Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

January 2024. Vol. 12, No. 1
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 267-274

Technology-Based Future Science Education: Axiological Philosophy in the Framework of Bibliometric Analysis

***[a]Sukainil Ahzan, [a]Saiful Prayogi, [a]Irham Azmi, [a]Muhammad Asy'ari, [b]Taufik Samsuri**
[a]Department of Physics Education; [b]Department of Biology Education, Universitas Pendidikan Mandalika, Mataram, Indonesia

*Corresponding Author e-mail: sukainilahzan@undikma.ac.id

Received: December 2023; Revised: December 2023; Published: January 2024

Abstract

Science education is crucial in developing our understanding of the natural world and enhancing knowledge growth. With rapid advancements in information and communication technology, there is a unique opportunity to transform science education into a more interactive, inclusive, and relevant discipline. However, this evolution prompts philosophical questions, especially concerning axiology—the study of the value and impact of technology on the future of science education. This research explores the axiological aspects of technology integration in science education through a bibliometric analysis, focusing on how technology-based methods can enrich science learning. A comprehensive literature review reveals that technology is crucial in making science education more accessible, motivating students, facilitating the acquisition of new skills, fostering critical thinking, and boosting student engagement. It highlights the value of incorporating technology into educational practices and how it aligns with axiological considerations in science education. The findings emphasize the need for a deeper philosophical understanding of technology's role in science education to ensure its ongoing relevance and effectiveness. Looking forward, the integration of technology in science learning promises to advance our knowledge and suggests a fertile area for future research, emphasizing the exploration of innovative technological tools that can further enhance science education for all students.

Keywords: Technology, future science education, axiology, philosophy, bibliometric analysis

How to Cite: Ahzan, S., Prayogi, S., Azmi, I., Asy'ari, M., & Samsuri, T. (2024). Technology-Based Future Science Education: Axiological Philosophy in the Framework of Bibliometric Analysis. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 12*(1), 267-274. doi:https://doi.org/10.33394/j-ps.v12i1.10895

https://doi.org/10.33394/j-ps.v12i1.10895

INTRODUCTION

Science education serves as the cornerstone for cultivating human knowledge and comprehension of the natural world. A crucial aspect in attaining sustainable human resource development involves fostering a cohort of students who possess both proficiency and interest in science, perceiving it as a valuable asset in shaping their future careers (de Jong et al., 2013; Thomas, 2014; Ünal & Kaygın, 2020). As underscored by scholars (Biazus & Mahtari, 2022; Ekayanti et al., 2022; Fitriani et al., 2022; Prayogi et al., 2023; Suhirman & Ghazali, 2022), the significance of science education is escalating, contributing to knowledge development and sustainable resource support. Those engaged in scientific pursuits can harness these educational resources to hone critical thinking skills. By immersing students in science, they become active and well-informed contributors to society, enabling them to apply scientific reasoning for evidence-based decision-making and enhancing problem-solving capacities in their daily lives (Lin et al., 2021). Recognizing the profound impact of technological advancements on the contemporary landscape, it is imperative for science education to undergo substantial transformation to align with evolving needs and achieve its overarching goals.

In the contemporary era, the landscape of information and communication technology has undergone a transformative shift, altering the dynamics of how we acquire, process, and disseminate information. The realm of science education is not exempt from the far-reaching influence of this technological revolution. The advent of sophisticated tools, digital resources, and a diverse array of digital learning platforms presents a substantial opportunity for science education to evolve into a more interactive, inclusive, and pertinent field. The integration of technology into science education has paved the way for a multitude of innovations in teaching and learning methodologies (Asy'ari & Da Rosa, 2022; Bilad, 2023; Verawati et al., 2023). Educators can employ computer simulations to elucidate intricate concepts, facilitating a more comprehensible understanding for students. Moreover, the utilization of digital resources, such as educational videos, interactive applications, and e-books, introduces a flexible dimension to learning, enabling students to engage with educational material at their convenience, irrespective of time and location. Furthermore, the availability of diverse online learning platforms fosters collaboration among students spanning different geographical locations, fostering a global learning environment that enhances their overall educational experience.

