ChatGPT for the Future of Science Learning: A Systematic Literature Review

Yuliarman Saragih[1], Pradicta Nurhuda[2], Sudirman Sudirman[3], Gustina Indriati[4], Nugroho Susanto[5*]

[1] Electrical Engineering Study Program, Universitas Singaperbangsa, Karawang, Indonesia
[2] Badan Riset dan Inovasi Nasional, Jakarta, Indonesia
[3] Department of Physics Education, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Alauddin, Makassar, Indonesia
[4] Study Programs of Hyperkes and Occupational Safety, Sekolah Tinggi Ilmu Kesehatan Indonesia, Padang, Indonesia
[5] Sports Science Study Program, Faculty of Sports Science, Universitas Negeri Padang, Padang, Indonesia

Abstract: The rapid era of technological development has had a major impact on the world of education. At least the challenges faced by the education sector are related to the use of Chat GPT artificial intelligence in the science learning process. Through science education, students can engage in the impact of science in everyday life and the role of students in society. The provision of quality science education will have an impact on the development achievements of a country. for this reason, research was carried out. The purpose of the research is to explain ChatGPT for the Future of 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 We must know and practice changes in education and learning patterns at all levels of education by describing the characteristics of learning that are currently needed. The results of this research show that in science learning there are several main domains on which the learning objectives using the science approach pattern are based on the advantages of this approach. GPT chat can be used to get answers to various problems and questions, providing precise and fast responses. GPT chat plays an important role in shaping the science learning system of the future. Many benefits have been found from GPT chat in science learning.

Keywords: Chat GPT; Learning; Science Learning

Introduction

Natural Sciences (IPA) is one of the sciences that plays an important role in the world of education. Science studies various things related to everyday life, oneself, and the natural environment (Zidny et al., 2020). The science learning process emphasizes providing direct experience to students to develop competencies to understand the natural environment scientifically so that students can apply their knowledge in real life (Fauziah & Kuswanto, 2020). Science is a science that is very close to everyday human life. Science is very embedded in human life, so studying science means studying the symptoms that appear in life, which means

that science can reveal various problems in the surrounding environment (Xu et al., 2021). Natural Sciences (IPA) is related to how to find out about nature systematically so that science is not just mastery of a collection of knowledge in the form of facts, concepts, or principles only, but also a process of discovery. In line with this, (Fahmidani & Rohaeti, 2020) state that the nature of science includes four main elements, namely attitudes, processes, products, and applications. It is hoped that these four elements can emerge in learning as a whole (holistic) which actually cannot be separated from each other (Fawns, 2022). Education is an investment in the future for someone who wants to achieve a prosperous life. Education is also an effort

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aimed at enabling humans to develop their potential through the learning process (Darling-Hammond et al., 2020). An education is said to be good if it has implemented eight national education standards.

One of the national education standards is education management standards, where management standards are national education standards related to the planning, implementation, and supervision of educational activities (Baharun et al., 2021). The importance of technology in management is intended to help the learning process in achieving educational goals (Haleem et al., 2022). One of the problems that arises is that science learning has not been carried out optimally (Wilson et al., 2019). The causal factors are teachers, leadership, and government. One effort to improve the quality of science education is to improve the quality of teachers and include human resources in science education (Rahmouni & Aleid, 2020). What supports the achievement of science learning is that the existence of Chat GPT has provided a picture of the future regarding teaching and learning practices with the support of artificial intelligence (De Krom, 2023). With an artificial intelligence system such as Chat GPT, pupils and students can complete their assignments more easily and in a relatively short time. However, this also has its implications in the academic context (Montenegro-Rueda et al., 2023).

The emergence of artificial intelligence technology with extraordinary capabilities such as Chat GPT has positive and negative implications in the academic field, depending on the context of its use (Dwivedi et al., 2023). Proper use of this system will help and enrich the insight of its users. Vice versa, using it for negative purposes such as cheating will be very detrimental to users (Dwivedi et al., 2022). Therefore, it is important to pay attention to ethics in the use of this technology, one of which is in the field of education (Guan et al., 2023). The application of artificial intelligence technology will greatly determine the fate of education in the future (X. Wu, 2021). In this research, the Science Learning Domain, Science Approach Patterns, and the use of ChatGPT in future science learning environments will be studied. From previous research, it seems that there is no Systematic Literature Review that specifically reviews ChatGPT for Future Science Learning. Based on the background explained above, this research aims to examine ChatGPT for Future Science Learning.

