

DAFTAR PUSTAKA

- Ahrens, R. de B., Lirani, L. da S., & de Fransisco, A. C. (2020). Construct validity and reliability of the work environment assessment instrument WE-10. *International Journal of Environmental Research and Public Health*, 17(20), 1-19. <https://doi.org/10.3390/ijerph17207364>
- Akpan, I. J., & Shanker M. (2019). A comparative evaluation of the effectiveness of virtual reality, 3D visualization and 2D visual interactive simulation: An exploratory meta-analysis. *Simulation*, 95(2), 145-170. <https://doi.org/10.1177/0037549718757039>
- Al Said, R. S., Du, X., Al Khatib, H. A. H. M., Romanowski, M. H., & Barham, A. I. I. (2019). Math teachers' beliefs, practices, and belief change in implementing problem based learning in Qatari primary governmental school. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(5), 1-14. <https://doi.org/10.29333/ejmste/105849>
- Allcoat, D., & Adrian, von M. (2018). Learning in virtual reality: Effects on performance, emotion and engagement. *Research in Learning Technology*, 26, 1–13. <https://doi.org/10.25304/rlt.v26.2140>
- Almulla, M. A. (2023). Constructivism learning theory: A paradigm for students' critical thinking, creativity, and problem solving to affect academic performance in higher education. *Cogent Education*, 10(1). <https://doi.org/10.1080/2331186X.2023.2172929>
- Andriani, Y., Mulyani, S., & Wiji, W. (2021). Misconceptions and troublesome knowledge on chemical equilibrium. *Journal of Physics: Conference Series*, 1806(1), 1-6. <https://doi.org/10.1088/1742-6596/1806/1/012184>
- 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, 1-13. <https://doi.org/10.1016/j.compedu.2020.104121>
- Archila, P.A., Ortiz, B.T. & Truscott de Mejía, A. M. (2024). Beyond the passive absorption of information: Engaging students in the critical reading of scientific articles. *Science and Education*. <https://doi.org/10.1007/s11191-024-00507-1>
- Aroch, I., Katchevich, D., & Blonder, R. (2024). Modes of technology integration in chemistry teaching: Theory and practice. *Chemical Education Research and Practice*, 25(3), 843-861. <https://doi.org/10.1039/D3RP00307H>
- Arora, T.K. (2023). A study on problem solving ability among students of govt. senior secondary school: A comparative analysis. *ShodhKosh: Journal of Visual and Performing Arts*, 4(2), 2405–2409. <https://doi.org/10.29121/shodhkosh.v4.i2.2023.3804>
- Ary, D., Jacobs, L. C., Sorensen, C., & Razavieh, A. (2010). *Introduction to research in education* (8th ed.). Cengage Learning.

- Asia Society/OECD. (2018). *Teaching for global competence in a rapidly changing world.* OECD Publishing. <https://doi.org/10.1787/9789264289024-en>
- Barrows, H. S. (1996). *Problem-based learning in medicine and beyond: A brief overview.* Jossey-Bass Publishers. <https://doi.org/10.1002/tl.37219966804>
- Bayar, V. & Çepni, S. (2022). A thematic content analysis of gifted and talented students in science education in Türkiye. *Journal of Turkish Science Education*, 19(4), 1037-1071. <https://doi.org/10.36681/tused.2022.162>
- Bentz, A., Krasowski, J., Standl, B., & Wiepcke, C. (2024). Empowering K–12 pupils: Fostering problem-solving skills through sustainable entrepreneurship and computational thinking. *Journal of the International Council for Small Business*, 6(2), 244-255. <https://doi.org/10.1080/26437015.2024.2403030>
- Busa, J., & Chung, S.-J. (2024). The effects of teacher-centered and student-centered approaches in TOEIC reading instruction. *Education Sciences*, 14(2), 1-13. <https://doi.org/10.3390/educsci14020181>
- Cao, S., Chu, J., Zhang, Z., & Liu, L. (2024). The effectiveness of VR environment on primary and secondary school students' learning performance in science courses. *Interactive Learning Environments*, 32(10), 7321-7337. <https://doi.org/10.1080/10494820.2024.2312921>
- Carruth, D. W. (2017). Virtual reality for education and workforce training. *2017 15th International Conference on Emerging eLearning Technologies and Applications*, Stary Smokovec, Slovakia, (pp. 1-6). <https://doi.org/10.1109/ICETA.2017.8102472>
- Chang, R. (2008). *General chemistry: The essential concepts* (5th ed.). McGraw-Hill Education.