The emergence of this opportunity raises a myriad of profound philosophical inquiries concerning the essence and objective of science education in an age dominated by technological advancements. One must ponder whether the integration of technology into science learning genuinely enhances students' comprehension and competencies, or if there exists a peril of excessive dependence on technology, leading to a detriment in both social interaction and profound understanding. The overarching concern revolves around safeguarding the ongoing relevance of science education amidst the relentless pace of technological evolution. These inquiries prompt contemplation on the imperative necessity of striking a delicate balance between technological tools and traditional methodologies within the realm of science education. As science education grapples with these quandaries, it is imperative to forge ahead in formulating strategies that cater to the contemporary needs of students while upholding the fundamental tenets integral to genuine scientific education.

From a broader standpoint, the landscape of science education is shaped by its inherent pedagogical framework, wherein the efficacy of education hinges on pedagogical mechanisms employing diverse learning resources, including technology. The utilization of resources and the learning trajectory, on the other hand, are underpinned by the learning theories that underlie them. In practical terms, educators incorporate learning theories or concepts into their instructional methodologies to foster more impactful and meaningful learning encounters for students (Rapanta et al., 2020). A nuanced comprehension of learning theories equips educators to better facilitate students' development and assist them in attaining their educational objectives. In the context of the current investigation, the nexus lies in the dynamic nature of the developed philosophical perspective, which gives rise to theories supporting the success of the learning process.

The philosophy of science relies on a foundational framework comprising ontology, epistemology, and axiology. By adopting a philosophical perspective, we can contemplate the harmonious integration of technology into science education, emphasizing inclusivity, empowerment, and alignment with contemporary demands. This philosophical exploration serves as the basis for formulating pedagogical approaches that are both relevant and responsible, addressing the evolving challenges in science education within an increasingly technology-dominated future. The primary objective of this study is to undertake a philosophical examination, with a particular focus on the axiological dimension, of the forthcoming paradigm of science education driven by technology. Through this inquiry into the role of philosophy, we aim to gain insights into the transformations and obstacles associated with the incorporation of technology into the science learning process.

METHOD

This study comprises a comprehensive literature review, drawing inspiration from the bibliometric analyses conducted by Sarkingobir et al. (2023) and Wirzal et al. (2022). To gather pertinent data, emphasis was placed on utilizing two primary sources: the Scopus database (https://www.scopus.com) and Google Scholar (https://scholar.google.com/). The decision to opt for these platforms was rooted in the global recognition of Scopus as the benchmark for evaluating the quality of scientific articles.

Scopus, renowned for providing abstracts and citations from diverse sources and disciplines, emerged as a vital repository of scientific knowledge. The database's extensive features facilitate easy exploration of experts, authors, data, metrics, and visualizations, offering valuable insights into the latest research trends across scientific domains. Employing contextually relevant keywords such as "axiological philosophy of technology-based future science education," researchers successfully identified a myriad of documents, including articles, conferences, and books related to this thematic area. Subsequently, these documents were meticulously scrutinized and integrated into the literature review to fulfill the research requirements.

In pursuit of a thorough literature review, the researchers extended their scope beyond the Scopus database by incorporating documents from the Google Scholar search engine (https://scholar.google.com/). This strategic inclusion aimed to ensure the inclusivity of all relevant literature pertaining to the research topic. The dual utilization of these data sources afforded a more extensive and profound coverage in identifying literature pertinent to the axiology of technology-based future science education.

The focal point of this literature review was the axiology of future science education rooted in technology. This targeted approach allowed researchers to delve deeply into understanding how technology shapes the axiological landscape of future science education. The anticipated outcome of this review is to furnish valuable insights for researchers, educational practitioners, and stakeholders engaged in science education, thereby contributing to the ongoing advancements in science education facilitated by technology.

