



The Influence of the Jigsaw Model Based on Higher Order Thinking Skills on Students 21st Century Skills : Meta-Analysis

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Abstrak

Tujuan penelitian untuk mengetahui pengaruh model pembelajaran jigsaw berbasis Higher Order Thinking Skills terhadap keterampilan berpikir abad-21 siswa. Jenis penelitian ini adalah penelitian kuantitatif dengan pendekatan meta-analisis. Sumber data dalam penelitian ini berasal dari 10 jurnal nasional dan Internasional terbit tahun 2018-2023. Proses pencarian sumber data melalui database google scholar, Eric dan Wiley. Kriteria inklusi dalam penelitian ini adalah a) penelitian harus memiliki kelas eksperimen dan kontrol, b) penelitian berasal dari jurnal atau prosiding terindeks Scopus dan SINTA, c) penelitian memiliki keterkaitan dengan model pembelajaran jigsaw berbasis Higher Order Thinking Skills Terhadap keterampilan abad-21 siswa, d) penelitian harus terbitan 5 tahun terakhir rentang 2018-2023; e) artikel harus mempunyai nilai (t), (r), (f) ; f) ukuran sampel > 20 siswa. Analisis data dalam meta-analisis ini dengan bantuan aplikasi JSAP 0.8.5. Hasil analisis 10 penelitian menyimpulkan Dari meta-analisis ini dapat disimpulkan adanya pengaruh yang signifikan model pembelajaran jigsaw berbasis Higher Order Thinking Skills terhadap keterampilan berpikir abad-21 siswa ($Z = 1.431$; $p < 0.001$; CI 95% [0.612;0.942]. Pengaruh ini kriteria yang tinggi ($rRE = 0.845$). Temuan ini menjelaskan model pembelajaran model pembelajaran jigsaw berbasis Higher Order Thinking Skills memberikan pengaruh yang tinggi terhadap keterampilan berpikir abad-21 siswa.

Kata Kunci: Model Jigsaw, Efek Size, HOTS, Keterampilan abad-21, Meta-analisis

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Abstract

The purpose of the study was to determine the effect of jigsaw learning model based on Higher Order Thinking Skills on students' 21st century thinking skills. This type of research is quantitative research with a meta-analysis approach. The data sources in this study came from 10 national and international journals published in 2018-2023. The process of searching for data sources through google scholar, Eric and Wiley databases. The inclusion criteria in this study are a) research must have experimental and control classes, b) research comes from

Scopus and SINTA indexed journals or proceedings, c) research has a relationship with the Higher Order Thinking Skills-based jigsaw learning model towards students' 21st century skills, d) research must be published in the last 5 years range 2018-2023; e) articles must have a value (t), (r), (f); f) sample size > 20 students. Data analysis in this meta-analysis with the help of JSAP 0.8.5 application. From this meta-analysis, it can be concluded that there is a significant effect of jigsaw learning model based on Higher Order Thinking Skills on students' 21st century thinking skills ($Z = 1.431$; $p < 0.001$; 95% CI [0.612; 0.942]). This effect is criterion high ($rRE = 0.845$). This finding explains the learning model of jigsaw learning model based on Higher Order Thinking Skills provides a high influence on students' 21st century thinking skills.

Keywords: Jigsaw model, Effect size, HOTS, 21st century skills, Meta-analysis

Introduction

21st century thinking skills are skills that students must have to face the era of globalisation (Kuloğlu & Karabekmez, 2022; Chehimi & Alameddine, 2022; Elfira et al., 2023; Supriyadi et al., 2023). The 21st century thinking skills are known as the 4Cs which consist of critical thinking & problem solving, creative, communicative and collaborative (Warrick & Woodward, 2021; Rahman et al., 2023). 21st century thinking skills help students in solving symptoms or phenomena that occur in life (Sarigöz, 2023; Thiel & Marx, 2019). Furthermore, 21st century thinking skills develop higher order thinking skills in the learning process (Zulkifli et al., 2022; Suryono et al., 2023; Nurtamam et al., 2023). Students have 21st century thinking skills are more critical, active and innovative in learning (Laar et al., 2017).

