

META-ANALYSES: THE EFFECT OF STEM-BASED E-LEARNING ON STUDENTS' HIGHER ORDER THINKING SKILLS IN INDONESIA

Tomi Apra Santosa¹, Ilwandri², Abdul Rahman³.

^{1,2} Universitas Negeri Padang

³ Universitas Sebelas Maret

E-mail: santosatomiapra@gmail.com

Abstract

Please Many studies have described meta-analysis on the overall effect of e-learning influence in learning. However, there has been no meta-analysis of the overall effect of STEM-based e-learning on Higher Order Thinking Skills (HOTS). The purpose of this study investigates the effect of STEM-based e-learning on students' critical thinking skills in Indonesia. This type of research is a Systematic Literature Review (SL) and meta-analysis. Data sources came from 12 national and international journals published in 2018-2023. The process of searching for data sources through Google Scholar, ScienceDirect, Wiley, Eric, and Springer. Data analysis used the Hedge formula to calculate effect size with the help of the JSAP application. The findings show that the effect size value ($ES = 0.84$) is very high. This explains that STEM-based e-learning provides a very high positive impact and is effective in improving students' Higher Order Thinking Skills (HOTS). Furthermore, HOTS characteristics do not cause heterogeneity in the results of STEM-based e-learning research on students' Higher Order Thinking Skills. The findings suggest that educators should choose STEM-based e-learning as one of the learning models to improve students' Higher Order Thinking skills in Indonesia.

Keywords: E-learning, STEM, Higher Order Thinking Skill, SLR dan Meta-analisis

INTRODUCTION

Higher Order Thinking Skills (HOTS) is a high-level thinking ability that must be possessed by students (Shanti et al., 2022; Wardani et al., 2020; Hamzah & Yusoff, 2021; Putranta et al., 2021). Higher Order Thinking Skills (HOTS) are important for students to think critically in solving a difficult problem (Tsaparlis, 2020; Syafryadin et al., 2022; Razak et al., 2021). Students who have high-level thinking skills find it easier to understand the concepts of the lesson (How et al., 2022; Tyas et al., 2020). According to Royan & Diniyah (2022) stated that Higher Order Thinking Skills are highly emphasized on students in the 2013 curriculum so that students are able to solve problems in life. Furthermore, students who have Higher Order Thinking Skills will be more creative and innovative in learning (Akatsuka, 2019;

Suprpto et al., 2020; Saepuzaman et al., 2021).

The level of Higher Order Thinking Skills of students in Indonesia is still low (Azid et al., 2022). This can be seen from the results of the Program of International Students Assessment (PISA) in 2015 Hodiyoanto (2018) Indonesia is ranked 62 out of 72 member countries. PISA in 2018 the level of science literacy of Indonesian students is still low, the average score of Indonesian students is only 396, ranked 70 out of 78 member countries. (Zulkifli et al., 2022; Takiddin et al., 2020; Supriyadi et al., 2023; Elfira et al., 2023; Oktarina et al., 2021). The Higher Order Thinking Skills criteria set by PISA put more emphasis on the ability to think, analyze, solve problems and communicate that are guided by students' Higher Order Thinking Skills. (Kahar et al.,

2021; Alsowat, 2016; Kareem, 2022; Yunita et al., 2020).

The low quality of Higher Order Thinking Skills in students is influenced by various factors. Rintayati et al., (2021) stated that the low level of Higher Order Thinking Skills is caused by the learning model used by teachers that has not led to students' higher order thinking skills. The teaching and learning process is still teacher-centered (Sofianora et al., 2023; Suharyat et al., 2022; Zulyusri et al., 2022; Rahman et al., 2023), so that students are less active in learning. In addition, the evaluation questions of the student teaching and learning process have not led to students' Higher Order Thinking Skills (Fitri et al., 2018).