RESULTS AND DISCUSSION

Terminology of Science Philosophy

Axiology is an integral component of the philosophy of science, alongside ontology and epistemology. Within the scope of the present study, the inclusion of a philosophical perspective aids in comprehending how technology contributes to the vision of future science education, aligning inclusivity with contemporary demands. Before delving into the context associated with the philosophy (axiology) of technology-based future science education, it is essential to elucidate the meaning of philosophy of science terminology, encompassing ontology, epistemology, and axiology. The term "philosophy of science" refers to the philosophical branch specifically addressing inquiries related to science, the scientific method, the nature of knowledge, and the scientific research process. Terminologically, it scrutinizes fundamental concepts and challenges arising in science, predominantly within three contexts: ontology, epistemology, and axiology.

Ontology pertains to fundamental inquiries about existence and reality, representing a branch of philosophy dealing with the nature of things. Etymologically, the word "ontology" originates from the Greek words "òn," meaning "exist" or "òntos," signifying "existence," and "lògos," denoting "science or thought." Therefore, ontology is defined as the science of existence (essence). Epistemology, derived from the Greek "epistēmē" meaning "knowledge" and "lògos" meaning "science," is, in linguistic terms, the science of knowledge itself, encompassing the study of the nature and basis of knowledge. In the context of the Indonesia Dictionary (KBBI), epistemology is characterized as a branch of philosophy addressing the foundations and limitations of knowledge. Broadly, it is a facet of philosophy exploring the occurrence, sources, origins, limitations, nature, methods, and truth of knowledge. Axiology, originating from the Greek "axion" meaning "value" and "lògos" meaning "science," signifies the value of science in language terminology. In a broader sense, axiology is a branch of the philosophy of science scrutinizing the nature and benefits inherent in knowledge. Within the terminology of science education, the presence of technology can axiologically contribute to the advancement of knowledge in the realm of science.

Axiology of Technology-Based Future Science Education

The exploration results on the Scopus database, using the keyword "filsafat aksiologi pendidikan sains masa depan berbasis teknologi," did not yield any specific documents (journal articles, conference proceedings, and books) addressing the theme. Nevertheless, documents discussing the terminology of axiology associated with the benefits of technology in future science education were identified. This was achieved by employing the keyword: "pendidikan sains masa depan berbasis teknologi." The distribution of documents is presented in Figure 1 as follows.