- Chasokela, D. (2025). Investigating the role of virtual reality to support student's engagement, spatial awareness and problem-solving skills in engineering education. *International Journal of Instruction*, 18(3), 613-636.
- Chavez, B., & Bayona, S. (2018). Virtual reality in the learning process. *Trends and Advances in Information Systems and Technologies*, 746, 1345–1356. https://doi.org/10.1007/978-3-319-77712-2_129
- Checa, D., & Bustillo, A. (2020). A review of immersive virtual reality serious games to enhance learning and training. *Multimedia Tools and Applications*, 79, 5501–5527. <https://doi.org/10.1007/s11042-019-08348-9>
- Chen, C. T., & She, H. C. (2015). The effectiveness of scientific inquiry with/without integration of scientific reasoning. *International Journal of Science and Mathematics Education*, 13(1), 1–20. <https://doi.org/10.1007/s10763-013-9508-7>
- Chen, L., & Lertamornsak, G. (2023). Internet of things (IoT) based investigation between instructors' insight of constructivist learning theory and learners

- performance analysis in higher vocational accounting training. *International Journal on Recent and Innovation Trends in Computing and Communication*, 11(6s), 217-227. <https://doi.org/10.17762/ijritcc.v11i6s.6824>
- Chen, MJ., She, HC. & Tsai, PY. (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>
- Choi, D.-H., & Noh, G.-Y. (2021). The impact of presence on learning transfer intention in virtual reality simulation game. *SAGE Open*, 11(3), 1-9. <https://doi.org/10.1177/21582440211032178>
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.
- Conrad, M., Kablitz, D., & Schumann, S. (2024). Learning effectiveness of immersive virtual reality in education and training: A systematic review of findings. *Computers & Education: X Reality*, 4. <https://doi.org/10.1016/j.cexr.2024.100053>
- Cooper, G., Thong, L. P., & Tang, K. S. (2024). Transforming science education with virtual reality: An immersive representations model. *Educational Media International*, 61(3), 229–251. <https://doi.org/10.1080/09523987.2024.2389348>
- Cresswell, J. W., & Creswell, J. D. (2018). *Research design* (5th ed.). SAGE publication.
- Csányi, R., & Molnár, G. (2025). Looking beyond students' exploration and learning strategies: The role of test-taking effort in complex problem-solving. *Intelligence*, 109. <https://doi.org/10.1016/j.intell.2025.101907>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management science*, 35(8), 982-1003. <https://doi.org/10.1287/mnsc.35.8.982>
- De Lorenzis, F., Praticò, F. G., Repetto, M., Pons, E., & Lamberti, F. (2023). Immersive virtual reality for procedural training: Comparing traditional and learning by teaching approaches. *Computers in Industry*, 144. <https://doi.org/10.1016/j.compind.2022.103785>
- Demirel, M., & Dağyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(8), 2115–2137. <https://doi.org/10.12973/eurasia.2016.1293a>
- Dinther, R. V., Putter, L. D., & Pepin, B. (2023). Features of immersive virtual reality to support meaningful chemistry education. *Journal of Chemical*

- Education*, 100(4), 1537-1546.