E-learning is a learning system that is carried out electronically through a learning platform via the internet network (Berestova et al., 2022; Bakarman & Almezeini, 2021). Aurora & Effendi (2019) stated that e-learning helps students' learning process more interesting and interactive without time limit (Suharyat et al., 2022; Santosa et al., 2021; Nuryatin et al., 2022; Lee et al., 2020). The e-learning process helps students in mastering technology (Caratiquit, 2022). Saleem et al., (2021) stated that e-learning helps foster interest and motivation in learning so that students are more active in learning. E-learning helps students' learning activities more effectively and practically because it is accessed through the internet (Krasodomska et al., 2021). Furthermore, Science Technology Engineering and Mathematics (STEM) based e-learning is one of the solutions to improve students' Higher Order Thinking Skills (HOTS).

STEM is a learning approach that combines science technology engineering and math in the learning process (Akoz et al., 2022; Suharyat et al., 2023; Rahman et al., 2023; Eroğlu, 2021). Fadlilmula (2022) STEM learning helps students be more creative and innovative in learning and

students understand the lesson more easily. The STEM approach helps students to encourage their thinking skills (Friedensen et al., 2018). Research results Mujib et al., (2020) stated that STEM learning can improve students' multiple intelligence skills. In addition, research results Wijayanto et al., (2015) stated that STEM learning trains students to solve a problem in learning.

Furthermore, previous research Yaniawati (2012) e-learning can train students' knowledge skills in learning. Research by Kusumantara et al., (2017) learning through e-learning effectively improves student learning outcomes. Research results Ibrahim et al., (2014) e-learning can help students in encouraging motivation and better student learning outcomes. Marín et al., (2018) e-learning explains that students are more active and motivated to learn so as to encourage their critical thinking skills. Not only that, the results of research by Nisa (2012) learning with e-learning methods has a significant effect on student learning outcomes. Based on this problem, this study aims to investigate the effect of STEM-based E-learning on students' Higher Order Thinking Skills in Indonesia.

RESEARCH METHOD

This research uses systematic literature review and meta-analysis. The use of systematic literature review and meta-analysis to look at relevant primary studies with a quantitative approach (Suparman et al., 2021). Menurut (Kim et al., 2017; Saraç, 2018; tehrani & Yamini, 2021) The steps for systematic literature review and meta-analysis are 1) Determine inclusion criteria; 2) Study search process; 3) data extraction; 4) study selection; and 5) data analysis. In this systematic literature review and meta-analysis, the effect size value was calculated using the Hedge formula (Borenstein & Hedges, 2009). Furthermore, meta-analysis of the effect size of each study, combined effect

size, effect size of moderator variables and publication bias were calculated with the help of JSAP application.

FINDING(S) AND DISCUSSION

Finding

From the results of searching data sources from the Google Scholar, ScienceDirect, Wiley, ProQuest, and Eric databases, a total of 663 journals related to the effect of STEM-based e-learning on elementary, junior high, high school and university students were obtained. However, there are 12 journals that have met the inclusion criteria. The effect size value of each journal can be seen in Table 2.

Table 2. Overall Effect Size

No	Penulis	Tahun	Hedge's	Standart Error	Kriteria Effect Size
1	Riyanti,	2020	0.88	0.421	Hight
2	Gustria & Fauzi	2020	0.92	0.319	Hight
3	Sigit <i>et al.</i> ,	2022	1.06	0.210	Very Hight
4	Mufida <i>et al.</i> ,	2020	0.64	0.231	Medium
5	Hasibuan <i>et al.</i> ,	2022	0.70	0.391	Medium
6	Noor <i>et al.</i> ,	2017	0.60	0.210	Medium
7	Kusuma	2020	0.73	0.326	Medium
8	Makmudah <i>et al.</i> ,	2021	0.83	0.201	Hight
9	Sury <i>et al.</i> ,	2020	0.95	0.170	Hight
10	Wiyono <i>et al.</i> ,	2022	0.62	0.258	Medium
11	Hidayah & Wiyono	2022	1.35	0.424	Very Hight
12	Widyaningsih	2021	0.81	0.272	Hight
<i>Average Effect Size value</i>			0.84		Hight

Table 2 shows that the average value of Effect Size (ES = 0.84) with high criteria. This explains that STEM-based e-learning has a significant effect on students' higher order thinking skills. The next stage, determining the effect size model by conducting a heterogeneity test. The results of the heterogeneity test can be seen in Table 3.