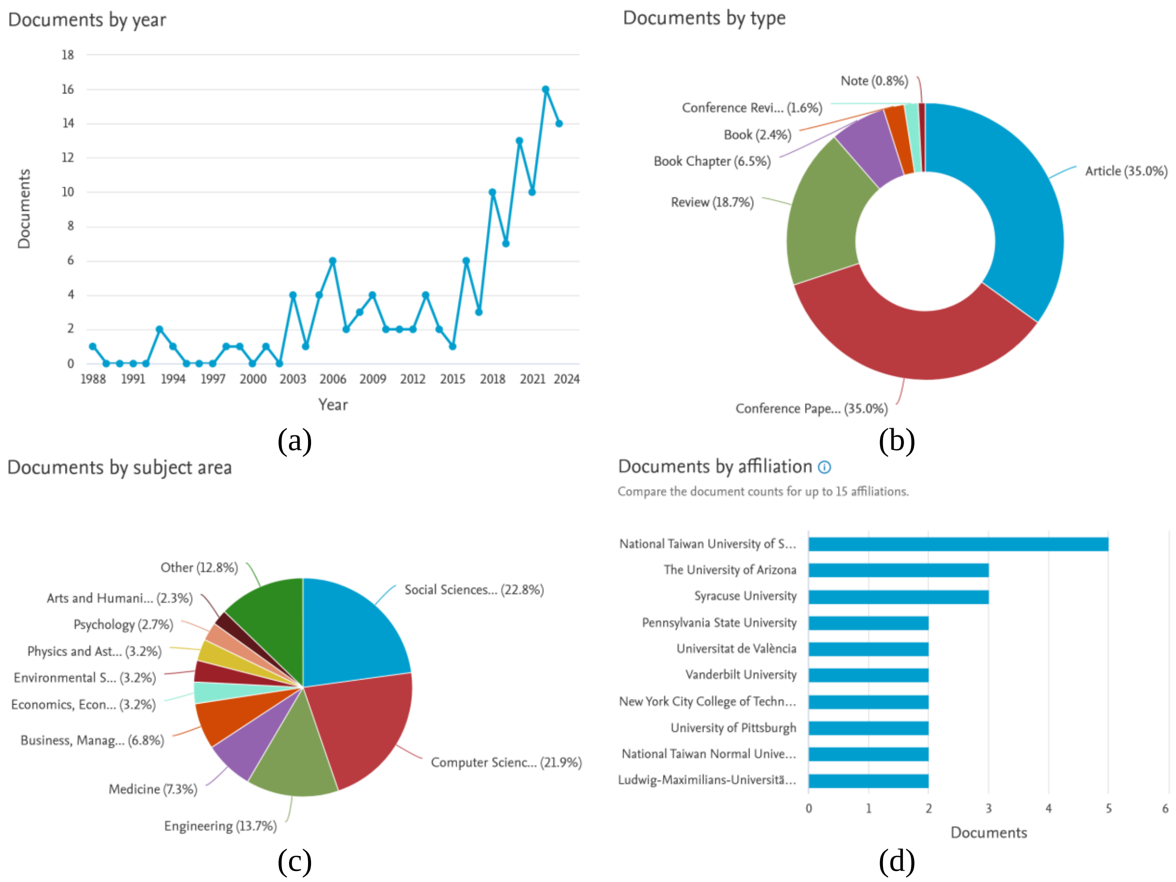

Figure 1. The distribution of documents discussing future technology-based science education: (a) documents categorized by year, (b) documents categorized by type, (c) documents categorized by subject area, and (d) documents categorized by affiliation.

The results in Figure 1a indicate that a total of 123 documents were found in the Scopus database. Documents addressing the relevant theme span from 1988 to 2023, with distribution by document type being articles (35.00%), conference papers (35.00%), and the remaining comprising books, book chapters, review papers, and others (Figure 1b). The discovered documents encompass subject areas such as social sciences (22.80%), computer science (21.90%), and others (Figure 1c). These documents originate from 15 affiliations (Figure 1d), which are universities with an intent to conduct studies related to the utilization and development of technology.

The documents found in the Scopus database were compared with the findings of studies on the Google Scholar page (https://scholar.google.com/). This comparison was made to strengthen the discussions related to the theme of technology-based future science education.

Essentially, the elaboration of the existing documents highlights the usefulness of technology in supporting the development of future science education. Researchers discuss how science is closely related to experimentation to prove scientific concepts or reveal facts about science, making technological interventions crucial in science education.

Exploring science through various experiments is a crucial element in the science education process, and learning science is meaningless without experimental experiences (Chen, 2010). Scientific experiments can help students develop a positive attitude towards science (Chen et al., 2014). The demand for knowledge development in science is advancing and diverse, including how the science context can be adequately visualized, which is impossible to achieve through regular experiments in a real laboratory environment. Moreover, science should be accessible to everyone, but this is not realized when science is presented to students with physical limitations (disabilities). Therefore, the presence of technology is essential to benefit and reach knowledge under all conditions and for all groups.

