PENGARUH PENERAPAN *MULTIPLE REPRESENTATION* TERINTEGRASI *LEARNING CYCLE* TERHADAP HASIL BELAJAR DAN MOTIVASI SISWA SMA PADA MATERI SISTEM SARAF

TESIS

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Magister Pendidikan Biologi

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PROGRAM STUDI MAGISTER PENDIDIKAN BIOLOGI
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KATA PENGANTAR

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Penulis

Pengaruh Penerapan *Multiple Representation* Terintegrasi *Learning Cycle* terhadap Hasil Belajar dan Motivasi Siswa SMA pada Materi Sistem Saraf

ABSTRAK

Pembelajaran biologi di sekolah belum sepenuhnya melatih penguasaan konsep dan keterampilan representasi. Penelitian ini bertujuan untuk memperoleh informasi mengenai bagaimana pengaruh penerapan *multiple representation* terintegrasi *learning cycle* terhadap hasil belajar yang difokuskan pada penguasaan konsep dan keterampilan representasi, serta motivasi belajar siswa pada materi sistem saraf. Desain penelitian ini adalah *non-equivalent control group pre-test and post-test* dengan subjek penelitian merupakan siswa kelas XI yang terdiri dari kelompok eksperimen dengan penerapan *multiple representation* terintegrasi *learning cycle* 5E dan kontrol dengan penerapan bentuk visual terintegrasi *learning cycle* 5E. Instrumen yang digunakan untuk mengukur hasil belajar adalah soal tes penguasaan konsep dan keterampilan representasi, serta angket *self-assessment* motivasi belajar. Analisis data yang digunakan dalam penelitian meliputi uji prasyarat, uji hipotesis, besaran efek, ketuntasan KKM, dan analisis nilai rata-rata *normalized gain*. Hasil penelitian menunjukkan bahwa intervensi pembelajaran terlaksana dengan baik, teramati dari aktivitas siswa yang aktif dan keterlibatan dalam representasi visual serta sosial. Pembelajaran berkontribusi positif terhadap hasil belajar, meskipun tidak terdapat perbedaan signifikan secara statistik dengan besaran efek lemah. Penguasaan konsep eksperimen memperoleh persentase ketuntasan KKM (88,89%) sedangkan kontrol (83,33%). Keterampilan representasi eksperimen memperoleh persentase ketuntasan KKM (27,78%) sedangkan kontrol (25%) dengan peningkatan sedang di antara kedua kelompok. Sementara itu, hasil uji hipotesis motivasi belajar menunjukkan nilai signifikansi sebesar 0,038 < 0,05 yang mengindikasikan bahwa terdapat pengaruh intervensi terhadap motivasi belajar siswa, meskipun besaran efek yang diperoleh lemah. Berdasarkan hasil dari penelitian ini dapat disimpulkan bahwa terdapat pengaruh penerapan *multiple representation* terhadap hasil belajar, khususnya pada penguasaan konsep siswa dengan capaian keterampilan representasi sedang, dan motivasi belajar intrinsik siswa pada materi sistem saraf.

Kata Kunci: *Multiple Representation*, *Learning Cycle* 5E, Hasil Belajar, Motivasi Belajar, dan Materi Sistem Saraf

The Effect of Implementation Multiple Representation Integrated Learning Cycle on Learning Outcomes and Motivation of High School Students on Nervous System Material

ABSTRACT

Learning biology in school does not fully train students in mastering concepts and representation skills. This study aims to obtain information on how the implementation of multiple representation integrated learning cycle affects learning outcomes focused on mastery of concepts and representation skills, as well as student learning motivation in nervous system material. The research design was a non-equivalent control group pre-test and post-test, with the research subjects being 11^{th} grade students divided into an experimental group using the integrated multiple representation learning cycle 5E and a control group using the integrated visual form of the learning cycle 5E. The instruments used to measure learning outcomes were concept mastery and representation skill tests, as well as a self-assessment questionnaire on learning motivation. The data analysis used in this study included prerequisite tests, hypothesis testing, effect size, KKM completeness, and normalized gain mean value analysis. Results indicate that the learning intervention was implemented effectively, as evidenced by students' active participation and engagement in visual and social representations. Learning positively contributed to learning outcomes, although no statistically significant differences were observed with a weak effect size. Experimental concept mastery achieved a KKM completion rate (88.89%), while the control group (83.33%). The experimental group's representation skills achieved a KKM completion rate (27.78%), while the control group (25%), with a moderate increase between the two groups. Meanwhile, the learning motivation hypothesis test results showed a significance value $0.038 < 0.05$, indicating that there was an effect of the intervention on students' learning motivation, although the effect size obtained was weak. According to the results of this study, it can be concluded that there is an effect of the application of multiple representation on learning outcomes, particularly on students' mastery of concepts with moderate representation skills and intrinsic learning motivation on nervous system material.

Keywords: Multiple Representation, Learning Cycle 5E, Learning Outcomes, Learning Motivation, and Nervous System Material

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DAFTAR PUSTAKA

Abdullah, N., Khaldun, I., & Musman, M. (2021). The Influence of Pocketbook to Improve Student Learning Outcomes and Motivation on Electron Configuration Material. *Jurnal Penelitian Pendidikan IPA*, *7*(3), 298-304. https://doi.org/10.29303/jppipa.v7i3.647

Abdullayev, A. (2025). Conceptual Integration, Meaning, and Understanding. *International Journal of Arts and Humanities*, *13*(1), 1-4.

Adelia, D., Linda, R., & Erna, M. (2023). Development of E-module Based on Multiple Representation to Improve the Competence of Chemical Literacy and Learning Independence of Students on the Material Reaction Rate. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11101-11110. https://doi.org/10.29303/jppipa.v9i12.5541

Agung, F. P., Suyanto, S., & Aminatun, T. (2020). E-Modul Gerak Refleks Berbasis Pendekatan Kontekstual untuk Meningkatkan Pemahaman Konsep Siswa SMA. *Jurnal Pendidikan*: *Teori*, *Penelitian*, *dan Pengembangan*, *5*(3), 279-289. http://journal.um.ac.id/index.php/jptpp/

Ainsworth, S. E. (2018). Multi-Modal, Multi-Source Reading: A Multi-Representational Reader's Perspective. *Learning and Instruction*, *57*, 71-75. https://doi.org/10.1016/j.learninstruc.2018.01.014

Ajayi, K. O., Adenaike, F. A., Salomi, M. O., & Momodu, K. S. (2024). Effect of Mastery Learning Strategy on Students' Learning Outcomes in Senior Secondary School Biology in Lagos State. *Essays in Education*, *30*(1), 1-14. https://openriver.winona.edu/eie/vol30/iss1/2

Akbar, B., & Delvira, A. (2022). Hubungan Keterampilan membuat Tabel dengan Keterampilan membuat Grafik pada Siswa SMA. *Jurnal Pendidikan Glasser*, *6*(2), 202-208.

Akbar, S. (2013). *Instrumen Perangkat Pembelajaran*. Bandung: PT. Remaja Rosda Karya.

