

DAFTAR PUSTAKA

- Aidoo, B. (2024). A reflective study on adopting inquiry-based science teaching methods. *Disciplinary and Interdisciplinary Science Education Research*, 6(29). <https://doi.org/10.1186/s43031-024-00119-3>
- Albati, Jukwati, & Lepa, A. A. (2022). Solubility and solubility product phenomena: Papua senior high school students mental model. *Journal of Turkish Science Education*, 19(2), 481-495. <https://doi.org/10.36681/v23i1>
- AlGerafi, M. A., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), 3953. <https://doi.org/10.3390/electronics12183953>
- Almanasreh, E., Moles, R., & Chen, T. F. (2019). Evaluation of methods used for estimating content validity. *Research in Social and Administrative Pharmacy*, 15(2), 214-221. <https://doi.org/10.1016/j.sapharm.2018.03.066>
- Araiza-Alba, P., Keane, T., Chen, W. S., & Kaufman, J. (2021). Immersive virtual reality as a tool to learn problem-solving skills. *Computers & Education*, 164, 104121. <https://doi.org/10.1016/j.compedu.2020.104121>
- Artigue, M., & Blomhøj, M. (2013). Conceptualizing inquiry-based education in mathematics. *ZDM- Mathematics Education*, 45, 797-810. <https://doi.org/10.1007/s11858-013-0506-6>
- Ary, D., Jacobs, L. C., Sorensen, C., & Razavieh, A. (2010). *Introduction to research in education* 8th edition. Cengage Learning.
- Aydoğan, Y., & Ömeroğlu, E. (2003). Acquisition of general problem solving skills in early childhood period. *OMEF-2003 World Council Meeting and Conference Declaration Book 2* (pp. 458-468). OMEP.
- Bamodu, O., & Ye, X. (2013). Virtual reality and virtual reality system components. *Advanced Materials Research*, 765-767, 1169-1172. <https://doi.org/10.4028/www.scientific.net/AMR.765-767.1169>
- Begam, A. A. (2018). Psychomotor domain of Bloom's taxonomy in teacher education. *Shanlax International Journal of Education*, 6(3), 11-14. <https://doi.org/10.5281/zenodo.1299766>
- Bhardwaj, V., Zhang, S., Tan, Y., & Pandey, V. (2025). Redefining learning: student-centered strategies for academic and personal growth. *Frontiers in Education*, 10, 1518602. <https://doi.org/10.3389/feduc.2025.1518602>

- Bruder, R., & Prescott, A. (2013). Research evidence on the benefits of IBL. *ZDM-Mathematics Education*, 45, 811-822. <https://doi.org/10.1007/s11858-013-0542-2>
- Cao, S., Chu, J., Zhang, Z., & Liu, L. (2024). The effectiveness of VR environment on primary and secondary school students' learning performance in science. *Interactive Learning Environments*, 32(10), 7321–7337. <https://doi.org/10.1080/10494820.2024.2312921>
- Chan, P., Gerven, T., Dubois, J.L., & Bernaerts, K. (2021). Virtual chemical laboratories: A systematic literature review of research, technologies and instructional design. *Computers and Education*, 2, 100053. <https://doi.org/10.1016/j.caeo.2021.100053>
- Chance, E. (2025). The combined impact of AI and VR on interdisciplinary learning and patient safety in healthcare education: A narrative review. *BMC Med Educ*, 25, 1039. <https://doi.org/10.1186/s12909-025-07589-7>
- Chasokela, D. (2025). Investigating the role of virtual reality to support student' engagement, spatial awareness and problem-solving skills in engineering education. *International Journal of Instruction*, 18(3), 613-636. <https://doi.org/10.29333/iji.2025.18332a>
