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Meta-Analysis of the Effect of Applying the Problem Based Learning (PBL) Model on Science and Physics Learning on Students' High Order Thinking Skills (HOTS)

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Abstract: The purpose of this study was to determine the effect of the problem-based learning model on students' high order thinking skills. The topic of this essay is meta-analysis. Meta analysis is a study conducted by collecting, analyzing, and comparing data from several previously completed studies. Research samples were made from 27 nationally and internationally accredited journals with criteria according to the problem formulation. The data analysis method used in this study is a method that minimizes the effect size of each article. Based on the results of the research, it has been determined that the effect of the problem-based learning model on students' high order thinking skills. First, the problem based learning model has a significant influence on improving students' high order thinking skills. Second, the problem based learning model based on educational level states that there is a significant influence on students' higher level thinking abilities. Third, the problem based learning model based on science and physics subjects does not have a significant difference in students' high order thinking skills.

Keywords: High order thinking skills; Learning model; Problem based learning

Introduction

Education in the 21st century should be able to develop students' competencies in a holistic and balanced manner. This competency is needed by students to achieve success in learning, daily life, and in the future (Asrizal et al., 2020). The 21st century competency framework includes a broad definition that emphasizes the skills, attitudes, and knowledge students need in school, in the world of work, and in their lives (Chen et al., 2017). In order for these expectations to be fulfilled, people must have creative and critical thinking and the ability to work together effectively. The ability to think critically and creatively is one aspect of higher order thinking skills (Djamilah et al., 2019).

HOTS is the ability or skill to connect, manipulate, and transform knowledge and experience (Imamah et al., 2020). Higher Order Thinking Skills (HOTS) aims to improve students' thinking skills and make decisions in complex situations (Saputra, 2016). HOTS which means educators must involve students directly in learning (Yen et al., 2015). HOTS includes thinking skills that require more than just remembering or memorizing information (Ivie, 1998). The role of educators as facilitators in learning is expected to improve students' abilities and encourage students to think broadly and deeply so that they can improve students' high order thinking skills (Nurhayani et al., 2018).

However, the problem that often occurs in the learning process is the use of learning models that are not optimal. The use of learning models that are not in

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accordance with the abilities of students makes the learning atmosphere monotonous and even boring. This limits the ability of students to find and try new things and solve a problem they face. Educators often equate learning models for all basic competencies, even though each demand for basic competencies is different. So that students lack the ability of students' high order thinking skills.

Based on these problems, a learning model is needed that can improve students' high order thinking skills.One learning model that can be used is Problem Based Learning. Problem Based Learning is a model that requires full student activity and involvement. PBL is also often referred to as problem-based learning (Imamah et al., 2020). According to Riyanto (2014) that problem-based learning is a model designed and developed to develop students' ability to solve problems. Problem solving is done in a collaborative pattern and using higher-order thinking skills, namely analysis-synthesis and evaluation abilities.

Problem Based Learning is learning that can cause students' thinking abilities to be truly optimized through a systematic group or team work process, so that students can empower, hone, test, and develop their thinking skills on an ongoing basis (Wijayanti et al., 2022). Meanwhile according to Tumanggor et al. (2020) that the focus of learning on the Problem Based Learning model is on the selected problem so that students not only learn concepts related to problems but scientific methods to solve these problems so that they can cultivate higher-order thinking patterns.

Many previous studies have conducted studies on the influence of problem based learning models on students' high order thinking skills. However, previous research has limitations. These limitations include, 1) the results obtained do not explain the influence of the problem based learning model on students' High Order Thinking Skills, 2) only applying the problem based learning model at one level of education, 3) only using one subject. Based on these limitations, this research wants to integrate all existing similar research to determine the effect of applying the problem based learning model in science and physics learning on students' High Order Thinking Skills using the meta-analysis method.

Meta-analysis research was chosen as a research method for several reasons. First, many articles discuss the influence of applying the problem based learning model on High Order Thinking Skills. Second, meta-analysis research does not depend on school conditions, thereby reducing the risk of research delays. Third, the impact of using the problem based learning model on students' high order thinking skills has not been studied. Fourth, it is not yet known the effect of using the problem based learning model on students' High Order Thinking Skills abilities, which has a significant effect based on the level of education and subjects used.

High Order Thinking Skills abilities can be developed by incorporating problem based learning models into teaching materials or by direct learning processes. Many previous studies have proven this, but they have produced different conclusions. Considering this, it is important to conduct a meta-analysis study on how problem based learning models influence students' High Order Thinking Skills abilities. The aim of this research is to determine the extent of the influence of the use of the problem based learning model on students' High Order Thinking Skills abilities in terms of education level and subjects used.