Result

The application of STEM-based e-learning has a positive impact on students' Higher Order Thinking Skills (HOTS) at school. This can be seen from the average Effect size value (ES = 0.837), meaning that STEM-based e-learning has a significant effect on Higher Order Thinking Skills (HOTS). Learning with STEM-based e-

learning makes students' teaching and learning activities more interactive and fun (Berestova et al., 2022; El-aasar & Farghali, 2022). E-STEM-based learning helps students utilize technology for teaching and learning (Aljaser, 2019). Dewi et al., (2020) stated that the teaching and learning process through STEM-based E-learning makes it easy for teachers and students to access information that can stimulate students' higher order thinking skills (HOTS).

Furthermore, STEM-based e-learning is effective in increasing the Higher Order Thinking Skill (HOTS) of students in Indonesia. It can be seen from the value ($z = 6.012$ or $p\text{-value} < 0.00$), then STEM-based E-learning is one of the solutions in improving students' HOTS. Nudin et al., (2021) stated that E-learning is very effective for students and teachers to improve learning outcomes and students' Higher Order Thinking Skills (HOTS). Students who have high Higher Order Thinking Skills (HOTS) will find it easier to solve problems (Murthy, 2018; Bismala et al., 2022; Çalışır, 2022). So, STEM-based E-learning is very important to be implemented by teachers so that students can grow Higher Order Thinking Skills.

Baji et al., (2022) stated that students who learn through STEM-based E-Learning will be faster in obtaining information from various available on the internet. Students who have extensive knowledge will more quickly accept the subject matter delivered by the teacher (Ferdyan et al., 2021; Ferry et al., 2019; Friedensen et al., 2018). In this meta-analysis, E-learning has a high positive effect on students' thinking skills. Sari et al., (2021) E-learning has a huge influence in improving Higher Order Thinking Skills (HOTS) in Indonesia. Therefore, the application of STEM-based E-learning becomes a new learning in improving the progress of education in Indonesia. E-learning allows students and teachers to learn online through a learning platform (Hamad et al., 2022).

CONCLUSION

Both From this study it can be concluded that the effect size value ($ES = 0.85$) with a very high category. This explains that STEM-based e-learning gives a very high positive impact and is effective to improve students' Higher Order Thinking Skill (HOTS). Furthermore, HOTS characteristics do not cause heterogeneity in the results of STEM-based e-learning research on students' Higher Order Thinking Skill. These findings suggest that educators should choose STEM-based e-learning as one of the learning models to improve students' Higher Order Thinking Skill in Indonesia. STEM-based e-learning helps students to grow their digital literacy in learning. Furthermore, learning through E-learning can be done online so that it helps students to be more nuanced in accessing learning resources.

REFERENCES

- Ak, O., Deni, H., & Gen, H. (2022). European Journal of Education Studies A COURSE CONTENT DESIGNED IN ACCORDANCE WITH THE 5E TEACHING MODEL WITHIN THE SCOPE OF STEM LEARNING APPROACH IN ENVIRONMENTAL EDUCATION COURSE : MY SMART GREENHOUSE. *European Journal of Education Studies*, 274–295. <https://doi.org/10.46827/ejes.v9i4.4263>
- Akatsuka, Y. (2019). Awareness of Critical Thinking Attitudes and English Speaking Skills: The Effects of Questions. *Journal of Pan-Pacific Association of Applied Linguistics*, 23(2), 59–84.
- ALJASER, A. M. (2019). THE EFFECTIVENESS OF E-LEARNING ENVIRONMENT IN DEVELOPING ACADEMIC ACHIEVEMENT AND THE ATTITUDE. *Turkish Online Journal of Distance Education-TOJDE*, 20(2), 176–194.
- Alsowat, H. (2016). An EFL Flipped Classroom Teaching Model : Effects on English Language Higher-order Thinking Skills , Student Engagement and Satisfaction. *Journal of Education and Practice*, 7(9), 108–121.
- Aurora, A., & Effendi, H. (2019). Pengaruh Penggunaan Media Pembelajaran E-learning terhadap Motivasi Belajar Mahasiswa di Universitas Negeri Padang. *JTEV (JURNAL TEKNIK ELEKTRO DAN VOKASIONAL*, 05(02), 11–16.
- Azfin Gustria, 2*Ahmad Fauzi. (2020). EFEKTIFITAS E-MODUL PEMBELAJARAN FISIKA BERBASIS STEM EDUCATION TERINTEGRASI MATERI Azfin Gustria , Ahmad Fauzi Program Studi Magister Pendidikan Fisika , Universitas Negeri Padang Jurusan Fisika FMIPA , Universitas Negeri Padang * email : ahmadfauzi@fmip. *Jurnal Pendidikan Fisika*, 9(2), 105–111.
- Azid, N., Khuluqo, I. El, Purwanto, S. E., Susanti, E. N., & Info, A. (2022). Higher order thinking skills , school-based assessment and students ' mathematics achievement : Understanding teachers ' thoughts. *International Journal of Evaluation and Research in Education (IJERE)*, 11(1), 290–302. <https://doi.org/10.11591/ijere.v11i1.22030>
- Baji, F., Azadeh, F., Sabaghinejad, Z., & Zalpour, A. (2022). Determinants of e-learning acceptance amongst Iranian postgraduate students. *Journal of Global Education and Research*, 6(2), 181–191.
- Bakarman, A., & Almezeini, N. (2021). FACTORS INFLUENCING STUDENTS ' ACCEPTANCE OF E-LEARNING PLATFORMS IN PRIMARY AND SECONDARY SCHOOLS IN SAUDI ARABIA.