But in reality, the 21st century thinking skills of Indonesian students are still relatively low (Vari, 2022; Oktarina et al., 2021). This result can be seen from the Trends in International Mathematics and Science Study (TIMSS) survey of students' critical thinking skills in the field of science is low, only obtaining a score of 397 from an international average score of 500 (Putra et al., 2023; Zulyusri et al., 2023; Suhaimi et al., 2022; Rahman, 2023). The low level of 21st-century thinking skills in students is influenced by various factors. According to (Aulia et al., 2023) The low level of students' 21st-century

thinking skills is due to the learning process that does not involve students learning more actively. The learning process is teacher-centered, making it difficult for students to understand the subject matter (Şahin, 2021; Luciana et al., 2023; Fradila et al., 2021). In addition, the selection of learning methods and models that do not encourage students' 21st century thinking skills.

The Jigsaw learning model is a learning model that can encourage students' 21st century thinking skills (Saputra et al., 2019; Zainil et al., 2023). The jigsaw learning model is a learning model that designs origin group and expert group patterns to encourage students to take responsibility in the learning process (Abed et al., 2019; Cashata et al., 2023). This jigsaw learning model can train students to be more active and creative in learning (Usman et al., 2022; Septiani et al., 2020; Azmin, 2015). Hasil penelitian (Susanti, 2019) jigsaw learning model can train students to be skilled in collaboration. Furthermore, the jigsaw learning model is able to grow students' high self-esteem in learning (Aydin & Biyikli, 2017; Dat, 2016). Not only that, the jigsaw learning model helps students more easily understand learning concepts (Saputri, 2020).

Furthermore, the jigsaw learning model based on higher order thinking skills is one of the solutions in improving students' 21st century thinking skills. Higher order thinking skills is a high-level thinking ability that is needed by students in analysing a problem that occurs (Obeidat & Saleh, 2022; Razak et

al., 2021). Learning based on higher order thinking skills students have high thinking and analysing power in learning (Zain et al., 2022; Zhou, 2020).

Research results Widyaningrum & Harjono (2019) jigsaw learning model can improve student learning outcomes. Research by (Ade Wilda Pebrina&, 2019) The jigsaw model can have a positive influence on students' critical thinking skills. Furthermore, the research results Karacop (2017) The jigsaw learning model has a significant effect on students' science process skills. But in fact, many studies on the jigsaw learning model have not found research on the effect size of the jigsaw model based on higher order thinking skills on students' 21st century thinking skills. based on the above problems, this study aims to determine the effect of the jigsaw learning model based on Higher Order Thinking Skills on students' 21st century thinking skills.

Methods

This research is a type of meta-analysis research. Meta-analysis research is a type of research that analyses previous studies that can be analysed quantitatively (Sayyah et al., 2022; Suharyat et al., 202; Suparman et al., 2020; Karim et al., 2023; Santosa et al., 2021; Balemen, 201; lchsan et al., 2022). According to Borenstein et al.,(2010) The steps of meta-analysis research consist of 1) inclusion criteria; 2) literature collection; 3) literature screening; 4) Coding; 5) Data analysis.

Inclusion Criteria

The inclusion criteria in this meta-analysis study are a) research must have experimental and control classes, b) research comes from Scopus and SINTA indexed journals or proceedings, c) research has a relationship with the Higher Order Thinking Skills-based jigsaw learning model towards students' 21st century skills, d) research must be published in the last 5 years in the range

2018-2023; e) articles must have a value (t), (r), (f); f) sample size > 20 students; f) research must be accessed from the google scholar, Eric, Wiley and Proquest databases.

Data Collection and Screening

The data collection process in this meta-analysis is through google scholar, ERIC, Wiley and ProQuest databases. The keywords for searching data sources were "jigsaw learning model", "higher order thinking skills", and "21st century thinking skills". The method of selecting data sources through the PRISMA method. Furthermore, the data screening process goes through the stages of identification, screening, eligibility and inclusion. From the data screening process, 10 national and international journals were obtained for meta-analysis.

Coding data

The coding in this meta-analysis consists of researchers, publication year, journal index, (r), (t) and (f) values and journal type. the results of data coding can be seen in table 1.

