The Effect of The Project Based Learning Model on Students' Science Process Skills. : A Meta-Analysis

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Abstrak

Penelitian ini bertujuan untuk mengetahui pengaruh model project based learning terhadap keterampilan proses sains siswa.Jenis penelitian ini adalah meta-analisis. Sumber data penelitian berasal dari 10 jurnal nasional dan internasional. Proses penelusuran sumber data melalui google scholar, ScienceDirect, Eric Journal dan Plos ONE. Kata kunci pencarian sumber data adalah model project based learning dan kemampuan proses sains. Kriteria inklusi adalah 1) jurnal internasional dan nasional terbit 2015-2023; 2) Jenis penelitian eksperimen atau kuasi eksperimen; 3) Jurnal nasional dan internasional terindeks SINTA, DOAJ, dan Scopus; 4) Penelitian memiliki data yang lengkap uji t, uji F dan standard deviasi. Teknik pengumpulan data adalah observasi dan dokumentasi melalui database. Analisis data adalah analisis statistik kuantitatif dengan bantuan aplikasi JSAP. Hasil penelitian ini menyimpulkan bahwa nilai rata-rata effect size (ES = 0.986). Temuan ini menunjukan bahwa adanya pengaruh.

Kata Kunci: Pendidikan, Model Project Based Learning, Keterampilan Proses Sains, Meta-analisis

Abstract

This study aims to determine the effect of the project-based learning model on students' science process skills.This type of research is a meta-analysis. The research data sources came from 10 national and international journals. The process of searching data sources through google scholar, ScienceDirect, Eric Journal and Plos ONE. The keywords for searching data sources are project-based learning model and science process skills. Inclusion criteria are 1) international and national journals published 2015-2023; 2) Experimental or quasi-experimental type of research; 3) National and international journals indexed by SINTA, DOAJ, and Scopus; 4) Research has complete data t test, F test and standard deviation. Data collection techniques are observation and documentation through the database. Data analysis

is quantitative statistical analysis with the help of the JSAP application. The results of this study concluded that the average effect size value (ES = 0.986) This finding shows that there is a significant effect of project-based learning model on students' science process skills.

Keywords: *Education, Project Based Learning Model, Science Process Skills, Meta-analysis*

Introduction

Science process skills are the ability of students to develop curiosity, responsibility and independence in learning activities (Janah & Widodo, 2013; Ilma et al., 2020; Roslina et al., 2020). Science process skills play an important role in developing students' cognitive potential in learning (Dewi et al., 2021; Amrulloh et al., 2022; Nurjanah et al., 2021). In addition, science process skills help students more easily understand the subject matter (Wijanarko et al., 2017; Sholahuddin et al., 2020). Seda (2021) Scientific process skills can shape students' character to behave scientifically in learning.

Science process skills in Indonesian students are still low (Maghfiroh et al., 2016; Hikmawati et al., 2017). These results can be seen from the Trends In Mathematics And Science Study (TIMSS) survey in 2011 students' science process skills obtained a score of 406 ranked 40th out of 42 participating countries (Rahman et al., 2023; Luciana et al., 2023; Nurtamam et al., 2023). Furthermore, the results of the 2018 PISA survey showed that the level of science literacy of students in the learning process obtained a score of 392, ranked 71 out of 78 member countries (Oktarina et al., 2021; Suharyat et al., 2022; Anggreni et al., 2020; Ichsan et al., 2022; Elfira et al., 2023). These results reflect the low science literacy of Indonesian students in learning.

The low level of students' science process skills is influenced by teacher-centred learning activities, teachers still use conventional learning and teachers do not prepare students in scientific work (Waluyo et al., 2021; Razak et al., 2021; Suhaimi et

al., 2022; Roziqin et al., 2015; Wirda et al., 2015). Research results (Anggreni et al.,, 2019) The low science process skills of students are due to the selection of an inappropriate learning model that makes students become menotonous and boring. Students are less active in learning so that the learning process is less fun (Utomo, 2021; Suharyat et al., 2022; Suryono et al., 2023; Farisi et al., 2017). Therefore, it is necessary to have a learning model that can train students' science process skills.

Project Based Learning model is an effective learning model to improve students' science process skills (Hasanah & Utami, 2017). Project Based Learning is a learning model that leads students to create a project in the learning process activities (Aho & Wright, 2020; Lazic, 2021; Mursid et al., 2022; Suharyat et al., 2022; Syawaludin et al., 2022). The Project Based Learning model helps students be more creative in learning so as to encourage their science process skills (Safitri, 2021). Research results (Noviyana, 2017) Project Based Learning model can improve the ability to think creatively in learning. Furthermore, the Project Based Learning model can involve students more actively in learning so as to encourage science process skills (Anggraini & Wulandari, 2021).