So far, the presence of technology has proven beneficial in advancing knowledge and fostering profound thinking approaches in science. Assistive technology in science, initially designed to meet and facilitate access to the learning rights of students with disabilities (Smith, 2021), has evolved into a learning visualization instrument alongside the progress of simulation technology. It is now recognized as assistive virtual simulation (Suhirman & Prayogi, 2023). Virtual technology has been studied and can be beneficial in terms of accessibility (simplifying the learning process) (Zhang et al., 2021), motivating students in learning (Ismail, 2022), and serving as a digital learning bridge to comprehend abstract concepts (Verawati et al., 2022). The presence of various technologies, such as virtual simulation, is increasingly prevalent due to their role in cultivating the new skills required (Bedetti et al., 2018), including fostering students' critical thinking (Bilad et al., 2022). Previous studies also revealed the role of technology in supporting students' in-depth mastery of various learning materials (Fan et al., 2018) and promoting student engagement with instructional content (Toli & Kallery, 2021).

Based on a review of several empirical studies on the utilization of technology to support science learning, the axiology of technology-based science education brings benefits to the development of knowledge in the science context, provides accessibility, motivates, fosters new skills in science, trains thinking skills, and supports student engagement in learning. The advancement of scientific knowledge in the future will continue to be intertwined with technological developments. Ultimately, the development of technology and progress in science is an inseparable duo.

CONCLUSION

Science education plays a crucial role in advancing human knowledge and comprehension of the natural world. In our technology-driven era, it is imperative for science education to evolve continuously to align with contemporary advancements. The integration of technology into science education has ushered in transformative opportunities, fostering interactive, inclusive, and pertinent learning experiences. Computer simulations, instructional videos, interactive applications, and online platforms have empowered students to engage in more efficient and flexible learning modalities. This study underscores the necessity to philosophically examine the future landscape of technology-based science education, particularly through the lens of axiology.

Axiology in technology-based science education delves into the values associated with leveraging technology for the enhancement of scientific knowledge. The findings of this investigation illuminate the explicit advantages of axiologically grounded technology-based science education, elucidating its capacity to facilitate knowledge development within the scientific domain. This educational approach not only ensures accessibility but also serves as a motivational catalyst, cultivating new scientific skills, honing critical thinking abilities, and actively involving students in the learning process. As we look ahead, the symbiotic relationship between the evolution of scientific knowledge and technological progress becomes increasingly apparent. In conclusion, the intertwined trajectories of technological development and scientific progress underscore their inseparability, emphasizing the interconnected journey they embark on together.

RECOMMENDATION

Based on the comprehensive analysis of the role and impact of technology in science education, it's evident that integrating technology into science learning is not just beneficial but essential for the contemporary and future educational landscape. The philosophical examination underlines the value (axiology) of technology in enhancing science education by facilitating access to knowledge, motivating students, and supporting the development of critical thinking and other crucial skills. The absence of specific documents addressing the axiology of technology-based future science education in the Scopus database, contrasted with findings from Google Scholar, underscores an emerging field ripe for exploration and contribution. Given these insights, it is recommended that educational institutions and policymakers prioritize the integration of technology in science curricula. This should include investment in virtual simulation tools and assistive technologies that make science accessible to all students, including those with disabilities, ensuring inclusivity. Furthermore, teacher training programs should incorporate modules on effectively utilizing technology in science education, emphasizing the creation of interactive and engaging learning experiences.

The importance of technology in science learning extends beyond mere engagement; it fosters deeper understanding and critical thinking. Thus, future research should focus on identifying and developing innovative technological tools that can simulate complex scientific concepts in an accessible manner. Collaborations between educational technologists, scientists, and educators are crucial to designing technology-based learning resources that align with current scientific inquiries and pedagogical best practices.In conclusion, the integration of technology in science education represents a significant step towards preparing students for the demands of the 21st century. By embracing technological advancements, educators can enhance the learning experience, making it more relevant, engaging, and accessible to a diverse student population. This approach not only supports the development of scientific knowledge but also cultivates the critical, creative, and analytical skills necessary for future scientific endeavors.