Table 1. Meta-analysis Data Coding

Journal Code	Index jurnal	r	t	f	Journal Type
A1	Scopus	1.10			International
A2	Sinta		2.30		Nasional
A3	Sinta		1.09		Nasional
A4	Sinta	0.92			Nasional
A5	Scopus	0.58			International
A6	Sinta	1.30			Nasional
A7	Sinta	0.82		2.60	Nasional
A8	Sinta		3..11		Nasional
A9	Scopus		2.82		International
A10	Sinta	0.75			Nasional

Data Analysis

Data analysis in the meta-analysis used the JSAP application. According to Borenstein et al., (2010) Data analysis steps in meta-analysis research consist of 1) calculating the effect value of the entire study, 2) conducting heterogeneity tests and calculating the overall

effect size value, 3) analysing moderator variables and 4) calculating publication bias. Furthermore, the effect size value criteria for research can be seen in table 2.

Table 2. Effect Size Value Categories

Effect Size	Category
0.0 < ES ≤ 0.20	Low
0.20 < ES ≤ 0.80	Medium
ES ≥ 0.80	High

Source : Cohen in (Ramdhayani et al., 2019) ;Rahman et al., 2023; Santosa et al., 2023; Suharyat et al., 2023)

Result and Discussion

From the analysis of 119 studies on the effect of jigsaw learning model based on higher order thinking skills on students' 21st century thinking skills, there were only 10 studies that met the inclusion criteria. Furthermore, studies that have met the criteria are tested for heterogeneity. The results of the heterogeneity test can be seen in table 3.

Table 3. Heterogeneity Test Results

	Q	df	p
Omnibus test of Model Coefficients	62.372	1	< 0.001
Test of Residual Heterogeneity	510.812	9	< 0.001

Note. *p* value are approximate

Tabel 4. The Residual Heterogeneity Test Result

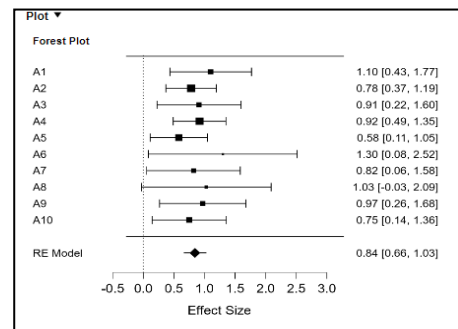
	Estimates	Lower bound	Upper Bound
τ^2	0.3110	0.2864	0.7621
τ	0.6415	0.4184	0.8203
I^2 (%)	96.761	94.227	97.890
H^2	39.758	23.6612	51.976

Based on tables 3 and 4, it explains that the 8 studies are heterogeneously distributed. This can be seen from the *p* value < 0.001; Q = 62.372; τ^2 or $t > 0$ and I^2 (%) = 96.761 close to 100%. The next step is to calculate the summary effect value or mean effect size of the entire research sample. The results of the summary effect size test or mean effect size can be seen in Table 5.

Table5. Hajji uji Summary Effect Size atau Mean Effect Size

	Estimates	Standard Error	z	p	Lower bound	Upper bound
Interept	0.845	0.292	7.913	< 0.001	0.612	0.942

Based on Table 5. explains that the value of $z = 7.913$; $p < 0.001$. This result shows that the application of inquiry learning model based on mobile learning has an effect on students' creative thinking skills. Furthermore, the results can be categorised as a large effect based on the estimated standard error value of 0.845 (0.612; 0.942). In addition, the summary effect size analysis test can be illustrated by the forest plot in Figure 2.



Gambar 1. Forest Plot

Based on Figure 1. explains that the overall effect size of the study has a significant effect. Furthermore, knowing the publication bias of each study. In this meta-analysis research, publication bias can be known by using funnel plot. Funnel plot effect size of the entire study can be seen in Figure 3.

