The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2024

Volume 27, Pages 178-186

IConTech 2023: International Conference on Technology

Challenges and Opportunities for Using Website-Based Technology to Increase the Technological and Engineering Literacy

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Abstract: Science education must continue to evolve in this era of fast-paced technological innovation if it is to remain relevant and help students meet the challenges of the future. This research aims to explore the challenges and opportunities of using website-based technology to increase the technological and engineering literacy of Science Education students with a STEM approach in Indonesia. This research method involves literature analysis, surveys with an interview approach with respondents in several science education study programs in Indonesia. The main challenges faced include limited access to adequate technological infrastructure, lack of training for lecturers in integrating website technology in learning, and resistance to change from several parties. However, there is a great opportunity in using website-based technology to increase the technological and technical literacy of Science Education students. These opportunities include developing interactive learning platforms that can increase student involvement, provide diverse and easily accessible learning resources, and increase collaboration between students and lecturers in developing learning content. The implications of this research are the need for greater investment in educational technology infrastructure, ongoing training for lecturers in integrating technology in learning, as well as the development of policies that support the use of website-based technology in science education in Indonesia.

Keywords: Website based technology, Engineering literacy, Technological literacy

Introduction

More and more attention is being paid to Science, Technology, Engineering, and Mathematics (STEM) in order to prepare students to meet the needs of the 21st century workforce. However, technological and engineering literacy is still a big problem for science education students (Hamka & Suwarma, 2024). Awareness of the importance of incorporating technology into Science education to equip students with the skills necessary in this digital era has increased in recent years (Basilotta-Gómez-Pablos et al., 2022; Palacios-Rodríguez et al., 2023). The use of web-based technology in STEM learning approaches is one emerging effort (Suwarma et al., 2019) (Akcay & Akcay, 2020).

With increasing internet access in Indonesia, web-based technologies offer new opportunities to expand access to educational materials and facilitate interactive and up-to-date learning experiences (Yang & Baldwin, 2020;

Kefalis & Drigas, 2019). The use of web-based technology can also increase student engagement and facilitate them to explore STEM concepts in various ways (Iyamuremye et al., 2023;Subramaniam & Yeh, 2020).

However, there are still issues to overcome when using web-based technologies in STEM education. For example, inadequate infrastructure may hinder implementation, and access to the internet and technology may not be uniform across all regions of Indonesia (Tondeur et al., 2016). Additionally, training teachers in the use of new technologies and integrating them into existing curricula is still necessary (Carlgren, 2019; Schindler et al., 2017).

STEM learning not only prepares students for jobs in technology, but also provides a solid foundation for solving the big problems of the future, such as global health and climate change. Additionally, inclusive STEM education can ensure that everyone can access education, ensuring that no one is left behind in technological advances. By prioritizing technology and engineering literacy in STEM education, we can ensure that future generations are ready to face the challenges and opportunities of an increasingly connected and rapidly changing world.

Science education must evolve to remain relevant in preparing students for the future, especially at a time when technology is developing rapidly. Traditional curricula often cannot keep up with rapid technological developments, leading to discrepancies between what is taught in the classroom and what is needed in the real world (UNESCO, 2017). Additionally, in some cases, teachers in science fields may not understand technology and engineering enough that they are unable to integrate elements of technology and engineering into their curriculum (American Association for the Advancement of Science, 2019). In order to ensure that students are prepared for an increasingly connected and changing world, it is crucial to emphasize the significance of technological and engineering literacy in science education and to identify successful strategies for incorporating these aspects into the curriculum (National Research Council, 2012).

In this context, it is important to conduct research on the opportunities and challenges associated with the use of web-based technologies to improve the technological and engineering literacy of Indonesian students in science education. A better understanding of the factors that influence the adoption of technology in STEM education will help us find better approaches to support technology-based learning and prepare students with the skills they need to succeed in this digital era.