ACKNOWLEDGMENT

The author expresses gratitude to the individuals and entities that played a crucial role in facilitating the execution of this study. Special acknowledgment is extended to the research team, whose unwavering commitment to intellectual effort and time proved instrumental in successfully completing this research endeavor. Their dedication and contributions significantly enriched the study's overall implementation, underscoring the research process's collaborative nature. Appreciation is also extended to other stakeholders whose support and involvement were integral to the successful realization of this research. The collaborative efforts of all parties involved, both within and outside the research team, have collectively contributed to the successful execution of this study, highlighting the importance of a synergistic approach in academic investigations.

REFERENCES

Asy’ari, M., & Da Rosa, C. T. W. (2022). Prospective Teachers’ Metacognitive Awareness in Remote Learning: Analytical Study Viewed from Cognitive Style and Gender. *International Journal of Essential Competencies in Education*, *1*(1), 18–26. https://doi.org/10.36312/ijece.v1i1.731

Bedetti, B., Bertolaccini, L., Patrini, D., Schmidt, J., & Scarci, M. (2018). Virtual simulation and learning new skills in video-assisted thoracic surgery. *Video-Assisted Thoracic Surgery*, *3*, 35–35. https://doi.org/10.21037/vats.2018.08.03

Biazus, M. de O., & Mahtari, S. (2022). The Impact of Project-Based Learning (PjBL) Model on Secondary Students' Creative Thinking Skills. *International Journal of Essential Competencies in Education*, *1*(1), 38–48. https://doi.org/10.36312/ijece.v1i1.752

Bilad, M. R. (2023). Enhancing Engineering Electromagnetics Education: A Comparative Analysis of Synchronous and Asynchronous Learning Environments. *International Journal of Essential Competencies in Education*, *2*(1), 66–74. https://doi.org/10.36312/ijece.v2i1.1369

Bilad, M. R., Anwar, K., & Hayati, S. (2022). Nurturing Prospective STEM Teachers' Critical Thinking Skill through Virtual Simulation-Assisted Remote Inquiry in Fourier Transform Courses. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.728

Chen, S. (2010). The view of scientific inquiry conveyed by simulation-based virtual laboratories. *Computers & Education*, *55*(3), 1123–1130. https://doi.org/10.1016/j.compedu.2010.05.009

Chen, S., Chang, W.-H., Lai, C.-H., & Tsai, C.-Y. (2014). A Comparison of Students' Approaches to Inquiry, Conceptual Learning, and Attitudes in Simulation-Based and Microcomputer-Based Laboratories. *Science Education*, *98*(5), 905–935. https://doi.org/10.1002/sce.21126

de Jong, T., Linn, M. C., & Zacharia, Z. C. (2013). Physical and Virtual Laboratories in Science and Engineering Education. *Science*, *340*(6130), 305–308. https://doi.org/10.1126/science.1230579

Ekayanti, B. H., Prayogi, S., & Gummah, S. (2022). Efforts to Drill the Critical Thinking Skills on Momentum and Impulse Phenomena Using Discovery Learning Model. *International Journal of Essential Competencies in Education*, *1*(2), Article 2. https://doi.org/10.36312/ijece.v1i2.1250

Fan, X., Geelan, D., & Gillies, R. (2018). Evaluating a Novel Instructional Sequence for Conceptual Change in Physics Using Interactive Simulations. *Education Sciences*, *8*(1), Article 1. https://doi.org/10.3390/educsci8010029

Fitriani, H., Samsuri, T., Rachmadiarti, F., Raharjo, R., & Mantlana, C. D. (2022). Development of Evaluative-Process Learning Tools Integrated with Conceptual-Problem-Based Learning Models: Study of Its Validity and Effectiveness to Train Critical Thinking. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.736

Ismail. (2022). The Implementation of E-Learning Supported by Social Reality Videos in Mobile Applications: Its Impact on Student's Learning Outcomes. *International Journal of Interactive Mobile Technologies (iJIM)*, *16*(17), Article 17. https://doi.org/10.3991/ijim.v16i17.33041