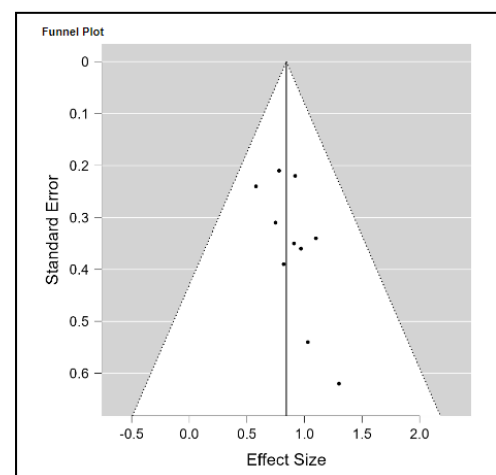


Figure 2. Funnel Plot Standard Error

Based on Figure 2. Explains that the points of the study that are extended domina are in the middle of the curve. This shows the effect size but it is difficult to determine whether this meta-analysis is symmetrical or asymmetrical so it is necessary to do the Egger test. The results of the Egger test can be seen in Table 6.

Table 6. Egger Test Results

	z	p
sei	1.431	1.568

Table 6. Explaining the value of Z = 1.431; p-value > 0.05, the funnel plot distribution is symmetrical. The funnel plot shows that there is no publication bias in this study. Furthermore, to increase the validity of publication bias, it is necessary to conduct the Fail Safe N (FSN) test. The results of the fail safe N test can be seen in Table 7.

Table 7. Fail Safe Test Results N

	Fail safe N	Target Significance	Observed significance
Rosenthal	472	0.050	< 0.001

Based on table 7. The value of fail safe N (FSN) is 472. Furthermore, the value of fail safe N is compared with the value of $k = (5.10) + 10 = 60$. Therefore, the value of fail safe N $472 / 60 = 7.8 > 1$ means that this meta-analysis study is resistant to publication bias.

Discussion

The meta-analysis of 10 studies on jigsaw learning model based on higher order thinking skills showed a positive influence on students' 21st century thinking skills. This result can be seen from the summary effect size value or mean effect size of (Z = 7.913; P < 0.001). Furthermore, the jigsaw learning model has a high effect on students' 21st century thinking skills (rRE = 1.045; SE = 0.292). This result is in line with Hulinggi et al., (2023) The jigsaw learning model has a significant effect on students' collaborative and critical thinking skills. The jigsaw learning model helps students be more active and creative in the learning process (Affandi et al., 2022; Jermstittiparsert et al., 2021). Furthermore, the jigsaw learning model based on higher order thinking skills can train students to communicate better and critically (Akkuş &

Doymuş, 2022; Saputra et al., 2019; Mukrimaa et al., 2016).

Research results Tamur et al., (2021) The jigsaw teaching model helps students play an active role in achieving learning objectives so that it can encourage students to have 21st century thinking skills. 21st century skills help students be more critical, creative, communicative and collaborative in solving a problem (Bell, 2010; Icela, 2022). Students' 21st century thinking skills are needed to face the industrial revolution 4.0. Research Indrawan et al., (2021) jigsaw learning model based on higher order thinking skills increases students' sense of courage in expressing opinions in a group.

Furthermore, in a meta-analysis it is necessary to calculate publication bias before conducting research hypotheses (Yusuf et al., 2022). Calculation of publication bias in meta-analysis of jigsaw learning model based on higher order thinking skills through funnel plot. In the funnel plot analysis, the effect size curve is in a vertical line but does not know whether it is symmetrical or asymmetrical. Therefore, it is necessary to do the Eggers test to determine whether the funnel plot is symmetrical or asymmetrical. The results of the Eggers test obtained a value (z = 1.431; p> 0.05) meaning that the meta-analysis curve is symmetrical. In addition, to determine the objectivity of research in meta-analysis, it is necessary to fail safe N. The results of the fail safe N test obtained (k = 7.8 > 1) can be concluded in this meta-analysis there is no publication bias. So, the jigsaw learning model based on higher order thinking skills is very well applied by teachers to encourage students' 21st century thinking skills.

Conclusion

From this meta-analysis, it can be concluded that there is a significant effect of jigsaw learning model based on Higher Order Thinking Skills on students' 21st century thinking skills (Z = 1.431; p < 0.001; 95% CI [0.612;0.942]). This effect is criterion high (rRE = 1.045). This finding explains the Higher Order Thinking Skills-based jigsaw learning model provides a high influence on students' 21st century thinking skills. Higher order thinking skills-based jigsaw learning model is

very necessary to help students in developing students' 21st century skills.