Previous research results (Saenab et al., 2019) Project Based Learning model can improve students' cooperation skills in learning. Not only that, the Project Based Learning model fosters students' scientific and independent attitudes in the learning process (Wuttphan & Klinhom, 2023; Mulhim, 2023). Research results by (Nurfitriyanti, 2016) Project Based Learning

model has a positive influence on students' problem solving skills. But in fact, many studies on Project Based Learning models in learning are still few studies on Project Based Learning models on students' science process skills. Based on this problem, this study aims to determine the effect of project-based learning model on students' science process skills.

Methods

This study is a type of meta-analysis research. Meta-analysis is a type of research that statistically analyses previous studies (Tamur et al., 2020; Zulyusri et al., 2023; Supriyadi et al., 2023; Wati et al., 2022). The data source of this research comes from the analysis of 10 national and international journals. The process of searching for data sources through the google scholar database, Eric journal, ScienceDirect and Wiley. The source selection process is the PRISMA method. The keywords for searching data sources are Project Based learning model and science process skills.

Furthermore, the inclusion criteria are 1) international and national journals published 2015-2023; 2) Type of experimental or quasi-experimental research; 3) National and international journals indexed by SINTA, DOAJ, and Scopus; 4) Research has complete data t test, F test and standard deviation. Data analysis is quantitative statistical analysis by calculating the effect size value. The way to obtain effect size (Izzah et al., 2021), can be seen in table 1.

Table 1. Formula for Obtaining Effect Size

No	Description	formula
1	Average in one group	$ES = \dfrac{X_{post} - X_{pre}}{SD_{pre}}$
2	Average in each group (two group posttest only)	$ES = \dfrac{X_E - X_C}{SD_C}$
3	Mean of each group (two group	$ES = \dfrac{(X_{post} - X_{pre})_E - (X_{post} - X_{pre})_C}{\dfrac{SD_{preC} + SD_{preE} + SD_{PostC}}{3}}$

	pretest-post test)	
4	t-count	$ES = \sqrt{\dfrac{1}{n_E} + \dfrac{1}{n_C}}$

Furthermore, the effect size criteria can be seen in Table 2.

Table 2. Effect Size Criteria

Effect Size	Kriteria Effect Size
0 ≤ ES ≤ 0.2	Low
0.2 ≤ ES ≤ 0.8	Moderate
ES ≥ 0.8	High

Source: Cohen in (Sutiarso, 2020; Sofianora et al., 2023; Zulkifli et al., 2022)

Result And Discussion

Result

From the search for data sources on the effect of the Project Based Learning model on students' science process skills, only 11 national and international journals have met the inclusion criteria. Data sources that have met the inclusion criteria can be presented in Table 2.

Table 2. Data sources that met the inclusion criteria

No	Author	Year	Journal Type	Variabel	Effect Size
1	Maghfiroh et al.,	2016	National	Science Process Skills	0.88
2	Nurjanah et al.,	2021	National	Science Process Skills	0.72
3	Demirçalı & Selvi	2022	International	Science Process Skills	1.32
4	Anggriani et al.,	2019	Nasional	Science Process Skills	1.08
5	Fitriyani & Anggraini	2018	International	Science Process Skills	0.62
6	Wulandari et al.,	2016	National	Science Process Skills	0.90
7	Roziqin et al.,	2015	National	Science Process Skills	1.10
8	Siwa et al.,	2013	National	Science Process Skills	0.41
9	Amanda et al.,	2023	National	Science Process Skills	0.59
10	Hasanah et al.,	2018	National	Science Process Skills	1.42

11	Rusmini et a., 2021)	2021	Internationa l	Science Process Skills	0.93
	Average Effect Size				0.906

Based on Table 2. the average effect size value of the entire study is 0.906 with high criteria. These results explain the application of the Project Based Learning model has a high influence on students' science process skills. The next step is to test the heterogeneity of the research and the selection of the estimation model. The results of the heterogeneity test can be seen in Table 3.

