JPPIPA 9(8) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Current Trend of Artificial Intelligence-Augmented Reality in Science Learning: Systematic Literature Review

Dona Budi Kharisma[1], Sudirman Sudirman[2*], Firman Edi[3], Ruth Rize Paas Megahati S[4]

[1] Faculty of Law, Universitas Sebelas Maret, Surakarta, Indonesia.
[2] Department of Physics Education, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Alauddin Makassar, Indonesia.
[3] Engineering Management Study Program, Faculty of Industrial Technology, Institut Teknologi Batam, Batam, Indonesia.
[4] Medical Laboratory Engineering Study Program, Kesuma Bangsa Health Polytechnic, Bandar Lampung, Indonesia.

Received: June 28, 2023
Revised: July 4, 2023
Accepted: August 25, 2023
Published: August 31, 2023

Corresponding Author:
Sudirman Sudirman
sudirman.raja@uin-alauddin.ac.id

DOI: 10.29303/jppipa.v9i8.4484

Abstract: Technologies enable organizations to support and improve knowledge management practices. First, it will be easier to define augmented and virtual reality concepts to better understand them. Artificial Intelligence technology enables organizations to support and improve knowledge management practices. The research aims to explain the current trend of artificial intelligence-augmented reality in science learning. A review is conducted on the state-of-the-art methods using the preferred reporting items for reviews and meta-analyses (PRISMA) guidelines. An innovation in educational technology to support learning is the existence of AI technology. Technology may speed up education when used wisely and responsibly. The development of artificial intelligence technology can help pupils become more independent. The teacher does not have to play such a dominant role, but his responsibilities are laid out in the context of offering illumination through significant keywords. The basis for every use of technology for teachers is to continue to prioritize the essence of teaching, namely managing the morale and behavior of students.

Keywords: Artificial intelligence; ChatGPT; Industrial revolution 4.0; Learning media

Introduction

Learning science is not just mastering a set of knowledge in the form of facts, concepts, principles, or theories, but learning will be more meaningful if students experience what they are learning, therefore educators have struggled in every way by trying to make what students learn at school so that they can use it in their daily lives. Augmented reality and virtual reality are technologies that have been researched for several years (Al-Ansi et al., 2023). Even so, several products have been developed in the line and are accessible to the general public. However, due to societal needs and variations, this technology has stagnated in certain areas. It is therefore important to know the evolution of the research they have carried out in recent years and, thanks to that, to study current trends to anticipate the areas where they will be applied in the coming years.

The Knowledge Age, sometimes referred to as Era 4.0, is one in which more knowledge-based alternatives are used to meet demands in many situations. both in the industrial sector and in the domains of education, the economy, society, and politics. The advent of computer science and technology served as the catalyst for this. They stand out as particularly effective learning and training tools in both education and business, leading to more effective, interactive, and participatory learning. Given the evolving educational landscape, technology must now be considered an enabler for learning media sets. Tools for various applications have been developed, both hardware and software standards have been made available to the general public for various learning purposes (Kamińska et al., 2019). Therefore, the use of technology in the learning process should be accepted as something of value in all educational institutions.

How to Cite:
Kharisma, D. B., Sudirman, S., Edi, F., & S, R. R. P. M. (2023). Current Trend of Artificial Intelligence-Augmented Reality in Science Learning: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 404–410. https://doi.org/10.29303/jppipa.v9i8.4484

The demand for the use of technology in educational facilities has given rise to new groups who have different values, cultures, perspectives and beliefs, and intelligence toward technology. This new group is known as Millennial Generation which creates a lot of difficulties for instructors because it tends towards learning that combines data through frameworks that incorporate images, symbols, sounds, videos, complex creative activities, diversions, and complex artificial intelligence. The birth of the millennial generation is one of the reasons we have to change our vision in the field of education, namely creating new learning to encourage students to identify resources for learning skills and knowledge, building on where and how to learn, and performing through data-driven adjustments. In this process, peers become very important in learning by learning together, and the teacher acts as a facilitator in learning (Svellingen et al., 2021).

The existence of technological developments, the transfer of generations, and the vision of education, of course, cannot completely replace the role of teachers, peers, and culture in the students' environment because technology only helps humans to increase the performance of an effective learning process. Artificial Intelligence Technologies enable organizations to support and improve knowledge management practices. First, it will be easier to define augmented and virtual reality concepts to better understand them. Virtual reality (VR) has many definitions, however the following is arguably the broadest and most inclusive one: According to a definition by "Virtual Reality is defined as a real or simulated environment in which an observer experiences telepresence" (Tjostheim & Waterworth, 2022).