Reference

- Abdul Rahman, Ilwandri, Tomi Apra Santosa, Revi Gina Gunawan, Yayat Suharyat, Ringgo Putra, A. S. (2023). Effectiveness of Problem-Based Learning Model in Science Learning: A Meta- Analysis Study. *JUARA : Jurnal Olahraga*, 8(2), 713–726.
- Abed, A. Z., Sameer, S. A., Kasim, M. A., & Othman, A. T. (2019). Predicting Effect Implementing the Jigsaw Strategy on the Academic Achievement of Students in Mathematics Classes. *International Electronic Journal of Mathematics Education*, 15(1), 1–7. <https://doi.org/10.29333/iejme/5940>
- Ade Wilda Pebrina, I. S. (2019). PENGARUH MODEL PEMBELAJARAN KOOPERATIF TIPE JIGSAW TERHADAP KETERAMPILAN SOSIAL DAN KEMAMPUAN BERPIKIR KRITIS SISWA. *Equilibrium: Jurnal Penelitian Pendidikan Dan Ekonom*, 16(1), 70–81. <https://doi.org/10.25134/equi.v16i01.A bstract>
- Affandi, Y., Darmuki, A., & Hariyadi, A. (2022). The Evaluation of JIDI (Jigsaw Discovery) Learning Model in the Course of Qur an Tafsir. *International Journal of Instruction*, 15(1), 799–820. <https://doi.org/10.29333/iji.2022.15146 a>
- Akkuş, A., & Doymuş, K. (2022). Effect of Subject Jigsaw and Reading Writing Presentation Techniques on Academic Achievement of 6 th Grade. *Journal of Turkish Science Education*, 19(2), 496–510.
- Aulia, H., Kantun, S., & Kurnianto, F. A. (2023). Integrasi Keterampilan Abad 21 dan Keterampilan Berpikir Spasial pada Buku Teks Geografi. *JPG (Jurnal Pendidikan Geografi)*, 10(1), 129–141. <https://doi.org/10.20527/jpg.v10i1.14528>
- Aydin, A., & Biyikli, F. (2017). The Effect of Jigsaw Technique on the Students' Laboratory Material Recognition and Usage Skills in General Physics Laboratory-I Course. *Universal Journal of Educational Research*, 5(7), 1073–1082. <https://doi.org/10.13189/ujer.2017.050701>
- Azmin, N. H. (2015). Effect of the Jigsaw-Based Cooperative Learning Method on Student Performance in the General Certificate of Education Advanced-Level Psychology: An Exploratory Brunei Case Study. *International Education Studies*, 9(1), 91. <https://doi.org/10.5539/ies.v9n1p91>
- Balemen, N. (2018). THE EFFECTIVENESS OF PROJECT-BASED LEARNING ON SCIENCE EDUCATION : A META-ANALYSIS SEARCH. *International Online Journal of Education and Teaching (IOJET)*, 5(4), 849–865.
- Bell, S. (2010). Project-Based Learning for the 21st Century : Skills for. *The Clearing House*, 83, 39–43. <https://doi.org/10.1080/00098650903505415>
- Borenstein, M., Hedges, L. V., Borenstein, M., Hedges, L. V., & Higgins, J. P. T. (2010). A basic introduction to fixed and random effects models for meta-analysis A basic introduction to fixed-effect and random-effects models for meta-analysis. *Res. Syn. Meth*, 1, 97–111. <https://doi.org/10.1002/jrsm.12>
- Cashata, Z. A., Seyoum, D. G., & Gashaw, F. E. (2023). Enhancing College Students' Procedural Knowledge of Physics Using Blended Jigsaw-IV Problem-Solving Instruction. *International Journal of Research in Education and Science*, 9(1), 148–164. <https://doi.org/10.46328/ijres.3035>
- Chehimi, G., & Alameddine, M. M. (2022). The Making of a 21st Century English Language Teacher during the Pandemic. *International Journal on Social and*