<https://doi.org/10.1021/acs.jchemed.2c01069>
- Doyle, E., & Buckley, P. (2022). The impact of co-creation: An analysis of the effectiveness of student authored multiple choice questions on achievement of learning outcomes. *Interactive Environments*, 30(9), 1726-1735. <https://doi.org/10.1080/10494820.2020.1777166>
- Durukan, A., Artun, H., & Temur, A. (2020). Virtual reality in science education: A descriptive review. *Journal of Science Learning*, 3(3), 132 – 142. <https://doi.org/10.17509/jsl.v3i3.21906>
- E., S., Benjamin, A.E.W. (2024). Studying the student's perceptions of engagement and problem-solving skills for academic achievement in chemistry at the higher secondary level. *Education and Information Technology*, 29, 8347–8368. <https://doi.org/10.1007/s10639-023-12165-x>
- Emmert-Streib, F., & Dehmer, M. (2019). Understanding statistical hypothesis testing: The logic of statistical inference. *Machine Learning and Knowledge Extraction*, 1(3), 945-961. <https://doi.org/10.3390/make1030054>
- Etikan, I., Musa, S. A., & Alkassim, R.S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1-4. <https://doi.org/10.11648/j.ajtas.20160501.11>
- Ghaleb, B. D. S. (2024). Effect of exam-focused and teacher-centered education systems on students' cognitive and psychological competencies. *International Journal of Multidisciplinary Approach Research and Science*, 2(02), 611–631. <https://doi.org/10.59653/ijmars.v2i02.648>
- Godsk, M., & Møller, K.L. (2025). Engaging students in higher education with educational technology. *Education and Information Technologies*, 30, 2941–2976. <https://doi.org/10.1007/s10639-024-12901-x>
- González Hernández, W. (2022). The teaching-learning process or the teaching process and the learning process. *Culture & Psychology*, 29(1), 96-115. <https://doi.org/10.1177/1354067X221097610>
- Grabowski, A., & Jankowski, J. (2015). Virtual reality-based pilot training for underground coal miners. *Safety Science*, 72, 310–314. <https://doi.org/10.1016/j.ssci.2014.09.017>
- Halabi, O. (2020). Immersive virtual reality to enforce teaching in engineering education. *Multimedia Tools and Application*, 79, 2987–3004. <https://doi.org/10.1007/s11042-019-08214-8>
- Hamilton, D., McKechnie, J., Edgerton, E. et al. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, 8, 1–32. <https://doi.org/10.1007/s40692-020-00169-2>

- 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>
- Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences*, 3(2), 220–227. <https://doi.org/10.1177/2372732216655542>
- Hmelo-Silver, C.E. (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>
- Hsin, W.-J., Lin, Y.-R., & Su, C.-Y. (2023). Features of immersive virtual reality to support meaningful chemistry education. *Journal of Chemical Education*, 100(6), 2428–2435. <https://doi.org/10.1021/acs.jchemed.2c01069>
- Hsu, YS., Fang, SC. (2019). *Opportunities and challenges of STEM education*. Springer. https://doi.org/10.1007/978-981-15-0768-7_1
- 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>
- Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: A mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computer Assisted Learning*, 2(4), 449-473. <https://doi.org/10.1007/s40692-015-0043-0>
- Iskandarov, A. Y. (2024). Didactic significance of problem-solving activity in chemistry education. *The American Journal of Management and Economics Innovations*, 6(11), 111–114. <https://doi.org/10.37547/tajmei/volume06issue11-11>
- Jayasinghe, K. (2021). Constructing constructivism in management accounting education: Reflections from a teaching cycle with innovative learning elements. *Qualitative Research in Accounting & Management*, 18(2), 282-309. <https://doi.org/10.1108/QRAM-05-1010-0067>
- Jones, N. (2018). The virtual lab: Can a simulated laboratory experience provide the same benefits for students as access to a real-world lab? *Nature*, 562, S5–S7. <https://doi.org/10.1038/d41586-018-06831-1>
- Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of problem-based learning on developing science process skills and learning achievement on the topic of safety in our environment. *Journal of Turkish Science Education*, 19(3), 872–886. <https://doi.org/10.36681/tused.2022.154>
- Khaira, K., & Ibrahim, M. M. (2024). Analysis of student problems on acids and bases subject to improve problem-solving skills. *Edukimia*, 6(2), 19-29. <https://doi.org/10.24036/ekj.v6.i2.a543>

- Khan, S., Shiraz, M., Shah, G., & Muzamil, M. (2023). Understanding the factors contributing to low enrollment of science students in undergraduate programs. *Cogent Education*, 10(2), 1-22. <https://doi.org/10.1080/2331186X.2023.2277032>
- Kim et al. (2018). The role of problem solving ability on innovative behavior and opportunity recognition in university students. *Journal of Open Innovation: Technology, Market, and Complexity*, 4 (4). <https://doi.org/10.1186/s40852-018-0085-4>
- Kim, T. K. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*, 68 (6), 540 – 546. <https://doi.org/10.4097/kjae.2015.68.6.540>
- Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, 41(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1
- Klegeris, A., McKeown, S.B., Hurren, H. et al. (2017). Dynamics of undergraduate student generic problem-solving skills captured by a campus-wide study. *Higher Education*, 74, 877–896. <https://doi.org/10.1007/s10734-016-0082-0>
- Kuleto, V., Ilić, M.P., Ranković, M., Radaković, M., & Simović, A. (2024). *Augmented and virtual reality in the metaverse context: The impact on the future of work, education, and social interaction*. Springer. https://doi.org/10.1007/978-3-031-57746-8_1
- Kumar, A., & Gorai, J. (2025). Effectiveness of augmented reality and virtual reality interventions on learning outcomes: A meta-analysis in higher education. *Tech Trends*. <https://doi.org/10.1007/s11528-025-01106-9>
- Lee, E., Wong, K.W., Fung, C.C. (2010). How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. *Computers & Education*, 55(4), 1424–1442. <https://doi.org/10.1016/j.compedu.2010.06.006>
- Li, Z., Cao, Y., & Luo, J. (2022). Application of virtual reality technology in the chemistry teaching process. *Proceedings of the 2022 2nd International Conference on Education, Information Management and Service Science*, 7, 1253–1258. https://doi.org/10.2991/978-94-6463-024-4_129
- Liao, S. (2018). The characteristics and applications of virtual reality technology. *Public Communication of Science & Technology*, 21, 127-135. <https://doi.org/10.16607/j.cnki.1674-6708.2018.21.064>
- Liu, R., Wang, L., Lei, J., Wang, Q., & Ren, Y. (2020). Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons. *British Journal of Education Technology*, 51(6), 2034-2049. <https://doi.org/10.1111/bjet.13028>

- Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, 45, 1-21. <https://doi.org/10.1016/j.tsc.2022.101069>
- Lui, M., Chong, KY.A., Mullally, M., & McEwen, R. (2023). Facilitated model-based reasoning in immersive virtual reality: Meaning-making and embodied interactions with dynamic processes. *International Journal of Computer-Supported Collaborative Learning*, 18, 203–230. <https://doi.org/10.1007/s11412-023-09396-y>
- Maas, M. J., & Hughes, J. M. (2020). Virtual, augmented and mixed reality in K–12 education: A review of the literature. *Technology, Pedagogy and Education*, 29(2), 231–249. <https://doi.org/10.1080/1475939X.2020.1737210>
- Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development*, 66, 1141–1164. <https://doi.org/10.1007/s11423-018-9581-2>
- Makransky, G., & Petersen, G. B. (2021). The cognitive and motivational effects of immersive virtual reality learning environments: A systematic review and meta-analysis. *Computers & Education*, 166, 104144. <https://doi.org/10.1016/j.compedu.2021.104144>