Alsalhi, N. R. I. (2020). The Representation of Multiple Intelligences in the Science Textbook and the Extent of Awareness of Science Teachers at the Intermediate Stage of this Theory. *Thinking Skills and Creativity*, *38*, 1-15. https://doi.org/10.1016/j.tsc.2020.100706

Altindis, N., Bowe, K. A., Couch, B., Bauer, C. F., & Aikens, M. L. (2024). Exploring the Role of Disciplinary Knowledge in students' Covariational Reasoning during Graphical Interpretation. *International Journal of STEM Education*, *11*(32), 1-23. https://doi.org/10.1186/s40594-024-00492-5

AM, M. A., & Istiyono, E. (2022). Multiple Representation Ability of High School Students in Physics: A Study of Modern Response Theory. *Thabiea*: *Journal of Natural Science Teaching*, *5*(1), 85-97.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A Taxonomy for Learning*, *Teaching*, & *Assessing* a *Revision of Bloom's Taxonomy of Educational Objectives a Bridged Edition*. New York: Longman, Inc.

Anderson, T. R., Schönborn, K. J., Plessis, L. d., Gupthar, A. S., & Hull, T. L. (2013). Identifiying and Developing Students' Ability to Reason with Concepts and Representations in Biology. In: Treagust, D., Tsui, CY. (eds) Multiple Representations in Biological Education. *Models and Modeling in Science Education*, *7*. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4192-8_2

Anggoro, S., Fitriati, A., Thoe, N. K., Talib, C. A., & Mareza, L. (2024). Differentiated Instruction Based on Multiple Intelligences as Promising Joyful and Meaningful Learning. *IJERE*: *International Journal of Evaluation and Research in Education*, *13*(2), 1194-1204. https://doi.org/10.11591/ijere.v13i2.24791

Arikunto, S. (2013). *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta.

Astuti, A. I. (2025). Struktur, Fungsi, dan Regulasi Sistem Saraf Otonom pada Tubuh Manusia. *Health & Medical Science*, *2*(3), 1-8. https://doi.org/10.47134/phms.v2i3.401

Avazbek, A. (2024). Thesis for a Research on Zone of Proximal Development and its Effectiveness. *Conference Kokand University*.

Avianti, R & Yonata, B. (2015). Keterampilan Proses Sains melalui Penerapan Model Pembelajaran Kooperatif Materi Asam Basa Kelas XI SMAN 8 Surabaya. *Jurnal of Chemical Education*. *4*(2), 224-231.

Bakker, A. B., & Mostert, K. (2024). Study Demands–Resources Theory: Understanding Student Well-Being in Higher Education. *Educational Psychology Review*, *36*(92), 1-29. https://doi.org/10.1007/s10648-024-09940-8

Bandhu, D., Mohan, M. M., Nittala, N. A. P., Jadhav, P., Bhadauria, A., & Saxena, K. K. (2024). Theories of Motivation: A Comprehensive Analysis of Human Behavior Drivers. *Acta Psychologica*, *244*, 1-16. https://doi.org/10.1016/j.actpsy.2024.104177

Bielik, T,M Krell, M., Zangori, L., & Assaraf, O. B. Z. (2023). Editorial: Investigating Complex Phenomena: Bridging between Systems Thinking anda Modeling in Science Education. *Frontiers in Education*, *8*, 1-5. https://doi.org/10.3389/feduc.2023.1308241

Bizimana, E., Mutangana, D., & Mwesigye, A. (2022). Enchancing Students' Attitude Towards Biology Using Concept Mapping and Cooperative Mastery Learning Instructional Strategies: Implication on Gender. *International Journal on Math*, *Science and Technology Education*, *10*(1), 242-266. https://doi.org/10.31129/LUMAT.10.1.1728

Bologna, V., Longo, F., Peressi, M., & Sorzio, P. (2022). Monitoring PCK Physics Teachers' Strategies for Math and Physics Languages Integration: The Teacher Footprint. *Journal of Physics*: *Conference Series*, *2297*(1), 1-9. https://doi.org/10.1088/1742-6596/2297/1/012034

Borba, M. C., Souto, D. L. P., Cunha, J. F. T., & Domingues, N. S. (2023). Humans-with-Media: Twenty-Five Years of a Theoretical Construct in Mathematics Education. *Springer Nature Switzerland*, 1-26.

Bosch, E., Seifried, E., & Spinath, B. (2021). What Successful Students do: Evidence-Based Learning Activities matter for Students' Performance in Higher Education beyond Prior Knowledge, Motivation, and Prior Achievement. *Learning and Individual Differences*, *91*, 1-12. https://doi.org/10.1016/j.lindif.2021.102056

BSKAP. (2025). *Badan Standar*, *Kurikulum*, *dan Asesmen Pendidikan Kementerian Pendidikan Dasar dan Menengah*.

Budianti, Y., Arrahim., & Wahyuningsih, R. (2023). Penerapan Model Pembelajaran Learning Cycle 5E terhadap Hasil Belajar IPA Siswa Sekolah Dasar. *Jurnal Elementaria Edukasi*, *6*(2), 842-855. https://doi.org/10.31949/jee.v6i2.5087

Bureau, J. S., Howard, J. L., Chong, J. X. Y., & Guay, F. (2022). Pathways to Student Motivation: A Meta-Analysis of Antecedents of Autonomous and Controlled Motivations. *Review of Educational Research*, *92*(1), 46-72. https://doi.org/10.3102/00346543211042426

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. Colorado Springs Co: BSCS, 5, 88–98. https://bscs.org/reports/the-bscs-5e-instructional-model-origins-and-effectiveness/

Cahyani, A., Listiana, I. D., & Larasati, S. P. D. (2020). Motivasi Belajar Siswa SMA pada Pembelajaran Daring di Masa Pandemi Covid-19. *IQ* (*Ilmu Al-qur'an*) *Jurnal Pendidikan Islam*, *3*(1), 123-140.

Cahyani, P., Muhlis., & Bahri, S. (2024). Pengaruh Pembelajaran Biologi Berbasis Aplikasi Canva terhadap Penguasaan Konsep Biologi. *Journal of Classroom Action Research*, *6*(4), 814-821.

Capunitan, K. B., Lirado, J. D., & Gregana, C. F. (2023). Motivational Factors in Science Learning, Learner's Satisfaction and Learning Outcomes of Pre-Service Teachers. *International Journal of Scientific and Management Research*, *6*(5), 72-115. http://doi.org/10.37502/IJSMR.2023.6504

Cents-Boonstra, M., Lichtwarck-Aschoff, A., Denessen, E., Aelterman, N., & Haerens, L. (2020). Fostering Student Engagement with Motivating Teaching: an Observation Study of Teacher and Student Behaviours. *Research Papers in Education*, *36*(6), 754-779. https://doi.org/10.1080/02671522.2020.1767184

Chand, S. P. (2022). Constructivism in Education: Exploring the Contributions of Piaget, Vygotsky, and Bruner. *International Journal of Science and Research* (*IJSR*), *12*(7), 274-278.

