

DAFTAR PUSTAKA

- Adıgüzel, T., Aşık, G., Bulut, M. A., Kaya, M. H., & Özel, S. (2023). Teaching self-regulation through role modeling in K-12. *Frontiers in Education*, 8, 1–14. <https://doi.org/10.3389/feduc.2023.1105466>
- Al-Duhani, F., Saat, R. M., & Abdullah, M. N. S. (2024). Effectiveness of web-based virtual laboratory on grade eight students' self-regulated learning. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(3), 1–20. <https://doi.org/10.29333/ejmste/14282>
- Alenezi, M., Wardat, S., & Akour, M. (2023). The need of integrating digital education in higher education: Challenges and opportunities. *Sustainability (Switzerland)*, 15(6), 1–12. <https://doi.org/10.3390/su15064782>
- Alvi, E., & Gillies, R. M. (2020). Teachers and the teaching of self-regulated learning (srl): The emergence of an integrative, ecological model of srl-in-context. *Education Sciences*, 10(4). <https://doi.org/10.3390/educsci10040098>
- Amirbekova, E., Shertayeva, N., & Mironova, E. (2023). Teaching chemistry in the metaverse: The effectiveness of using virtual and augmented reality for visualization. *Frontiers in Education*, 8, 1–9. <https://doi.org/10.3389/feduc.2023.1184768>
- Araiza-Alba, P., Keane, T., Chen, W. S., & Kaufman, J. (2021). Immersive virtual reality as a tool to learn problem-solving skills. *Computers and Education*, 164, 104121. <https://doi.org/10.1016/j.compedu.2020.104121>
- Archer, L., Francis, B., Moote, J., Watson, E., Henderson, M., Holmegaard, H., & MacLeod, E. (2023). Reasons for not/choosing chemistry: Why advanced level chemistry students in England do/not pursue chemistry undergraduate degrees. *Journal of Research in Science Teaching*, 60(5), 978–1013. <https://doi.org/10.1002/tea.21822>
- Bamiro, A. O. (2015). Effects of guided discovery and think-pair-share strategies on secondary school students' achievement in chemistry. *SAGE Open*, 5(1). <https://doi.org/10.1177/2158244014564754>
- Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, 50(2), 248–287. [https://doi.org/10.1016/0749-5978\(91\)90022-L](https://doi.org/10.1016/0749-5978(91)90022-L)
- Bandura, A. (1999). Social cognitive theory: Theories of personality. In *Handbook of Personality* (2nd ed., pp. 154–196). Guilford Publications.
- Barnard, L., Lan, W. Y., To, Y. M., Paton, V. O., & Lai, S. L. (2009). Measuring self-regulation in online and blended learning environments. *Internet and Higher Education*, 12(1), 1–6. <https://doi.org/10.1016/j.iheduc.2008.10.005>
- Bereiter, C. (1994). Constructivism, socioculturalism, and Popper's world 3. *Educational Research*, 23(7), 21–23. <https://doi.org/https://doi.org/10.2307/1176935>