Lin, X., Yang, W., Wu, L., Zhu, L., Wu, D., & Li, H. (2021). Using an Inquiry-Based Science and Engineering Program to Promote Science Knowledge, Problem-Solving Skills and Approaches to Learning in Preschool Children. *Early Education and Development*, *32*(5), Article 5. https://doi.org/10.1080/10409289.2020.1795333

Prayogi, S., Ardi, R. F. P., Yazidi, R. E., Tseng, K.-C., & Mustofa, H. A. (2023). The Analysis of Students' Design Thinking in Inquiry-Based Learning in Routine University Science Courses. *International Journal of Essential Competencies in Education*, *2*(1), Article 1. https://doi.org/10.36312/ijece.v2i1.1338

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2020). Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity. *Postdigital Science and Education*, *2*(3), 923–945. https://doi.org/10.1007/s42438-020-00155-y

Sarkingobir, Y., Egbebi, L. F., & Awofala, A. O. A. (2023). Bibliometric Analysis of the Thinking Styles in Math and Its' Implication on Science Learning. *International*

Journal of Essential Competencies in Education, *2*(1), 75–87. https://doi.org/10.36312/ijece.v2i1.1391

Smith, E. M. (2021). Assistive technology research: Evidence for a complex and growing field. *Assistive Technology*, *33*(4), 177–177. https://doi.org/10.1080/10400435.2021.1958650

Suhirman, & Prayogi, S. (2023). Problem-based learning utilizing assistive virtual simulation in mobile application to improve students' critical thinking skills. *International Journal of Education and Practice*, *11*(3), 351–364. https://doi.org/10.18488/61.v11i3.3380

Suhirman, S., & Ghazali, I. (2022). Exploring Students' Critical Thinking and Curiosity: A Study on Problem-Based Learning with Character Development and Naturalist Intelligence. *International Journal of Essential Competencies in Education*, *1*(2), 95–107. https://doi.org/10.36312/ijece.v1i2.1317

Thomas, I. (2014). Special Issue—Pedagogy for Education for Sustainability in Higher Education. *Sustainability*, *6*(4), Article 4. https://doi.org/10.3390/su6041705

Toli, G., & Kallery, M. (2021). Enhancing Student Interest to Promote Learning in Science: The Case of the Concept of Energy. *Education Sciences*, *11*(5), Article 5. https://doi.org/10.3390/educsci11050220

Ünal, F., & Kaygın, H. (2020). Citizenship Education for Adults for Sustainable Democratic Societies. *Sustainability*, *12*(1), Article 1. https://doi.org/10.3390/su12010056

Verawati, N. N. S. P., Handriani, L. S., & Prahani, B. K. (2022). The Experimental Experience of Motion Kinematics in Biology Class Using PhET Virtual Simulation and Its Impact on Learning Outcomes. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.729

Verawati, N. N. S. P., Rijal, K., & Grendis, N. W. B. (2023). Examining STEM Students' Computational Thinking Skills through Interactive Practicum Utilizing Technology. *International Journal of Essential Competencies in Education*, *2*(1), 54–65. https://doi.org/10.36312/ijece.v2i1.1360

Wirzal, M. D. H., Nordin, N. A. H. M., Bustam, M. A., & Joselevich, M. (2022). Bibliometric Analysis of Research on Scientific Literacy between 2018 and 2022: Science Education Subject. *International Journal of Essential Competencies in Education*, *1*(2), 69–83. https://doi.org/10.36312/ijece.v1i2.1070

Zhang, N., Tan, L., Li, F., Han, B., & Xu, Y. (2021). Development and application of digital assistive teaching system for anatomy. *Virtual Reality & Intelligent Hardware*, *3*(4), 315–335. https://doi.org/10.1016/j.vrih.2021.08.005