Cheng, M. M. W., & Gilbert, J. K. (2015). Students' Visualization of Diagrams Representing the Human Circulatory System: The Use of Spatial Isomorphism and Representational Conventions. *International Journal of Science Education*, *37*(1), 136-161.

Cindiati, M., Claudianingrum, H., Ramadhanty, J. A., Suprapto, P. K., & Diella, D. (2021). The Correlation between Critical Thinking Skills and the Learning Outcomes on Musculoskeletal System. *Bioedukasi*: *Jurnal Pendidikan Biologi*, *14*(2), 122-133. https://doi.org/10.20961/bioedukasi-uns.v14i2.49911

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Science*. London: Lawrence Erlbaum Associates, Publishers.

Conesa, P. J., Onandia-Hinchado, I., Du˜nabeitia, J. A., & Moreno, M. A. (2022). Basic Psychological Needs in the Classroom: A Literature Review in Elementary and Middle School Student. *Learning and Motivation*, *79*, 1-22. https://doi.org/10.1016/j.lmot.2022.101819

Cresswell, J. W. (2014). *Fourth Edition Research Design Qualitative*, *Quantitative*, and *Mixed Methods Approaches*. New York City: SAGE Publications, Inc.

D'Alessio, F. A., Avolio, B. E., & Charles, V. (2019). Studying the Impact of Critical Thinking on the Academic Performance of Executive MBA Students. *Thinking Skills and Creativity*, *31*, 275-283. https://doi.org/10.1016/j.tsc.2019.02.002

Daugirdiene, A., Cesnaviciene, J., & Brandisauskiene, A. (2024). Insights from the Active Use of Neuroscience Findings in Teaching and Learning. *Behaviour Science*, *14*, 1-12. https://doi.org/10.3390/bs14080639

Diani, R., Viyanti., Lengkana, D., Jalmo, T., Destiana, A., Saregar, A., & Putra, F. G. (2024). Trends, Challenges, and Opportunities of Multiple-Representation in Science Learning: A Systematic Literature Review. *Review of Science*, *Mathematics and ICT Education*, *8*(1), 29-52.

Dianningrum, M. C., & Sufian, E. K. M. (2023). Improving Students' Understanding and Representational Fluency of Kinematics Through Learning Cycle 5E with Multi Representational Approach. *Jurnal Pendidikan Sains*, *13*(1), 20-25. http://dx.doi.org/10.17977/jps.v13i12025p020

Dring, J. C. (2019). Problem-Based Learning-Experiencing and Understanding the Prominence during Medical School: Perpective. *Annals of Medicine and Surgery*, *47*, 27-28. https://doi.org/10.1016/j.amsu.2019.09.004

Edelsbrunner, P. A., Malone, S., Hofer, S. I., Küchemann, S., Kuhn, J., Schmid, R., Altmeyer, K., Brünken, R., & Lichtenberger, A. (2023). The Relation of Representational Competence and Conceptual Knowledge in Female and Male Undergraduates. *International of STEM Education*, *10*(44), 1-19. https://doi.org/10.1186/s40594-023-00435-6

Eseinkraft, A. (2003). Expanding the 5E Model. *The Science Teacher*, *70*(6), 56-59. https://4myfiles.wordpress.com/wp-content/uploads/2013/09/expanding-5e.pdf

Fakhri, N., Syarifuddin, N., Dewi, E. M. P., & Buchori, S. (2023). Learning Motivation and Student Engagement among Senior High School Students. *Jurnal Konseling Andi Matappa*, *7*(2), 73-81.

Fathonah, S., Cahyono, E., Iswari, R. S., Haryani, S., Sarwi., Lestari, N. H., & Kadarwati, S. (2023). Effects of Multirepresentation-Based Creative Problem-Solving Learning Model on Students' Critical Thinking Anddiet Nutritional Quality. *Journal of Turkish Science Education*, *20*(4), 669-694.

Fatmawati, A., Zubaidah, S., Mahanal, S., & Sutopo. (2022a). Representation Skills of Students with Different Ability Levels when Learning Using the LCMR Model. *Pegem Journal of Education and Instruction*, *13*(1), 177-192. https://doi.org/10.47750/pegegog.13.01.20

Fatmawati, A., & Jannah, H. (2022b). Penguasaan Konsep Mahasiswa pada Materi Fotosintesis: Korelasinya dengan Kemampuan Representasi pada Vertical Translations Across Level. *Bioscientist*: *Jurnal Ilmiah Biologi*, *10*(1), 193-201. https://doi.org/10.33394/bioscientist.v10i1.4967

Fatmawati, A., Zubaidah, S., Mahanal, S., Sutopo, Bilad, M. R., & Shahril, M. (2024). Students' Concept Matery in Plant Physiology Course Using Learning Cycle Multiple Representation Model. *Pegem Journal of Education and Instruction*, *14*(2), 91-102.

Favela, L. H., & Machery, E. (2023). Investigating the Concept of Representation in the Neural and Psychological Science. *Frontiers in Psychology*, *14*, 1-13. https://doi.org/10.3389/fpsyg.2023.1165622

Fenwick, L., & Unsworth, L. (2022). Including Visual Representations within Senior High School Biology Assessment: Considerations of Grammatical Complexity. *The Curriculum Journal*, *34*(3), 412-436. https://doi.org/10.1002/curj.181

Fernando, C., Osindero, S., & Banarse, D. (2024). The Origin and Function of External Representations. *Adaptive Behavior*, 1-35. https://doi.org/10.1177/10597123241262534

Fortus, D., & Touitou, I. (2021). Changes to Students' Motivation to Learn Science. *Disciplinary and Interdisciplinary Science Education Research*, *3*(1), 1-14.

Friesen, M. E., & Kuntze, S. (2020). The Role of Professional Knowledge for Teachers' Analysing of Classroom Situations Regarding the Use of Multiple Representations. *Research in Mathematics Education*, *22*(2), 1-19. https://doi.org/10.1080/14794802.2019.1710555

Fullan, M., Quinn, J., & McEachen, J. (2018). *Deep Learning Engage the World Change the World*. California: Sage Company.

Gao, Z., Zheng, L., Gouws, A., Krieger-Redwood, K., Wang, X., Varga, D., Smallwood, J., & Jefferies, E. (2023). Context Free and Context-Dependent Conceptual Representation in the Brain. *Cerebral Cortex*, *33*(1), 152-166. https://doi.org/10.1093/cercor/bhac058

Giberti, C., Santi, G., & Spagnolo, C. (2023). The role of Metaphors in Interpreting Students' difficulties in Operating with Percentages: A Mixed Method Study Based on Large Scale Assessment. *European Journal of Science and Mathematics Education*, *11*(2), 297-321. https://doi.org/10.30935/scimath/12642

Gómez-Márquez, J. (2021). What Is Life?. *Molecular Biology Reports*, *48*, 6223-6230. https://doi.org/10.1007/s11033-021-06594-5

Grau, F. G. I., Valls, C., Piqué, N., & Ruiz-Martin, H. (2021). The Long-Term Effects of Introducing the 5E Model of Instruction on Students' Conceptual Learning. *International Journal of Science Education*, *43*(9), 1441-1458. https://doi.org/10.1080/09500693.2021.1918354