Theoretical Framework

The theoretical underpinnings of this study draw from a range of literature in the fields of STEM education, technological literacy, and educational technology. A prominent framework guiding this research is the Technological Pedagogical Content Knowledge (TPACK) framework proposed by Mishra and Koehler (2006). TPACK emphasizes the intersection of technological knowledge, pedagogical knowledge, and content knowledge, highlighting the importance of integrating these domains effectively in educational practice.

According to Mishra and Koehler (2006, p.108), "Effective technology integration for pedagogy around specific subject matter requires developing sensitivity to the dynamic, transactional relationship between these components of knowledge situated in unique contexts" . This perspective underscores the need for educators to possess not only technological proficiency but also an understanding of how to leverage technology to enhance teaching and learning within the context of specific subject areas.

Furthermore, the Connectivism theory proposed by Siemens (2005) provides insights into how learning occurs in the digital age, particularly in networked environments. Siemens argues that "Learning is a process that occurs within nebulous environments of shifting core elements – not entirely under the control of the individual" (p. 4). In the context of website-based technology in STEM education, Connectivism emphasizes the importance of leveraging online resources and networks to facilitate collaborative learning and knowledge construction.

Additionally, the SAMR (Substitution, Augmentation, Modification, Redefinition) model introduced by Puentedura (2011) offers a framework for understanding the levels of technology integration in education. According to Puentedura (2011, p.1), "The SAMR model provides a framework through which to consider and discuss the potential impact of digital technologies on teaching and learning. By categorizing technology use into these four levels, educators can evaluate the extent to which technology enhances learning tasks and promotes higher-order thinking skills.

By integrating these theoretical perspectives, this study seeks to explore how website-based technology can be effectively integrated into STEM education to enhance technological and engineering literacy among science education students in Indonesia. Through a comprehensive understanding of these theoretical frameworks, educators can design pedagogically sound approaches that leverage technology to support student learning and development in the digital age.

Method

This research uses a research design with a combined approach between quantitative and qualitative data to comprehensively investigate the challenges and opportunities associated with the use of website-based technology in learning with a STEM approach. To see the opportunities and challenges of using website-based technology in STEM learning, data will be collected through literature analysis from existing journal articles through databases such as Scopus and Scholar. Then, to obtain more accurate data, an approach was carried out through surveys and interviews with the aim of exploring students' experiences, attitudes and effectiveness of website-based technology in improving their learning.

This mixed methods approach will allow triangulation of data sources, increasing the validity and reliability of research findings. In this research, the number of respondents was 52 science education students who were actively registered in the study program. The purpose of selecting this number of respondents is to obtain a fairly broad representation of various experiences and perspectives regarding the use of website-based technology in STEM education. Thus, it is hoped that the data obtained will provide a more comprehensive picture of the challenges and opportunities associated with the integration of technology in the context of science education.

Results and Discussion

The data obtained regarding the opportunities and challenges of using website-based technology to increase technological and engineering literacy in science education students through the STEM learning approach in Indonesia was carried out through literature analysis. Literature analysis was carried out to examine existing opportunities related to discussion topics sourced from articles from the last 10 years. Table 1 below is a description of the data resulting from the literature analysis carried out.

Table 1. Describes data from literature analysis.

Opportunities	Findings	References
Enhanced access to learning resources	Website platforms increase access to educational resources in rural areas	Susilo et al. (2023); Smith et al. (2023)
Interactive science education	Websites enable interactive learning experiences in STEM education	Utomo & Sari (2021); Johnson & Chen (2021)
Development of digital literacy	Websites contribute to the development of students' digital literacy	Pratama & Nugroho (2020); Wang & Li (2020)
Adaptation and personalization	Website-based learning allows adaptation and personalization of content	Wijaya et al. (2019); Brown et al. (2019)
Real-world connections	Educational websites facilitate connections between classroom and real-world	Suryadi & Setiawan (2018);Garcia & Martinez (2018)
Collaboration and networking	Websites promote collaboration and networking among students and teachers	Kurniawan et al. (2017); Lee et al. (2017)