Table 3. Heterogeneity Test Results

	Q	df	p
Omnibus Test Of Model Coefficient	17.081	1	0.002
Test of Residual Heterogeneity	4.497	2	0.000

Table 3. It shows that the p value = 0.871 so that p < 0.00, the studies in the meta-analysis are heterogeneously distributed. Therefore, the meta-analysis model used is the random effect model. Next, determine the publication bias used in this study. The calculation of publication bias using funnel flot can be seen in Figure 1.
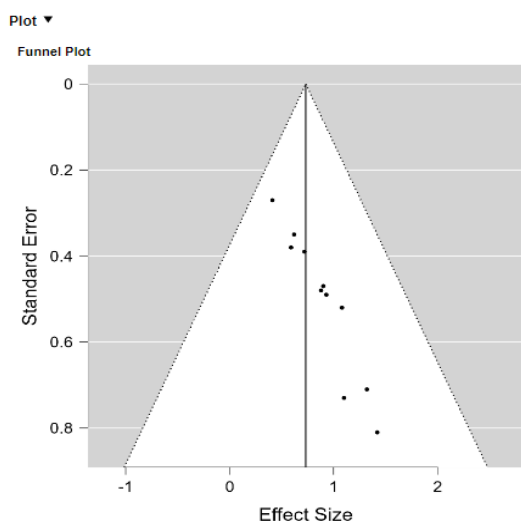

Figure1. Funnel Plot

Figure 1 shows that the spread of effect size is not entirely within the vertical line. Therefore, the Roshintal Fail safe N (FSN) test is needed to determine the resistance to publication bias. The results of the Roshintal Fail safe N (FSN) test with the JSAP application show that the N value is 130. Furthermore, the

calculation results of 130 / (5.11 + 10) > 1 = 2 > 1, so the research analysed is resistant to publication bias. Thus, no studies were added or omitted in this meta-analysis.

Next, calculate the p-value to test the research hypothesis. Calculation of p-value by looking at the comparison of estimation models. The results of the estimation model comparison can be seen in Table 4.

Table 4. Comparison of Analysis Results based on the Estiamation Model

Estimati on model	n	Z	ES	95% CI		Q	p
				Low er limit	Upp er limit		
Fixed Model	1 1	13.1 2	0.77 0	0.75	0.86	51. 9	0.0 0
Random model	1 1	9.38 6	0.98	0.57	1.90		

Based on Table 3. The Z value is 9.389 with a p value <0.00 and the overall effect size value in this study is 0.986 with high criteria. The results explain the application of the project-based learning model has a high positive effect on students' science process skills compared to the conventional learning model.

Discussion

The application of the Project Based Learning model has a high positive effect on students' science process skills. The results can be seen in table 4. The overall average effect size value is 0.986 with high criteria. This result is in line with (Waluyo et al., 2021) The project-based learning model gives a significant influence on students' science process skills and science literacy in learning compared to conventional learning. Research results (Pratiwi et al., 2020) The application of the Project Based Learning model trains students to improve students' science process skills. Students' science process skills serve to foster scientific attitudes and curiosity in learning (Özgelen, 2012; Darmaji et al., 2019). Furthermore, pre-science skills help students to be more active and creative in learning (Erg et al., 2011).

The project-based learning model trains students to be independent and

innovative in learning so as to foster science process skills (Jack, 2013). The results of the research on the application of the project-based learning model encourage students' science process skills so that they are able to learn more creatively, independently and responsibly in learning (Nisa, 2021; Aktamis et al., 2008; Rohaeti, 2018). The project-based learning model helps students in designing projects to achieve learning objectives (Amanda et al., 2023). Research results (Nurdiansah et al., 2021) stated that the project-based learning model encourages students to be able to solve problems and students' science process skills.

Furthermore, students' science process skills play an important role in improving the quality of education (Dirks & Cunningham, 2017). Not only that, science process skills train students faster in knowledge in learning (Setiadi, 2018). Not only that, science process skills train students faster in knowledge in learning (Santosa, 2021; Ferry et al., 2019; Rahman et al., 2023). Therefore, science process skills need to be instilled early in students (Kurniawan & Winda, 2020; Feyzİoğlu, 2012; Balanay, 2013). The project-based learning model helps teachers more effectively encourage students' science process skills. Not only that, the project-based learning model is one of the solutions in improving cognitive quality in the learning process of students in schools (Monhardt & Monhardt, 2006).

Conclusion

From this study, it can be concluded that the average effect size value (ES = 0.986) with high criteria. This finding shows that there is a significant effect of project-based learning model on students' science process skills. The project-based learning model can foster students' independence

and creativity in learning so as to stimulate students to be more scientific. Furthermore, science process skills foster an attitude of curiosity and high responsibility in learning.