Method

We conducted this research as a systematic review by following the PRISMA guidelines (Figure 1). The PRISMA guidelines provide several items that need to be considered in preparing a systematic review (Page et al., 2021). In this study, we will mainly focus on several key items: Chat GPT; Learning; Science Learning. This helps form the basis of our assessment. Initially, we collected the latest studies on ChatGPT for Future Science Learning, 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.
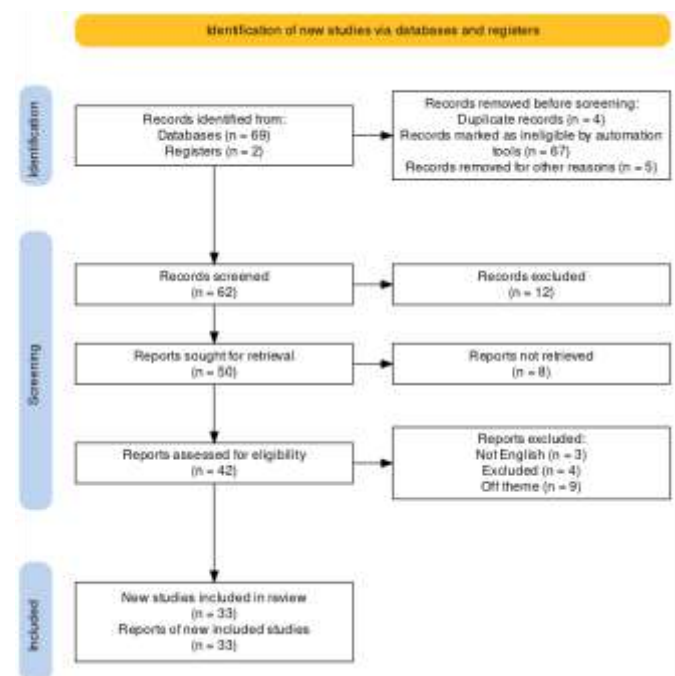

Figure 1. The PRISMA flow chart

Result and Discussion

Preferred Reporting Items for Systematic Review (PRISMA) is the preferred reporting technique used in this study. The research was conducted methodically throughout the necessary research stages. The information offered is thorough, and impartial, and attempts to combine pertinent study findings. The steps of a systematic review of the literature involve developing research questions, searching the literature, Completing articles published in international journals from 2017-2023, indexed in databases, and themed ChatGPT for Future Science Learning.

Table 1. Science Learning Domain

Source	Science Learning Domain
(Dwianto et al., 2017); (Kurniawati et al., 2017)	Domain 1
(Papaevripidou & Zacharia, 2015); (Pedaste et al., 2015)	Domain 2
(Maracani et al., 2023); (Fauzi et al., 2021); (Gess, Christopher et al., 2017); (Zhang et al., 2022); (Ansdell et al., 2018)	Domain 3
(Sommeillier et al., 2021); (Van Uum et al., 2021); (Setyawarno & Kurniawati, 2022); (Míriam Andrea et al., 2022)	Domain 4
(Mellor et al., 2020); (Kaplon-Schilis & Lyublinskaya, 2020); (Smiderle et al., 2020)	Domain 5

Through science learning based on five domains for science education, students are expected to not only increase their knowledge and skills but also develop a positive attitude towards science itself and its environment, as well as apply and relate it to life more actively every day. Domain 1- Knowing and Understanding (knowledge domain), in the form of facts, concepts, laws, several hypotheses and theories used by scientists, and scientific and social problems. Domain 2- Exploring and Discovering (Process of science domain), is: Basic science processes: observation, communication, classification, measurement, inference

and predictions; Integrated science process: identification of variables, preparation of tables data, making graphs, describing relationships between variables, providing and data processing, investigative analysis, hypothesis preparation, definition of operational variables, investigative design, and experiments.