Method

This research is a meta-analytic research by presenting quantitative data in the form of effect sizes from each study. The studies used in the meta-analysis were sourced from national and international journals. The search was carried out through Google Scholar using the keywords problem-based learning model for students' high order thinking skills. Title search restrictions and not included in the article section that uses these keywords. All search results are examined and measured for use in meta-analysis with the criteria, namely using publication years ranging from 2014 to 2022, the research measures the impact of the problem-based learning model on higher order thinking skills, the learning provides sufficient data information to calculate Effect Size (sample size, mean, standard deviation and t value), and problem-based learning models applied to science and physics learning.

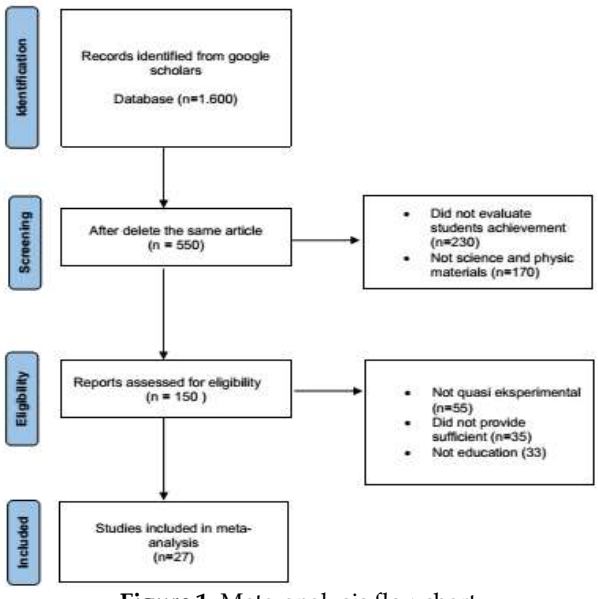

Figure 1. Meta-analysis flowchart

In finding the studies used, a systematic review and meta-analysis (PRISMA) werecarried out to obtain systematic results. The flow chart of the systematic review follows the PRISMA rules as shown in Figure 1.

The effect size is a measure of the magnitude of the effect of a variable on other variables. In estimating the effect size, excel and JASP applications are used as a tool. The excel application was used to process the data until an effect size was found, while the JASP application was used in a meta-analysis study to analyze heterogeneity and forest plots. To determine the size of the effect can beusing statistical parameters according to table 1 and table 2 categorize the following results:

Table 1. Method of Determining Effect Size (Becker et al., 2011)

Statistics	Formula
The effect size formula for the two-sample comparison test relates to the pretest-posttest mean and pretest-posttest standard deviation	$ES\ (d) = \frac{\overline{X}_{post} - \overline{X}_{pre}}{SD_{within}}$ $SD_{within} = \sqrt{\frac{SD_{Pretest^2} - SD_{Posttest^2}}{2}}$
The effect size formula for a comparison test of two independent samples. Used if it is known only the posttest data from the mean and standard deviation of the two sample groups.	$ES\ (d) = \frac{\overline{X}_E - \overline{X}_C}{SD_{within}}$ $SD_{within} = \sqrt{\frac{(n_E - 1)SD_{E^2} + (n_c - 1)SD_{C^2}}{n_E + n_{c^{-2}}}}$
The effect size formulas for the two independent sample groups for the posttest pretest mean scores and the pretest standard deviation for the experimental class are known, the pretest posttest mean scores, the pretest standard deviations and the control group posttest are known	$ES = \frac{(\overline{X}_{post} - \overline{X}_{pre})_E - (X_{post} - \overline{X}_{pre})_C}{SD_{within}}$ $SD\ within = \sqrt{\frac{(n_E-1)SD_{preE^2} + (n_c-1)SD_{preC^2} + (n_E-1)SD_{postE^2} + (n_c-1)SD_{postC^2}}{2(n_E + n_c - 2)}}$
t Count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$
To obtain the d variance for the two groups	$Vd = \frac{nE + nC}{nEnC} + \frac{d^2}{2(nE + nC)}$
Variance value d for one group data	$Vd = \frac{1}{n} + \frac{d^2}{2(n)}$
Standard error of d	$SEd = \sqrt{Vd}$
The correction factor is J	$J = 1 - \frac{3}{4df - 1}$
	The df values for the two independent groups viz $df = nE + nc - 2$.
	df value for one group ie $df = n-1$.
Effect size value	$g = J \times d$
Variance value	$Vg = J^2 \times Vd$
standard error	$SEg = \sqrt{Vg}$

Table 2. Category Effect Size (Becker et al., 2011)

Effect Size (ES)	Category
$0 \leq ES \leq 0.2$	Low
$0.2 \leq ES \leq 0.8$	Currently
$ES \geq 0.8$	Tall

Result and Discussion

This research was conducted to see the effect of applying the learning model to students' high order thinking skills. Data were obtained from relevant journals from 2014-2022 with this research and support the calculation of the effect size of each journal.