In order to avoid having to define Head Mounted Displays (HDM) or any other globe, this definition was adopted. Instead, we may concentrate on engineering and application in order to determine the direction that technology is taking. In a similar vein, we might characterize augmented reality (AR) as a method for adding extra information to the physical world (Gralak, 2020). With this definition, it is unnecessary to discuss particular hardware; instead, we may identify methodologies and applications and concentrate on the advancement of technology. Although AR and VR technologies have long been in development, we can argue that they have only lately started to emerge beyond the laboratories, mostly due to a combination of rising processing power and falling device numbers. At the moment, middle-class smartphones can be utilized with augmented reality and virtual reality. In fact, using a more advanced technology might be more engaging for more immersion, even if it is slightly more expensive.

Based on the background described above, it is necessary to study the current trend of artificial intelligence-augmented reality in science learning.

Method

We conducted this study as a systematic review following PRISMA guidelines. The PRISMA guidelines provide several things to consider when preparing a systematic review (Figure 1). This study will mainly focus on several main items: Artificial Intelligence, Industrial Revolution 4.0, Augmented Reality, and Learning media. Initially, we collected the latest studies on the current trend of artificial intelligence-augmented reality in science learning Integration, based on a few selected keywords. Then, we apply eligibility criteria to the collection. We only selected literature published in 2017 or later to provide an overview of recent trends. In addition, we limit the types of literature, namely only literature in the form of journals and proceedings.

Result and Discussion

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach is used in this investigation (Haddaway et al., 2022). This approach condenses the findings of primary research to deliver information that is more thorough and impartial. The provided material is complete, and objective, and makes an effort to take into account ongoing research discoveries. Creating research questions, searching the literature, screening and selecting pertinent articles, picking the best research findings, filtering and evaluating the results, synthesizing qualitative results, and preparing a research report are all phases of a systematic literature review. The processes in research process of a systematic literature review include writing the background and goal of the study, gathering research questions, scanning the literature, selecting articles, extracting articles, assessing the caliber of the basic studies, and synthesizing data.

Complete articles published in international journals from 2017-2023, indexed in databases, and themed current trends of artificial intelligence-augmented reality in science learning.