- Berrones-Yaulema, L. P., & Buenaño-Barreno, P. N. (2023). ChatGPT in the educational field. *Esprint Investigación*, 2(2), 45–54.
- Best, J. W., & Kahn, J. V. (2006). *Research in education* (10th ed.). Pearson Education Inc.
- Birt, J., Moore, E., & Cowling, M. (2017). Improving paramedic distance education through mobile mixed reality simulation. *Australasian Journal of Educational Technology*, 33(6), 69–83. <https://doi.org/10.14742/ajet.3596>
- Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research*, 31(6), 445–457. [https://doi.org/10.1016/S0883-0355\(99\)00014-2](https://doi.org/10.1016/S0883-0355(99)00014-2)
- Boesdorfer, S. B. (2019). Growing teachers and improving chemistry learning: How best practices in chemistry teacher education can enhance chemistry education [Chapter]. *ACS Symposium Series*, 1335, 1–6. <https://doi.org/10.1021/bk-2019-1335.ch001>
- Campos, E., Hidrogo, I., & Zavala, G. (2022). Impact of virtual reality use on the teaching and learning of vectors. *Frontiers in Education*, 7, 1–15. <https://doi.org/10.3389/feduc.2022.965640>
- Cao, L. (2024). A study of project-based learning to intermediate EFL learners in reading class: enhancing self-regulated learning of post-secondary students in Macao. *Asian-Pacific Journal of Second and Foreign Language Education*, 9(1). <https://doi.org/10.1186/s40862-024-00298-6>
- Cardellini, L. (2012). Chemistry: Why the subject is difficult? *Educacion Quimica*, 23, 305–310. [https://doi.org/10.1016/S0187-893X\(17\)30158-1](https://doi.org/10.1016/S0187-893X(17)30158-1)
- Cents-Boonstra, M., Lichtwarck-Aschoff, A., Denessen, E., Aelterman, N., & Haerens, L. (2021). 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>
- Chang, R. (2005). *Kimia dasar: Konsep-konsep inti* (3rd ed.). Erlangga.
- Cheng, K. H., & Tsai, C. C. (2020). Students' motivational beliefs and strategies, perceived immersion and attitudes towards science learning with immersive virtual reality: A partial least squares analysis. *British Journal of Educational Technology*, 51(6), 2139–2158. <https://doi.org/10.1111/bjet.12956>
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.
- Consoli, T., Schmitz, M. L., Antonietti, C., Gonon, P., Cattaneo, A., & Petko, D. (2024). Quality of technology integration matters: Positive associations with students' behavioral engagement and digital competencies for learning. *Education and Information Technologies*, 30(6), 7719–7752. <https://doi.org/10.1007/s10639-024-13118-8>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications, Inc.

- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97–140. <https://doi.org/10.1080/10888691.2018.1537791>
- David, L., & Weinstein, N. (2024). Using technology to make learning fun: Technology use is best made fun and challenging to optimize intrinsic motivation and engagement. *European Journal of Psychology of Education*, 39(2), 1441–1463. <https://doi.org/10.1007/s10212-023-00734-0>
- Ding, A. C. E., Huang, K. T. T., DuBois, J., & Fu, H. (2024). Integrating immersive virtual reality technology in scaffolded game-based learning to enhance low motivation students' multimodal science learning. *Educational Technology Research and Development*, 72(4), 2083–2102. <https://doi.org/10.1007/s11423-024-10369-7>
- Dolfing, R., Bulte, A. M. W., Pilot, A., & Vermunt, J. D. (2012). Domain-specific expertise of chemistry teachers on context-based education about macro-micro thinking in structure-property relations. *Research in Science Education*, 42(3), 567–588. <https://doi.org/10.1007/s11165-011-9211-z>
- Dunmoye, I. D., Martin, J. P., Brown, J. S., Fakiyesi, V. O., Moyaki, D., & May, D. (2024). Exploring engineering student's self-regulatory strategies in collaborative virtual reality learning environments: Preliminary findings from a land- surveying task. *2024 IEEE Frontiers in Education Conference (FIE)*, 1–5. <https://doi.org/10.1109/FIE61694.2024.10892977>
- Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2017). Virtual laboratories in science education: Students' motivation and experiences in two tertiary biology courses. *Journal of Biological Education*, 51(4), 358–374. <https://doi.org/10.1080/00219266.2016.1257498>
- Ferrell, J. B., Campbell, J. P., McCarthy, D. R., McKay, K. T., Hensinger, M., Srinivasan, R., Zhao, X., Wurthmann, A., Li, J., & Schneebeil, S. T. (2019). Chemical exploration with virtual reality in organic teaching laboratories. *Journal of Chemical Education*, 96(9), 1961–1966. <https://doi.org/10.1021/acs.jchemed.9b00036>
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). McGraw-Hill.
- Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. *11th International Conference ELearning and Software for Education*, 1, 133–141. <https://doi.org/10.12753/2066-026x-15-020>
- Grover, S., Pea, R., & Cooper, S. (2015). Designing for deeper learning in a blended computer science course for middle school students. *Computer Science Education*, 25(2), 199–237. <https://doi.org/10.1080/08993408.2015.1033142>
- Gu, P., & Lee, Y. (2019). Promoting students' motivation and use of SRL strategies in the web-based mathematics learning environment. *Journal of Educational*