Researchers collect data from various sources such as Google Scholar, crossref, and others.

A total of 27 journals were selected based on certain standards. The first is a study of the effect of the Problem Based Learning (PBL) learning model on students' High Order Thinking Skills (HOTS). Both are implemented in learning. Third, the types of journals come from national and international journals. The results of the effect size calculation on 27 journals are divided into three categories. First, based on students' high order thinking skills. Second, based on education level. Third, based on subjects. Article codification can be seen in Table 3.

Table 3. Journal Coding, Sources, Effect Sizes, and Formulas Used

Code	Journal Source	Scale	Effect Size	Category
J1	(Hasyim et al., 2019)	International	0.20	Currently
J2	(Gultom et al., 2021)	Indonesia	0.02	Low
J3	(Utomo et al., 2019)	Indonesia	0.30	Currently
J4	(Suastra et al., 2019)	International	0.80	Tall
J5	(Widiatsih et al., 2020)	International	0.21	Currently
J6	(Amalia et al., 2017)	Indonesia	0.84	Tall
J7	(Puspitasari et al., 2020)	Indonesia	0.53	Currently
J8	(Khoiri et al., 2021)	Indonesia	0.94	Tall
J9	(Sugianti et al., 2018)	Indonesia	1.83	Tall
J10	(Jayanti et al., 2016)	Indonesia	0.60	Currently
J11	(Widyaningsih et al., 2019)	Indonesia	0.24	Currently
J12	(Astikawati et al., 2020)	Indonesia	0.87	Tall
J13	(Wahyuni et al., 2019)	Indonesia	1.17	Tall
J14	(Yulita et al., 2018)	Indonesia	0.29	Currently
J15	(Yuliawan, 2021)	Indonesia	0.96	Tall
J16	(Chandra et al., 2017)	Indonesia	1.05	Tall
J17	(Putri et al., 2022)	Indonesia	1.30	Tall
J18	(Mairani et al., 2018)	Indonesia	0.24	Currently
J19	(Wijayanti et al., 2022)	Indonesia	0.41	Currently
J20	(Flamboyant et al., 2018)	Indonesia	0.51	Currently
J21	(Londa et al., 2020)	Indonesia	0.49	Currently
J22	(Imamah et al., 2020)	Indonesia	1.52	Tall
J23	(Siregar, 2022)	Indonesia	0.40	Currently
J24	(Tumanggor et al., 2020)	International	0.87	Tall
J25	(Alpindo et al., 2014)	Indonesia	0.41	Currently
J26	(Syarifah et al., 2020)	Indonesia	1.53	Tall
J27	(Fitri et al., 2018)	Indonesia	0.20	Tall
Average Effect Size			0.67	Currently

Based on table 3, it shows that the average effect size of the influence of the problem-based learning model on students' High Order Thinking Skills is 0.67 in the medium category. This shows that the effect of applying the problem-based learning model can improve students' High Order Thinking Skills.

High Order Thinking Skillsvery much needed in the current era of globalization and very much needed in the learning process becauseHigh Order Thinking Skillsisthinking process that is not just memorizing and relaying information. Students are able to solve problems by maximizing their thinking skills, so they can practice problem solving skills in new situations with critical and creative thinking skills (Azzahra et al., 2020; Daryanti et al., 2019; Imamah et al., 2020; Rasmuin et al., 2021). Such thinking requires students to be directed from remembering, understanding, to even solving complex problems. So it can be concluded that an important aspect in learning and teaching is the ability of High Order Thinking Skills (HOTS).

One strategy that can be used to improve students' High Order Thinking Skills is to apply a learning model that makes students active. According to Joyce in 1992 the application of learning models will direct students to obtain information, ideas, skills, and values through the process of thinking and expressing themselves (Azzahra et al., 2020).

To encourage students to obtain information, ideas, skills and values through the process of thinking and expressing themselves, it is highly recommended to use the Problem Based Learning (PBL) learning model. Because the Problem Based Learning (PBL) learning model requires the process of solving problems as a focus in learning. Students are trained to analyze problems further students are guided to compile questions. Students are trained forreveal temporary allegations, collect information and conduct

investigations, convey results, to evaluate these results. These activities will train and mature students' ability to solve high-level problems (Sugianti et al., 2018).

Influence Problem Based Learning Learning Model for High Order Thinking Skills (HOTS)

The results of the effect size data are used to test the meta-analysis research hypothesis. The null hypothesis proposed is that there is no effect of the problem based learning model on students' high order thinking skills. The data presented were obtained from the heterogeneity test. In the heterogeneity test, data were obtained in the form of Q, p and I values. Q and I values were heterogeneous values. However, the value of I indicates the true heterogeneity of the data distribution. The null hypothesis will be accepted if the p value <0.05. The results of the heterogeneity calculation are shown in Table 4.