- International Conference E-Learning*, 20, 23–33.
- Berestova, A., Burdina, G., Lobuteva, L., & Lobuteva, A. (2022). Academic Motivation of University Students and the Factors that Influence it in an E-Learning Environment. *The Electronic Journal of E-Learning*, 20(2), 201–210.
- Binti Hamzah, L. M., & Binti Wan Yusoff, W. M. (2021). A Scoping Review on Implementation of I-Think Maps and Its Effects on Higher Order Thinking Skills in Malaysian Schools. *Asian Journal of University Education*, 17(2), 169–182. <https://doi.org/10.24191/AJUE.V17I2.13386>
- Bismala, L., Manurung, Y. H., & Siregar, G. (2022). The Impact of E-Learning Quality and Students' Self-Efficacy Toward the Satisfaction in the Using of E-Learning. *Malaysian Online Journal of Educational Technology*, 10(2), 141–150.
- Borenstein, M., & Hedges, L. V. (2009). *Introduction to Meta-Analysis Introduction*.
- Çalışır, E. Ç. (2022). Reflections of Metaverse-Based Education on E-Learning. *EJERCongress 2022 Conference Proceedings Internet*, 103–115.
- Caratiquit, K. (2022). Influence of Technical Support on Technology Acceptance Model to Examine the Project PAIR E-Learning System in Distance Learning Modality. *Participatory Educational Research (PER)*, 9(5), 468–485.
- Dabiriyani-tehrani, H., & Yamini, S. (2021). Systematic review and meta-analysis of Altruistic and Game-playing love (Revisión sistemática y meta- análisis del amor Altruista y Lúdico). *Studies in Psychology*, 42(1), 1–46. <https://doi.org/10.1080/02109395.2020.1857596>
- Dewi, K. A. I. D., Suarsana, I. M., & Juniantari, M. (2020). Pengaruh E-Learning Berbasis Rumah Belajar Terhadap Kemampuan Berpikir Kritis Matematika Siswa. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, 14(1), 65–77.
- 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.
- Duden Saepuzaman1*, Heri Retnawati2, Edi Istiyono3, H. (2021). Can Innovative Learning Affect Students' HOTS Achievements?: A Meta-Analysis Study. *Pegem Journal of Education and Instruction*, 11(4), 290–305. <https://doi.org/10.47750/pegegog.11.04.28>
- El-aasar, S. A., & Predictive, G. F. (2022). Predictive Study of the Factors and Challenges Affecting the Usability of E-Learning Platforms in the Light of To cite this article : Predictive Study of the Factors and Challenges Affecting the Usability of E-Learning Platforms in the Light of COVID-19. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, 10(3), 568–589.
- 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>
- eyide EROĞLU, O. B. (2021). HIGH SCHOOL STUDENTS' VIEWS ON THE 5E-BASED STEM. *Acta Didactica Napocensia*, 14(2), 203–215.