Reference

Aho, W., & Wright, E. (2020). Evaluating the Influence of Venue on Experiential , Project - Based Learning Supporting Global Business Education since 1901 © 2020 SIEC - ISBE Supporting Global Business Education since 1901 © 2020 SIEC - ISBE. *International Journal for Business Education*, *3*(160), 9–21.

Aktamis, H., Faculty, A. M., & Eyl, D. (2008). The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements. *Asia-Pacific Forum on Science Learning and Teaching*, *9*(1), 1–21.

Amanda, N. G., Biru, L. T., & Suryani, D. I. (2023). Pengaruh Model Pembelajaran Project Based Learning terhadap Keterampilan Proses Sains. *PENDIPA Journal of Science Education*, *7*(2), 168–177.

Amrulloh, M. S., Galushasti, A., & Info, A. (2022). Professional development teacher to improve skills of science process and creativity of learners. *Journal of Education and Learning (EduLearn)*, *16*(3), 299–307. https://doi.org/10.11591/edulearn.v16i3.20404

Anggraini, P. D., & Wulandari, S. S. (2021). Analisis Penggunaan Model Pembelajaran Project Based Learning Dalam Peningkatan Keaktifan Siswa Analisis Penggunaan Model Pembelajaran Project Based Learning … .. *Jurnal Pendidikan Administrasi Perkantoran (JPAP)*, *9*(2), 292–299.

Anggreni, L. D., Jampel, I. N., & Diputra, K. S.

(2020). Pengaruh Model Project Based Learning Berbantuan Penilaian Portofolio Terhadap Literasi Sains. *Jurnal Mimbar Ilmu, 25*(1), 41–52.

Anggriani, F., Wijayati, N., & Susatyo, E. B. (2019). PENGARUH PROJECT-BASED LEARNING PRODUK KIMIA TERHADAP PEMAHAMAN KONSEP DAN KETERAMPILAN PROSES SAINS. *Jurnal Inovasi Pendidikan Kimia*, *13*(2), 2404–2413.

Azzahrotul Hasanah1, L. U. (2017). PENGARUH PENERAPAN MODEL PROBLEM BASED LEARNING TERHADAP KETERAMPILAN PROSES SAINS SISWA. *Jurnal Pendidikan Sains (JPS)*, *5*(2), 56–64.

Balanay, C. A. S. (2013). Assessment on Student s ' Science Process Skills : A Student- Centred Approach. *International Journal of Biology Education*, *3*(1), 24–44.

Darmaji, D., Kurniawan, D. A., & Irdianti, I. (2019). Physics education students ' science process skills. *International Journal of Evaluation and Research in Education (IJERE)*, *8*(2), 293–298. https://doi.org/10.11591/ijere.v8i2.28 646

Demirçalı, S., & Selvi, M. (2022). Effects of Model- Based Science Education on Students ' Academic Achievement and Scientific Process Skills. *Journal of Turkish Science Education*, *19*(2), 545–558.

Dewi, C. A., Erna, M., Martini, Haris, I., & Kundera, I. N. (2021). Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability. *Journal of Turkish Science Education*, *18*(3), 525–541. https://doi.org/10.36681/tused.2021. 88

Dharma Ferry1*, Tomi Apra Santosa2, D. K. (2019). Pengetahuan Mahasiswa Institut Agama Islam Negeri Kerinci Tentang Teori Asal Usul Manusia Dharma. *Bioeduca: Journal of Biology Education*, *1*(1), 12–17.

Dirks, C., & Cunningham, M. (2017). Enhancing Diversity in Science : Is Teaching Science Process Skills the Answer ? *CBE—Life Sciences Education*, *5*(8), 218–226. https://doi.org/10.1187/cbe.05

Elfira, I., & Santosa, T. A. (2023). Literature Study : Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 133–143. https://doi.org/10.29303/jppipa.v9i1. 2555

Erg, R., Ekl, Y., & Lek, Z. D. (2011). THE EFFECTS OF INQUIRY-BASED SCIENCE TEACHING ON ELEMENTARY SCHOOL STUDENTS ' SCIENCE PROCESS. *Bulgarian Journal of Science and Education Policy (BJSEP)*, *5*(1), 48–68.

Farisi, A., Hamid, A., & Melvina. (2017). Pengaruh Model Pembelajaran Problem Based Learning TerhadapKemampuan Berpikir Kritis Dalam Meningkatkan Hasil BelajarSiswa Pada Konsep Suhu Dan Kalor. *Jurnal Ilmiah Mahasiswa (JIM) Pendidikan Fisika*, *2*(3), 283–287.