Table 4. Heterogeneity Test of High Order Thinking Skills of Students

Variable	Overalls	95% Confidence Lower	Upper
Number of Samples (K)	27		
Heterogeneity test (Q)	82.54		
probability value (p)	<0.001	0.50	0.84
Score standard (z)	7.63		
Heterogeneity test (τ^2)	0.13	0.056	0.33
Heterogeneity test (τ)	0.36	0.24	0.57
Heterogeneity test (I^2 %)	68.02	47.53	84.11
Heterogeneity test (H^2)	3.13	1.91	6.29

The results of the analysis showed that the effect sizes of the 27 studies analyzed were heterogeneous with a value of Q = 82.54, p <0.001 for a 95% degree of confidence. Thus, the random effect model is suitable for measuring the average effect size of the research being analyzed. The results of the random effect analysis show that there is a positive correlation between the influence of the use of problem-based learning models and high order thinking skills with a value of 0.67 in the medium category (Becker et al., 2011). In addition, the z score with a score of 7.63 provides information that there is an increase in the significance of the use of problem based learning models for students' high order thinking skills. The use of problem based learning learning models can improve students' higher order thinking (Imamah et al., 2020). The attractiveness of student learning through the problem-based learning model increases in understanding the material presented (Gultom et al., 2021). The results of heterogeneity indicate the influence of moderator variables on problem-based learning models in improving students' high order thinking skills. In addition, based on point estimates and confidence intervals are shown in Figure 2. The 95% confidence level for the lowest and highest values is 0.50 and 0.84. While the average effect size is 0.67 in the medium category.

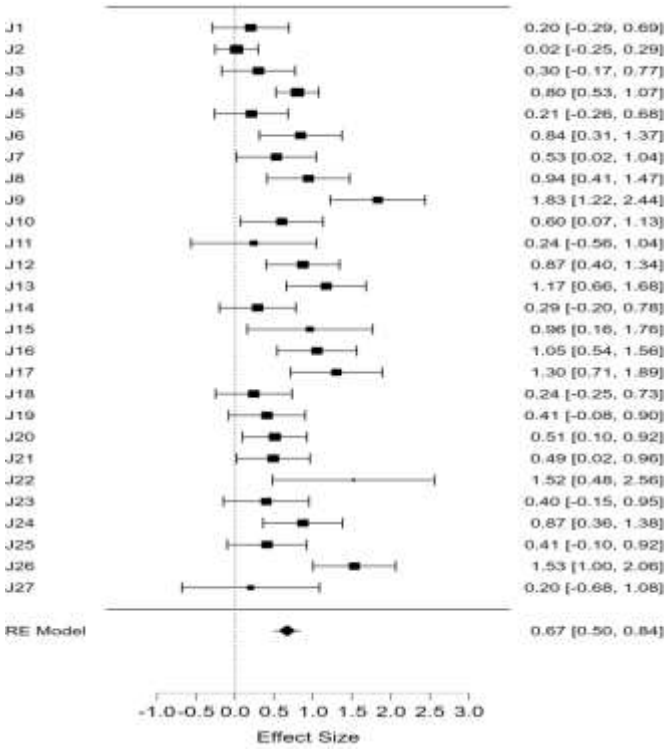

Figure 2. Forest plots

The Effect of Application of Learning Models on High Order Thinking Skills of Students Based on Education Level

To evaluate the effect of the problem based learning model on high order thinking skills based on educational level, calculations were performed on Combined heterogeneity (Qw) and intermediary heterogeneity (Qb) Table 5 displays the value of the moderator variable which measures the effect of the problem based learning model on high order thinking skills at the educational level.

The use of problem based learning learning models for high order thinking skills is found at the elementary, middle and high school education levels.From the calculation of the effect size of the influence of the application of the learning model on the High Order Thinking Skill of students based on educational level, for the Elementary School (SD) education level, the effect size is obtained: 1.10 in the high category; for the education level of Junior High School the effect size is obtained: 0.60 in the medium category; and for the level of senior high school education the effect size is obtained: 0.55 in the medium category.

Mark p.sobtained is 0.0003 <0.05. These results indicate that the modellearning problem based learning on high order thinking skillshas a significant difference in the average effect size when applied to elementary

school, junior high school and senior high school. According to Maslakhatunni'mah et al. (2022) generally the Problem Based Learning learning model can be implemented starting from the elementary level to the tertiary level.this is possible because the implementation aspect of the learning model does not depend on age so that it makes it easier for teachers to carry out learning in the classroom (Rohana, 2020). So it can be concluded that the application of the Problem Based Learning learning model to students' High Order Thinking Skills is not based on their level of education.