- <https://doi.org/10.24193/adn.14.2.15>
- Fadlilmula, F. K. (2022). STEM learning during the COVID-19 pandemic in Qatar : Secondary school students ' and teachers ' perspectives. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(6), 1–13.
- Fadlul Amin Nudin, Ruffi'i*, D. A. W. (2021). PENGARUH E-LEARNING, PEMBELAJARAN LANGSUNG, DAN FAKTOR GAYA KOGNITIF TERHADAP HASIL BELAJAR PRAKARYA KEWIRAUSAHAAN. *Edcomtech: Jurnal Kajian Teknologi Pendidikan*, 6(2), 222–235. <https://doi.org/10.17977/um039v6i12021p222>
- Ferdyan, R., Padang, U. N., Padang, U. N., Padang, U. N., Santosa, T. A., Padang, U. N., Razak, A., & Padang, U. N. (2021). Model Pendidikan Lingkungan Hidup : Kegiatan Pembelajaran pada Siswa Sebagai Bagian dari Lingkungan di Era New Normal. *Natural Science: Jurnal Penelitian Bidang IPA Dan Pendidikan IPA*, 7(1), 51–61.
- Friedensen, R., Lauterbach, A., Kimball, E., & Mwangi, C. G. (2018). Students with High-Incidence Disabilities in STEM : Barriers Encountered in Postsecondary Learning Environments. *Journal of Postsecondary Education and Disability*, 34(1), 77–90.
- Hamad, A. L., Abouelnaga, H. M., & Baz, A. (2022). JOURNAL OF LANGUAGE The Importance Of E-Learning To The Students And Teachers. *JOURNAL OF LANGUAGE AND LINGUISTIC STUDIES*, 18(2), 952–968.
- Hasibuan, M. P., Sari, R. P., & Syahputra, R. A. (2022). Application of Integrated Project-based and STEM-based E-learning Tools to Improve Students ' Creative Thinking and Self-Regulation Skills. *Jurnal Penelitian Pendidikan IPA*, 8(1), 51–56. <https://doi.org/10.29303/jppipa.v8i1.1050>
- Hidayah, R. N., & Wiyono, K. (2022). Effectiveness of Using E-learning at STEM-Based Sound-Wave Materials to Improve Collaboration Skills of High School Students. *Berkala Ilmiah Pendidikan Fisika*, 10(3), 331–341. <https://doi.org/10.20527/bipf.v10i3.13850>
- Hikmah Fitri , Agus Wahyuni, M. (2018). Pengaruh Model Problem 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.
- Hodiyanto. (2018). PENGARUH MODEL PROBLEM BASED LEARNING TERHADAP HIGHER ORDER THINKING SKILLS (HOTS) MATEMATIS SISWA Hodiyanto. *Buana Matematika: Jurnal Ilmiah Matematika Dan Pendidikan Matematika*, 8(2), 101–108.
- Ibrahim, D. S., Suardiman, S. P., & Yogyakarta, U. N. (2014). THE EFFECTS OF THE USE OF E-LEARNING ON THE LEARNING MOTIVATION AND ACHIEVEMENT IN MATHEMATICS. *Jurnal Prima Edukasia*, 2, 66–79.
- Ikke Pradima Sari, 1 Putri Jannatur Rahmah, 2 Mir'atun Nur Arifah. (2021). PENGARUH E-LEARNING TERHADAP HOTS (HIGHER ORDER THINKING SKILLS) MAHASISWA UNIVERSITAS. *At-Thullab*, 2(2), 455–468.
- Kareem, A. (2022). Higher-Order Thinking Skills and Scientific Attitudes Components as Predictors of Scientific