- Education Sciences*, 4(1), 101–120.
<https://doi.org/10.46328/ijonses.297>
- Dat, T. Van. (2016). The Effects of Jigsaw Learning on Students' Knowledge Retention in Vietnamese Higher Education. *International Journal of Higher Education*, 5(2), 236–253.
<https://doi.org/10.5430/ijhe.v5n2p236>
- 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>
- Febrianto Yopi Indrawan^{1*}, Edi Irawan², Titah Sayekti³, I. A. M. (2021). Efektivitas Metode Pembelajaran Jigsaw Daring Dalam Meningkatkan Keterampilan Kolaborasi Siswa SMP. *Jurnal Tadris IPA Indonesia*, 1(3), 259–268.
- Fradila, E., Razak, A., Santosa, T. A., Arsih, F., & Chatri, M. (2021). Development Of E-Module-Based Problem Based Learning (PBL) Applications Using Sigil The Course Ecology And Environmental Education Students Master Of Biology. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 27(2), 673–682.
- H G Ramdhayani^{1*}, A. A. P. and M. M. (2019). Meta analysis : the effect of applying project-based learning models to students ' science process skills Meta analysis : the effect of applying project-based learning models to students ' science process skills. *Journal of Physics: Conference Series*, 1321, 1–5.
<https://doi.org/10.1088/1742-6596/1321/3/032089>
- Hulinggi, S. A., Samaela, D. P., Studi, P., Biologi, P., & Maroso, U. S. (2023). Pengembangan Asesmen Autentik Dengan Menggunakan Metode Jigsaw Untuk Mengukur Kemampuan Kolaboratif Dan Berpikir Kritis Mahasiswa Pendidikan Biologi. *BIOSFER*, 8(1), 56–66.
- Icela, L. (2022). Components of Education 4 . 0 in 21st Century Skills Frameworks : Systematic Review. *Sustainability*, 14, 1–31.
- Ichsan et al. (2022). Pengaruh Model Pembelajaran Problem Based Learning Berbasis TPACK Terhadap Keterampilan Literasi Sains Dalam Pembelajaran IPA Siswa Tingkat SD Sampai SMA: Sebuah Meta-Analisis. *Jurnal Pendidikan Dan Konseling*, 4, 2173–2181.
- Jermisittiparsert, K., Menacho-vargas, I., Supondori, F., Yaneth, Y., Centellas, T., Ivanova, O. N., State, A., Planning, H. E., & Board, C. (2021). Cypriot Journal of Educational Cooperative strategies and listening comprehension : The cases of Jigsaw and Missing information techniques. *Cypriot Journal of Educational Sciences*, 16(3), 1257–1268.
- Karacop, A. (2017). The Effects of Jigsaw Technique Based on Cooperative Learning on Prospective Science Teachers ' Science Process Skill 1. *Journal of Education and Practice*, 8(6), 86–97.
- KULOĞLU, A., & KARABEKMEZ, V. (2022). The Relationship Between 21st-century Teacher Skills and Critical Thinking Skills of Classroom Teacher. *International Journal of Psychology and Educational Studies*, 9(1), 91–101.
<https://doi.org/10.52380/ijpes.2022.9.1.551>
- M. Karim , Syafrul Antoni², Karlini Oktarina³, T. A. S. (2023). The Effect of Teacher Professionalism in Islamic Religious Education in the Era of Society 5.0 in Indonesia: A Meta-Analysis. *Jurnal Pendidikan Dan Konseling*, 5(2), 1349–1358.
- Maximus Tamur¹, Subaryo², Apolonia H Ramda¹, Adi Nurjaman³, Sebastianus Fedi¹, A. H. (2021). PENGARUH PEMBELAJARAN KOOPERATIF TIPE JIGSAW TERHADAP KEMAMPUAN BERPIKIR KRITIS SISWA SMP. *Journal of Honai Math*, 4(2), 173–182.
- Mukrimaa, S. S., Nurdyansyah, Fahyuni, E. F.,