Domain 3 - Exploring and Discovering (process of science domain). There are some important human capabilities in this domain, viz combining several objects and ideas in new ways; producing alternatives or using unusual objects used; imagining; dreaming; and generating ideas. Domain 4- Feeling and Valuing (attitudinal domain), this domain includes: the development of positive attitudes towards science in general, science in schools, and science teachers, the development of a positive attitude towards oneself, development of sensitivity, and appreciation for the feelings of others and decision making on social and environmental issues. Domain 5 - Using and Applying (application and connection domain) in the form of observing examples of science concepts and skills that have been studied.

Table 2. Science Approach Patterns

Source	Science Approach Patterns
(Wang et al., 2021); (Serdyukov, 2017)	Realizing that there is a problem and having a desire or willingness to solve the problem
(Lee et al., 2023)	Collect data or facts that are related to the problem faced.
(Doumas et al., 2022)	Develop a temporary answer or hypothesis
(W.-H. Wu et al., 2019)	Conduct experiments to test the truth of the hypothesis
(Amon et al., 2022)	Make conclusions

Realizing that there is a problem and having a desire or willingness to solve the problem. A scientist has deep rigor paying close attention to the circumstances around him, as well as high curiosity. Before Newton, no one had a problem with the apple falling to the ground and why not fall into the sky? People also don't mind opinions that heavy objects fall faster than light objects. Before Galileo conducted the famous experiment from the top of the Pisa Tower, people simply accepted Aristotle's opinion that heavy objects were faster. Collect data or facts that are related to the problem faced. The data or facts collected can be in the form of observations and experiments, and can also be in the form of literature studies or written works

of people who never solved the problem. This activity also requires precision in recording every detail of the facts you find. Develop a temporary answer or hypothesis. From data or facts that have been noted, a scientist can make preliminary conclusions about the problems he encountered.

This initial conclusion or hypothesis is in the form of an estimate of answers to problems and facts that he has obtained. Conduct experiments to test the truth of the hypothesis. In testing a hypothesis, a scientist must be neutral about all possibilities that he found. Every possibility is tested carefully and in portions of the same interest. In other words, experiments are not only carried out on one or two possibilities that are considered true.

Additionally, experiments are carried out repeatedly to minimize errors that may occur. Make conclusions. From several experiments that have been carried out, a scientist will get the right answer from several

hypotheses that were tested. This is the hypothesis that has been proven to be true the conclusion of the problem he found.

Table 3. The usefulness of ChatGPT in future science learning environments

Source	The usefulness of ChatGPT in future science learning environments
(Grassini, 2023); (Mina et al., 2023); (Liao & Pan, 2023); (Essel et al., 2022)	Science Learning Virtual Assistant
(Prananta et al., 2023a)	Online Group Discussion on Science Learning
(Prananta et al., 2023b)	Simulation-Based on the theme of science learning
(Yu, 2023)	Recommended reading for science learning
(Oktaria et al., 2023)	Development of science learning ideas
(Ray, 2023)	Popular Science Learning
(Supriyadi & Kuncoro, 2023)	Problem Resolution in Science Learning
(Vasconcelos & Dos Santos, 2023)	Comprehension of Complex Texts in Science Learning

Science Learning Virtual Assistant: Use ChatGPT as a virtual assistant to answer student questions about lesson materials and science learning assignments. Science Learning Online Group Discussions: Use ChatGPT to moderate online group discussions with students about science learning topics. Simulation-Based on a Science Learning Theme: Create a simulation based on a specific theme, and let ChatGPT be the narrator in the simulation. Science learning reading recommendations: ChatGPT can recommend books, articles, or reading sources that are relevant to science learning subject matter.

Developing science learning ideas: ChatGPT can help students develop science learning research ideas. Popular Science Learning: Use ChatGPT to explain science concepts more simply and popularly. Problem Resolution in Science Learning: ChatGPT can help students solve science learning problems and explain the steps. Comprehension of Complex Texts in Science Learning: ChatGPT can help in analyzing and explaining complex texts in science learning. It is important to remember that the use of ChatGPT should support learning objectives and increase student engagement and understanding. Apart from that, also pay attention to the ethical use of technology in education and accordance with applicable guidelines.

Conclusion

Science is a branch of knowledge that studies natural objects and phenomena through a process of scientific observation to produce scientific products such as facts, principles, concepts, laws, or theories. Science has a very important role in providing understanding to students, arousing a very high sense of curiosity in the field of science. Many factors cause science problems in the learning process which result in science learning not

being carried out optimally, one of which is the use of technology that is not optimal. GPT chat is one solution to increase students' intelligence in science learning in the future.