- Creativity Among Preservice Biology Teachers. *International Journal of Progressive Education*, 18(4), 0–1. <https://doi.org/10.29329/ijpe.2022.459.2>
- Kim How, R. P. T., Zulnaldi, H., & Rahim, S. S. A. (2022). HOTS in Quadratic Equations: Teaching Style Preferences and Challenges Faced by Malaysian Teachers. *European Journal of Science and Mathematics Education*, 10(1), 15–33. <https://doi.org/10.30935/SCIMATH/11382>
- Kim, N. J., Belland, B. R., & Walker, A. E. (2017). Effectiveness of Computer-Based Scaffolding in the Context of Problem-Based Learning for Stem Education : Bayesian Meta-analysis. *Educ Psychol Rev*, 1–10. <https://doi.org/10.1007/s10648-017-9419-1>
- Krasodomska, J., Godawska, J., & Krasodomska, J. (2021). E-learning in accounting education : the influence of students ' characteristics on their engagement and performance characteristics on their engagement and performance. *Accounting Education*, 4(2), 22–40. <https://doi.org/10.1080/09639284.2020.1867874>
- Kusuma, L. (2020). The Perceptions of Teacher and Student in Senior High School to the Needs of STEM-based E-learning in Physics Learning Process. *The 4th ICLIQE (2020)*, 1–7.
- Kusumantara, K. S., Santyadiputra, G. S., Sugihartini, N., Ganesha, U. P., & Digital, S. (2017). PENGARUH E-LEARNING SCHOODOLOGY TERHADAP HASIL BELAJAR. *Jurnal Pendidikan Teknologi Dan Kejuruan*, 14(2), 126–135.
- Lee, R., Looi, K. H., Faulkner, M., Neale, L., Lee, R., Looi, K. H., Faulkner, M., & The, L. N. (2020). The moderating influence of environment factors in an extended community of inquiry model of e- learning. *Asia Pacific Journal of Education*, 00(00), 1–15. <https://doi.org/10.1080/02188791.2020.1758032>
- 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.
- Makhmudah, S., Suyitno, H., & Rusilowati, A. (2021). Mathematics Critical Thinking Ability Reviewing from Gender and Independent Learning Students in Stem Problem-Based Learning Assisted by Web E Learning School. *Unnes Journal of Mathematics Education Research*, 10(2), 211–219.
- Marín, S. L. T., García, F. B., & Vázquez, S. G. (2018). Behaviour & Information Technology A technological acceptance of e-learning tools used in practical and laboratory teaching , according to the European higher education area. *Behaviour & Information Technology*, 27(6), 37–41. <https://doi.org/10.1080/01449290600958965>
- Mei Ardaning Tyas, Joko Nurkamto, & Sri Marmanto. (2020). Cultivating Students ' Higher -Order Thinking Skills in Efl Classes : the Role of the Teacher and the. *International Online Journal of Education and Teaching (IOJET)*, 7(1), 267–276.
- Milner-bolotin, M., & Marotto, C. C. F. (2018). Parental engagement in children ' s STEM education . Part I: Meta-analysis of the literature. *LUMAT: International Journal on Math, Science*