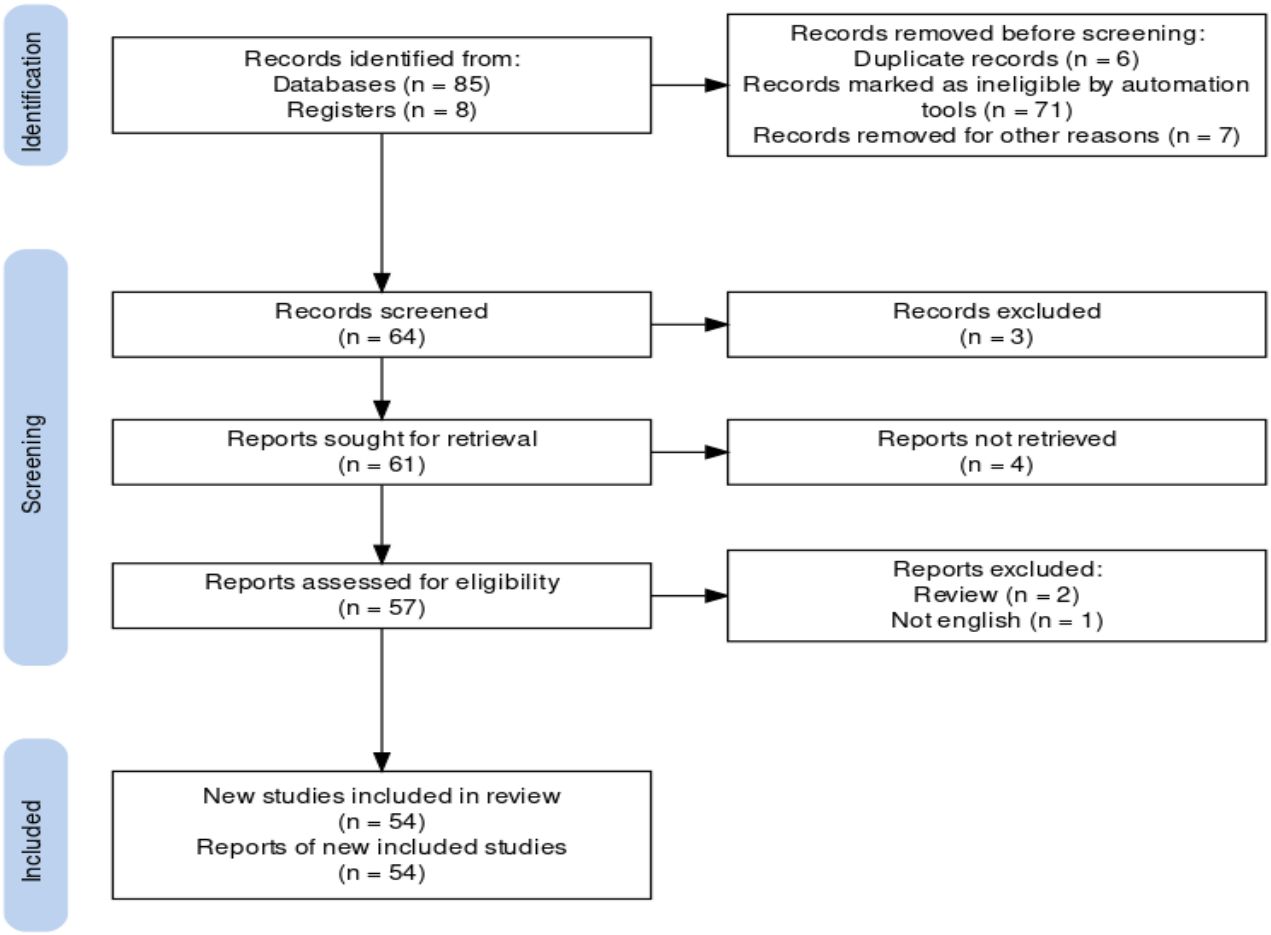

Figure 1. Flow process literature search based on PRISMA guidelines

Table 1. Artificial Intelligence

Sources	Artificial Intelligence (AI) components
(Humm et al., 2023); (Jarrahi et al., 2023); (Anumba & Khallaf, 2022); (Min, 2010); (Zhai et al., 2021)	Knowledge-Based
(Adriyendi, 2018); (Sasmito, 2017); (Hakim, 2019); (Arbain et al., 2022);	Inference Engine

There are two components needed to create applications for artificial intelligence. The primary ones that are most critical are. Each Artificial Intelligence (AI) component is Knowledge-Based and contains facts and theories, as can be seen from the table 1. An intriguing capacity conclusion based on experience is the inference engine. thoughts, and how they are related to one another.

Table 2. Industrial Revolution 4.0

Sources	Technologies in the Industrial Revolution 4.0
(Dilberoglu et al., 2017); (Haleem & Javaid, 2019); (Prashar et al., 2022)	Additive manufacturing
(Özdemir & Hekim, 2018); (Javaid et al., 2022); (Mishra et al., 2023)	Artificial intelligence
(Adel, 2022); (Rosário & Dias, 2022); (Ajayi et al., 2023)	Cloud computing
(Witkowski, 2017); (Papadopoulos et al., 2022); (Özdemir & Hekim, 2018)	Big data
(Vaidya et al., 2018); (Gamil et al., 2020); (Khan & Javaid, 2022)	Internet of things

The table 2 it can be explained each of them named in the Industrial Revolution 4.0 Additive manufacturing is a breakthrough in the manufacturing industry by utilizing 3D printing machines or often known as 3D printing. Artificial Intelligence (AI): AI is a computer or machine technology that has human-like intelligence and can be adjusted according to human desires. Cloud computing is a technology that makes the Internet a center for managing data and applications, where users of the computer are given access rights (login) to use the

cloud to be able to configure servers (servers) via the Internet. Big Data is a term that describes large volumes of data, both structured and unstructured. IoT is a system that uses computing devices, mechanical devices, and digital machines in an interrelated connection.