Feyzİoğlu, B. (2012). Developing a Science Process Skills Test for Secondary Students : Validity and Reliability Study *. *Educational Sciences: Theory & Practice*, *12*(3), 1899–1906.

Fitriyani, L. O., & Anggraini, W. (2018). PROJECT BASED LEARNING : PENGARUHNYA TERHADAP KETERAMPILAN PROSES SAINS PESERTA DIDIK DI TANGGAMUS PROJECT BASED LEARNING : THE EFFECT ON STUDENT ' S SCIENCE PROCESSES SKILLS IN TANGGAMUS keseluruhan keterampilan ilmiah yang kelebihn yaitu menjadikan sisw. *Indonesian Journal of Science and*

Mathematics Education, *01*(3), 243–253.

Hasanah, I., & Maret, U. S. (2018). PENGEMBANGAN MODUL SUHU DAN KALOR BERBASIS PROJECT BASED LEARNING UNTUK MENINGKATKAN KETERAMPILAN PROSES SAINS DAN KEMAMPUAN BERPIKIR KRITIS SISWA SMA / MA. *Jurnal Pendidikan (Teori Dan Praktik)*, *3*(1), 38–44.

Hikmawati, N., Studi, P., Fisika, P., & Mataram, U. (2017). PENGARUH MODEL PEMBELAJARAN BERBASIS MASALAH DENGAN PEMBEKALAN PENGETAHUAN AWAL TERHADAP KETERAMPILAN PROSES SAINS. *Jurnal Pendidikan Fisika Dan Teknologi*, *III*(1), 92–100.

Ichsan et al. (2022). Pengaruh Model Pembelajaran Problem Based Learning Berbaisis TPACK Terhadap Ketrampilan Literasi Sains Dalam Pembelajaran IPA Siswa Tingkat SD Sampai SMA: Sebuah Meta-Analisis. *Jurnal Pendidikan Dan Konseling*, *4*, 2173–2181.

Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Saptasari, M. (2020). The correlation between science process skills and biology cognitive learning outcome of senior high school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(1), 55–64. https://doi.org/10.22219/jpbi.v6i1.10794

Jack, G. U. (2013). The Influence of Identified Student and School Variables on Students' Science Process Skills Acquisition. *Journal of Education and Practice*, *1735*, 16–23.

Janah, M. C., & Widodo, A. T. (2013). PENGARUH MODEL PROBLEM BASED LEARNING TERHADAP HASIL BELAJAR DAN KETERAMPILAN PROSES SAINS Mely Cholifatul Janah *, Antonius Tri Widodo , dan Kasmui. *Jurnal Inovasi Pendidikan Kimia*, *12*(1), 2097–2107.

Jurnal, D. (2020). Jurnal Pelita Pendidikan DENGAN MENGGUNAKAN MODEL PEMBELAJARAN PROBLEM BASED LEARNING (PBL) DAN PROJECT BASED LEARNING (PJBL) PADA MATERI KEANEKARAGAMAN HAYATI. *Jurnal Pelita Pendidikan*, *8*(1), 0) 062-070.

Kurniawan, D. A., & Winda, F. R. (2020). The Correlation Between Student Perceptions of the Use of E- Modules with Students ' Basic Science Process Skills. *JPI*, *9*(4), 719–729. https://doi.org/10.23887/jpi-undiksha.v9i4.28310

Lazic, B. D. (2021). The influence of project-based learning on student achievement in elementary mathematics education. *South African Journal of Education, 41*(3), 1–10.

Maghfiroh, N., Susilo, H., Gofur, A., Biologi, P., & Malang, P. N. (2016). PENGARUH PROJECT BASED LEARNING TERHADAP KETERAMPILAN PROSES SAINS SISWA KELAS X SMA NEGERI SIDOARJO. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(8), 1588–1593.

Mekkah, U. S., & Mekkah, U. S. (2020). The Student Ability in Graph Understanding for Mastering Natural Science Concepts through the Process Skills Approach. *International Journal of Instruction*, *13*(4), 145–160.

Monhardt, L., & Monhardt, R. (2006). Creating a Context for the Learning of Science Process Skills Through Picture Books. *Early Childhood Education Journal, 34*(1), 67–71. https://doi.org/10.1007/s10643-006-0108-9

Muhammad Khoirur Roziqin, 1)Albertus Djoko Lesmono, 1)Rayendra Wahyu Bachtia. (2015). PENGARUH MODEL PEMBELAJARAN BERBASIS PROYEK (PROJECT BASED LEARNING) TERHADAP MINAT BELAJAR DAN KETERAMPILAN PROSES. *Jurnal Pembelajaran Fisika*, *7*(1), 108–115.