- Makransky, G., Borre-Gude, S., & Mayer, R. E. (2019). Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments. *Journal of Computer Assisted Learning*, 35(6), 691–707. <https://doi.org/10.1111/jcal.12375>
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225–236. <https://doi.org/10.1016/j.learninstruc.2017.12.007>
- Matovu, H., Won, M., Hernandez-Alvarado, R.B. et al. (2024). The perceived complexity of learning tasks influences students' collaborative interactions in immersive virtual reality. *Journal of Science Education and Technology*, 33, 542–555. <https://doi.org/10.1007/s10956-024-10103-1>
- Matovu, H., Won, M., Tasker, R. et al. (2025). "It is not just the shape, there is more": Students' learning of enzyme–substrate interactions with immersive virtual reality. *Chemistry Education Research and Practice*, 26(1), 259-270. <https://doi.org/10.1039/D4RP00210E>
- Matovu, H., Won, M., Treagust, D. F., Ungu, D. A. K. et al. (2023). Change in students' explanation of the shape of snowflakes after collaborative immersive virtual reality. *Chemistry Education Research and Practice*, 24(2), 509. <https://doi.org/10.1039/D2RP00176D>

- Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, 70, 29–40. <https://doi.org/10.1016/j.compedu.2013.07.033>
- Merchant, Z., Goetz, E.T., Keeney-Kennicutt, W., Cifuentes, L., Kwok, O., & Davis, T.J. (2013). Exploring 3-D virtual reality technology. *Journal of Computer Assisted Learning*, 29, 579-590. <https://doi.org/10.1111/jcal.12018>
- Miller, M.D., Castillo, G., Medoff, N. et al. (2021). Immersive VR for organic chemistry: Impacts on performance and grades for first-generation and continuing-generation university students. *Innovative Higher Education*, 46, 565–589. <https://doi.org/10.1007/s10755-021-09551-z>
- Muhanna, M.A. (2015). Virtual reality and the CAVE: Taxonomy, interaction challenges and research directions. *Journal of King Saud University – Computer and Information Science*, 27(3), 344–361. <https://doi.org/10.1016/j.jksuci.2014.03.023>
- Murthy, S., Warriem, J.M., & Iyer, S. (2017). Technology integration for student-centered learning: A model for teacher professional development programs. In Kong, S., Wong, T., Yang, M., Chow, C., Tse, K. (Eds.). *Emerging Practices in Scholarship of Learning and Teaching in a Digital Era*. Springer. https://doi.org/10.1007/978-981-10-3344-5_4
- Nagahi, M., Maddah, A., Jaradat, R., & Mohammadi, M. (2021). Development of perceived complex problem-solving instrument in domain of complex systems. *Systems*, 9(3), 1-24. <https://doi.org/10.3390/systems9030051>
- Naji, K. K., Ebead, U., Al-Ali, A. K., & Du, X. (2020). Comparing models of problem and project-based learning (PBL) courses and student engagement in civil engineering in Qatar. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(8), 1–16. <https://doi.org/10.29333/EJMSTE/8291>
- Nayeri, N., Noodeh, F., Nia, H., Yaghoobzadeh, A., Allen, K., & Goudarzian, A. H. (2024). Statistical procedures used in pretest-posttest control group design: A review of papers in five Iranian journals. *Acta Medica Iranica*, 61(10), 584-591. <https://doi.org/10.18502/acta.v61i10.15657>
- Ocak, G., Doğruel, A. B., & Tepe, M. E. (2021). An analysis of the relationship between problem solving skills and scientific attitudes of secondary school students. *International Journal Contemporary Educational*, 8(1), 72-83. <https://doi.org/10.33200/ijcer.780710>
- OECD. (2014). *PISA 2012 results: Creative problem solving (volume V): Students' skills in tackling real-life problems*. OECD Publishing. <https://doi.org/10.1787/9789264208070-en>

- Otto, S., Bertel, L.B., Lyngdorf, N.E.R. et al. (2024). Emerging digital practices supporting student-centered learning environments in higher education: A review of literature and lessons learned from the Covid-19 pandemic. *Education and Information Technologies*, 29, 1673–1696. <https://doi.org/10.1007/s10639-023-11789-3>