- Chen, F., & Chen, G. (2025). Technology-enhanced collaborative inquiry in K–12 classrooms: A systematic review of empirical studies. *Science & Education*, 34, 1731-1773. <https://doi.org/10.1007/s11191-024-00538-8>
- Chen, K.F., Hwang, G.J., & Chen, M.R. A. (2025). Precision diagnosis in virtual learning contexts: A predict-observe-explain-diagnose-based approach to scientific inquiry. *Education Tech Research Dev*, 73, 3569–3596. <https://doi.org/10.1007/s11423-025-10527-5>
- Chen, M., She, H., & Tsai, P. (2024). The effects of online simulation-based collaborative problem-solving on students' problem-solving, communication and collaboration attitudes. *Education and Information Technology*, 29, 19141-19162. <https://doi.org/10.1007/s10639-024-12609-y>
- Chen, S.-J., Chen, C.-Q., & Shan, X.-F. (2024). The effects of an immersive virtual-reality-based 3D modeling approach on the creativity and problem-solving tendency of elementary school students. *Sustainability*, 16(10), 4092. <https://doi.org/10.3390/su16104092>
- Chen, Y., Wilson, K., & Lin, H. (2019). Identifying the challenging characteristics of systems thinking encountered by undergraduate students in chemistry problem-solving of gas laws. *Chem. Educ. Res. Pract.*, 20(3), 594-605. <https://doi.org/10.1039/C9RP00070D>

- Chiang, CH., Huang, CM., Sheu, JJ., Liao, JY., Hsu, HP., Wang, SW., & Guo, JL. (2021). Examining the effectiveness of 3D virtual reality training on problem-solving, self-efficacy, and teamwork among inexperienced volunteers helping with drug use prevention: Randomized controlled trial. *J Med Internet Res*, 23(11), e29862. <https://doi.org/10.2196/29862>
- Cipresso, P., Giglioli, I. A., Raya, M. A., & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Front. Psychol.*, 9, 2086. <https://doi.org/10.3389/fpsyg.2018.02086>
- Cirneanu, A.-L., & Moldoveanu, C.-E. (2024). Use of digital technology in integrated mathematics education. *Appl. Syst. Innov*, 7, 66. <https://doi.org/10.3390/asi7040066>
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education (8th ed.)*. Routledge.
- Conrad, M., Kabitz, D., & Schumann, S. (2024). Learning effectiveness of immersive virtual reality in education and training: A systematic review of findings. *Computers & Education: X Reality*, 4, 100053. <https://doi.org/10.1016/j.cexr.2024.100053>
- Corder, G. W., & Foreman, D. I. (2014). *Nonparametric Statistics (2nd ed.)*. John Wiley & Sons.
- Council, N. R. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. The National Academies Press. <https://doi.org/10.17226/9596>
- Creane, S., Crotty, Y., & Farren, M. (2015). A proposed use of virtual and augmented reality for supporting inquiry based learning. *2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCTL)* (pp. 393–395). IEEE. <https://doi.org/10.1109/IMCTL.2015.7359628>
- Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.)*. Pearson.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.)*. Sage.
- da Silva Soares, R. J., Ramirez-Chavez, K., Tufanoglu, A., Barreto, C., Sato, J., & Ayaz, H. (2024). Cognitive effort during visuospatial problem solving in physical real world, on computer screen, and in virtual reality. *Sensors*, 24(3), 977. <https://doi.org/10.3390/s24030977>
- Dewey, J. (1966). *Democracy and education*. The Free Press (Original work published 1916).