Hake, R. R. (1998). Interactive-Engagement Versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics*, *66*(1), 64-74. https://doi.org/10.1119/1.18809

Hansen, J., & Richland, L. E. (2020). Teaching and Learning Science through Multiple Representations: Intuitions and Executive Functions. *CBE Life Sciences Education*, *19*(4), 1-15. https://doi.org/10.1187/cbe.19-11-0253

Harmain, R. (2021). Upaya Meningkatkan Partisipasi Siswa pada Materi Mengidentifikasi Macam-Macam Limbah Melalui Metode Diskusi. *Jurnal Pengabdian Masyarakat*: *DIKMAS*, *1*(1), 35-42. https://ejurnal.pps.ung.ac.id/index.php/dikmas/article/view/854

Hasyaty, A., Sriyati, S., & Amprasto. (2023). The Effect of Using Teacher Feedback on Concept Mastery and Students' Self-Assessment of the Essay Test on Monohybrid and Dihybrid Cross Topic. *Assimilation*: *Indonesian Journal of Biology Education*, *6*(1), 33-40.

Heinonen, A., Lehtelä, B., Hellas, A., & Fagerholm, F. (2023). Synthesizing Research on Programmers' Mental Models of Programs, Tasks and Concepts—A Systematic Literature Review. *Information and Software Technology*, *164*, 1-17. https://doi.org/10.1016/j.infsof.2023.107300

Herlinawati., Marwa., Ismail, N., Junaidi., Ledya., Liza, O., & Situmorang, D. D. B. (2024). The Integration of 21st Century Skills in the Curriculum of Education. *Heliyon*, *10*(15), 1-11. https://doi.org/10.1016/j.heliyon.2024.e35148

Hiltunen, M., Kärkkäinen, S., & Keinonen, T. (2019). Biology Student Teachers' Dialogic Talk in Inquiry Based Instruction. *Journal of Biological Education*, *54*(3), 1-16. https://doi.org/10.1080/00219266.2019.1575264

Hull, R. (2024). *The Pocket Atlas of Anatomy and Physiology A Concise Reference for Students*. United States: Human Kinetics. https://bit.ly/4jw3tTN

Husna, H., Nerita, S., & Safitri, E. (2023). Analysis of Student Difficulties in Learning Biology. *Journal of Biology Education Research*, *4*(1), 1-8. https://doi.org/10.55215/jber.v4i1.5963

Ilyas., Liu, A.N.A.M. (2020). The Effect of Based E-learning Contextual Approach on Student Learning Motivation. *Jurnal Penelitian Pendidikan IPA*, *6*(2), 184-189. https://doi.org/10.29303/jppipa.v6i2.425

Irsyad, M., Linuwih, S., & Wiyanto. (2018). Learning Cycle 7E Model-Based Multiple Representation to Reduce Misconseption of the Student on Heat Theme. *Journal of Innovative Science Education*, *7*(1), 45-52.

Jansen, T. Meyer, J., & Möller, J. (2022). Which Student and Instructional Variables Are Most Strongly Related to Academic Motivation in K-12 Education? A Systematic Review of Meta-Analyses. *Psychological Bulletin*, *148*(1-2), 1–26. https://doi.org/10.1037/bul0000354

Joswick, C., & Hulings, M. (2024). A Systematic Review of BSCS 5E Instructional Model Evidence. *International Journal of Science and Mathematics Education*, *22*, 167-188. https://doi.org/10.1007/s10763-023-10357-y

Juniadi, R. R., Imanudin, I., Umaran, U., & Subarjah, H. (2024). Perbandingan Urutan Item Tes Daya Tahan Otot Tungkai Berdasarkan Sumber Energi. *JSKK*: *Jurnal Sains Keolahragaan dan Kesehatan*, *9*(2), 190-202.

Kadarusman, I., Rahmat, A., & Priyandoko, D. (2020). The Relationship of Students' Thinking Level and the Ability to Develop Proposition Network Representation of Human Nervous System in Modeling Based Learning (MBL). *Jurnal Pendidikan IPA Indonesia*, *9*(3), 361-370. https://doi.org/10.15294/jpii.v9i3.24214

Karayaka, F., Arik, S., & Yilmaz, M. (2022). Context-Based Biology Motivations of Secondary School Students. *Science Education International*, *33*(4), 376-382. https://doi.org/10.33828/sei.v33.i4.4

Karim, S. A., Sudiro, S., & Sakinah, S. (2021). Utilizing Test Items Analysis to Examine the Level of Difficulty and Discriminating Power in a Teacher-Made Test. *EduLite*: *Journal of English*, *Literature*, *and Culture*, *6*(2), 256-269. http://dx.doi.org/10.30659/e.6.2

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and Using Multiple Models to Promote Scientific Literacy in the Context of Socio-Scientific Issues. *Science & Education*, *30*, 509-607. https://doi.org/10.1007/s11191-021-00206-1

Kim, Y. H., Kim, B. H., Kim, J., Jung, B., & Bae, S. (2023). Item Difficulty Index, Discrimination Index, and Reliability of the 26 Health Professions Licensing Examinations in 2023, Korea: A Psychometric Study. *Journal of Educational Evaluation for Health Professions*, *21*(40), 1-4. https://doi.org/10.3352/jeehp.2024.21.40

Kim, M. K., & Park, J. (2024). Linking Scientific Concepts with Students' Personal Daily Lives: Using the Metaphysical Meaning of Scientific Concepts. *Journal of Baltic Science Education*, *23*(5), 882-898. https://doi.org/10.33225/jbse/24.23.882

Koc-Januchta, M. M., Schönborn, K. J., Roeghrig, C., Chaudhri, V. K., Tibell, L. A., & Heller, H. C. (2022). Connecting Concepts Helps put Main Ideas together: Cognitive Load and Usability in Learning with an AI-enriched Textbook. *International Journal of Educational Technology in Higher Education*, *19*(1), 1-22. https://doi.org/10.1186/s41239-021-00317

Koenka, A. C. (2020). Academic Motivation Theories Revisited: An Interactive Dialog between Motivation Scholars on Recent Contributions, Underexplored Issues, and Future Directions. *Contemporary Educational Psychology*, *61*, 1-16. https://doi.org/10.1016/j.cedpsych.2019.101831

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy. *Theory into Practice*, *41*(4), 212–219. https://doi.org/10.1207/s15430421tip4104

Kustandi, C., Zianadezdha, A., Fitri, A. K., Farhan, M., & L. N. A. (2021). Pemanfaatan Media Visual dalam Tercapainya Tujuan Pembelajaran. Akademika: *Jurnal Teknologi Pendidikan*, 10(2), 291-299. https://doi.org/10.34005/akademika.v10i02.1402

Kvello, P., & Gericke, N. (2021). Identifying Knowledge Important to Teach About the Nervous System in the Context of Secondary Biology and Science Education a Delphy Study. *Plos One*, *16*(12), 1-32. https://doi.org/10.1371/journal.pone.0260752