- Ou,K.L.; Liu, Y.H.; Tarng, W. (2021). Development of a virtual ecological environment for learning the Taipei tree frog. *Sustainability*, 13(11), 1-20. <https://doi.org/10.3390/su13115911>
- Oyelere, S.S., Bouali, N., Kaliisa, R. et al. (2020). Exploring the trends of educational virtual reality games: A systematic review of empirical studies. *Smart Learning Environment*, 7(31), 1-22. <https://doi.org/10.1186/s40561-020-00142-7>
- Palaigeorgiou, G., Papadopoulou, A., & Kazanidis, I. (2019). Interactive video for learning: A review of interaction types, commercial platforms, and design guidelines. In Tsitouridou, M., A. Diniz, J., Mikropoulos, T. (Eds.), *Communications in Computer and Information Science: Vol. 993. Technology and Innovation in Learning, Teaching and Education* (pp.503-518). Springer. https://doi.org/10.1007/978-3-030-20954-4_38
- Passig, D., Tzuriel, D., & Eshel-Kedmi, G. (2016). Improving children's cognitive modifiability by dynamic assessment in 3D Immersive Virtual Reality environments. *Computers and Education*, 95, 296–308. <https://doi.org/10.1016/j.compedu.2016.01.009>
- Prokša, M., Drozdíková, A., & Haláková, Z. (2018). Learners' understanding of chemical equilibrium at submicroscopic, macroscopic and symbolic levels. *Chemistry Didactics Ecology Metrology*, 23(1-2), 97–111. <https://doi.org/10.1515/CDEM-2018-0006>
- Qorbani, S., Dalili, S., Arya, A., & Joslin, C. (2024). Assessing learning in an immersive virtual reality: A curriculum-based experiment in chemistry education. *Education Science*, 14(5), 1-23. <https://doi.org/10.3390/educsci14050476>
- Radianti, J., Majchrzak, T. A., 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, 1-29. <https://doi.org/10.1016/j.compedu.2019.103778>
- Rahman, H., Wahid, S.A., Ahmad, F. et al. (2024). Game-based learning in metaverse: Virtual chemistry classroom for chemical bonding for remote education. *Education and Information Technologies*, 29, 19595–19619. <https://doi.org/10.1007/s10639-024-12575-5>
- Rashid, S., Khattak, A., Ashiq, M., Ur Rehman, S., & Rasool, R.M. (2021). Educational landscape of virtual reality in higher education: Bibliometric evidences of publishing patterns and emerging trends. *Publications*, 9(2), 1-17. <https://doi.org/10.3390/publications9020017>

- Renninger, A. K., & Hidi, S. (2016). *The power of interest for motivation and engagement*. Routledge. <https://doi.org/10.4324/9781315771045>
- Robles-Gómez, A., Ros, S., Hernández, R., Tobarra, L., Caminero, A. C., & Agudo, J. M. (2015). User acceptance of a proposed self-evaluation and continuous assessment system. *Educational Technology & Society*, 18(2), 97-109. <https://www.jstor.org/stable/jeductechsoci.18.2.97>
- Rodolico, G., & Hirsu, L. (2023). Virtual reality in education: supporting new learning experiences by developing self-confidence of Postgraduate Diploma in Education (PGDE) student-teachers. *Educational Media International*, 60(2), 92–108. <https://doi.org/10.1080/09523987.2023.2262195>
- Rosida, N., Widarti, H. R., & Yahmin, Y. (2023). Analysis of students' misconceptions on chemical equilibrium material using four-tier diagnostic test. *AIP Conference Proceedings*, 2569(1). <https://doi.org/10.1063/5.0112168>
- Russo, A., Warren, L., Neri, L., Herdan, A., & Brickman, K. (2022). Enhancing accounting and finance students' awareness of transferable skills in an integrated blended learning environment. *Accounting Education*, 31(1), 67-91. <https://doi.org/10.1080/09639284.2021.1961087>
- Sa'diyah, N., & Saptono, S. (2023). The effectiveness of real problem-based e-LKPD to improve problem solving and collaboration abilities on environmental change material in Madrasah Aliyah. *Journal of Biology Education*, 12(3), 306-313.