Table 5. Effect of Application of Problem Based Learning Learning Model Based on Education Level

Variable	Elementary School	Junior High School	Senior High School
Number of Samples (K)	6	6	15
Heterogeneity test (Q)	14.32	25.62	25.50
probability value (p)	5.32	2.98	5.88
Effect Size (d)	1.10	0.60	0.55
Heterogeneity test (τ^2)	0.16	0.19	0.06
Heterogeneity test (τ)	0.40	0.43	0.24
Heterogeneity test (I^2 %)	67.26	78.46	45.70
Heterogeneity test (H^2)	3.05	4.64	1.84
95% Lower	0.69	0.20	0.37
95% Upper	1.51	0.99	0.73
Qw			66.34
Qb			16.20
P-value			0.0003

The Influence of Application of Learning Models on Students' High Order Thinking Skills Based on Subjects

Furthermore, to evaluate the effect of the problem-based learning model on high order thinking skills based on educational level, calculations are performed on combined heterogeneity (Qw) and intermediate heterogeneity (Qb). Table 6 displays the value of the moderator variable which measures the effect of the problem based learning model on high order thinking skills in subjects.

Table 6. Effect of Application of Problem Based Learning Learning Model Based on Subjects

Variable	IPA	Physics
Number of Samples (K)	10	11
Heterogeneity test (Q)	52.46	20.70
probability value (p)	5.02	4.88
Effect Size (d)	0.88	0.58
Heterogeneity test (τ^2)	0.24	0.08
Heterogeneity test (τ)	0.49	0.28
Heterogeneity test (I^2 %)	81.96	52.58
Heterogeneity test (H^2)	5.54	2.11
95% Lower	0.54	0.35
95% Upper	1.23	0.82
Qw		73.16
Qb		0.94
P-value		0.33

The results of the effect size analysis of the effect of applying the learning model on students' High Order Thinking Skills based on subjects, the highest average effect size is 0.88 in science subjects, which is in the high category. While the average effect size in physics subjects is 0.58 in the medium category.

Mark p. sobtained is 0.33> 0.05. These results indicate that the modellearning problem based learning on high order thinking skills does not have a significant difference in the average effect size in science and physics material. In line with research Ulhaq et al. (2024) Educators play a role in conveying material to foster knowledge and activeness of students and it is very important for students to develop thinking skills at a higher level by activating reasoning power in understanding concepts related to subject matter and the realities of life. Also supported by research Azmi et al. (2021) that the Problem Based Learning model for High Order Thinking Skills is effectively used in science and Physics learning because through the problem based learning (PBL) model students are required to be skilled at asking questions and expressing opinions, finding relevant information, looking for various alternative ways to get solutions, and determine the most effective way to solve the problem. In other words, students themselves are responsible for building knowledge in their minds through scientific activities, the teacher is only a facilitator. The teacher's role as a facilitator in the problem-based learning (PBL) model is reflected in the delivery of problems related to subject matter at the beginning of learning and students must look for answers in groups.

Conclusion

Based on data from meta-analysis research results, several conclusions can be drawn. First, the problem based learning model has a significant influence on improving students' high order thinking skills. Second,

the problem based learning model based on educational level states that there is a significant influence on students' higher level thinking abilities. Third, the problem based learning model based on science and physics subjects does not have a significant difference in students' high order thinking skills. This research can be a reference in using the problem based learning model as research relevant to students' high order thinking skills.

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Author Contribuions
The author's contributions include Endang Aldilla, Jufiani Ulfa and Yelfi Rahmi: collecting data, analyzing data, writing original drafts and methodology, and so on; Asrizal and Fatni Mufit: focus on review of writing.

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Conflicts of Interest
The authors declare no conflict of interest.

References

Alpindo, O., & Amir, H. (2014). Pengaruh Pemberian Pertanyaan Higher Order Thinking Skill (Hots) Dalam Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar Fisika Siswa Kelas Xi Sman 2 Padang. *Pillar of Physics Education*, *3*(1), 113–120. Retrieved from https://103.216.87.80/students/index.php/pfis/article/view/1919/1526

Amalia, T., & Purwanto, J. (2017). The Influence of Integration-Interconnection-Based Project Based Learning Model on Students' Higher Order Thinking Ability in Material Temperature and Heat. *COMPTON: Scientific Journal of Physics Education*, *4*(2). Retrieved from https://core.ac.uk/reader/230375170

Asrizal, A., & Festiyed, F. (2020). Studi Pendampingan Pengembangan Bahan Ajar Tematik Terintegrasi Literasi Baru dan Literasi Bencana Pada Guru IPA Kabupaten Agam. *Jurnal Eksakta Pendidikan (JEP)*, *4*(1), 97. https://doi.org/10.24036/jep/vol4-iss1/431