Table 3. Augmented Reality

Sources	Augmented Reality Components
(Simorangkir & Rohaeti, 2019); (Baker et al., 2023); (Hübner et al., 2018); (Balaji et al., 2022); (Blut & Blankenbach, 2021); (Poschke et al., 2022)	Tracking system
(Lv et al., 2021); (Navab et al., 2022); (Sobota et al., 2020)	Graphic system
(Arena et al., 2022); (Xiong et al., 2021); (Liu et al., 2023)	System display

From the table 3 it can be explained each of the Augmented reality components is the tracking system that determines the position and orientation of objects in the real world. Graphics systems use the information provided by the tracking system to draw virtual images at the appropriate places, for example through objects real. The system view combines the real world with virtual images and sends the result to the user, saying it's sent to the HMD, but the view is normal also like a monitor can be used.

Table 4. Learning media

Sources	Science Learning Domain
(Mork et al., 2021); (de Jong, 2019); (Papaevripidou & Zacharia, 2015); (Simorangkir & Rohaeti, 2019); (Wu et al., 2022);	Domain 1
(Wilujeng et al., 2019); (Matteson, 2022); (Sartika & Shofiyah, 2020); (Wirzal et al., 2022)	Domain 2
(Bustamante et al., 2018); (Sand et al., 2022); (Kelley & Knowles, 2016); (Ruben et al., 2020)	Domain 3
(Indana et al., 2018); (Badrun et al., 2021)	Domain 4

From the table 4 it can be explained each Science learning domain is Domain 1 is Knowing and Understanding, in the form of facts, concepts, laws, several hypotheses and theories used by scientists, and scientific and social issues. Domain 2- Exploring and Discovering, basic science processes: observation, communication, classification, measurement, inference and prediction, Integrated science processes: identification of variables, preparation of data tables, graphing, description of relationships between variables, provision and processing o; f data, investigative analysis, preparation of hypotheses, operational definitions of variables, investigative designs, and experiments. Feeling and Valuing, this domain includes: developing a positive attitude towards science in general, science in schools, and science teachers, developing a positive attitude towards oneself, developing sensitivity and respect for the feelings of others, and making decisions about social and environmental issues. Domain 5 - Using and Applying in the form of observing examples of learned science concepts and skills.

Conclusion

An innovation in educational technology to support learning is the existence of AI technology. Technology may speed up education when used wisely and responsibly. The development of artificial intelligence technology can help pupils become more independent. The teacher does not have to play such a dominant role, but his responsibilities are laid out in the context of offering illumination through significant keywords. The basis for every use of technology for teachers is to continue to prioritize the essence of teaching, namely managing the morale and behavior of students. As for students, the existence of educational technology can help them control and monitor their learning, enabling them to live and work well in the future.

Acknowledgments
Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions
Conceptualization, L. S., K. T. N., R. R., S. M., A. N. I., A. E., A. E. P., Y. S.; methodology, L. S.; validation, K. T. N and R. R.; formal analysis, S. M.; investigation, A. N. I and A. E.; resources, A. E. P and Y. S.; data curation, L. S.: writing—original draft preparation, K. T. N and R. R.; writing—review and editing, S. M.: visualization, A. N. I and A. E.; Supervision, A. E. P.; project administration, Y. S.; funding acquisition, L. S and Y. S. All authors have read and agreed to the published version of the manuscript.

Funding
This research was independently funded by researchers.

Conflicts of Interest
The authors declare no conflict of interest.

References

Adel, A. (2022). Future of Industry 5.0 in society: Human-centric solutions, challenges, and prospective research areas. *Journal of Cloud Computing*, *11*(1), 40. https://doi.org/10.1186/s13677-022-00314-5

Adriyendi, A. (2018). Inference Menggunakan Forward Chaining Pada Food Affordability. *Sainstek: Jurnal Sains dan Teknologi*, *9*(2), 108. https://doi.org/10.31958/js.v9i2.671

Ajayi, O., Bagula, A., & Maluleke, H. (2023). The Fourth Industrial Revolution: A Technological Wave of Change. In M. Gordan, K. Ghaedi, & V. Saleh (Eds.), *Artificial Intelligence*. IntechOpen. https://doi.org/10.5772/intechopen.106209

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences & Humanities Open*, *8*(1), 100532. https://doi.org/10.1016/j.ssaho.2023.100532

Anumba, C., & Khallaf, R. (2022). Use of Artificial Intelligence to Improve Knowledge Management in Construction. *IOP Conference Series: Earth and Environmental Science*, *1101*(3), 032004. https://doi.org/10.1088/1755-1315/1101/3/032004