- Technology Systems*, 47(3), 391–410.
<https://doi.org/10.1177/0047239518808522>
- Guerra-Tamez, C. R. (2023). The impact of immersion through virtual reality in the learning experiences of art and design students: The mediating effect of the flow experience. *Education Sciences*, 13(2).
<https://doi.org/10.3390/educsci13020185>
- Gungor, A., Kool, D., Lee, M., Avraamidou, L., Eisink, N., Albada, B., van der Kolk, K., Tromp, M., & Bitter, J. H. (2022). The use of virtual reality in a chemistry lab and its impact on students' self-efficacy, interest, self-concept and laboratory anxiety. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(3), 1–13. <https://doi.org/10.29333/ejmste/11814>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Multivariate Data Analysis. In *International Journal of Multivariate Data Analysis* (7th ed.). Pearson Education Limited.
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Hammer, D. (1997). Discovery learning and discovery teaching. *Cognition and Instruction*, 15(4), 485–529. https://doi.org/10.1207/s1532690xcil504_2
- Hasija, Y. (2023). Statistical methods in bioinformatics. In Y. Hasija (Ed.), *All About Bioinformatics* (pp. 43–75). Academic Press.
<https://doi.org/https://doi.org/10.1016/B978-0-443-15250-4.00009-5>
- Hayes, A. F. (2005). *Statistical methods for communication science* (1st ed.). Routledge.
- Helate, T. H., Metaferia, T. F., & Gezahegn, T. H. (2022). English language teachers' engagement in and preference for experiential learning for professional development. *Heliyon*, 8(10), e10900.
<https://doi.org/10.1016/j.heliyon.2022.e10900>
- Hermanns, J., & Schmidt, B. (2019). Developing and applying stepped supporting tools in organic chemistry to promote students' self-regulated learning. *Journal of Chemical Education*, 96(1), 47–52.
<https://doi.org/10.1021/acs.jchemed.8b00565>
- Hu-Au, E., & Okita, S. (2021). Exploring differences in student learning and behavior between real-life and virtual reality chemistry laboratories. *Journal of Science Education and Technology*, 30(6), 862–876.
<https://doi.org/10.1007/s10956-021-09925-0>
- Javaid, M., Haleem, A., Singh, R. P., & Dhall, S. (2024). Role of virtual reality in advancing education with sustainability and identification of additive manufacturing as its cost-effective enabler. *Sustainable Futures*, 8, 100324.
<https://doi.org/10.1016/j.sfr.2024.100324>
- Jayalath, K. P., Keung, H., Ng, T., Manage, A. B., & Riggs, K. E. (2017). Improved

tests for homogeneity of variances. *Communications in Statistics-Simulation and Computation*, 46(9), 7423–7446.

Jegstad, K. M. (2024). Inquiry-based chemistry education: A systematic review. *Studies in Science Education*, 60(2), 251–313. <https://doi.org/10.1080/03057267.2023.2248436>

Jemberie, L. W. (2021). Teachers' perception and implementation of constructivist learning approaches: Focus on Ethiopian Institute of textile and fashion technology, Bahir Dar. *Cogent Education*, 8(1). <https://doi.org/10.1080/2331186X.2021.1907955>

Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, 23(4), 1515–1529. <https://doi.org/10.1007/s10639-017-9676-0>

Jin, S. H., Im, K., Yoo, M., Roll, I., & Seo, K. (2023). Supporting students' self-regulated learning in online learning using artificial intelligence applications. *International Journal of Educational Technology in Higher Education*, 20(1). <https://doi.org/10.1186/s41239-023-00406-5>

Jong, M. S. Y., Tsai, C. C., Xie, H., & Kwan-Kit Wong, F. (2020). Integrating interactive learner-immersed video-based virtual reality into learning and teaching of physical geography. *British Journal of Educational Technology*, 51(6), 2063–2078. <https://doi.org/10.1111/bjet.12947>

Kara, A., Ergulec, F., & Eren, E. (2024). The mediating role of self-regulated online learning behaviors: Exploring the impact of personality traits on student engagement. *Education and Information Technologies*, 29(17), 23517–23546. <https://doi.org/10.1007/s10639-024-12755-3>

