jurnal Hasil Kajian, Inovasi, Dan Aplikasi Pendidikan Fisika*, *7*(1), 229-232. Retrieved from https://journal.ummat.ac.id/index.php/orbita/article/view/4710/4080

Yunarni, A. (2018), Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematika Siswa Kelas VII di SMP Negeri Pangkajene. *Jurnal Mosharafa*, 7(1). Retrieved from https://journal.institutpendidikan.ac.id/index.php/mosharafa/article/view/mv7n1_6/345

Zhafirah, T., Erna, M., & Rery, R. U. (2021). Efektivitas penggunaan e-modul hidrokarbon berbasis problem based learning untuk meningkatkan kemampuan pemecahan masalah peserta didik. *Prosiding Penelitian Pendidikan dan Pengabdian 2021*, *1*(1), 206-216. Retrieved from http://prosiding.rcipublisher.org/index.php/prosiding/article/view/135/26