- D'zurilla, T. J., & Nezu, A. M. (1990). Development and preliminary evaluation of the social problem-solving inventory. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, 2(2), 156-163. <https://psycnet.apa.org/doi/10.1037/1040-3590.2.2.156>
- Ebenezer, J., & Erickson, G. (1996). Chemistry students' conceptions of solubility: A phenomenography. *Science Education*, 80(2), 181-201. [https://doi.org/10.1002/\(SICI\)1098-237X\(199604\)80:2%3C181::AID-SCE4%3E3.0.CO;2-C](https://doi.org/10.1002/(SICI)1098-237X(199604)80:2%3C181::AID-SCE4%3E3.0.CO;2-C)
- Elaish, M. M., Yadegaridehkordi, E., & Ho, Y.-S. (2025). Publication performance and trends in virtual reality research in education fields: A bibliometric analysis. *Multimedia Tools and Applications*, 84, 6999–7026. <https://doi.org/10.1007/s11042-024-19238-0>
- Engeln, K., Euler, M., & Maass, K. (2013). Inquiry-based learning in mathematics and science: A comparative baseline study of teachers' beliefs and practices across 12 European countries. *ZDM-Mathematics in Education*, 45, 65-75. <https://doi.org/10.1007/s11858-013-0507-5>
- Expo'sito-Ruiz, M., Pe'rez-Vicente, S., & Rivas-Ruiz, F. (2010). Statistical inference: Hypothesis testing. *Allergologia et Immunopathologia*, 38(5), 266-277. <https://doi.org/10.1016/j.aller.2010.06.003>
- Far, S. S., Marzaleh, M. A., Soltani, R., & Golab, F. G. (2026). Applications and challenges of virtual reality in medical sciences education: A systematic review. *Journal of Advances in Medical Education & Professionalism*, 14(1), 21-31. <https://doi.org/10.30476/jamp.2025.104655.2076>
- Faul, F., Erdfelder, E., & Lang, A. G. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175-191. <https://doi.org/10.3758/BF03193146>
- Gabr, M. A., Sleem, W., & El-wkeel, N. S. (2025). Effect of virtual reality educational program on critical thinking disposition among nursing students in Egypt: A quasi-experimental pretest–posttest design. *BMC Nursing*, 24(874), 874. <https://doi.org/10.1186/s12912-025-03488-w>
- Gkitzia, V., Salta, K., & Tzougraki, C. (2020). Students' competence in translating between different types of chemical representations. *Chem. Educ. Res. Pract.*, 21, 874. <https://doi.org/10.1039/C8RP00301G>
- Guan, J., Zhang, M., Li, X., Chen, Q., & Hwang, G. (2025). Effects of a VR-based blended approach on tourist geographic literacy, satisfaction, and problem-solving in geography field trips. *Interactive Learning Environments*, 1-20. <https://doi.org/10.1080/10494820.2025.2570491>

- Gürsoy, A. (2006). *Education programs and teaching*. Ankara: University Bookstore.
- Hamash, M., & Tiernan, P. (2024). Trends in virtual reality research for post-primary education (2013-2024). *2024 IEEE 13th international conference on engineering* (pp. 1-6). <https://doi.org/10.1109/ICEED62316.2024.10923821>
- Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Computers in Education*, 8(1), 1-32. <https://doi.org/10.1007/s40692-020-00169-2>
- Han, X., Luo, H., Wang, Z., & Zhang, D. (2025). Using virtual reality for teacher education: A systematic review and meta-analysis of literature from 2014 to 2024. *Front. Virtual Real.*, 6, 1620905. <https://doi.org/10.3389/frvir.2025.1620905>
- Hanine, H., Farajy, N., & Moumen, A. (2025). Virtual laboratories in STEM education: A scoping literature review on e-learning innovation. *Engineering Proceedings*, 112(1), 17. <https://doi.org/10.3390/engproc2025112017>
- Hanusz, Z., & Tarasinska, J. (2015). Normalization of the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality. *Biometrical Letters*, 52(2), 85-93. <https://doi.org/10.1515/bile-2015-0008>
- Hmelo-Silver, C. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, 16, 235-266. <https://doi.org/10.1023/B:EDPR.0000034022.16470.f3>
- Huang, H.-M., & Liaw, S.-S. (2018). An analysis of learners' intentions toward virtual reality learning based on constructivist and technology acceptance approaches. *The International Review of Research in Open and Distributed Learning*, 19(1), 91-115. <https://doi.org/10.19173/irrodl.v19i1.2503>
- Huang, H.-M., Rauch, U., & Liaw, S.-S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education*, 55(3), 1171-1182. <https://doi.org/10.1016/j.compedu.2010.05.014>