Astikawati, N. W., Tegeh, I. M., & Warpala, I. W. S. (2020). Pengaruh Model Problem Based Learning (PBL) Terhadap Kemampuan Berpikir Tingkat Tinggi IPA Terpadu dan Kemandirian Belajar Siswa. *Jurnal Teknologi Pembelajaran Indonesia*, *10*(2), 76–85. https://doi.org/10.23887/jtpi.v10i2.3351

Azmi, N., Asrizal, A., & Mufit, F. (2021). Meta Analisis: Pengaruh Model Problem Based Learning Terhadap Motivasi Belajar Dan Keterampilan Proses Sains Fisika Siswa SMA. *ORBITA: Jurnal Pendidikan Dan Ilmu Fisika*, *7*(2), 291. https://doi.org/10.31764/orbita.v7i2.5940

Azzahra, W., & Alberida, H. (2020). The Effect of Problem Solving Model Towards Higher Order Thinking Skills and Students Learning Activities. *Bioeducation Journal*, *4*(1), 20–28. https://doi.org/10.24036/bioedu.v4i1.247

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), 23–38. Retrieved from https://www.jstem.org/jstem/index.php/JSTEM/article/view/1509

Chandra, W. A., Insani, M. D., & Mustikasari, V. R. (2017). Perbedaan penerapan pembelajaran problem based learning dan discovery learning terhadap kemampuan berpikir tingkat tinggi siswa SMP kelas VIII pada materi sistem peredaran darah manusia. *Prosiding Seminar Nasional Pembelajaran IPA Ke-2 Tahun 2017*, 320.

Chen, H.-L. S., & Huang, H. yi. (2017). *21st Century Competencies in Taiwan*. National Taiwan Normal University. Retrieved from https://asiasociety.org/sites/default/files/21st-century-competencies-taiwan.pdf

Daryanti, S., Sakti, I., & Hamdani, D. (2019). Pengaruh Pembelajaran Model Problem Solving Berorientasi Higher Order Thinking Skills Terhadap Hasil Belajar Fisika Dan Kemampuan Pemecahan Masalah. *Jurnal Kumparan Fisika*, *2*(2), 65–72. https://doi.org/10.33369/jkf.2.2.65-72

Djamilah, S., & Fajriah, N. (2019). Mengembangkan Motivasi Belajar Matematika Peserta Didik Sma Dengan Penerapan Model Pembelajaran Think Talk Write (Ttw). *SENPIKA II (Seminar Nasional Pendidikan Matematika) FKIP Universitas Lambung Mangkurat Banjarmasin*, *12*, 1–10. Retrieved from https://repo-dosen.ulm.ac.id/handle/123456789/11119

Fitri, H., Wahyuni, A., & Mustafa. (2018). Pengaruh Model Problrm Based Learning (Pbl) Terhadap Kemampuan Penyelesaian Soal-Soal Higher Order Thinking Skills (Hots) Pada Materi Gelombang Bunyi Di Sma Negeri 1 Darul Imarah. *Jurnal Ilmiah*

Mahasiswa (JIM) Pendidikan Fisika, *3*(1), 19–23. Retrieved from https://jim.usk.ac.id/pendidikan-fisika/article/view/18613

Flamboyant, F. U., Murdani, E., & Soeharto, S. (2018). Pengaruh Model Problem Based Learning Terhadap Higher Order Thinking Skills Peserta Didik SMA Negeri di Kota Singkawang pada Materi Hukum Archimedes. *Variabel*, *1*(2), 51. https://doi.org/10.26737/var.v1i2.810

Gultom, S. T., Siahaan, P., & Suhandi, A. (2021). Effect of PBL Hybrid Learning on the Higher Order Thinking Skills of Seventh Grade Students in Global Warming and Their Environmental Care Attitudes. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 272–280. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1012

Hasyim, S. H., Hasan, M., Nurbia, S., Firdauzi, F. S., Widiantie, R., & Handayani, H. (2019). Application of Higher Order Thinking Skills (Hots)-Based Problem-Based Learning Models To Increase the Critical Thinking Ability of Students in Education in Economic Lessons in Class XII 11 Makassar. *Quagga : Jurnal Pendidikan Dan Biologi*, *4*(1), 51. Retrieved from http://eprints.unm.ac.id/15369/%0Ahttp://eprints.unm.ac.id/15369/1/IJSDR1910020.pdf

Imamah, E. N., Sunardi, Yudianto, E., Sari, M. P., & Laily, N. I. (2020). The effect of problem based learning model on junior high school students' higher order thinking skills. *Journal of Physics: Conference Series*, *1538*(1), 72–89. https://doi.org/10.1088/1742-6596/1538/1/012079