Karabulut, H., Gökçe, H., & Kariper, İ. A. (2024). Implementation of discovery learning-based STEM education with hands-on activities in distance education. *Innovations in Education and Teaching International*, 62(2), 594–611. <https://doi.org/10.1080/14703297.2024.2327833>

Keller, C., Walker, G., Amenduni, F., Tela, A., & Cattaneo, A. (2025). Find the apartment's flaws! The impact of virtual reality on vocational students' performance in general education classes and the roles of flow experience, motivation, and sense of presence. *Education and Information Technologies*, 0123456789. <https://doi.org/10.1007/s10639-025-13320-2>

Kemendikbudristek. (2022). *Capaian pembelajaran mata pelajaran kimia fase E dan fase f untuk SMA/MA/Program Paket C*. Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.

Khukalenko, I. S., Kaplan-Rakowski, R., An, Y., & Iushina, V. D. (2022). Teachers' perceptions of using virtual reality technology in classrooms: A large-scale survey. *Education and Information Technologies*, 27, 11591–11613. <https://doi.org/https://doi.org/10.1007/s10639-022-11061-0>

Lamb, R. (2022). Virtual reality and science, technology, engineering, and

- mathematics education. *International Encyclopedia of Education: Fourth Edition*, 11, 189–197. <https://doi.org/10.1016/B978-0-12-818630-5.13075-1>
- León, J., Núñez, J. L., & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement. *Learning and Individual Differences*, 43, 156–163. <https://doi.org/10.1016/j.lindif.2015.08.017>
- Lin, C. Y., & Wu, H. K. (2021). Effects of different ways of using visualizations on high school students' electrochemistry conceptual understanding and motivation towards chemistry learning. *Chemistry Education Research and Practice*, 22(3), 786–801. <https://doi.org/10.1039/d0rp00308e>
- Lin, X. P., Li, B. Bin, Yao, Z. N., Yang, Z., & Zhang, M. (2024). The impact of virtual reality on student engagement in the classroom—a critical review of the literature. *Frontiers in Psychology*, 15, 1–8. <https://doi.org/10.3389/fpsyg.2024.1360574>
- Liu, C., Meng, S., Zheng, W., & Zhou, Z. (2025). Research on the impact of immersive virtual reality classroom on student experience and concentration. *Virtual Reality*, 29(2). <https://doi.org/10.1007/s10055-025-01153-w>
- Liu, Z., Yu, P., Liu, J., Pi, Z., & Cui, W. (2023). How do students' self-regulation skills affect learning satisfaction and continuous intention within desktop-based virtual reality? A structural equation modelling approach. *British Journal of Educational Technology*, 54(3), 667–685. <https://doi.org/10.1111/bjet.13278>
- Lo, S. C., & Tsai, H. H. (2022). Design of 3D virtual reality in the metaverse for environmental conservation education based on cognitive theory. *Sensors*, 22(21), 1–20. <https://doi.org/10.3390/s22218329>
- Lopez, M., Arriaga, J. G. C., Nigenda Álvarez, J. P., González, R. T., Elizondo-Leal, J. A., Valdez-García, J. E., & Carrión, B. (2021). Virtual reality vs traditional education: Is there any advantage in human neuroanatomy teaching? *Computers and Electrical Engineering*, 93. <https://doi.org/10.1016/j.compeleceng.2021.107282>
- Lowell, V. L., & Tagare, D. (2023). Authentic learning and fidelity in virtual reality learning experiences for self-efficacy and transfer. *Computers & Education: X Reality*, 2, 100017. <https://doi.org/10.1016/j.cexr.2023.100017>
- Maeyer, J., & Talanquer, V. (2013). Making predictions about chemical reactivity: Assumptions and heuristics. *Journal of Research in Science Teaching*, 50(6), 748–767. <https://doi.org/10.1002/tea.21092>
- Majewska, A. A., & Vereen, E. (2023). Using immersive virtual reality in an online biology course. *Journal for STEM Education Research*, 6(3), 480–495. <https://doi.org/10.1007/s41979-023-00095-9>
- Manyilizu, M. C. (2023). Effectiveness of virtual laboratory vs. paper-based experiences to the hands-on chemistry practical in Tanzanian secondary schools. *Education and Information Technologies*, 28(5), 4831–4848.