MULHIM, E. N. AL. (2023). TECHNOLOGY

FATIGUE DURING THE COVID-19 PANDEMIC : THE CASE OF DISTANCE PROJECT-BASED LEARNING ENVIRONMENTS. *Turkish Online Journal of Distance Education-TOJDE January*, *24*(1), 234–245.

Mursid, R., Saragih, A. H., & Hartono, R. (2022). The Effect of the Blended Project-based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. *International Journal of Education in Mathematics, Science and Technology*, *10*(1), 218–235. https://doi.org/10.46328/ijemst.2244

N Izzah1, 3, Asrizal2, F. M. (2021). Meta Analisis Pengaruh Model Project Based Learning dalam Variasi Bahan Ajar Fisika Terhadap Hasil Belajar Siswa SMA / SMK. *Jurnal Penelitian Pembelajaran Fisika*, *12*(2), 159–165. https://doi.org/10.26877/jp2f.v12i2.8 970

Nisa, S. S. dan F. A. (2021). Jurnal Pendidikan Indonesia Pendidikan KONTRIBUSI STEAM PROJECT BASED LEARNING DALAM MENGUKUR KETERAMPILAN PROSES SAINS DAN BERPIKIR KREATIF SISWA Siti Suryaningsih dan Fakhira Ainun Nisa Universitas Islam Negeri Syarif Hidayatullah Jakarta , Indonesia IN. *Jurnal Pendidikan Indonesia*, *2*(6), 1097–1111.

Noviyana, H. (2017). PENGARUH MODEL PROJECT BASED LEARNING TERHADAP. *Jurnal Edumath* , *3*(2), 110–117.

Nurdiansah, I., Makiyah, Y. S., Studi, P., Fisika, P., & Siliwangi, U. (2021). Efektivitas Modul Hybrid Project Based Learning (H-Pjbl) Berbasis Laboratorium Untuk Meningkatkan Keterampilan Proses Sains Siswa. *Urnal Pendidikan Fisika Dan Teknologi (JPFT)*, *7*(2), 104–110.

NURFITRIYANTi, M. (2016). MODEL PEMBELAJARAN PROJECT BASED LEARNING TERHADAP KEMAMPUAN PEMECAHAN MASALAH. *Jurnal Formatif*, *6*(2), 149–160.

Nurjanah*, & , Ucu Cahyana, N. (2021). Pengaruh Penerapan Online Project Based Learning Dan Berpikir Kreatif. *B U A N A P E N D I D I K A N*, *17*(1), 51–58.

Nurtamam, M. E., Santosa, T. A., Aprilisia, S., Rahman, A., & Suharyat, Y. (2023). Meta-analysis : The Effectiveness of Iot-Based Flipped Learning to Improve Students ' Problem Solving Abilities. *Edumaspul :Jurnal Pendidikan*, *7*(1), 1491–1501.

Occe Luciana, Tomi Apra Santosa, Agus Rofi'i3, Taqiyuddin4, B. N. (2023). Meta-analysis: The effect of problem-based learning on students' critical thinking skills. *Edumaspul: Jurnal Pendidikan*, *7*(2), 2058–2068. https://doi.org/10.1063/1.5139796

Oktarina, K., Santosa, T. A., Razak, A., & Ahda, Y. (2021). Meta-Analysis : The Effectiveness of Using Blended Learning on Multiple Intelligences and Student Character Education during the Covid-19 Period. *IJECA International Journal of Education & Curriculum Application*, *4*(3), 184–192.

Özgelen, S. (2012). Students' Science Process Skills within a Cognitive Domain Framework. *Eurasia Journal of Mathematics, Science & Technology Education*, *8223*(8), 4. https://doi.org/10.12973/eurasia.201 2.846a

Rahman, A., Santosa, T. A., Suharyat, Y., & Aprilisia, S. (2023). The Effectiveness of AI Based Blended Learning on Student Scientific Literacy : *LITERACY : International Scientific Journals Of Social, Education and Humaniora*, *2*(1), 141–150.

Razak, Abdul, Santosa, Tomi Apra, Lufri., et al. (2021). Meta-Analisis: Pengaruh Soal HOTS (Higher Order Thinking Skill) Terhadap Kemampuan Literasi Sains

dan Lesson Study Siswa Pada Materi Ekologi dan Lingkungan Pada Masa Pandemi Covid-19. *Bioedusiana*, *6*(1), 79–87.