- and Technology Educatio*, 4(3), 1–10.
<https://doi.org/10.31129/LUMAT.6.1.2>
92
- Mufida, S. N., Sigit, D. V., Ristanto, R. H., Education, B., Science, N., & Jakarta, U. N. (2020). Integrated project-based e-learning with science, technology, engineering, arts, and mathematics (PjBeL-STEAM): its effect on science process skills. *Biosfer: Jurnal Pendidikan Biologi*, 13(2), 183–200.
- Muhammad Syahrul KAHAR1*, Ramadoni SYAHPUTRA2, Rahmatullah Bin ARSYAD3, Nursetiawan NURSETIAWAN4, M. M. (2021). Design of Student Worksheets Oriented to Higher Order Thinking Skills (HOTS) in Physics Learning. *Eurasian Journal of Educational Research*, 96, 14–29.
<https://doi.org/10.14689/ejer.2021.96.2>
- Mujib1, Mardiyah2, S. (2020). Stem : Its Impact To Mathematics Literacy And Stem : Pengaruhnya Terhadap Literasi Matematis Dan Kecerdasan Multiple Intelligence S. *Indonesian Journal of Science and Mathematics Education*, 03(March), 66–73.
<https://doi.org/10.24042/ijisme.v3i1.544>
8
- N.MURTHY, C. S. H. (2008). Designing E-Learning Programs For Rural Social Transformation And Poverty Reduction. *Turkish Online Journal of Distance Education-TOJDE*, 9(1), 169–179.
- Nisa, L. C. (2012). Pengaruh Pembelajaran E-Learning Kuliah Statistics Mahasiswa Tadris Iain WalisongO. *Jurnal PHENOMENO*, 2(1), 7–27.
- Noor, M. E., Hardyanto, W., & Wibawanto, H. (2017). Penggunaan E-Learning dalam Pembelajaran Berbasis Proyek di SMA Negeri 1 Jepara Abstrak. *Nnovative Journal of Curriculum and Educational Technology*, 6(1), 17–26.
- Nuryatin et al. (2022). Effectiveness of Online Learning at Universities: Do Sociocultural Differences Matte. *European Journal of Educational Research*, 11(4), 2153–2166.
- Oktarina, K., Suhaimi, S., Santosa, T. A., & ... (2021). Meta-Analysis: The Effectiveness of Using Blended Learning on Multiple Intelligences and Student Character Education During the Covid-19 Period. ... *Journal of Education* ..., 4(3), 184–192.
<http://journal.ummat.ac.id/index.php/IJECA/article/view/5505%0Ahttps://journal.ummat.ac.id/index.php/IJECA/article/download/5505/pdf>
- Putranta, H., Setiyatna, H., Choiriyah, S., & Brams, W. S. (2021). The Effect of Smartphone Usage Intensity on High School Students ' Higher Order Thinking Skills in Physics Learning. *Journal of Turkish Science Education*, 18(3), 421–438.
- R R Musna1, *, D. J. 1 and A. J. (2021). A meta-analysis study of the effect of Problem- Based Learning model on students ' mathematical problem solving skills A meta-analysis study of the effect of Problem-Based Learning model on students ' mathematical problem solving skills. *Journal of Physics: Conference Series*, 1–8.
<https://doi.org/10.1088/1742-6596/1882/1/012090>
- 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., & 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, 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.
- Rintayati et al. (2021). Development of Two-Tier Multiple Choice Test to Assess Indonesian Elementary Students' Higher-Order Thinking Skills. *International Journal of Instruction*, 14(1), 555–566.
- Riyanti. (2020). Efektivitas Penggunaan Perangkat Pembelajaran Project Based Learning (PjBL) Terintegrasi STEM Berbasis E-Learning Untuk meningkatkan Kemampuan Berpikir Kreatif. *DWIJA CENDEKIA :Jurnal Riset Pedagogik*, 4(2), 206–215.
- Royan Nurochman1, D., & 1. (2022). Pengaruh Penerapan Model Pembelajaran Problem Based Learning (Pbl) Dengan Pendekatan Blended Learning Terhadap Higher Order Thinking Skill (Hots) Siswa. *Journal of Natural Science Learning*, 01(01), 61–67.
- Saleem, M., Kamarudin, S., Shoaib, H. M., & Saleem, M. (2021). Influence of augmented reality app on intention towards e-learning amidst COVID-19 pandemic. *Interactive Learning Environments*, 0(0), 1–15. <https://doi.org/10.1080/10494820.2021.1919147>
- 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>
- Santosa, T. A., Sepriyani, E. M., & Razak, A. (2021). Analisis E-Learning Dalam Pembelajaran Evolusi Mahasiswa Pendidikan Biologi Selama Pandemi Covid-19. *Jurnal Edumaspul*, 5(1), 66–70.
- Saraç, H. (2018). The Effect of Science, Technology, Engineering and Mathematics-STEM Educational Practices on Students' Learning Outcomes: A Meta-Analysis Study. *Turkish Online Journal of Educational Technology - TOJET*, 17(2), 125–142.
- Shanti, M. R. S., Istiyono, E., & Munadi, S. (2022). The effectiveness of learning to improve students' higher-order thinking skills. *Cypriot Journal of Educational Sciences*, 17(5), 1576–1587. <https://doi.org/10.18844/cjes.v17i5.7220>
- Sigit, D. V. (2022). Integration of Project-Based E-Learning with STEAM: An Innovative Solution to Learn Ecological Concept. *International Journal of Instruction*, 15(3), 23–40.
- 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).
- 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., & Satria, E. (2023). The Effectiveness of STEM-