Lagoudakis, N., Vlachos, F., Christidou, V., & Vavougios, D. (2022). The Effectiveness of a Teaching Approach Using Brain-Based Learning Elements on Students' Performance in a Biology Course. *Cogent Education*, *9*(1), 1-14. https://doi.org/10.1080/2331186X.2022.2158672

Law, K. M.Y ., Geng, S., & Li, T. (2019). Student Enrollment, Motivation and Learning Performance in a Blended Learning Environment: The Mediating Effects of Social, Teaching, and Cognitive Presence. *Computers & Education*, *136*, 1-12. https://doi.org/10.1016/j.compedu.2019.02.021

Lengkana, D., Surbakti, A., & Amalia, D. (2019). The Effect of Mind Mapping and Learning Style on Concepts Mastery and Students' Representation Skills. ICOPE: *International Conference on Progressive Education*, *422*, 110-117. https://doi.org/10.2991/assehr.k.200323.101

Lestari, D. P., Supahar., Paldi., Suwarjo., & Herianto. (2023). Effect of Science Virtual Laboratory combination with Demonstration Methods on Lower-Secondary School Students' Scientific Literacy Ability in a Science Course. *Education and Information Technologies*, *28*, 16153-16175. https://doi.org/10.1007/s10639-023-11857-8

Luzyawati, L., Hamsyah, D., & Dewi, L. N. (2020). Analisis Penalaran Ilmiah Siswa pada Penggunaan Media Analog Proses Pembentukan Urine. *Biosfer*: *Junral Biologi dan Pendidikan Biologi*, *5*(2), 10-15.

Lyman, G. H. (2023). Perception, Cognition and Thought: Part I Nature, Evolution, and Development of Conceptual, and Symbolic Processes. *Cancer Investigation*, *41*(6), 535-538. https://doi.org/10.1080/07357907.2023.2229539

MacQueeney, P., Lewis, E., Fulton, G., Surber, C., Newland, K., Hochstetler, E., & Tilak, S. (2022). *Applying Piaget to Classroom Teaching*: *Stage Development And Social Learning Theory*. Columbus, United States: The Ohio State University Libraries.

Maduratna, M., & Jayanti, U. N. A. D. (2022). Visual Representation of Biology Books on Circulatory System Material. *Bioeduscience*, *6*(2), 124-136. https://doi.org/10.22236/j.bes/629415

Manik, R. J., Silalahi, M. V. ., & Silaen, S. (2022). Pengaruh Model Learning Cycle Terhadap Hasil Belajar Siswa Pada Materi Keanekaragaman Hayati Kelas X Di SMA Negeri 1 Pematang Siantar. Tut Wuri Handayani. *Jurnal Keguruan dan Ilmu Pendidikan*, *1*(4), 188–198. https://doi.org/10.59086/jkip.v1i4.181

Maran, T., Furtner, M., Liegl, S., Ravet-Brown, T., Haraped, L., & Schse, P. (2021). Visual Attention in Real-World Conversation: Gaze Patterns Are Modulated by Communication and Group Size. *Applied Psychology*: *An International Review*, *70*(4), 1602-1627. https://doi.org/10.1111/apps.12291

Marieb, E. N., & Keller, S. M. (2022). *Essentials of Human Anatomy & Physiology 13th Edition*. United Kingdom: Pearson Educated Limited. https://bit.ly/3PRmT8d

Marzola, P., Melzer, T., Pavesi, E., Gil-Mohapel, J., & Brocardo, P. S. (2023). Exploring the Role of Neuroplasticity in Development, Aging, and Neurodegeneration. *Brain Sciences*, *13*(12), 1-32. https://doi.org/10.3390/brainsci13121610

Maulana, A. (2022). Analisis Validitas, Reliabilitas, dan Kelayakan Instrumen Penilaian Rasa Percaya Diri Siswa. *Jurnal Kualita Pendidikan*, *3*(3), 133-139. https://doi.org/10.51651/jkp.v3i3.331

Mawardani, A., Dwandaru, W. S. B., Nugroho, M. P., & Surtini. (2021). Multimedia Learning Module (MLM) with Hologram Simulation to Improve Students' Mathematical Representation Ability. *Advances in Social Science, Education and Humanities Research*, *541*, 522-527.

Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. *Educational Psychology Review*, *36*(8), 1-25. https://doi.org/10.1007/s10648-023-09842-1

Melgarejo, T. F., Atanacio, L. M. M., Leandro, A. I. C., Faustino, L. K. B., Rivarola, M. M. C., López, J. R. A., & Chavez, J. T. G. (2024). The 5E Instructional Model in the Meaningful Learning of Science and Technology. *Frontiers in Education*, *9*, 1-7. https://doi.org/10.3389/feduc.2024.1435530

Mery., Martono., Halidjah, S., & Hartoyo, A. (2022). Sinergi Peserta Didik dalam Proyek Penguatan Profil Pelajar Pancasila. *Jurnal Basicedu*, *6*(5), 7840-7849. https://doi.org/10.31004/basicedu.v6i5.3617

Meter, P. V., List, A., Lombardi, D., & Kendeou, P. (2020). *Handbook of Learning from Multiple Representations and Perspectives*. United Kingdom: Routledge.

Miarti, E., Hasnunidah, N., & Abdurrahman. (2021). The Effect of Learning Cycle 5E on Critical Thinking Skills for Junior High School Students. *Scientiae Educatia*: *Jurnal Pendidikan Sains*, *10*(2), 177-183. https://doi.org/10.24235/sc.educatia.v10i2.9127

Mubeen, S., & Reid, N. (2014). The Measurement of Motivation with Science Students. *European Journal of Educational Research*, *3*(3), 129-144.

Mukul, E., & Büyük¨ozkan, G. (2023). Digital Transformation in Education: A Systematic Review of Education 4.0. *Technological Forecasting & Social Change*, *194*, 1-21. https://doi.org/10.1016/j.techfore.2023.122664

Muliana, A., Jufri, A. W., & Bahri, S. (2024). The Effect of Learning Cycle 5E Model on the Scientific Literacy 10th of Grade Students. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6662-6668. https://doi.org/10.29303/jppipa.v10i9.8415

Mulyaningsih, U. Y., & Mubarok, I. (2022 Implementation of Multiple Representation-Based Fungi E-module on Students' Cognitive Learning Outcomes and Writing Communication Skills. *Journal of Biology Education*, *11*(3), 397-405.

Munfaridah, N., Avraamidou, L., & Goedhart, M. (2021). The Use of Multiple Representations in Undergraduate Physics Education: What Do we Know and Where Do we Go from Here?. *Eurasia Journal of Mathematics*, *Science and Technology Education*, *17*(1), 1-19. https://doi.org/10.29333/ejmste/9577

Murni, H. P., Azhar, M., Ellizar., Nizar, U. K., & Guspatni. (2022). Three Levels of Chemical Representation-Integrated and Structured Inquiry-Based Reaction Rate Module: ItsEffect onStudents' Mental Models. *Journal of Turkish Science Education*, *19*(3), 758-772.