- Huang, Y.-M., Wang, W.-S., Lee, H.-Y., Lin, C.-J., & Wu, T.-T. (2024). Empowering virtual reality with feedback and reflection in hands-on learning: Effect of learning engagement and higher-order thinking. *Journal of Computer Assisted Learning*, 40(4), 1413-1427. <https://doi.org/10.1111/jcal.12959>

- Hu-Au, E. (2024). Learning abstract chemistry concepts with virtual reality: An experimental study using a VR chemistry lab and molecule simulation. *Electronics*, 13(16), 3197. <https://doi.org/10.3390/electronics13163197>
- Hu-Au, E., & Okita, S. (2021). Exploring differences in student learning and behavior between real-life and virtual reality chemistry laboratories. *J Sci Educ Technol*, 30, 862–876. <https://doi.org/10.1007/s10956-021-09925-0>
- Irwanto, Lintangnicita, T., Cahyana, U., & Cha, J. (2025). Examining the effect of immersive virtual reality on 11th-grade students' creative thinking disposition and academic achievement. *Discover Education*, 4, 438. <https://doi.org/10.1007/s44217-025-00880-1>
- Jiang, H., Zhu, D., Chugh, R., Turnbull, D., & Jin, W. (2025). Virtual reality and augmented reality-supported K-12 STEM learning: Trends, advantages and challenges. *Educ Inf Technol*, 30, 12827–12863. <https://doi.org/10.1007/s10639-024-13210-z>
- Johnstone, A. H. (1982). Macro- and micro-chemistry. *School Science Review*, 64, 377–379.
- Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology, Research and Development*, 45(1), 65-94. <https://doi.org/10.1007/BF02299613>
- Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research & Development*, 48(4), 63-85. <https://doi.org/10.1007/bf02300500>
- Keselman, A. (2003). Supporting inquiry learning by promoting normative understanding of multivariable causality. *Journal of Research in Science Teaching*, 40(9), 898-921. <https://doi.org/10.1002/tea.10115>
- Kim, T. K. (2015). T-test as a parametric statistic. *Korean Journal of Anesthesiology*, 68(6), 540. <https://doi.org/10.4097/kjae.2015.68.6.540>
- Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice*, 41(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2
- Küçükahmet, L. (1998). *Principles and methods of teaching*. Alkum.
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. *Applied Sciences*, 12(13), 6809. <https://doi.org/10.3390/app12136809>

- Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research*, 86(3), 1-38. <https://doi.org/10.3102/0034654315627366>
- Le, H. V., & Nguyen, L. Q. (2024). Promoting L2 learners' critical thinking skills: The role of social constructivism in reading class. *Front. Educ*, 9, 1241973. <https://doi.org/10.3389/feduc.2024.1241973>
- Leite, L., & Dourado, L. (2013). Laboratory activities, science education and problem-solving skills. *Procedia - Social and Behavioral Sciences*, 106, 1677-1686. <https://doi.org/10.1016/j.sbspro.2013.12.190>
- Li, D., Hu, X., Zhang, G., & Duan, H. (2016). Hot-redundancy CPCI measurement and control system based on probabilistic neural networks. In L. Cheng, Q. Liu, & A. Ronzhin (Eds.), *Advances in Neural Networks – ISNN 2016* (Vol. 9719). Cham: Springer. https://doi.org/10.1007/978-3-319-40663-3_41
- Lim, J., Yang, J. W., Song, M. H., & Park, J. (2024). Self-Study and Discussion Promote Students' Science Learning. *Science & Education*, 34, 2459-2477. <https://doi.org/10.1007/s11191-024-00562-8>
- Ling, Y., Zhou, L., Zhang, B., & Ren, H. (2024). Developing middle school students' problem-solving ability through interdisciplinary project-based learning. *Education for Chemical Engineers*, 46, 43-53. <https://doi.org/10.1016/j.ece.2023.11.001>
- Lorenzis, F., Visconti, A., Restivo, S., Mazzini, F., Esposito, S., Garofalo, S. F., Lamberti, F. (2024). Combining virtual reality with asymmetric collaborative learning: A case study in chemistry education. *Smart Learning Environments*, 11(43), 1-32. <https://doi.org/10.1186/s40561-024-00331-8>
- Luo, H., Li, G., Feng, Q., Yang, Y., & Zuo, M. (2021). Virtual reality in K-12 and higher education: A systematic review of the literature from 2000 to 2019. *Journal of Computer Assisted Learning*, 37(3), 887-901. <https://doi.org/10.1111/jcal.12538>
- Maddux, C. D., Johnson, D. L., & Willis, J. W. (1997). *Educational computing: Learning with tomorrow's technologies* (2nd ed.). Allyn & Bacon.