- Based Learning in Teaching 21st 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>
- Suprpto, E., Sumiharsono, R., & Ramadhan, S. (2020). The Analysis of Instrument Quality to Measure the Students' Higher Order Thinking Skill in Physics Learning. *Journal of TURKISH SCIENCE EDUCATION*, 17(4), 520–527.
<https://doi.org/10.36681/tused.2020.42>
- 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.
- Sury, K., Wiyono, K., & Siahaan, S. M. (2020). Effectiveness of Using E-learning at STEM-based Physics Learning to Improve Communication Skills of High School Students. *Jurnal Ilmiah Pendidikan Fisika*, 6(2), 539–548.
- Syafrayadin, Eka Chandra Wardhana, D., Noermanzah, Agus, R., & Awaluddin. (2022). Students' perspective and problems in implementing higher order thinking skill (HOTS) in speaking for presentation class. *Journal of Language and Linguistic Studies*, 18(1), 477–487.
<https://doi.org/10.52462/jlls.196>
- Takiddin et al. (2020). Improving Higher Order Thinking Skills Through Project Based Learning in Primary Schools. *TARBIYA: Journal of Education in Muslim Society*, 7(1), 16–28.
- Tsaparlis, G. (2020). Higher and lower-order thinking skills: The case of chemistry revisited. *Journal of Baltic Science Education*, 19(3), 467–483.
<https://doi.org/10.33225/jbse/20.19.467>
- uparman1*, Yohannes1, N. A. (2021). Enhancing mathematical problem-solving skills of Indonesian junior high school students through problem-based learning: A systematic review and meta-analysis. *Al-Jabar: Jurnal Pendidikan Matematika*, 12(1), 1–16.
- Wardani, N. E., Kurwidaria, F., & Supriyadi, F. (2020). Higher Order Thinking Skills dalam Pembelajaran Bahasa dan Sastra Indonesia di Sekolah Menengah Pertama Kota Madiun. *Lingua Didaktika: Jurnal Bahasa Dan Pembelajaran Bahasa*, 14(1), 29.
<https://doi.org/10.24036/ld.v14i1.108330>
- Widyaningsih, S. W. (2021). The Development of the HOTS Test of Physics Based on Modern Test Theory: Question Modeling through E-learning of Moodle LMS. *International Journal of Instruction*, 14(4), 51–68.
- Wijayanto, T., Supriadi, B., & Nuraini, L. (2015). Pengaruh Model Pembelajaran Project Based Learning Dengan Pendekatan Stem. *Jurnal Pembelajaran Fisika*, 9(3), 113–120.
- Wiyono, K., Sury, K., Hidayah, R. N., & Nazhifah, N. (2022). STEM-based E-learning: Implementation and Effect on Communication and Collaboration Skills on Wave Topic. *JPPPF (Jurnal Penelitian Dan Pengembangan Pendidikan Fisika)*, 8(2), 259–270.
- Yaniawati, R. P. (2012). Pengaruh E-Learning Untuk Meningkatkan Daya Matematik Mahasiswa. *Cakrawala Pendidikan*, 31(3), 381–393.
- Yunita, Y., Juandi, D., Nurhidayah, I. J., Wibowo, F. C., Astra, I. M., Diana, N., & Sukma, Y. (2020). Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model

Assisted by Geogebra Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra. *IOP Conf. Series: Journal of Physics: Conf. Series*, 1467, 1–9.
<https://doi.org/10.1088/1742-6596/1467/1/012027>

Zeng, Z., Yao, J., Gu, H., & Przybylski, R. (2021). *Education on Students' Abilities*. 1, 1–18.
<https://doi.org/10.15354/sief.18.re005>

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>

Zulyusri¹, Desy², Tomi Apra Santosa³, S. Y. (2022). Meta-analysis The Effect of the Technological Pedagogical Content Knowledge (TPACK) Model Through Online Learning Meta-analysis The Effect of the Technological Pedagogical Content Knowledge (TPACK) Model Through Online Learning on Biology Learning Outcome. *International Journal of Progressive Sciences and Technologies (IJPSAT)* ISSN: 2509-0119., 34(2), 285–294.