<https://doi.org/10.1007/s10639-022-11327-7>

- Marougkas, 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 (Switzerland)*, 12(13). <https://doi.org/10.3390/electronics12132832>
- Martin, H., Craigwell, R., & Ramjarrie, K. (2022). Grit, motivational belief, self-regulated learning (SRL), and academic achievement of civil engineering students. *European Journal of Engineering Education*, 47(4), 535–557. <https://doi.org/10.1080/03043797.2021.2021861>
- Martins van Jaarsveld, G., Wong, J., Baars, M., Specht, M., & Paas, F. (2024). Goal setting in higher education: how, why, and when are students prompted to set goals? A systematic review. *Frontiers in Education*, 9, 1–17. <https://doi.org/10.3389/feduc.2024.1511605>
- Matovu, H., Ungu, D. A. K., 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>
- Matsuyama, Y., Nakaya, M., Okazaki, H., Lebowitz, A. J., Leppink, J., & Van Der Vleuten, C. (2019). Does changing from a teacher-centered to a learner-centered context promote self-regulated learning: A qualitative study in a Japanese undergraduate setting. *BMC Medical Education*, 19(1), 1–12. <https://doi.org/10.1186/s12909-019-1550-x>
- Meer, N. Van Der, & Werf, V. Van Der. (2023). Virtual reality and collaborative learning: a systematic literature review. *Virtual Reality*, 4, 1–16. <https://doi.org/10.3389/frvir.2023.1159905>
- 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 and Education*, 70, 29–40. <https://doi.org/10.1016/j.compedu.2013.07.033>
- Meyer, O. A., Omdahl, M. K., & Makransky, G. (2019). Investigating the effect of pre-training when learning through immersive virtual reality and video: A media and methods experiment. *Computers and Education*, 140, 103603. <https://doi.org/10.1016/j.compedu.2019.103603>
- Mishra, P., Pandey, C. M., & Singh, U. (2019). Descriptive statistics and normality tests for statistical data. *Ann Card Anaesth*, 22(1), 67–72. <https://doi.org/10.4103/aca.ACA>
- Morris, S. B. (2008). Estimating effect sizes from pretest-posttest-control group designs. *Organizational Research Methods*, 11(2), 364–386. <https://doi.org/10.1177/1094428106291059>
- Muijs, D., & Bokhove, C. (2020). Metacognition and self-regulation: Evidence review. In *Educational Endowment Foundation*. Educational Endowment Foundation.

- Mukherjee, A. (2015). Effective use of discovery learning to improve understanding of factors that affect quality. *Journal of Education for Business*, 90(8), 413–419. <https://doi.org/10.1080/08832323.2015.1081866>
- Navas-Bonilla, C. del R., Guerra-Arango, J. A., Oviedo-Guado, D. A., & Murillo-Noriega, D. E. (2025). Inclusive education through technology: A systematic review of types, tools and characteristics. *Frontiers in Education*, 10, 1–22. <https://doi.org/10.3389/feduc.2025.1527851>
- Neber, H. (2012). Discovery learning. In *Encyclopedia of the Sciences of Learning*. Springer Science & Business Media. https://doi.org/https://doi.org/10.1007/978-1-4419-1428-6_1307
- Nzomo, C., Rugano, P., Njoroge Mungai, J., & Gitonga Muriithi, C. (2023). Inquiry-based learning and students' self-efficacy in chemistry among secondary schools in Kenya. *Heliyon*, 9(1). <https://doi.org/10.1016/j.heliyon.2022.e12672>
- Olusegun, B. S. (2015). The psychogenesis of knowledge and its epistemological significance. *Journal of Research and Method in Education*, 5(6), 23–34. <https://doi.org/10.9790/7388-05616670>
- Otgon, J. (2023). The study of the relationship between students' self-assessment and their attitudes towards learning. *Proceedings of the Quality Assurance in Higher Education International Conference (QAHE 2022)*, 121–129. <https://doi.org/10.2991/978-2-494069-41-1>
- Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, 8(422), 1–28. <https://doi.org/10.3389/fpsyg.2017.00422>
- Pappas, C. (2014). *Instructional design models and theories: The discovery learning model*. ELearning Industry. <https://elearningindustry.com/discovery-learning-model>
- Parra-Frutos, I. (2009). The behaviour of the modified Levene's test when data are not normally distributed. *Computational Statistics*, 24(4), 671–693. <https://doi.org/10.1007/s00180-009-0154-z>
- Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In *Handbook of Self-Regulation* (pp. 451–502). <https://doi.org/10.1016/b978-012109890-2/50043-3>
- 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), 489–497. <https://doi.org/10.1002/nur>
- Polit, D. F., Beck, T., & Owen, S. V. (2007). Focus on research methods is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research in Nursing & Health*, 30, 459–467. <https://doi.org/10.1002/nur>
- Profillidis, V. A., & Botzoris, G. N. (2019). Statistical methods for transport demand modeling. In *Modeling of Transport Demand* (pp. 163–224).