- Mahaffy, P. (2006). Moving chemistry education into 3d: A tetrahedral metaphor for understanding chemistry. *J. Chem. Educ*, 83(1), 49-55. <https://doi.org/10.1021/ed083p49>
- Makransky, G., & Mayer, R. (2022). Benefits of taking a virtual field trip in immersive virtual reality: Evidence for the immersion principle in

- multimedia learning. *Educational Psychology Review*, 34, 1771-1798. <https://doi.org/10.1007/s10648-022-09675-4>
- Makransky, G., Andreasen, N. K., Baceviciute, S., & Mayer, R. E. (2021). Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. *Journal of Educational Psychology*, 113(4), 719-735. <https://psycnet.apa.org/doi/10.1037/edu0000473>
- Mallek, F., Mazhar, T., Shah, S. F., Ghadi, Y. Y., & Hamam, H. (2024). A review on cultivating effective learning: Synthesizing educational theories and virtual reality for enhanced educational experiences. *PeerJ Computer Science*, 10, e2000. <https://doi.org/10.7717/peerj-cs.2000>
- Maroungkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: A review of learning theories approaches and methodologies for the last decade. *Electronics*, 12, 2832. <https://doi.org/10.3390/electronics12132832>
- Mastrolembo, V. S., Castronovo, F., Nikolić, D., & Ciribini, A. L. (2022). Implementation of virtual reality in construction education: A content-analysis based literature review. *ITcon*, 27, 705-731. <https://dx.doi.org/10.36680/j.itcon.2022.035>
- Matovu, H., Ungu, D. A., Won, M., Tsai, C. C., Treagust, D. F., Mocerino, M., & Tasker, R. (2023). Immersive virtual reality for science learning: Design, implementation, and evaluation. *Studies in Science Education*, 59(2), 205-244. <https://doi.org/10.1080/03057267.2022.2082680>
- Mayer, R. (1990). Problem solving. In *The Blackwell Dictionary of Cognitive Psychology* (pp. 284-288). Basil Blackwell.
- Mayer, R. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science*, 26, 49-63. <https://doi.org/10.1023/A:1003088013286>
- Mayer, R. E., & Wittrock, M. C. (1996). Problem-solving transfer. In & R. In D. C. Berliner (Ed.), *Handbook of educational psychology* (pp. 47-62). Macmillan.
- Michałowska-Kaczmarczyk, A. M., Spórna-Kucab, A., & Michałowski, T. (2017). Solubility Products and Solubility Concepts. In *In Descriptive Inorganic Chemistry Researches of Metal Compounds*. InTech. Retrieved from <https://doi.org/10.5772/67840>
- Mir, A. H., Alam, M. N., & Modi, A. (2025). Constructivist learning theory: A framework for student-centered instruction in the 21st century classroom.

- International Journal of Educational Review, Law And Social Sciences*, 5(4), 1273-1284. <https://doi.org/10.54443/ijerlas.v4i6.2061>
- Moro, C., Štromberga, Z., & Stirling, A. (2017). Virtualisation devices for student learning: Comparison between desktop-based (Oculus Rift) and mobile-based (Gear VR) virtual reality in medical and health science education. *Australasian Journal of Educational Technology*, 33(6), 1-10. <https://doi.org/10.14742/ajet.3840>
- OECD. (2017). *PISA 2015 results (Volume V): Collaborative problem solving*. OECD Publishing.