Arbain, A., Muhammad, M. A., Septiana, T., & Septama, H. D. (2022). Learning Hoax News Pada Local Dan Cloud Computing Deployment Menggunakan Google App Engine. *Jurnal Informatika dan Teknik Elektro Terapan*, *10*(3). https://doi.org/10.23960/jitet.v10i3.2646

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An Overview of Augmented Reality. *Computers*, *11*(2), 28. https://doi.org/10.3390/computers11020028

Badrun, K., Kartowagiran, B., & Rohaeti, E. (2021). A Critical Thinking Assessment Model Integrated with Science Process Skills on Chemistry for Senior High School. *European Journal of Educational Research*, *10*(1), 285–298. https://doi.org/10.12973/eu-jer.10.1.285

Baker, L., Ventura, J., Langlotz, T., Gul, S., Mills, S., & Zollmann, S. (2023). Localization and tracking of stationary users for augmented reality. *The Visual Computer*. https://doi.org/10.1007/s00371-023-02777-2

Balaji, A. N., Kimber, C., Li, D., Wu, S., Du, R., & Kim, D. (2022). RetroSphere: Self-Contained Passive 3D Controller Tracking for Augmented Reality. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *6*(4), 1–36. https://doi.org/10.1145/3569479

Blut, C., & Blankenbach, J. (2021). Three-dimensional CityGML building models in mobile augmented reality: A smartphone-based pose tracking system. *International Journal of Digital Earth*, *14*(1), 32–51. https://doi.org/10.1080/17538947.2020.1733680

Bustamante, A., Greenfield, D., & Nayfeld, I. (2018). Early Childhood Science and Engineering: Engaging Platforms for Fostering Domain-General Learning Skills. *Education Sciences*, *8*(3), 144. https://doi.org/10.3390/educsci8030144

de Jong, T. (2019). Moving towards engaged learning in STEM domains; there is no simple answer, but a road ahead. *Journal of Computer Assisted Learning*, *35*(2), 153–167. https://doi.org/10.1111/jcal.12337

Dilberoglu, U. M., Gharehpapagh, B., Yaman, U., & Dolen, M. (2017). The Role of Additive Manufacturing in the Era of Industry 4.0. *Procedia Manufacturing*, *11*, 545–554. https://doi.org/10.1016/j.promfg.2017.07.148

Gamil, Y., A. Abdullah, M., Abd Rahman, I., & Asad, M. M. (2020). Internet of Things in construction industry revolution 4.0: Recent trends and challenges in the Malaysian context. *Journal of Engineering, Design, and Technology*, *18*(5), 1091–1102. https://doi.org/10.1108/JEDT-06-2019-0164

Gralak, R. (2020). A Method of Navigational Information Display Using Augmented Virtuality. *Journal of Marine Science and Engineering*, *8*(4), 237. https://doi.org/10.3390/jmse8040237

Hakim, A. R. (2019). Artificial Intelligence Based Autogate System Development Concept in Immigration Examination for Indonesian Citizens at Immigration Examination In Soekarno-Hatta International Airport. *Tematics: Technology Management and Informatics Research Journals*, *1*(1), 69–80. https://doi.org/10.52617/tematics.v1i1.74

Haleem, A., & Javaid, M. (2019). Additive Manufacturing Applications in Industry 4.0: A Review. *Journal of Industrial Integration and Management*, *04*(04), 1930001. https://doi.org/10.1142/S2424862219300011

Hübner, P., Weinmann, M., Hillemann, M., Jutzi, B., & Wursthorn, S. (2018). Combining Independent Visualization and Tracking Systems for Augmented Reality. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII–2*, 455–462. https://doi.org/10.5194/isprs-archives-XLII-2-455-2018

Humm, B. G., Archer, P., Bense, H., Bernier, C., Goetz, C., Hoppe, T., Schumann, F., Siegel, M., Wenning, R., & Zender, A. (2023). New directions for applied knowledge-based AI and machine learning: Selected results of the 2022 Dagstuhl Workshop on

Applied Machine Intelligence. *Informatik Spektrum*, *46*(2), 65–78. https://doi.org/10.1007/s00287-022-01513-9