Mustamiah, D., & Widanti, N. S. (2020). Learning Motivation as Predictor of Student Engagement in Private Junior High Schools Students. *In Proceedings of the 3rd International Conference on Psychology in Health, Educational, Social, and Organizational Settings-Improving Mental Health and Harmony in Global Community*, 486-493.

Napitulu, G., Silalahi, M., & Gultom, S. (2023). Implementasi Manajemen Kurikulum Merdeka Belajar dalam Peningkatan Mutu Pendidikan di SMA Negeri 1 Bandar. *Jurnal on Education*, *6*(1), 5397-5406.

Narca, M. L. G., & Caballes, D. G. (2021). Learning Motivation: Strategies to Increase Students' Engagement in Online Learning at San Sebastian College-Recoletos, Manila. *International Journal of Asian Education*, *2*(4), 573-580. https://doi.org/10.46966/ijae.v2i4.217

Natalia, D., Johari, A., Anggereini, E., & Lestari, I. (2023). Study of Multiple Representation Learning in Improving Pre-Service Biology Teacher's Representation Ability. ASSEHR: *Advances in Social Science*, *Education*, *and Humanities Research*, *72*, 273-274.

Nedjat-Haiem, M., & Cooke, J. E. (2021). Student Strategies when Taking Open-Ended Test Questions. *Cogent Education*, *8*(1), 1-22. https://doi.org/10.1080/2331186X.2021.1877905

Nuraysha, A. D., Winarno, N., Fadly, W., Hakim, L., & Emiliannur. (2024). Analyzing Student's Motivation Towards Science Learning in Junior High School. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 4138-4148. https://doi.org/10.29303/jppipa.v10i7.7297

Nurfadillah, W., Saptono, A., & Lestari, F. D. (2024). Analisis Implementasi Kurikulum Merdeka Belajar dalam Meningkatkan Keterampilan Abad-21 pada SMA Negeri 36 Jakarta. *Journal of Higher Education and Academic Advancement*, *1*(7), 25-30. https://doi.org/10.61796/ejheaa.v1i7.719

Ogegbo, A. A., & Ramnarain, U. (2024). A Systematic Review of Pedagogical Practices for Integrating Indigenous Knowledge Systems in Science Teaching. *African Journal of Research in Mathematics*, *Science and Technology Education*, 1-20. https://doi.org/10.1080/18117295.2024.2374133

Ong, E. T., Govindasamy, D., Singh, C. K. S., Ibrahim, M. N., Wahab, N. A., Borhan, M. T., & Tho, S. W. (2021). The 5E Inquiry Learning Model: Its Effect on the Learning of Electriciry among Malaysian Students. *Cakrawala Pendidikan Jurnal Ilmiah Pendidikan*, *40*(1), 170-182. https://doi.org/10.21831/cp.v40i1.33415

Orina, J. O., Kiumi, J. K., & Githae, P. K. (2022). Determinants of Teachers' Motivation and Professiona Development in Public Secondary Schools in Kenya. *International Journal of Educational Administration and Policy Studies*, *14*(1), 45-52. https://doi.org/10.5897/IJEAPS2021.0702

Patriot, E. A. (2019). Kemampuan Multirepresentasi Siswa Pada Materi Usaha dan Energi melalui Penerapan Pembelajaran Konseptual Interaktif. *Jurnal Inovasi dan Pembelajran Fisika*, *6*(2), 152-158.

Permendikbudristek. (2022). *Standar Penilaian Pendidikan pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah*.

Peters, B., & Kriegeskorte, N. (2021). Capturing the Objects of Vision with Neural Networks. *Nature Human Behaviour*, *5*(9), 1-25. https://doi.org/10.1038/s41562-021-01194-6

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and Self-Regulated Learning Components of Classroom Academic Performance. *Journal of Educational Psychology*, *82*(1), 33-40. https://psycnet.apa.org/doi/10.1037/0022-0663.82.1.33

Prasad, N. R. (2020). Preception and Reality. *Spinger Nature Switzerland Statistical and Fuzzy Approaches to Data Processing, with Applications to Econometrics and Other Areas, Studies in Computational Intelligence*, *892*, 193-218. https://doi.org/10.1007/978-3-030-45619-1_15

Polanin, J. R., Austin, M., Taylor, J. A., Steingut, R. R., Rodgers, M. A., & Williams, R. (2024). Effects of the 5E Instructional Model: A Systematic Review and Meta-Analysis. AERA: *Article* , *10*(1), 1-16. https://doi.org/10.1177/23328584241269866

Polman, J., Hornstra, L., & Volman, M. (2021). The Meaning of Meaningful Learning in Mathematics in Upper-Primary Education. *Learning Environments Research*, *24*, 469-486. https://doi.org/10.1007/s10984-020-09337-8

Rachmaningsih, F., & Purnomo, T. (2024). Validitas dan Keefektifan Video Pembelajaran Materi Ekosistem Menggunakan Powtoon untuk Meningkatkan Hasil Belajar Siswa Kelas X SMA. *Bioedu*: *Berkala Ilmiah Pendidikan Biologi*, *13*(2), 392-404.

Rachmawati, N., Marini, A., Nafiah, M., & Nurasiah, I. (2022). Projek Penguatan Profil Pancasila dalam Implementasi Kurikulum Prototipe di Sekolah Penggerak Sekolah Dasar. *Jurnal Basicedu*, *6*(3), 3613-3625.

Rachmawati, V. Y., Budiyanto, M., & Susiyawati, E. (2021). Penerapan Self-Assessment dalam Pembelajaran Daring untuk Meningkatkan Kemampuan Self-Regulation Siswa SMPN 1 Gresik. *Pensa E-Jurnal*: *Pendidikan Sains*, *9*(3), 414-421.

Rahmi, N., Sumarmin, R., Ahda, Y., Alberida, H., & Razak, A. (2021). Relationship between Learning Motivation and Biology Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 537-541. https://doi.org/10.29303/jppipa.v7i4.773

Rangkuti, S. D. H., Armadani., Ketaren, E. B., Siregar, L., & Novita, R. (2021). Meningkatkan Kemampuan Berpikir Tingkat Tinggi (HOTS) dengan Penerapan Model 5E Learning Cycle pada Kelas XI IPA SMA Negeri 2 Bagan Sinembah T.P 2020/2021. *Journal of Natural Science*, *2*(2), 44-52. https://doi.org/10.34007/jonas.v2i2.98

Resmol, K., & Leasa, M. (2022). The Effect of Learning Cycle 5E+Powtoon on Students' Motivation: The Concept of Animal Metamorphosis. *Jurnal Pendidikan Biologi Indonesia*, *8*(2), 121-128.

Rizki, D., Yusrizal., Halim, A., & Sykri, M. (2023). Application of the 5E Learning Cycle Learning Model Increase Student Learning Motivation in Sound Wave Material. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 412-416.