- Onyeaka, H., Passaretti, P., Miri, T., Hart, A., Favero, C., Anumudu, C. K., & Robbins, P. (2023). Pre-lab video demonstrations to enhance students' laboratory experience in a first-year chemical engineering class. *Biochem Mol Biol Educ*, 51(1), 29-38. <https://doi.org/10.1002/bmb.21688>
- Oriakhi, C. O. (2021). Solubility and complex-ion equilibria. In *Chemistry in quantitative language: Fundamentals of general chemistry calculations* (2nd ed., pp. 313-324). Oxford Academic. Retrieved from <https://doi.org/10.1093/oso/9780198867784.003.0019>
- Ornstein, A. C., & Hunkins, F. P. (1998). *Curriculum: Foundations, principles, and issues* (3rd ed.). Allyn & Bacon.
- Pedaste, M., Mäeots, M., Siiman, L. A., Jong, T. D., Riesen, S. A., Kamp, E. T., Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47-61. <http://dx.doi.org/10.1016/j.edurev.2015.02.003>
- Pellas, N., Dengel, A., & Christopoulos, A. (2020). A Scoping Review of Immersive Virtual Reality in STEM Education. *IEEE Transactions on Learning Technologies*, 13(4), 748-761. <https://doi.org/10.1109/TLT.2020.3019405>
- Piaget, J. (1971). *Biology and knowledge: An essay on the relations between organic regulations and cognitive processes*. University of Chicago Press.
- Polit, D. F., & Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing & Health*, 29(5), 487-497. <https://doi.org/10.1002/nur.20147>
- Protopsaltis, A., & Papagiannakis, G. (2020). Virtual reality: A model for understanding immersive computing. In N. Lee (Ed.), *Encyclopedia of Computer Graphics and Games* (pp. 1-4). Springer International Publishing. https://doi.org/10.1007/978-3-319-08234-9_165-1
- Radianti, J., Majchrzak, T., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education:

- Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Rahman, H., Wahid, S. A., Ahmad, F., & Ali, N. (2024). Game-based learning in metaverse: Virtual chemistry classroom for chemical bonding for remote education. *Educ Inf Technol*, 29, 19595–19619. <https://doi.org/10.1007/s10639-024-12575-5>
- Rahmawati, Y., Zulhipri, Hartanto, O., Falani, I., & Iriyadi, D. (2022). Students' conceptual understanding in chemistry learning using PhET interactive simulations. *Journal of Technology and Science Education*, 12(2), 303-326. <https://doi.org/10.3926/jotse.1597>
- Rahmi, C., Katmiati, S., Wiji, & Mulyani, S. (2017). Students' mental models on the solubility and solubility product concept. *AIP Conf. Proc.*, 1848(1), 030001. <https://doi.org/10.1063/1.4983933>
- Safaeipour, R., Aalaa, M., Mojtahedzadeh, R., Mohammadi, A., Asadzandi, S., & Mousavi, A. (2025). Virtual or blended laboratories for healthcare students education: A systematized review. *BMC Medical Education*, 25(1), 1-13. <https://doi.org/10.1186/s12909-025-07937-7>
- Salame, I. I., & Nikolic, D. (2021). Examining Some of the Challenges Students Face in Learning about Solubility and the Dissolution Process. *Interdisciplinary Journal of Environmental and Science Education*, 17(3), 1-11. <https://doi.org/10.21601/ijese/9333>
- Samala, A., Rawas, S., Rahmadika, S., Criollo, S., Fikri, R., & Sandra, R. (2025). Virtual reality in education: Global trends, challenges, and impacts—game changer or passing trend? *Discover Education*, 4(229), 1-45. <https://doi.org/10.1007/s44217-025-00650-z>
- Sa-ngiemjit, M., Vázquez-Alonso, Á., & Mas, M. (2024). Problem-solving skills of high school students in chemistry. *International Journal of Evaluation and Research in Education*, 13(3), 1825-1831. <https://doi.org/10.11591/ijere.v13i3.27421>
- Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education*, 36, 111-139. <https://doi.org/10.1007/s11165-005-3917-8>
- Scurati, G. W., Bertoni, M., Graziosi, S., & Ferrise, F. (2021). Exploring the use of virtual reality to support environmentally sustainable behavior: A framework to design experiences. *Sustainability*, 13(2), 943. <https://doi.org/10.3390/su13020943>
- Shane, S. (2003). *A general theory of entrepreneurship: The individual-opportunity nexus*. Edward Elgar Publishing.