Conflicts of Interest
The authors declare no conflict of interest.

References

Amon, D. J., Gollner, S., Morato, T., Smith, C. R., Chen, C., Christiansen, S., Currie, B., Drazen, J. C., Fukushima, T., Gianni, M., Gjerde, K. M., Gooday, A. J., Grillo, G. G., Haeckel, M., Joyini, T., Ju, S.-J., Levin, L. A., Metaxas, A., Mianowicz, K., … Pickens, C. (2022). Assessment of scientific gaps related to the effective environmental management of deep-seabed mining. *Marine Policy*, *138*, 105006. https://doi.org/10.1016/j.marpol.2022.105006

Ansdell, M., Ioannou, Y., Osborn, H. P., Sasdelli, M., 2018 NASA Frontier Development Lab Exoplanet Team, Smith, J. C., Caldwell, D., Jenkins, J. M., Räissi, C., Angerhausen, D., & 2018 NASA Frontier Development Lab Exoplanet Mentors. (2018).

Scientific Domain Knowledge Improves Exoplanet Transit Classification with Deep Learning. *The Astrophysical Journal*, *869*(1), L7. https://doi.org/10.3847/2041-8213/aaf23b

Baharun, H., Mundiri, A., Zamroni, Z., & Jannah, F. (2021). Quality Assurance of Education in Senior High School During Covid-19 Pandemic. *AL-ISHLAH: Jurnal Pendidikan*, *13*(3), 2203–2212. https://doi.org/10.35445/alishlah.v13i3.1190

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

De Krom, G. (2023). Approaches to written assignments -how students write, and instructors read. *Assessment & Evaluation in Higher Education*, *48*(1), 67–76.
https://doi.org/10.1080/02602938.2022.2040946

Doumas, L. A. A., Puebla, G., Martin, A. E., & Hummel, J. E. (2022). A theory of relation learning and cross-domain generalization. *Psychological Review*, *129*(5), 999–1041. https://doi.org/10.1037/rev0000346

Dwianto, A., Wilujeng, I., Prasetyo, Z. K., & Suryadarma, I. G. P. (2017). The Development of Science Domain Learning Media Which is Integrated with Local Potential to Improve Science Process Skill and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, *6*(1). https://doi.org/10.15294/jpii.v6i1.7205

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., … Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice, and policy. *International Journal of Information Management*, *66*, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., … Wright, R. (2023). Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges, and implications of generative conversational AI for research, practice, and policy. *International Journal of Information Management*, *71*, 102642. https://doi.org/10.1016/j.ijinfomgt.2023.102642

Essel, H. B., Vlachopoulos, D., Tachie-Menson, A., Johnson, E. E., & Baah, P. K. (2022). The impact of a virtual teaching assistant (chatbot) on students' learning in Ghanaian higher education. *International Journal of Educational Technology in Higher Education*, *19*(1), 57. https://doi.org/10.1186/s41239-022-00362-6

Fahmidani, Y., & Rohaeti, E. (2020). Attitude toward chemistry: Student's perception based on the learning experience. *Journal of Physics: Conference Series*, *1440*(1), 012016. https://doi.org/10.1088/1742-6596/1440/1/012016

Fauzi, M. R., Zakiyati, I. I., & Qomarudin, A. Q. (2021). Constraints for Assessment of Psychomotor Domain (Reading Surah al-Maidah verses 2-3) in Grade 6 SDN 2 Bantarwuni during the Covid-19 Pandemic. *AS-SABIQUN*, *3*(1), 1–13. https://doi.org/10.36088/assabiqun.v3i1.1106

Fauziah, A. N., & Kuswanto, H. (2020). Analysis of Junior High School students' critical thinking ability on ecosystem materials. *Journal of Physics: Conference Series*, *1440*(1), 012098. https://doi.org/10.1088/1742-6596/1440/1/012098

Fawns, T. (2022). An Entangled Pedagogy: Looking Beyond the Pedagogy—Technology Dichotomy. *Postdigital Science and Education*, *4*(3), 711–728. https://doi.org/10.1007/s42438-022-00302-7

Gess, Christopher, Wessels, Insa, & Blömeke, Sigrid. (2017). Domain-specificity of research competencies in the social sciences: Evidence from differential item functioning. *Journal for educational research online, 9*(2), 11-36. https://doi.org/10.25656/01:14895