Rosanti, D. F., Diantoro, M., Kusairi, S., & Yulianti, E. (2023). The Influence of the 5E Learning Cycle Strategy with a Link Map on Students' Mastery of Physics Concepts and Science Process Skills. *Jurnal Pendidikan Sains*, *11*(1), 27-34. http://dx.doi.org/10.17977/jps.v11i12023p027

Ruiz-Martin, H., & Bybee, R. W. (2022). The Cognitive Principles of Learning underlying the 5E Model of Instruction. *International Journal of STEM Education*, *9*(21), 1-9. https://doi.org/10.1186/s40594-022-00337-z

Ryan, R. M., & Deci, E. L. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist Association*, *55*(1), 68-78. https://selfdeterminationtheory.org/SDT/documents/2000_RyanDeci_SDT.pdf

Sabouripour, F., Roslan, S., Ghiami, Z., & Memon, M. A. (2021). Mediating Role of Self-Efficacy in Relationship between Optimism, Psychological Well-Being, and Resilience among Iranian Students. *Frontiers in Psychology*, *12*, 1-11. https://doi.org/10.3389/fpsyg.2021.675645

Sahiti, Q., & Stamp, J. A. (2022). The Use of Visuals in Undergraduate Neuroscience Education: Recommendations for Educators. *Teaching of Psychology*, *49*(1), 276-283. https://psycnet.apa.org/doi/10.1177/00986283211000326

Saïd, M., & Belarbi, M. A. (2022). Large Scale Multimedia Management: Recent Challenges. *Information*, 13(28), 1-4. https://doi.org/10.3390/info13010028

Salar, R., & Turgut, U. (2021). Effect of Differentiated Instruction and 5E Learning Cycle on Academic Achievement and Self-efficacy of Students in Physics Lesson. *Science Education Internation*, *32*(1), 4-13. https://doi.org/10.33828/sei.v32.i1.1

Saleem, S., Dhuey, E., White, L., & Perlman, M. (2024). Understanding 21st Century Skills needed in Response to Industry 4.0: Exploring Scholary Insight Using Bibliometric Analysis. *Telematics and Informatics Reports*, *13*, 1-12. https://doi.org/10.1016/j.teler.2024.100124

Sali, S., & Aydin, M. (2023). The Effects of a Story-Telling approach on Sixth-Grade Pupils' Values, Attitudes and Motivation with Regard to Studies of the Human Nervous System. *Journal of Turkish Science Education*, *20*(3), 369-378. https://doi.org/10.36681/tused.2023.021

Santoso., S. (2014). *Panduan Lengkap SPSS versi 20 edisi Revisi*. Jakarta: Elex Media Komputindo.

Saputri, H. A., Zulhijrah., Larasati, N. J., & Shaleh. (2023). Analisis Instrumen Assesmen: Validitas, Reliabilitas, Tingkat Kesukaran, dan Daya Beda Butir Soal. *Didaktik*: *Jurnal Ilmiah PGSD FKIP Universitas Mandiri*, *9*(5), 2986-2995.

Sari, E., Suryawati, E., & Mahadi, I. (2024). Diagnostic Assessment to Identify Learning Styles and Critical Thinking in Independent Learning. *JPBI*: *Jurnal Pendidikan Biologi Indonesia*, *10*(3), 860-873.

Scherrer, V., & Preckel, F. (2019). Development of Motivational Variables and Self-Esteem during the School Career: A Meta-Analysis of Longitudinal Studies. *Review of Educational Research*, *89*(2), 211-258. https://doi.org/10.3102/0034654318819127

Schönborn, K. J., & Anderson, T. R. (2009). A Model of Factors Determining Students' Ability to Interpret External Representation in Biochemistry. *International Journal of Science Education*, *31*(2), 193-232.

Sethi, J., & Scales, P. C. (2020). Developmental Relationships and School Success: How Teachers, Parents, and Friends Affect Educational Outcomes and What Actions Students Say Matter most. *Contemporary Educational Psychology*, *63*, 1-18. https://doi.org/10.1016/j.cedpsych.2020.101904

Sholahudin, N. P., Sudarmin, S., Nabilah, S., Lestari, A. N., Winarno, N., & Hamdiyati, Y. (2024). Exploring the Correlation between Motivation and Self-Regulation in Science Learning among Junior High School Students: A Case Study. *Unnes Science Education Journal*, *13*(1), 20-32.

Siahaan, K. W. A., Lumbangaol, S. T. P., Marbun, J., Nainggolan, A. D., Ritonga, J. M., & Barus, D. P. (2021). Pengaruh Model Pembelajaran Inkuiri Terbimbing dengan Multi Representasi terhadap Keterampilan Proses Sains dan Penguasaan Konsep IPA. *Jurnal Basicedu*, *5*(1), 195–205. https://doi.org/10.31004/basicedu.v5i1.614

Sidiq, Y., Ishartono, N., Desstyn, A., Prayitno, H. J., Anif, S., & Hidayat, M. I. (2021). Improving Elementary School Students' Critical Thinking Skill in Science Through Hots-Based Science Quenstions: A Quasi-Experimental Study. *Jurnal Pendidikan IPA Indonesia*, *10*(3), 378-386.

Singh, J. (2024). Exploring the Impact of the Human Nervous System on Creative Problem-Solving Skills and Learning Outcomes in Students. *International Journal of Novel Research and Development*, *9*(3), 317-328. https://ijnrd.org/papers/IJNRD2403243.pdf

Slavova, V., & Soschen, A. (2015). On Mental Representations: Language Structure and Meaning Revised. *International Journal of Information Theories & Applications*, *22*(4), 314-325.

Sopiansyah, D., Masruroh, S., Zaqiah, Q. Y., & Erihadiana, M. (2022). Konsep dan Implementasi Kurikulum MBKM (Merdeka Belajar Kampus Merdeka). *Religion Education Social Laa Roiba Journal*, *4*(1), 34-41. https://doi.org/10.47467/reslaj.v4i1.458

Sugiyono. (2016). *Metode Penelitian Kuantitatif*, *Kualitatif*, *dan R&D*. Bandung: Alfabeta.

Sugiyono. (2022). *Metode Penelitian Kuantitatif*, *Kualitatif*, *dan R&D*. Bandung: Alfabeta.

Sukmayadi, V., & Yahya, A. H. (2020). Indonesian Education Landscape and the 21st Century Challenges. *Indonesian of Social Studies Education Research*, *11*(4), 219-234.

Sumarni, W., Sudarmin., Sumarti, S. S., & Kadarwati, S. (2021). Indigenous Knowledge of Indonesian Traditional Medicines in Science Teaching and Learning Using a Science–Technology–Engineering–Mathematics (STEM) Approach. *Cultural Studies of Science Education, 17*, 467-510. https://doi.org/10.1007/s11422-021-10067-3

Supervia, P. U., Bordás, C. S., & Robres, A. Q. (2022). The Mediating Role of Sefl-Esteem in the Relationship between Resilience and Satisfaction with Life in Adolescent Students. *Psychology Research and Behavior Management*, 15, 1121-1129. https://doi.org/10.2147/PRBM.S361206

Syahri, W., Yusnaidar., Epinur., Muhaimin., & Habibi, A. (2021). Effectiveness of Multimedia Based on Multiple Representation of Hess' Law: Concept and Skills of Pre-service Science Teachers. *International Journal of Instruction*, *14*(3), 451-462. https://doi.org/10.29333/iji.2021.14326a

Syarifudin, A. (2023). Pengaruh Penggunaan Media Pembelajaran Berbasis Visual terhadap Prestasi Belajar Mata Pelajaran Aqidah Akhlak Siswa di MIN Kapuas Hulu. *Al Qalam*: *Jurnal Ilmiah Keagamaan dan Kemasyarakatan*, *17*(2), 1108-1119. https://jurnal.stiq-amuntai.ac.id/index.php/al-qalam

Takda, A., Jadmiko, B., & Erman. (2022). Development of INoSIT (Integration Nature of Science in Inquiry with Technology) Learning Models to Improve Science Literacy: A Preliminary studies. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 18-31.