- Specht, M., Bedek, M., Duval, E., Okada, A., Krassen, S., Parodi, E., Strahovnik, V. (2012). WESPOT: Inquiry-based learning meets learning analytics. *Proceedings of the Third International Conference on e-Learning* (pp. 15-20). Metropolitan University.
- Spivack, G., Platt, J. J., & Shure, M. B. (1976). *The problem-solving approach to adjustment*. Jossey-Bass.
- Stevenson, H. H., & Jarillo, J. C. (1990). A paradigm of entrepreneurship: Entrepreneurial management. *Strategic Management Journal*, 11, 17-27. <http://www.jstor.org/stable/2486667>
- Stracke, C., Bothe, P., Adler, S., Heller, E., Deuchler, J., Pomino, J., & Wölfel, M. (2025). Immersive virtual reality in higher education: A systematic review of the scientific literature. *Virtual Reality*, 29(64), 1-21. <https://doi.org/10.1007/s10055-025-01136-x>
- Stroumpouli, C., & Tsaparlis, G. (2022). Chemistry students' conceptual difficulties and problem solving behavior in chemical kinetics, as a component of an introductory physical chemistry course. *Chemistry Teacher International*, 4(3), 279-296. <https://doi.org/10.1515/cti-2022-0005>
- Supahar, & Widodo, E. (2021). The effect of virtual laboratory application of problem-based learning model to improve science literacy and problem-solving skills. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*. 528, pp. 633-640. Atlantis Press.
- Sutherland, I. E. (1968). A head-mounted three dimensional display. *AFIPS '68 (Fall, Part I): Fall Joint Computer Conference* (pp. 757-764). ACM. <https://doi.org/10.1145/1476589.1476686>
- Tene, T., Tixi, J. A., Robalino, M. L., Salazar, M. J., Gomez, C. V., & Bellucci, S. (2024). Integrating immersive technologies with STEM education: A systematic review. *Front. Educ.*, 9, 1410163. <https://doi.org/10.3389/educ.2024.1410163>
- Treagust, D., Chittleborough, G., & Mamiala, T. (2003). The role of submicroscopic and symbolic representations in chemical explanations. *International Journal of Science Education*, 25(11), 1353-1368. <http://dx.doi.org/10.1080/0950069032000070306>
- Treve, M. (2024). Comparative analysis of teacher-centered and student-centered learning in the context of higher education: A co-word analysis. *Iberoamerican Journal of Science Measurement and Communication*, 4(2), 1-12. doi:10.47909/ijsmc.117

- Tümay, H. (2016). Reconsidering learning difficulties and misconceptions in chemistry: Emergence in chemistry and its implications for chemical education. *Royal Society Of Chemistry*, 17, 229-245. <https://doi.org/10.1039/C6RP00008H>
- Ungu, D. A., Won, M., Matovu, H., Hernandez-Alvarado, R. B., Treagus, D. F., Mocerino, M., Tsai, C.-C. (2025). Students' perceptions of physical magnetic models and immersive virtual reality for chemistry learning. *International Journal of Science Education*, 1-23. <https://doi.org/10.1080/09500693.2025.2574523>
- Ventura-León, J., Lino-Cruz, C., Tocto-Muñoz, S., Sánchez-Villena, A., & Gamboa-Melgar, G. (2025). Problem-solving: development and validation of a short instrument for higher education. *Front. Educ.*, 10, 1555167. <https://doi.org/10.3389/feduc.2025.1555167>
- Villena-Taranilla, R., & Diago, P. D. (2025). Challenges and Implications of Virtual Reality in History Education: A Systematic Review. *Applied Sciences*, 15(10), 1-13. <https://doi.org/10.3390/app15105589>
- Vo, K., Sarkar, M., & White, P. (2022). Problem solving in chemistry supported by metacognitive scaffolding: teaching associates' perspectives and practices. *The Royal Society of Chemistry*, 23(2), 436–451. <https://doi.org/10.1039/D1RP00242B>