<https://doi.org/10.1016/b978-0-12-811513-8.00005-4>

- Protopsaltis, S., & Baum, S. (2019). Does online education live up to its promise? A look at the evidence and implications for federal policy. *The Laura and John Arnold Foundation*, 1(January 2019), 1–52. <https://jesperbalslev.dk/wp-content/uploads/2020/09/OnlineEd.pdf>
- 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 and Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Radović, S., Seidel, N., Menze, D., & Kasakowskij, R. (2024). Investigating the effects of different levels of students' regulation support on learning process and outcome: In search of the optimal level of support for self-regulated learning. *Computers and Education*, 215, 105041. <https://doi.org/10.1016/j.compedu.2024.105041>
- Rafanan, R. J. L., De Guzman, C. Y., & Rogayan, D. V. (2020). Pursuing stem careers: Perspectives of senior high school students. *Participatory Educational Research*, 7(3), 38–58. <https://doi.org/10.17275/per.20.34.7.3>
- Ramsurrun, H., Elaheebocus, R., & Chiniah, A. (2024). Decline in enrollment in science and technology education: From the perspectives of Mauritian educators. *STEM Education*, 5(1), 1–18. <https://doi.org/10.3934/steme.2025001>
- Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student ' s motivation in high school and higher education: A systematic review. *Heliyon*, 9(8), e19033. <https://doi.org/10.1016/j.heliyon.2023.e19033>
- Raymer, E., MacDermott, Á., & Akinbi, A. (2023). Virtual reality forensics: Forensic analysis of Meta Quest 2. *Forensic Science International: Digital Investigation*, 47, 1–10. <https://doi.org/10.1016/j.fsidi.2023.301658>
- Reginald, G. (2023). Teaching and learning using virtual labs: Investigating the effects on students' self-regulation. *Cogent Education*, 10(1). <https://doi.org/10.1080/2331186X.2023.2172308>
- Rojas-Sánchez, M. A., Palos-Sánchez, P. R., & Folgado-Fernández, J. A. (2023). Systematic literature review and bibliometric analysis on virtual reality and education. In *Education and Information Technologies* (Vol. 28, Issue 1). Springer US. <https://doi.org/10.1007/s10639-022-11167-5>
- Salkind, N. J. (2007). Pearson product-moment correlation coefficient. In *Encyclopedia of measurement and statistics* (pp. 751–755). Sage Publications, Inc. <https://doi.org/https://doi.org/10.4135/9781412952644>
- Shariff, S. B. M., & Shah, P. M. (2019). Pupils perception of using YouTube and autonomous learning. *Creative Education*, 10(13), 3509–3520. <https://doi.org/10.4236/ce.2019.1013270>
- Shatz, I. (2024). Assumption-checking rather than (just) testing: The importance of