Ivie, S. D. (1998). Ausubel's learning theory: An approach to teaching higher order thinking skills. *The High School Journal*, *82*(1), 35–42. Retrieved from https://www.jstor.org/stable/40364708?seq=1

Jayanti, R. D., Romlah, & Saregar, A. (2016). Efektivitas pembelajaran fisika model problem based learning (PBL) melalui metode POE terhadap kemampuan berpikir tingkat tinggi peserta didik. *Prosiding Seminar Nasional Pendidikan*, 208–214. Retrieved from https://repository.radenintan.ac.id/3314/1/2016antomifisikaunila_Rina.pdf

Khoiri, A., Evalina, Komariah, N., Utami, R. T., Paramarta, V., Siswandi, Janudin, & Sunarsi, D. (2021). 4Cs Analysis of 21st Century Skills-Based School Areas. *Journal of Physics: Conference Series*, *1764*(1), 012142. https://doi.org/10.1088/1742-6596/1764/1/012142

Londa, K., & Domu, I. (2020). Pengaruh Model Pembelajaran Berbasis Proyek Berbasis Web terhadap Keterampilan Berpikir Tingkat Tinggi (HOTS). *MARISEKOLA: Journal of Mathematics Research Education and Collaboration*, *1*(2), 25–28. Retrieved from https://ejurnal.unima.ac.id/index.php/mariseko la/article/download/1029/493

Mairani, E., & Simatupang, S. (2018). Pengaruh Model Problem Based Learning Terhadap Hasil Belajar Ranah Kognitif Tingkat Tinggi Siswa Pada Materi Suhu Dan Kalor Kelas X Semester II SMA Negeri 5 Tanjung Balai T.P 2016/2017. *INPAFI (Inovasi Pembelajaran Fisika)*, *6*(1). https://doi.org/10.24114/inpafi.v6i1.9488

Maslakhatunni'mah, D., & Dimas, A. (2022). Meta Analisis Kemampuan Berpikir Tingkat Tinggi (HOTS) pada Mata Pelajaran IPA. *SPEKTRA: Jurnal Kajian Pendidikan Sains*, *8*(2), 176–187. Retrieved from http://spektra.unsiq.ac.id/index.php/spek/article/view/243

Nurhayani, N., Syamsudduha, S., & Afiif, A. (2018). Kesulitan Guru Dalam Pengembangan Keterampilan Berpikir Tingkat Tinggi Siswa Dalam Pembelajaran Biologi Kelas XII DI Sma Negeri 2 Gowa. *Jurnal Biotek*, *6*(1), 93. https://doi.org/10.24252/jb.v6i1.5153

Puspitasari, R., Hamdani, D., & Risdianto, E. (2020). Pengembangan E-Modul Berbasis HOTS Berbantuan Flipbook Marker Sebagai Bahan Ajar Alternatif Siswa SMA. *Jurnal Kumparan Fisika*, *3*(3), 247–254. https://doi.org/10.33369/jkf.3.3.247-254

Putri, S. A., Nuriman, N., & Wardoyo, A. A. (2022). Pengaruh Model Pembelajaran Berbasis Masalah Terhadap Kemampuan Berpikir Tingkat Tinggi Siswa Kelas IV SDN Mojosari 01 Kabupaten Jember. *Jurnal Ilmu Pendidikan Sekolah Dasar*, *9*(2), 152. https://doi.org/10.19184/jipsd.v9i2.27863

Rasmuin, R., & Syah, S. (2021). Pengaruh Metode Pembelajaran Problem Solving Terhadap Higher Order Thingking Skill (HOTS) pada Siswa SMP. *Jurnal Akademik Pendidikan Matematika*, 72–80. https://doi.org/10.55340/japm.v7i1.393

Riyanto, H. Y. (2014). *New Paradigm of learning: As a reference for educators in the Implementation of Effective and quality Learning*. Prenada Media.

Rohana, S. (2020). MODEL PEMBELAJARAN DARING PASCA PANDEMI COVID-19. *At-Ta'dib: Jurnal Ilmiah Prodi Pendidikan Agama Islam*, *192–208*, 192. https://doi.org/10.47498/tadib.v12i02.441

Saputra, H. (2016). *Pengembangan Mutu Pendidikan Menuju Era Global: Penguatan Mutu Pembelajaran dengan Penerapan HOTS*. SMILE's publishing.

Siregar, N. F. (2022). The Effect of the Problem Based

Learning Model on Higher Order Thinking Skills of Middle School Students. *EKSAKTA: Journal of Research and Learning MIPA*, *7*(1), 14–23.