Rohaeti, E. (2018). UNDERGRADUATE STUDENTS ' SCIENCE PROCESS SKILLS IN TERMS OF SOME VARIABLES : A PERSPECTIVE FROM INDONESIA ISSN 1648-3898 ISSN 2538-7138. *Journal of Baltic Science Education*, *17*(5), 751–764.

Rusmini , Suyono, R. A. (2021). *Journal of Technology and Science Education STUDENTS THROUGH SELF-PROJECT BASED LEARNING (SjBL) IN*. *11*(2), 371–387.

Safitri, D. (2021). Journal of Technology and Science Education STUDENTS ' PERCEPTIONS OF THE PROJECT BASED ON THE POTENTIAL OF THEIR REGION : A PROJECT-BASED LEARNING. *Journal of Technology and Science Education*, *11*(2), 295–314.

Santosa, T. A. (2021). Journal of Digital Learning and Education Meta-Analisis : Pengaruh Bahan Ajar Berbasis Pendekatan STEM Pada Pembelajaran Ekologi. *Journal of Digital Learning and Education*, *01*(1), 1–9. https://doi.org/10.52562/jdle.v1i01.24

Seda, A. (2021). The effect of the integration of science and mathematics on critical thinking and scientific process skills of the gifted students *. *International Journal of Curriculum and Instruction 13(1)*, *13*(1), 290–312.

Setiadi, I. (2018). European Journal of Education Studies THE EFFECT OF INQUIRY MODEL ON SCIENCE PROCESS SKILLS AND. *European Journal of Education Studies*, *4*(3), 177–182. https://doi.org/10.5281/zenodo.1344846

Sholahuddin et al. (2020). Applying The Cognitive Style-Based Learning Strategy in Elementary Schools to Improve Students ' Science Process Skills. *Journal of TURKISH SCIENCE EDUCATION*, *17*(2), 289–301. https://doi.org/10.36681/tused.2020.27

Sitti Saenab1, Sitti Rahma Yunus2, dan H. (2019). Pengaruh Penggunaan Model Project Based Learning Terhadap Keterampilan Kolaborasi Mahasiswa Pendidikan IPA Sitti. *Jurnal Biology Science & Education*, *8*(1), 29–41.

Siwa, I. B., Muderawan, I. W., & Tika, I. N. (2013). PEMBELAJARAN KIMIA TERHADAP KETERAMPILAN PROSES SAINS DITINJAU DARI GAYA KOGNITIF SISWA. *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, *3*(3), 1–13.

Sofianora, A., Suharyat, Y., & Santosa, T. A. (2023). *PENGARUH PROFESIONALITAS GURU MATEMATIKA DALAM MENINGKATKAN KOMPETENSI SISWA ERA REVOLUSI INDUSTRI 5 . 0 DI INDONESIA : SEBUAH META-ANALISIS*. *10*(2).

Suhaimi, Santosa, T. A., & Aprilisia, S. (2022). Analisis Pendekatan Saintifik Dalam Pembelajaran IPA Selama Pandemi Covid-19 di Sekolah Dasar. *Jurnal Didika: Wahana Ilmiah Pendidikan Dasar*, *8*(1), 92–101.

Suharyat, Y., Ichsan, Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-Analisis Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Ketrampilan Abad-21 Siswa Dalam Pembelajaran IPA. *Jurnal Pendidikan Dan Konseling*, *4*(5), 5081–5088.

Suharyat, Y., Santosa, T. A., Aprilisia, S., & Yulianti, S. (2022). International Journal of Education and Literature (IJEL) Meta-Analysis Study : The Effectiveness of Problem Solving Learning in Science Learning in Indonesia. *International Journal of Education and Literature (IJEL) Amik*

Veteran Porwokerto, *1*(3), 6–13.

Suharyat, Y., Santosa, T. A., Yulianti, S., & Amalia, K. N. (2022). *International Journal of Education and Literature (IJEL) Literature Review : TPACK-Based Science Learning in Supporting Teacher Quality in Indonesia*. 2014–2020.

Supriyadi, A., Suharyat, Y., Santosa, T. A., & Sofianora, A. (2023). The Effectiveness of STEM-Integrated Blended Learning on Indonesia Student Scientific Literacy : A Meta-analysis. *International Journal of Education and Literature (IJEL)*, *2*(1), 41–48.

Suryono, W., Haryanto, B. B., Santosa, T. A., Suharyat, Y., & Sappaile, B. I. (2023). The Effect of The Blended Learning Model on Student Critical Thinking Skill : Meta-analysis. *Edumaspul - Jurnal Pendidikan*, *7*(1), 1386–1397.