- visualization and effect size in statistical diagnostics. *Behavior Research Methods*, 56(2), 826–845. <https://doi.org/10.3758/s13428-023-02072-x>
- Shechtman, N., DeBarger, A. H., Dornsife, C., Rosier, S., & Yarnall, L. (2013). Promoting grit, tenacity, and perseverance: Critical factors for success in the 21st century, annual review of psychology. In *US Department of Education, Department of Educational Technology*. US Department of Education, Department of Educational Technology.
- Shrotryia, V. K., & Dhanda, U. (2019). Content validity of assessment instrument for employee engagement. *SAGE Open*, 1–7. <https://doi.org/10.1177/2158244018821751>
- Singh, G., Mantri, A., Sharma, O., & Kaur, R. (2021). Virtual reality learning environment for enhancing electronics engineering laboratory experience. *Computer Applications in Engineering Education*, 29(1), 229–243. <https://doi.org/10.1002/cae.22333>
- Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. *Frontiers Robotics AI*, 3(DEC), 1–47. <https://doi.org/10.3389/frobt.2016.00074>
- Smutny, P. (2023). Learning with virtual reality: A market analysis of educational and training applications. *Interactive Learning Environments*, 31(10), 6133–6146. <https://doi.org/10.1080/10494820.2022.2028856>
- Statista Search Department. (2025). *Forecast user base of the augmented and virtual reality (VR) software market worldwide in 2020 and 2025, by segment*. Statista. <https://www.statista.com/statistics/610126/worldwide-forecast-augmented-and-mixed-reality-software-users-by-segment/>
- Staus, N. L., Falk, J. H., Penuel, W., Dierking, L., Wyld, J., & Bailey, D. (2020). Interested, disinterested, or neutral: Exploring STEM interest profiles and pathways in a low-income urban community. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(6), 1–14. <https://doi.org/10.29333/EJMSTE/7927>
- Stavridou, H., & Solomonidou, C. (1998). Conceptual reorganization and the construction of the chemical reaction concept during secondary education. *International Journal of Science Education*, 20(2), 205–221. <https://doi.org/10.1080/0950069980200206>
- Svinicki, M. D. (1998). A theoretical foundation for discovery learning. *The American Journal of Physiology*, 275(6), 20–23. <https://doi.org/10.1152/advances.1998.275.6.s4>
- Taber, K. S. (2009). Learning at the symbolic level. In *Multiple Representations in Chemical Education* (pp. 75–105). Springer. https://doi.org/10.1007/978-1-4020-8872-8_5
- Takaya, K. (2008). Jerome Bruner's theory of education: From early Bruner to later Bruner. *Interchange*, 39(1), 1–19. <https://doi.org/10.1007/s10780-008-9039-2>

- Tang, Y. M., Au, K. M., Lau, H. C. W., Ho, G. T. S., & Wu, C. H. (2020). Evaluating the effectiveness of learning design with mixed reality (MR) in higher education. *Virtual Reality*, 24(4), 797–807. <https://doi.org/10.1007/s10055-020-00427-9>
- UNESCO. (2024). *Unleashing innovation: Embracing digital transformation in education in Indonesia*. <https://www.unesco.org/en/articles/unleashing-innovation-embracing-digital-transformation-education-indonesia>
- Uttley, J. (2019). The journal of the illuminating engineering society power analysis, sample size, and assessment of statistical assumptions — Improving the evidential value of lighting research. *LEUKOS - Journal of Illuminating Engineering Society of North America*, 1–20. <https://doi.org/10.1080/15502724.2018.1533851>
- van Dinther, R., de Putter, L., & 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>
- Van Driel, J. H., De Vos, W., Verloop, N., & Dekkers, H. (1998). Developing secondary students' conceptions of chemical reactions: The introduction of chemical equilibrium. *International Journal of Science Education*, 20(4), 379–392. <https://doi.org/10.1080/0950069980200401>
- Wang, P., Wu, P., Wang, J., Chi, H. L., & Wang, X. (2018). A critical review of the use of virtual reality in construction engineering education and training. *International Journal of Environmental Research and Public Health*, 15(6), 1–18. <https://doi.org/10.3390/ijerph15061204>
- Wang, Q. J., Barbosa Escobar, F., Alves Da Mota, P., & Velasco, C. (2021). Getting started with virtual reality for sensory and consumer science: Current practices and future perspectives. *Food Research International*, 145, 110410. <https://doi.org/10.1016/j.foodres.2021.110410>
- Wang, W.-S., Pedaste, M., Lin, C.-J., Lee, H.-Y., Huang, Y.-M., & Wu, T.-T. (2024). Signaling feedback mechanisms to promoting self-regulated learning and motivation in virtual reality transferred to real-world hands-on tasks. *Interactive Learning Environments*, 1–16. <https://doi.org/10.1080/10494820.2024.2331151>
- Wang, W. S., Lee, H. Y., Lin, C. J., Li, P. H., Huang, Y. M., & Wu, T. T. (2024). Enhancing students' learning outcomes in self-regulated virtual reality learning environment with learning aid mechanisms. *British Journal of Educational Technology*, 56, 366–387. <https://doi.org/10.1111/bjet.13512>
- Wang, X., Hsu, Y., Xu, R., Zhang, Z., & Fan, D. (2025). Ease over effort: achieving consistent learning outcomes through a more relaxed approach in immersive virtual reality for hands-on education. *Interactive Learning Environments*, 1–19. <https://doi.org/https://doi.org/10.1080/10494820.2025.2479179>
- Wesarg-Menzel, C., Ebbes, R., Hensums, M., Wagemaker, E., Zaharieva, M. S., Staaks, J. P. C., van den Akker, A. L., Visser, I., Hoeve, M., Brummelman, E.,