Suastra, I. W., Suarni, N. K., & Dharma, K. S. (2019). The effect of Problem Based Learning (PBL) model on elementary school students' science higher order thinking skill and learning autonomy. *Journal of Physics: Conference Series*, *1318*(1), 012084. https://doi.org/10.1088/1742-6596/1318/1/012084

Sugianti, L., & Marhaeni, A. A. I. (2018). Pengaruh Model Pembelajaran Berbasis Masalah Terhadap Kemampuan Berpikir Tingkat Tinggi Dan Kemampuan Menanya Dalam Pembelajaran Matematika Kelas V SD. *PENDASI: Jurnal Pendidikan Dasar Indonesia*, *2*(1), 35–46. https://doi.org/10.23887/jpdi.v2i1.2691

Syarifah, R., & Ritonga, W. (2020). Application of Problem Based Learning Model on Student Learning Outcomes on Momentum and Impulse Materials. *IPER (Indonesian Physics Education Research)*, *1*(1). https://doi.org/10.24114/iper.v1i1.14193

Tumanggor, M., Sobandi, A., & Sojanah, J. (2020). Students' Higher-Order Thinking Skills through Problem-Based Learning in Bandung. *The International Conference on Innovations in Social Sciences and Education (ICoISSE)*, *1*(1), 322–327. Retrieved from http://conference.loupiasconference.org/index.php/ICoISSE/article/view/51

Ulhaq, R., Huda, I., Rahmatan, H., Fathiya, N., & Chan, K. M. (2024). The Influence of The Problem-Based Learning with Radical Constructivism Module on Students' Problem-Solving Skills. *Jurnal Pendidikan Sains Indonesia*, *12*(2), 457–466. https://doi.org/10.24815/jpsi.v12i2.37609

Utomo, S. W., Joyoatmojo, S., Jutmini, S., & Suryani, N. (2019). Improving Higher Order Thinking Skills Through Problem Based Learning with a Scientific Approach. *Dinamika Pendidikan*, *14*(1), 76–86. https://doi.org/10.15294/dp.v14i1.18776

Wahyuni, T. W., Ningsih, K., & Wahyuni, E. S. (2019). Pengaruh Model Pbl Terhadap Keterampilan Berpikir Tingkat Tinggi Materi Pencemaran Lingkungan Kelas Vii Smp. *Equatorial Journal of Education and Learning (JPPK)*, *8*(11), 1–9. https://doi.org/10.26418/jppk.v8i11.37489

Widiatsih, A., Wardani, D. A. R., Royhana, U., Djamali, F., & Septory, B. J. (2020). The development of mathematical problem based on Higher Order Thinking Skill (HOTS) on comparative material by implementing PBL and its effect on the teacher's creative thinking skill. *Journal of Physics: Conference Series*, *1538*(1), 12110. https://doi.org/10.1088/1742-6596/1538/1/012110

Widyaningsih, S. W., Komariah, N., Mujasam, M., & Yusuf, I. (2019). Pengaruh Penerapan Model PBL Berbantuan Media Google Classroom Terhadap HOTS, Motivasi Dan Minat Peserta Didik. *Silampari Jurnal Pendidikan Ilmu Fisika*, *1*(2), 102–113. https://doi.org/10.31540/sjpif.v1i2.788

Wijayanti, N., & Jatmiko, B. (2022). Pembelajaran Virtual Fisika Dengan Model Problem Based Learning Untuk Meningkatkan Higher Order Thinking Skill Siswa SMA. *Briliant: Jurnal Riset Dan Konseptual*, *7*(1), 145. https://doi.org/10.28926/briliant.v7i1.964

Yen, T. S., & Halili, S. H. (2015). Effective teaching of higher order thinking (HOT) in education. *The Online Journal of Distance Education and E-Learning*, *3*(2), 41–47. Retrieved from www.tojdel.net

Yuliawan, A. (2021). Pengaruh Model Pembelajaran Berbasis Masalah (PBM) Terhadap Keterampilan Berpikir Tingkat Tinggi (HOTS) Siswa Pada Mata Pelajaran Matematika Materi Pengukuran Kelas III DI SDN 1 Weru Lor Kabupaten Cirebon. *UNIEDU: Universal Journal of Educational Research*, *2*(1), 256–273. https://doi.org/10.1234/uniedu.v2i1.47

Yulita, E., Fadiawati, N., & Dawati, C. (2018). Efektivitas Pembelajaran Berbasis Masalah Pencemaran Limbah Cairan Pemutih dalam Meningkatkan Keterampilan Berpikir Tingkat Tinggi. *Journal of Chemistry Education and Learning*, *7*(2), 1–14. Retrieved from https://jurnal.fkip.unila.ac.id/index.php/JPK/article/view/15873/pdf