Grassini, S. (2023). Shaping the Future of Education: Exploring the Potential and Consequences of AI and ChatGPT in Educational Settings. *Education Sciences*, *13*(7), 692. https://doi.org/10.3390/educsci13070692

Guan, X., Feng, X., & Islam, A. Y. M. A. (2023). The dilemma and countermeasures of educational data ethics in the age of intelligence. *Humanities and Social Sciences Communications*, *10*(1), 138. https://doi.org/10.1057/s41599-023-01633-x

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

Kaplon-Schilis, A., & Lyublinskaya, I. (2020). Analysis of Relationship Between Five Domains of TPACK Framework: TK, PK, CK Math, CK Science, and TPACK of Pre-service Special Education Teachers.

Technology, Knowledge and Learning, 25(1), 25–43. https://doi.org/10.1007/s10758-019-09404-x

Kurniawati, A. P., Prasetyo, Z. K., Wilujeng, I., & Suryadarma, I. G. P. (2017). The effectiveness of science domain-based science learning integrated with local potency. In *AIP Conference Proceedings, 1868*(1). https://doi.org/10.1063/1.4995185

Lee, H.-Y., Lin, C.-J., Wang, W.-S., Chang, W.-C., & Huang, Y.-M. (2023). Precision education via timely intervention in K-12 computer programming courses to enhance programming skills and affective-domain learning objectives. *International Journal of STEM Education*, 10(1), 52. https://doi.org/10.1186/s40594-023-00444-5

Liao, X., & Pan, X. (2023). Application of Virtual Assistants in Education: A Bibliometric Analysis in WOS Using CiteSpace. *Proceedings of the 2023 14th International Conference on E-Education, E-Business, E-Management and E-Learning*, 113–123. https://doi.org/10.1145/3588243.3588274

Maracani, A., Pastore, V. P., Natale, L., Rosasco, L., & Odone, F. (2023). In-domain versus out-of-domain transfer learning in plankton image classification. *Scientific Reports*, 13(1), 10443. https://doi.org/10.1038/s41598-023-37627-7

Mellor, D. J., Beausoleil, N. J., Littlewood, K. E., McLean, A. N., McGreevy, P. D., Jones, B., & Wilkins, C. (2020). The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare. *Animals*, 10(10), 1870. https://doi.org/10.3390/ani10101870

Mina, P. N. R., Solon, I. M., Sanchez, F. R., Delante, T. K., Villegas, J. K., Basay, F. J., Andales, J., Pasko, F., Estrera, M. F. R., Samson Jr., R., & Mutya, R. (2023). Leveraging Education through Artificial Intelligence Virtual Assistance: A Case Study of Visually Impaired Learners. *International Journal of Educational Innovation and Research*, 2(1), 10–22. https://doi.org/10.31949/ijeir.v2i1.3001

Míriam Andrea, H.-B., Jesús, S.-M., Isaac, C.-C., & Florentina, C.-C. (2022). Is sustainability an exhaustive concept? Bridging the gap from environmental awareness to emotional proficiency in science education through integral sustainability. *Heliyon*, 8(12), e12546. https://doi.org/10.1016/j.heliyon.2022.e12546

Montenegro-Rueda, M., Fernández-Cerero, J., Fernández-Batanero, J. M., & López-Meneses, E. (2023). Impact of the Implementation of ChatGPT in Education: A Systematic Review. *Computers*, 12(8), 153. https://doi.org/10.3390/computers12080153

Oktaria, R., Ali, I., & Putra, P. (2023). The Potential Utilizing ChatGPT for Education and Teaching Students: Understanding, Prospects, Challenges, and Utilization". *Educative: Jurnal Ilmiah Pendidikan*, 1(2), 87–94. https://doi.org/10.37985/educative.v1i2.75

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, 10(1), 89. https://doi.org/10.1186/s13643-021-01626-4

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

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Prananta, A. W., Susanto, N., Purwantoro, A., & Fuadah, N. (2023a). ChatGPT Artificial Intelligence Integration in Science Learning Media: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(7), 315–321. https://doi.org/10.29303/jppipa.v9i7.4386