Indana, S., Agustini, R., & Rahayu, Y. S. (2018). Profile of Scientific Literacy Skills in Junior High School One Roof. *Proceedings of the Mathematics, Informatics, Science, and Education International Conference (MISEIC 2018)*, 150-153. https://doi.org/10.2991/miseic-18.2018.37

Jarrahi, M. H., Askay, D., Eshraghi, A., & Smith, P. (2023). Artificial intelligence and knowledge management: A partnership between human and AI. *Business Horizons*, *66*(1), 87–99. https://doi.org/10.1016/j.bushor.2022.03.002

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2022). Artificial Intelligence Applications for Industry 4.0: A Literature-Based Study. *Journal of Industrial Integration and Management*, *7*(1), 83–111. https://doi.org/10.1142/S2424862221300040

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual Reality and Its Applications in Education: Survey. *Information*, *10*(10), 318. https://doi.org/10.3390/info10100318

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3*(1), 11. https://doi.org/10.1186/s40594-016-0046-z

Khan, I. H., & Javaid, Mohd. (2022). Role of Internet of Things (IoT) in Adoption of Industry 4.0. *Journal of Industrial Integration and Management*, *7*(4), 515–533. https://doi.org/10.1142/S2424862221500068

Liu, Z., Wang, D., Gao, H., Li, M., Zhou, H., & Zhang, C. (2023). Metasurface-enabled augmented reality display: A review. *Advanced Photonics*, *5*(3). https://doi.org/10.1117/1.AP.5.3.034001

Lv, Z., Lloret, J., & Song, H. (2021). Real-time image processing for augmented reality on mobile devices. *Journal of Real-Time Image Processing*, *18*(2), 245–248. https://doi.org/10.1007/s11554-021-01097-9

Matteson, D. S. (2022). *Data Science in Science:* A New Journal with a Radically Collaborative Mission. *Data Science in Science*, *1*(1), 1–2. https://doi.org/10.1080/26941899.2022.2043137

Min, H. (2010). Artificial intelligence in supply chain management: Theory and applications. *International Journal of Logistics Research and Applications*, *13*(1), 13–39. https://doi.org/10.1080/13675560902736537

Mishra, M. S., Singh, S., Joshi, S., & Tomar, R. (2023). A Review Paper on Industries Revolution 4.0 Powering The Future Of Health Care Sector. *International Journal of Pharma Professional's Research (IJPPR)*, *14*(2), 1-14. Retrieved from http://www.ijppronline.com/index.php/IJPPR/article/view/275

Mork, S. M., Henriksen, E. K., Haug, B. S., Jorde, D., & Frøyland, M. (2021). Defining knowledge domains for science teacher educators. *International Journal of Science Education*, *43*(18), 3018–3034. https://doi.org/10.1080/09500693.2021.2006819

Navab, N., Martin-Gomez, A., Seibold, M., Sommersperger, M., Song, T., Winkler, A., Yu, K., & Eck, U. (2022). Medical Augmented Reality: Definition, Principle Component, Domain Modeling, and Design-Development-Validation Process. *Journal of Imaging*, *9*(1), 4. https://doi.org/10.3390/jimaging9010004

Özdemir, V., & Hekim, N. (2018). Birth of Industry 5.0: Making Sense of Big Data with Artificial Intelligence, "The Internet of Things" and Next-Generation Technology Policy. *OMICS: A Journal of Integrative Biology*, *22*(1), 65–76. https://doi.org/10.1089/omi.2017.0194

Papadopoulos, T., Singh, S. P., Spanaki, K., Gunasekaran, A., & Dubey, R. (2022). Towards the next generation of manufacturing: Implications of big data and digitalization in the context of industry 4.0. *Production Planning & Control*, *33*(2–3), 101–104. https://doi.org/10.1080/09537287.2020.1810767

Papaevripidou, M., & Zacharia, Z. C. (2015). Examining how students' knowledge of the subject domain affects their process of modeling in a computer programming environment. *Journal of Computers in Education*, *2*(3), 251–282. https://doi.org/10.1007/s40692-015-0034-1

Poschke, A., Jütte, L., Küster, B., & Overmeyer, L. (2022). *An Augmented Reality Assistance System to See-Through Vehicle Components*. In Research Square. https://doi.org/10.21203/rs.3.rs-1754735/v1

Prashar, G., Vasudev, H., & Bhuddhi, D. (2022). Additive manufacturing: Expanding 3D printing horizon in industry 4.0. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 1-15. https://doi.org/10.1007/s12008-022-00956-4