Sutiarso, S. (2020). META-ANALISIS PENGARUH ALQURUN TEACHING MODEL TERHADAP KEMAMPUAN MATEMATIS. *Histogram: Jurnal Pendidikan Matematika*, *4*(2), 462–478.

Syawaludin, A., Prasetyo, Z. K., Safruddin, C., & Jabar, A. (2022). The Effect of Project-based Learning Model and Online Learning Settings on Analytical Skills of Discovery Learning , Interactive Demonstrations , and Inquiry Lessons. *Journal of Turkish Science Education*, *19*(2), 608–621.

Tamur, M., Jehadus, E., Nendi, F., Mandur, K., & Murni, V. (2020). Assessing the effectiveness of the contextual teaching and learning model on students' mathematical understanding ability: A meta-analysis study. *Journal of Physics: Conference Series*, *1657*(1). https://doi.org/10.1088/1742-6596/1657/1/012067

Utomo, D. P. (2021). An Analysis of the Statistical Literacy of Middle School Students in Solving TIMSS Problems To cite this article : An Analysis of the Statistical Literacy of Middle School Students in Solving TIMSS Problems. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, *9*(2), 181-197.

Waluyo, E., Matematika, F., Alam, P., & Hamzanwadi, U. (2021). Pengembangan Desain Instruksional Model Project Based Learning Terintegrasi Keterampilan Proses Sains Untuk Meningkatkan Literasi Sains Pendahuluan. *Jurnal IPA Dan Pembelajaran IPA*, *5*(1), 101–111. https://doi.org/10.24815/jipi.v5i1.20145

Wati*, W. W., Asrizal, A., & Usmeldi, U. (2022). Analisis Effect Size Pengaruh Pembelajaran IPA Berbasis SETS Terhadap Kemampuan Proses Sains dan Hasil Belajar Peserta didik. *Jurnal IPA & Pembelajaran IPA*, *6*(1), 54–69. https://doi.org/10.24815/jipi.v6i1.23894

Wijanarko, A. G., Supardi, K. I., & Marwoto, P. (2017). Keefektifan Model Project Based Learning Terbimbing untuk Meningkatkan Keterampilan Proses Sains dan Hasil Belajar IPA Abstrak. *Journal of Primary Education*, *6*(2), 120–125.

Wirda1, A. G. H. dan I. K. (2015). Penerapan pembelajaran model problem based learning (pbl) untuk meningkatkan keterampilan proses sains dan motivasi belajar siswa pada materi alat-alat optik. *Jurnal Pendidikan Sains Indonesia (JPSI)*, *03*(02), 131–142.

Wulandari, F. E., Sidoarjo, U. M., & Proses, K. (2016). PENGARUH PEMBELAJARAN BERBASIS PROYEK UNTUK MELATIHKAN KETERAMPILAN PROSES MAHASISWA. *JURNAL PEDAGOGIA*, *5*(2), 247–254.

Wuttphan, N., & Klinhom, N. (2023). The Role of Project-Based Learning in Promoting Preservice Teachers ' Communicative Capabilities. *Journal of*

Education and Learning, *12*(1), 52–60. https://doi.org/10.5539/jel.v12n1p52

Yosi Dwi Anggreni1) , Festiyed2), A. (2019). META-ANALISIS PENGARUH MODEL PEMBELAJARAN PROJECT BASED LEARNING TERHADAP KEMAMPUAN BERPIKIR KRITIS PESERTA DIDIK SMA Program Studi Magister Pendidikan Fisika , FMIPA Universitas Negeri Padang Dosen Program Studi Magister Pendidikan Fisika , FMIPA Univers. *Pillar of Physics Education*, *12*(4), 881–888.

Zulkifli Zulkifli, Agus Supriyadi, Erwinsyah Satria, & Tomi Apra Santosa. (2022). Meta-analysis: The Effectiveness of the Integrated STEM Technology Pedagogical Content Knowledge Learning Model on the 21st Century Skills of High School Students in the Science Department. *Psychology, Evaluation, and Technology in Educational Research*, *1*(2), 68–76. https://doi.org/10.55606/ijel.v1i2.32

Zulyusri, Tomi Apra Santosa, Festiyed, Yerimadesi1, Yohandri1, Abdul Razak1, S. (2023). Effectiveness of STEM Learning Based on Design Thiking in Improving Critical Thinking Skills in Science Learning : A. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 112–119. https://doi.org/10.29303/jppipa.v9i6.3709