- Dekkers, T. J., Schuitema, J. A., Larsen, H., Colonnaesi, C., Jansen, B. R. J., Overbeek, G., Huizenga, H. M., & Wiers, R. W. (2023). Development and socialization of self-regulation from infancy to adolescence: A meta-review differentiating between self-regulatory abilities, goals, and motivation. *Developmental Review*, 69, 101090. <https://doi.org/10.1016/j.dr.2023.101090>
- Wolters, C. A., Pintrich, P. R., & Karabenick, S. A. (2003). *Assessing academic self-regulated learning*. https://doi.org/10.1007/0-387-23823-9_16
- Won, M., Mocerino, M., Tang, K., Treagust, D. F., & Tasker, R. (2019). Interactive immersive virtual reality to enhance students' visualisation of complex molecules. In *Research and Practice in Chemistry Education: Advances from the 25th IUPAC International Conference on Chemistry Education 2018* (pp. 51–64). Springer Singapore. <https://doi.org/10.1007/978-981-13-6998-8>
- Wu, M., Sun, D., Yang, Y., Li, M., & Sun, J. (2023). Investigating students' performance at self-regulated learning and its effects on learning outcomes in chemistry class at the senior secondary school. *International Journal of Science Education*, 45(16), 1395–1418. <https://doi.org/10.1080/09500693.2023.2209693>
- Wu, W. L., Hsu, Y., Yang, Q. F., Chen, J. J., & Jong, M. S. Y. (2023). Effects of the self-regulated strategy within the context of spherical video-based virtual reality on students' learning performances in an art history class. *Interactive Learning Environments*, 31(4), 2244–2267. <https://doi.org/10.1080/10494820.2021.1878231>
- Yang, H., Cai, M., Diao, Y., Liu, R., Liu, L., & Xiang, Q. (2023). How does interactive virtual reality enhance learning outcomes via emotional experiences? A structural equation modeling approach. *Frontiers in Psychology*, 13, 1–16. <https://doi.org/10.3389/fpsyg.2022.1081372>
- Žammit, J. (2023). Exploring the effectiveness of Virtual Reality in teaching Maltese. *Computers & Education: X Reality*, 3, 100035. <https://doi.org/10.1016/j.cexr.2023.100035>
- Zheng, B., & Zhang, Y. (2020). Self-regulated learning: The effect on medical student learning outcomes in a flipped classroom environment. *BMC Medical Education*, 20(1), 1–7. <https://doi.org/10.1186/s12909-020-02023-6>
- Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2010). *Business research methods* (8th ed.). South Western Cengage Learning.
- Zimmerman, B. J. (2000). Attaining self-regulation : A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 13–39). Academic Press.
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2
- Zou, 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. <https://doi.org/10.3389/feduc.2025.1562391>