- Sakir, N. A. I., & Kim, J. G. (2020). Enhancing students' learning activity and outcomes via implementation of problem-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(12), 1-22. <https://doi.org/10.29333/ejmste/9344>
- Salame, I. I., Satter, S. A., & Warda, F. (2024). Examining students' problem-solving approaches in organic chemistry and its impact on performance and learning. *Interdisciplinary Journal of Environmental and Science Education*, 20(2), 1-8. <https://doi.org/10.29333/ijese/14421>
- Samala, A.D., Rawas, S., Criollo-C, S. et al. (2024). Emerging technologies for global education: A comprehensive exploration of trends, innovations, challenges, and future horizons. *SN Computer Science*, 5(1175). <https://doi.org/10.1007/s42979-024-03538-1>
- Sampanis, N. (2020). Transitioning knowledge levels through problem solving methods. In Vlamos, P. (Eds.), *Advances in Experimental Medicine and Biology: Vol 1194. GeNeDis 2018* (pp. 459–474). Springer. https://doi.org/10.1007/978-3-030-32622-7_45
- Schmidt, H. G., Cohen-Schotanus, J., & Arends, L. R. (2009). Impact of problem-based, active learning on graduation rates for 10 generations of Dutch

- medical students. *Medical Education*, 43(3), 211-218. <https://doi.org/10.1111/j.1365-2923.2008.03287.x>
- Shin, K.-S., Cho, C., Ryu, J. H., & Jo, D. (2023). Exploring the perception of the effect of three-dimensional interaction feedback types on immersive virtual reality education. *Electronics*, 12(21), 4414. <https://doi.org/10.3390/electronics12214414>
- Shishigu, A., Hailu, A., & Anibo, Z. (2018). Problem-based learning and conceptual understanding of college female students in physics. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(1), 145–154. <https://doi.org/10.12973/ejmste/78035>
- Skare, M., & Soriano, D. R. (2021). How globalization is changing digital technology adoption: An international perspective. *Journal of Innovation & Knowledge*, 6(4), 222-233. <https://doi.org/10.1016/j.jik.2021.04.001>
- Steidtmann, L., Kleickmann, T., & Steffensky, M. (2023). Declining interest in science in lower secondary school classes: Quasi-experimental and longitudinal evidence on the role of teaching and teaching quality. *Journal of Research in Science Teaching*, 60(1), 164–195. <https://doi.org/10.1002/tea.21794>
- Strat, T. T. S., Henriksen, E. K., & Jegstad, K. M. (2023). Inquiry-based science education in science teacher education: A systematic review. *Studies in Science Education*, 60(2), 191–249. <https://doi.org/10.1080/03057267.2023.2207148>
- Stuchlikova, L., Kosa, A., Benko, P., et al. (2017). Virtual reality vs. reality in engineering education. *2017 15th International Conference on Emerging E-Learning Technologies and Applications*, Stary Smokovec, Slovakia, (pp. 1-6). <https://doi.org/10.1109/ICETA.2017.8102533>
- Swart, A. J. (2014). Using problem-based learning to stimulate entrepreneurial awareness among senior African undergraduate students. *Eurasia Journal of Mathematics, Science and Technology Education*, 10(2), 125–134. <https://doi.org/10.12973/eurasia.2014.1023a>
- Taber, K. S. (2013). Revisiting the chemistry triplet: Drawing upon the nature of chemical knowledge and the psychology of learning to inform chemistry education. *Chemistry Education Research and Practice*, 14(2), 156-168. <https://doi.org/10.1039/C3RP00012E>
- Taber, K.S. (2020). Conceptual confusion in the chemistry curriculum: Exemplifying the problematic nature of representing chemical concepts as target knowledge. *Foundations of Chemistry*, 22, 309–334. <https://doi.org/10.1007/s10698-019-09346-3>
- Tarng, W., Pan, I.-C., & Ou, K.-L. (2022). Effectiveness of virtual reality on attention training for elementary school students. *Systems*, 10(4), 104. <https://doi.org/10.3390/systems10040104>

- Tarng, W., Tseng, Y.-C., & Ou, K.-L. (2022). Application of augmented reality for learning material structures and chemical equilibrium in high school chemistry. *Systems*, 10(5), 141. <https://doi.org/10.3390/systems10050141>