- YULIA CITRA, A., Schulz, N. D., غسان, د., Taniredja, T., Faridli, E. M., & Harmianto, S. (2016). The Jigsaw Design Challenge: An Inclusive Learning Activity To Promote Cooperative Problem-Solving. *Journal of Effective Teaching in Higher Education*, 4(3), 20–34.
- 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.
- Obeidat, F. A. A., & Saleh, S. (2022). The Relationship of Fluid Intelligence Level with Higher-order Thinking Skills in Work and Energy among Sixth-grade Students in Jordan. *Journal of Curriculum and Teaching*, 11(4), 224–234. <https://doi.org/10.5430/jct.v11n4p224>
- Occe Luciana1*, Tomi Apra Santosa2, 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.
- Putra, M., Rahman, A., Suhayat, Y., Santosa, T. A., & Putra, R. (2023). The Effect of STEM-Based REACT Model on Students ' Critical Thinking Skills : A Meta-Analysis Study. *LITERACY: International Scientific Journals Of Social, Education and Humaniora*, 2(1), 207–217.
- Rahman, A., Islam, P. A., Bekasi, U. I., Ipa, P., Padang, U. N., Jambi, U., Pendidikan, M., Islam, A., Uin, F., & Bonjol, I. (2023). *Meta-Analysis : Pengaruh Pendekatan STEM berbasis Etnosains Terhadap Kemampuan Pemecahan Masalah dan Berpikir Kreatif Siswa*. 3, 2111–2125.
- Rahman, A., Santosa, T. A., & Suharyat, Y. (2023). *The Effect of Problem Based Learning-STEM on Students ' 21st Century Skills in Indonesia : A Meta-Analysis*. 2(1).
- Razak, A., Santosa, T. A., Lufri, & Zulyusri. (2021). Meta-Analisis: Pengaruh HOTS (Higher Order Thinking Skill) terhadap Kemampuan Literasi Sains dan Lesson Study Siswa pada Materi Ekologi dan Lingkungan pada Masa Pandemi Covid-19. *Bioedusiana: Jurnal Pendidikan Biologi*, 6(1), 79–87.
- ŞAHİN, H. (2021). THE EFFECT OF STEM-BASED EDUCATION PROGRAM ON PROBLEM SOLVING SKILLS OF FIVE YEAR OLD. *Malaysian Online Journal of Educational Technology*, 9(4), 69–88.
- Santosa, T. A., Razak, A., Arsih, F., & Sepriyani, E. M. (2021). Meta-Analysis : Science Learning Based on Local Wisdom Against Preserving School Environments During the Covid-19 Pandemic. *Journal of Biology Education*, 10(2), 244–251.
- Santosa, T. A., Siagian, G., Razak, A., & Zulyusri, S. (2023). Development of Higher Order Thinking Skill Instruments in Biology Learning on Ecology and Environment Materials. *Jurnal Edumaspul*, 7(1), 1093–1100.
- Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of Jigsaw model with problem-based learning model. *International Journal of Instruction*, 12(1), 1077–1094. <https://doi.org/10.29333/iji.2019.12169a>
- Saputri, L. (2020). Pengaruh Model Pembelajaran Kooperatif Tipe Jigsaw Terhadap Kemampuan Pemahaman Konsep Matematis. *Jurnal Serunai Matematika*, 12(1), 13–18. <https://doi.org/10.37755/jsm.v12i1.262>