Prananta, A. W., Susanto, N., Purwantoro, A., & Fuadah, N. (2023b). ChatGPT Artificial Intelligence Integration in Science Learning Media: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(7), 315–321. https://doi.org/10.29303/jppipa.v9i7.4386

Rahmouni, M., & Aleid, M. A. (2020). Teachers' practices and children's motivation towards science learning in MENA countries: Evidence from Tunisia and UAE. *International Journal of Educational Research*, 103, 101605. https://doi.org/10.1016/j.ijer.2020.101605

Ray, P. P. (2023). ChatGPT: A comprehensive review of the background, applications, key challenges, bias, ethics, limitations, and future scope. *Internet of Things and Cyber-Physical Systems*, 3, 121–154. https://doi.org/10.1016/j.iotcps.2023.04.003

Serdyukov, P. (2017). Innovation in education: What works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching & Learning*, 10(1), 4–33. https://doi.org/10.1108/JRIT-10-2016-0007

Setyawarno, D., & Kurniawati, A. (2022). Science learning is oriented to higher-order thinking in the

digital era. In *AIP Conference Proceedings, 2600*(1). https://doi.org/10.1063/5.0112450

Smiderle, R., Rigo, S. J., Marques, L. B., Peçanha De Miranda Coelho, J. A., & Jaques, P. A. (2020). The impact of gamification on students' learning, engagement, and behavior based on their personality traits. *Smart Learning Environments, 7*(1), 3. https://doi.org/10.1186/s40561-019-0098-x

Sommeillier, R., Quinlan, K. M., & Robert, F. (2021). The domain of validity framework: A new instructional theory for addressing students' preconceptions in science and engineering. *Studies in Science Education*, *57*(2), 205–239. https://doi.org/10.1080/03057267.2020.1824472

Supriyadi, E., & Kuncoro, K. S. (2023). Exploring the future of mathematics teaching: Insight with ChatGPT. *Union: Jurnal Ilmiah Pendidikan Matematika*, *11*(2), 305–316. https://doi.org/10.30738/union.v11i2.14898

Van Uum, M. S. J., Peeters, M., & Verhoeff, R. P. (2021). Professionalising Primary School Teachers in Guiding Inquiry-Based Learning. *Research in Science Education*, *51*(S1), 81–108. https://doi.org/10.1007/s11165-019-9818-z

Vasconcelos, M. A. R., & Dos Santos, R. P. (2023). Enhancing STEM learning with ChatGPT and Bing Chat as objects to think with A case study. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(7), em2296. https://doi.org/10.29333/ejmste/13313

Wang, W., Wang, H., Ran, Z.-Y., & He, R. (2021). Learning Robust Feature Transformation for Domain Adaptation. *Pattern Recognition*, *114*, 107870. https://doi.org/10.1016/j.patcog.2021.107870

Wilson, R. C., Shenhav, A., Straccia, M., & Cohen, J. D. (2019). The Eighty-Five Percent Rule for optimal learning. *Nature Communications*, *10*(1), 4646. https://doi.org/10.1038/s41467-019-12552-4

Wu, W.-H., Kao, H.-Y., Wu, S.-H., & Wei, C.-W. (2019). Development and Evaluation of Affective Domain Using Student's Feedback in Entrepreneurial Massive Open Online Courses. *Frontiers in Psychology*, *10*, 1109. https://doi.org/10.3389/fpsyg.2019.01109

Wu, X. (2021). Application of Artificial Intelligence in Modern Vocational Education Technology. *Journal of Physics: Conference Series*, *1881*(3), 032074. https://doi.org/10.1088/1742-6596/1881/3/032074

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C.-W., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M., … Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4), 100179. https://doi.org/10.1016/j.xinn.2021.100179

Yu, H. (2023). Reflection on whether Chat GPT should be banned by academia from the perspective of education and teaching. *Frontiers in Psychology*, *14*, 1181712. https://doi.org/10.3389/fpsyg.2023.1181712

Zhang, Z., Hu, Q., Xu, C., Zhou, J., & Li, J. (2022). Medical teachers' affective domain teaching dilemma and path exploration: A cross-sectional study. *BMC Medical Education*, *22*(1), 883. https://doi.org/10.1186/s12909-022-03870-1

Zidny, R., Sjöström, J., & Eilks, I. (2020). A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability. *Science & Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x