- Teo, T., Norman, M., Lee, G.A., Billinghamst, M., & Adcock, M. (2020). Exploring interaction techniques for 360 panoramas inside a 3D reconstructed scene for mixed reality remote collaboration. *Journal of Multimodal User Interfaces*, 14, 373–385. <https://doi.org/10.1007/s12193-020-00343-x>
- Terblanche, W., Fakir, D., Chinyamurindi, W., & Mish, S. (2021). Impact of self-esteem and student-and-lecturer interaction on academic performance in a chartered accounting programme. *Journal of Further and Higher Education*, 45(4), 464-480. <https://doi.org/10.1080/0309877X.2020.1781801>
- Timotheou, S., Miliou, O., Dimitriadis, Y. et al. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, 28, 6695–6726. <https://doi.org/10.1007/s10639-022-11431-8>
- Vats, S., & Joshi, R. (2024). The impact of virtual reality in education: A comprehensive research study. In Sharma, S. K., Dwivedi, Y. K., Metri, B., Lal, B., Elbanna, A. (Eds.), *IFIP Advances in Information and Communication Technology: Vol. 699. Transfer, Diffusion and Adoption of Next-Generation Digital Technologies* (pp. 126-136). Springer. https://doi.org/10.1007/978-3-031-50204-0_11
- Veerasamy, A. K., D'Souza, D., Lindén, R., & Laakso, M-J. (2018). Relationship between perceived problem-solving skills and academic performance of novice learners in introductory programming courses. *Journal of Computer Assisted Learning*, 35(2), 246-255. <https://doi.org/10.1111/jcal.12326>
- Velev, D., & Zlateva, P. (2017). Virtual reality challenges in education and training. *International Journal of Learning and Teaching*, 3(1), 33–37. <https://doi.org/10.18178/ijlt.3.1.33-37>
- Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273-315. <https://doi.org/10.1111/j.1540-5915.2008.00192.x>
- Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 46(2), 186-204. <https://doi.org/10.1287/mnsc.46.2.186.11926>
- Wang Y-P. (2021). Effects of online problem-solving instruction and identification attitude toward instructional strategies on students' creativity. *Frontiers in Psychology*, 12, 1-6. <https://doi.org/10.3389/fpsyg.2021.771128>

- Wang, Y., Liu, W., Meng, X., Fu, H., et al. (2016). Development of an immersive virtual reality head-mounted display with high performance. *Applied Optics*, 55(25), 6969–6977. <https://doi.org/10.1364/AO.55.006969>
- Willford, J.C. (2020). Problem-solving. In Zeigler-Hill,V., Shackelford, T. K. (Eds.). *Encyclopedia of Personality and Individual Differences*. Springer. https://doi.org/10.1007/978-3-319-24612-3_993
- 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>
- Wu, W. C. V., Manabe, K., Marek, M. W., & Shu, Y. (2021). Enhancing 21st-century competencies via virtual reality digital content creation. *Journal of Research on Technology in Education*, 55(3), 388–410. <https://doi.org/10.1080/15391523.2021.1962455>
- Wu, W.L., Hsu, Y., Yang, Q.-F., & Chen, J.J. (2021). A spherical video-based immersive virtual reality learning system to support landscape architecture students' learning performance during the COVID-19 era. *Land*, 10(6), 1-23. <https://doi.org/10.3390/land10060561>
- Wu, X. (2023). A review of virtual reality technology. *Applied and Computational Engineering*, 38, 1-6. <https://doi.org/10.54254/2755-2721/38/20230521>
- Yim, K.H., Nahm, F.S., Han, K.A., & Park, S.Y. (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>
- Zaineldeen, S., Li, H., Koffi, A. L., & Mohammed, B. (2020). Technology acceptance model' concepts, contribution, limitation, and adoption in education. *Universal Journal of Educational Research*, 8(11), 5061-5071. <https://doi.org/10.13189/ujer.2020.081106>
- Zhao, R., Chu, Q., & Chen, D. (2022). Exploring chemical reactions in virtual reality. *Journal of Chemical Education*, 99(4), 1635-1641. <https://doi.org/10.1021/acs.jchemed.1c01040>
- Zhou, Y., Zhu, Y., Wong, W. K. (2023). Statistical tests for homogeneity of variance for clinical trials and recommendations. *Contemporary Clinical Trials Communications*, 33, 1-11. <https://doi.org/10.1016/j.conctc.2023.101119>
- Zikmund et al. (2010). *Business Research Method* 8th edition.
- Zumdahl, S. S., & Zumdahl, S. A. (2018). *Chemistry* (10th ed.). Cengage Learning.