Tanti., Maison., Syefrinando, B., Daryanto, M., & Salma. (2020). Students' Self-Regulation and Motivation in Learning Science. *International Journal of Evaluation and Research in Education*, *9*(4), 865-873. http://doi.org/10.11591/ijere.v9i4.20657

Tedre, M., Toivonen, T., Kahila, J., Vartiainen, H., Valtonen, T., Jormanainen, I., & Pears, A. (2021). Teaching Machine Learning in K12 Classroom: Pedagogical and Technological Trajectories for Artificial Intelligence Education. *IEEE Access*, *9*, 110558-110572.

Tegegne, T. A., & Kelkay, A. D. (2023). Comparative Study of Using 5E Learning Cycle and the Traditional Teaching Method in Chemistry to Improve Student Understanding of Water Concept: The Case of Primary School. *Cogent Education*, *10*, 1-17. https://doi.org/10.1080/2331186X.2023.2199634

Tuan, H. L., Chin, C. C., & Shieh, S. H. (2005). The Development of a Questionnaire to Measure Students' Motivation towards Science Learning. *International Journal of Science Education*, *27*(6), 639-654. https://doi.org/10.1080/0950069042000323737

Treagust, D. F., & Tsui, C. Y. (2013). *Multiple Representations in Biological Education*. *Springer*. https://doi.org/10.1007/978-94-007-4192-8

Truman, A., & Kutas, M. (2024). Flexible Conceptual Representations. *Cognitive Science*, *48*(6), 1-34. https://doi.org/10.1111/cogs.13475

Uno, W. A., & Bidi, U. (2025). Desain Pembelajaran Interaktif Berbasis Multimedia: Studi Pengembangan pada Mata Kuliah Inovasi Pendidikan. *Jutech*: *Journal Education and Technology*, *6*(1), 255-264.

Urhahne, D., & Wijnia, L. (2023). Theories of Motivation in Education: An Integrative Framework. *Educational Psychology Review*, *35*(45), 1-35. https://doi.org/10.1007/s10648-023-09767-9

Urry, L.A., Cain, M., Wasserman, S., Minorsky, P., & Reece, J. (2021). *Campbell Biology*. London: Pearson Education.

Usman., Lestari, I. D., Rahmah, R. A., Handayani, P., Yuliasari., Lukmansyah, U., Aliyah, H. S., Hartati, T., & Widiya, Y. (2022). Proses Pembelajaran Biologi dalam Pelaksanaan Kurikulum Merdeka di SMAN 7 Tangerang. *Jurnal Inovasi Pendidikan dan Sains*, *3*(2), 56-60.

Utami, R. K., & Subiantoro, A. W. (2020). Visual Representations Analysis of Senior High School Biology Textbooks About Plants' Structure and Function. *Proceedings of the 7th International Conference on Research*, *Implementation*, *and Education of Mathematics and Sciences*, *Advances in Social Science, Education and Humanities Research*, *528*, 123-128.

Van Vu, T., Magis-Weinberg, L., Jansen, B. R. J., van Atteveldt, N., Janssen, T. W. P., Lee, N. C., van der Maas, H. L. J., Rajimakers, M. E. J., Sachisthal, M. S. M., & Meeter, M. (2022). Motivation-Achievement Cycles in Learning: a Literature Review and Research Agenda. *Educational Psychology Review*, *34*, 39-71. https://doi.org/10.1007/s10648-021-09616-7

Vhalery, R., Setyastanto, A. M., & Leksono, A. W. (2022). Kurikulum Merdeka Belajar Kampus Merdeka: sebuah Kajian Literatur. *Research and Development Journal of Education*, *8*(1), 185-201. http://dx.doi.org/10.30998/rdje.v8i1.11718

Varoglu, L., Yilmaz, A., & Sen, S. (2023). Effect of 5E Learning Cycle Assisted with Concept Maps on Conceptual Understanding. *Pedagogical Research*, *8*(3), 1-12. https://doi.org/10.29333/pr/13167

Vo, T. T. D., Tuliao, K. V., & Chen, C. W. (2022). Work Motivation: The Roles of Individual Needs and Social Conditions. *Behavioral Sciences*, *12*(2), 1-19. https://doi.org/10.3390/bs12020049

Weng, X., Chiu, T. K. F., & Tsang, C. C. (2022). Promoting Student Creativity and Entrepreneurship through Real-World Problem-Based Maker Education. *Thinking Skills and Creativity*, *45*, 1-16. https://doi.org/10.1016/j.tsc.2022.101046

Widodo, A. (2021). *Pembelajaran Ilmu Pengetahuan Alam Dasar-Dasar untuk Praktik*. Bandung: UPI Press.

Winggi, K. U. (2022). Penerapan Siklus Belajar 5E dengan Media PowerPoint untuk Meningkatkan Aktivitas Belajar dan Hasil Belajar Siswa. *Diajar*: *Jurnal Pendidikan dan Pembelajaran*, *1*(1), 22-30. https://doi.org/10.54259/diajar.v1i1.161

Zanolie, K., Ma, L., Bos, M. G. N., Schreuders, E., Vandenbroucke, A. R. E., Hoom, J. V., van Duijvencoorde, A. C. K., Wierenga, L., Crone, E. A., & Güro˘glu, B. (2022). Understanding the Dynamics of the Developing Adolescent Brain Through Team Science. *Frontiers in Integrative Neuroscience*, *16*, 1-8. https://doi.org/10.3389/fnint.2022.827097

Zhang, W., Li, H., Li, Y., Liu, H., Chen, Y., & Ding, X. (2021). Application of Deep Learning Algorithms in Geotechnical Engineering: a Short Critical Review. *Artificial Intelligence Review, 54*, 5633-5673. https://www.scimagojr.com/journalsearch.php?q=24141&tip=sid&clean=0

Zhou, J., Cui, G., Hu, S., Zhang, Z., Yang, C., Liu, Z., Wang, L., li, C., & Sun, M. (2017). Graph Neural Networks: A Review of Methods and Applications. *AI Open*, 57-81. https://doi.org/10.1016/j.aiopen.2021.01.001

Zubaidah, S., Corebima, A. D., Mahanal, S., & Mistianah. (2018). Revealing the Relationship between Reading Interest and Critical Thinking Skills through Remap GI and Remap Jigsaw. *International Journal of Instruction*, *11*(2), 41–56. https://doi.org/10.12973/iji.2018.1124a