- Vo, K., Sarkar, M., White, P., & Yuriev, E. (2024). Development of problem-solving skills supported by metacognitive scaffolding: Insights from students' written work. *Royal Society of Chemistry*, 25(4), 1197-1209. <https://doi.org/10.1039/D3RP00284E>
- Wang, L., Hodges, G., & Lee, J. (2022). Connecting macroscopic, molecular, and symbolic representations in high school chemistry: The case of redox reactions. *Educ. Sci*, 12(428). <https://doi.org/10.3390/educsci12070428>
- Wang, Y., & Chiew, V. (2008). On the cognitive process of human problem solving. *Cognitive Systems Research*, 11(1), 81-92. <https://doi.org/10.1016/j.cogsys.2008.08.003>
- Warner, M. (2002). Publics and Counterpublics. *Public Culture*, 14(1), 49-90. <https://doi.org/10.1215/08992363-14-1-49>
- Wong, J. Y., Azam, A. B., Cao, Q., Huang, L., Xie, Y., Winkler, I., & Cai, Y. (2024). Evaluations of virtual and augmented reality technology-enhanced learning for higher education. *Electronics*, 13, 1549. <https://doi.org/10.3390/electronics13081549>
- Wood, P. K. (1983). Inquiring systems and problem structures: Implications for cognitive development. *Human Development*, 26(5), 249-265. <https://doi.org/10.1159/000272887>

- Woods, P., & Copur-Gencturk, Y. (2024). Examining the role of student-centered versus teacher-centered pedagogical approaches to self-directed learning through teaching. *Teaching and Teacher Education*, 138, 104415. <https://doi.org/10.1016/j.tate.2023.104415>
- Wu, J., Guo, R., Wang, Z., & Zeng, R. (2021). Integrating spherical video-based virtual reality into elementary school students' scientific inquiry instruction: Effects on their problem-solving performance. *Interactive Learning Environments*, 29(3), 496-509. <https://doi.org/10.1080/10494820.2019.1587469>
- Yang, C., Zhang, J., Hu, Y., Yang, X., Chen, M., Shan, M., & Li, L. (2024). The impact of virtual reality on practical skills for students in science and engineering education: A meta-analysis. *IJ STEM Ed*, 11, 28. <https://doi.org/10.1186/s40594-024-00487-2>
- Yang, Q. F., Lin, H., Hwang, G. J., Su, P. Y., & Zhao, J. H. (2022). An exploration-based SVVR approach to promote students' chemistry learning effectiveness. *Interactive Learning Environments*, 32(5), 2003–2027. <https://doi.org/10.1080/10494820.2022.2135106>
- Yang, Y., Reniers, G., Chen, G., & Goerlandt, F. (2019). A bibliometric review of laboratory safety in universities. *safety science*, 120, 14-24. <https://doi.org/10.1016/j.ssci.2019.06.022>
- Yim, K., Nahm, F., Han, K., & Park, S. (2010). Analysis of statistical methods and errors in the articles published in the korean journal of pain. *Korean Journal Pain*, 23, 35-41. <https://doi.org/10.3344/kjp.2010.23.1.35>
- Yuriev, E., Naidu, S., Schembri, L., & Short, J. (2017). Scaffolding the development of problem-solving skills in chemistry: Guiding novice students out of dead ends and false starts. *The Royal Society of Chemistry*, 18(3), 486-504. <https://doi.org/10.1039/C7RP00009J>
- Zhou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: trends, challenges, and innovations in technology integration. *Frontiers in Education*, 10, 1562391. <https://doi.org/10.3389/feduc.2025.1562391>
- Zhou, Y., Zhu, Y., & Wong, W. K. (2023). Statistical tests for homogeneity of variance for clinical trials and recommendations. *Contemporary Clinical Trials Communications*, 33, 101119. <https://doi.org/10.1016/j.conctc.2023.101119>