- SARIGÖZ, O. (2023). Teaching the 21st Century Learning Skills with the Critical Thinking Technique Based on the Argumentation Method. *Educational Policy Analysis and Strategic Research*, 18(1), 0–2. <https://doi.org/10.29329/epasr.2023.525.9>
- Sayyah, M., Shirbandi, K., Saki-malehi, A., & Rahim, F. (2022). Use of a problem-based learning teaching model for undergraduate medical and nursing education : a systematic review and meta-analysis Use of a problem-based learning teaching model for undergraduate medical and nursing education : a systematic review and. *Advances in Medical Education and Practice* ISSN:, 1–11. <https://doi.org/10.2147/AMEP.S143694>
- Septiani, V., Paidi, S., & Darussyamsu, R. (2020). Jigsaw as a community learning strategy : Improving students ' social attitudes. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(3), 397–404.
- 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., Santosa, T. A., & Satria, E. (2023). The Effectiveness of STEM-Based Learning in Teaching 21 st Century Skills in Generation Z Student in Science Learning : A. *Jurnal Penelitian Pendidikan IPA*, 9(1), 160–166. <https://doi.org/10.29303/jppipa.v9i1.2517>
- 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.
- Suparman1*, D. J. and M. T. (2020). Review of problem-based learning trends in 2010-2020 : A meta-analysis study of the effect of problem-based learning in enhancing mathematical problem-solving skills of Indonesian students Review of problem-based learning trends in 2010-2020 : A meta-ana. *Journal of Physics: Conference Series*, Ser. 1722, 1–10. <https://doi.org/10.1088/1742-6596/1722/1/012103>
- 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.
- Susanti, E. (2019). Kemampuan Berpikir Kritis Siswa Sdn Margorejo VI Surabaya melalui Model Jigsaw. *Bioedusiana*, 4(2), 55–64. <https://doi.org/10.34289/285232>
- Thiel, B., & Marx, A. (2019). The Influence of Agriscience Research SAEs on Perceived Self-efficacy of 21st Century Skill Attainment. *Journal of Agricultural Education*, 60(01), 80–95. <https://doi.org/10.5032/jae.2019.01080>
- Usman, M., I, I. N., Utaya, S., & Kuswandi, D. (2022). The Influence of JIGSAW Learning Model and Discovery Learning on Learning Discipline and Learning Outcomes. *Pegem Egitim ve Ogretim Dergisi*, 12(2), 166–178. <https://doi.org/10.47750/pegegog.12.02.17>
- van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, 72, 577–588. <https://doi.org/10.1016/j.chb.2017.03.010>

- Vari, Y. (2022). PEMANFAATAN AUGMENTED REALITY UNTUK MELATIH KETERAMPILAN BERPIKIR ABAD 21 DI PEMBELAJARAN IPA. *INKUIRI: Jurnal Pendidikan IPA*, 11(2), 70–75. <https://doi.org/10.20961/inkuiri.v11i2.55984>
- Warrick, A., & Woodward, H. (2021). Reflections on 21st century skill development using interactive posters and virtual reality presentations. *CALL and Professionalisation: Short Papers from EUROCALL 2021, 2021*, 290–295. <https://doi.org/10.14705/rpnet.2021.54.1348>
- Widyaningrum, M. D., & Harjono, N. (2019). Pengaruh Model Pembelajaran Jigsaw Terhadap Hasil Belajar Ips Siswa Kelas 4 Sekolah Dasar. *JPPGuseda | Jurnal Pendidikan & Pengajaran Guru Sekolah Dasar*, 2(2), 57–60. <https://doi.org/10.33751/jppguseda.v2i2.1446>
- Yusuf, M., Putri, L. A., Alamin, N., & Ardinal, E. (2022). Theology of Character Education From The Perspective Of The Qur'an In Supporting Islamic Education Curriculum. *Jurnal Sustainable*, 5(2), 221–229.
- Zain, F. M., Sailin, S. N., & Mahmor, N. A. (2022). Promoting Higher Order Thinking Skills among Pre-Service Teachers through Group-Based Flipped Learning. *International Journal of Instruction*, 15(3), 519–542. <https://doi.org/10.29333/iji.2022.15329a>
- Zainil, M., Kenedi, A. K., Rahmatina, Indrawati, T., & Handrianto, C. (2023). The influence of a STEM-based digital classroom learning model and high-order thinking skills on the 21st-century skills of elementary school students in Indonesia. *Journal of Education and E-Learning Research*, 10(1), 29–35. <https://doi.org/10.20448/jeelr.v10i1.4336>
- Zhou, W. (2020). University of San Diego How Collaborative Learning Supports ESL Learners' Development of Higher Order Thinking Skills. *The CATESOL Journal 32.L*, 32(1), 45–58.
- Zulkifli, Z., Satria, E., Supriyadi, A., & Santosa, T. A. (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*, 5(1), 32–42.
- Zulyusri, Tomi Apra Santosa, Festiyed, Yerimadesi1, Yohandri1, Abdul Razak, 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>