Rosário, A. T., & Dias, J. C. (2022). Industry 4.0 and Marketing: Towards an Integrated Future Research Agenda. *Journal of Sensor and Actuator Networks*, *11*(3), 30. https://doi.org/10.3390/jsan11030030

Ruben, S., Setiawan, I., Illu, W., & Wahyuni, S. (2020). Promoting the Affective Domain within Global Pandemic: The Challenge of Christian Education. *International Research Journal on Advanced Science Hub*, *2*(9), 1–5. https://doi.org/10.47392/irjash.2020.138

Sand, O. P., Lockwood, E., Caballero, M. D., & Mørken, K. (2022). Three cases demonstrate how students connect the domains of mathematics and

computing. *The Journal of Mathematical Behavior*, *67*, 100955. https://doi.org/10.1016/j.jmathb.2022.100955

Sasmito, G. W. (2017). Sistem Pakar Diagnosis Hama dan Penyakit Tanaman Hortikultura dengan Teknik Inferensi Forward dan Backward Chaining. *Jurnal Teknologi Dan Sistem Komputer*, *5*(2), 69. https://doi.org/10.14710/jtsiskom.5.2.2017.70-75

Sartika, S. B., & Shofiyah, N. (2020). Psychomotor Skills of Pre-service Teachers of Natural Science on Melde's Experiment in Guided Inquiry Learning. *IJORER: International Journal of Recent Educational Research*, *1*(2), 108–115. https://doi.org/10.46245/ijorer.v1i2.32

Simorangkir, A., & Rohaeti, E. (2019). Exploring of Students' Self-Efficacy: The Beliefs while Learning Process in Buffer Solution. *Journal of Physics: Conference Series*, *1233*(1), 012017. https://doi.org/10.1088/1742-6596/1233/1/012017

Sobota, B., Korečko, Š., Hudák, M., & Sivý, M. (2020). *Mixed Reality and Three-Dimensional Computer Graphics*. IntechOpen. https://doi.org/10.5772/intechopen.92827

Svellingen, A., Røssland, A., & Røykenes, K. (2021). Students as Facilitators: Experiences of Reciprocal Peer Tutoring in Simulation-Based Learning. *Clinical Simulation in Nursing*, *54*, 10–16. https://doi.org/10.1016/j.ecns.2021.01.008

Tjostheim, I., & Waterworth, J. A. (2022). Feeling Present in Virtual Environments. In *The Psychosocial Reality of Digital Travel*, 51–72. https://doi.org/10.1007/978-3-030-91272-7_3

Vaidya, S., Ambad, P., & Bhosle, S. (2018). Industry 4.0 – A Glimpse. *Procedia Manufacturing*, *20*, 233–238. https://doi.org/10.1016/j.promfg.2018.02.034

Wilujeng, I., K.P., Z., & Suryadarma, I. (2019). Integrating Local Wisdom in Natural Science Learning. *Proceedings of the 1st International Conference on Innovation in Education (ICoIE 2018)*, 182-186. https://doi.org/10.2991/icoie-18.2019.42

Wirzal, M. D. H., Halim, N. S. A., Md Nordin, N. A. H., & Bustam, M. A. (2022). Metacognition in Science Learning: Bibliometric Analysis of Last Two Decades. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *6*(1), 43–60. https://doi.org/10.36312/esaintika.v6i1.665

Witkowski, K. (2017). Internet of Things, Big Data, Industry 4.0 – Innovative Solutions in Logistics and Supply Chains Management. *Procedia Engineering*, *182*, 763–769. https://doi.org/10.1016/j.proeng.2017.03.197

Wu, C.-H., Liu, C.-H., & Huang, Y.-M. (2022). The exploration of continuous learning intention in STEAM education through attitude, motivation, and cognitive load. *International Journal of STEM Education*, *9*(1), 35. https://doi.org/10.1186/s40594-022-00346-y

Xiong, J., Hsiang, E.-L., He, Z., Zhan, T., & Wu, S.-T. (2021). Augmented reality and virtual reality displays: Emerging technologies and future perspectives. *Light: Science & Applications*, *10*(1), 216. https://doi.org/10.1038/s41377-021-00658-8

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., Liu, J.-B., Yuan, J., & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complexity*, *2021*, 1–18. https://doi.org/10.1155/2021/8812542