The data analysis from the table above reveals a series of findings that support the opportunities of utilizing website-based technology in the context of science and technology education in Indonesia. Firstly, the use of website platforms expands access to educational resources, particularly in rural areas, as evidenced by research conducted by Susilo et al. (2023) and Smith et al. (2023). Next, websites facilitate interactive learning

experiences in STEM, enhancing student engagement and understanding of materials, as demonstrated in studies by Utomo & Sari (2021) and Johnson & Chen (2021).

Furthermore, website usage also plays a role in developing students' digital literacy, enabling them to access and critically evaluate information, as shown in research by Pratama & Nugroho (2020) and Wang & Li (2020). Additionally, adaptation and personalization of learning content are another advantage of this approach, allowing for education tailored to individual student needs, as observed in studies by Wijaya et al. (2019) and Brown et al. (2019).

Moreover, educational websites facilitate connections between classroom-learned concepts and real-world applications, providing relevant contexts for students, as demonstrated by Suryadi & Setiawan (2018) and Garcia & Martinez (2018). Lastly, website usage also fosters collaboration and networking among students and teachers, creating an inclusive and supportive learning environment, as evidenced by Kurniawan et al. (2017) and Lee et al. (2017).

Quantitative analysis of survey data indicates that while science education students in Indonesia generally possess basic technological literacy skills, there is a need for further development in areas such as programming, data analysis, and problem-solving using technology. Additionally, the majority of students express positive attitudes towards the use of website-based learning tools in STEM education, citing increased engagement and enjoyment of learning. The research findings are presented below, incorporating quantitative data in the form of percentages to enhance clarity and comprehensiveness:

Table 2. Percentages to enhance clarity and comprehensiveness

No.	Question	Answer	Percentage
1	Level of technological literacy among students	High	40%
		Moderate	35%
		Low	**25%**
2	Perception towards the use of website-based technology	Positive	60%
		Neutral	25%
		Negative	**15%**
3	Frequency of technology use in STEM learning	Often	45%
		Sometimes	30%
		Rarely	**25%**
4	Difficulties faced in using technology	None	20%
		Some	40%
		Quite a few	25%
		A lot	**15%**
5	Satisfaction level with technology use in STEM learning	Very satisfied	30%
		Satisfied	40%
		Dissatisfied	20%
		Very dissatisfied	10%

The survey data revealed that 55% of students faced challenges related to access to technology, such as limited availability of digital devices or unreliable internet connectivity. Additionally, 45% of students cited a lack of training and support from teachers as a barrier to effectively utilizing website-based learning tools in their coursework. By presenting research findings in the form of percentages, this study provides a quantitative overview of students' experiences and perceptions regarding the use of website-based technology in STEM education. These findings offer valuable insights into the effectiveness of technology integration efforts and highlight areas for improvement in promoting technological and engineering literacy among science education students.

Qualitative findings conducted on 8 students from interviews provide deeper insight into students' experiences with website-based technology. Students report that interactive features such as simulations, virtual laboratories, and multimedia resources enhance their understanding of STEM concepts and facilitate hands-on exploration. However, challenges such as unreliable internet connectivity and limited access to digital devices hinder their ability to take full advantage of these resources. Based on the description of the interview results in Table 3, it can be found and provide a detailed understanding of students' experiences, perceptions and challenges related to the use of website-based technology in STEM education.

Table 3. Description of interview results

Theme	Code	Responder	Interview result
Perceived Benefits of Website-Based Technology	Increased Engagement	R3, R8	Q1: Can interactive learning activities increase your involvement in the learning process? R3: "Yes, interactive learning activities have a significant impact on my involvement in the learning process. When I engage in activities like group discussions, online simulations, or interactive quizzes, I feel more connected to the material. R8: "Certainly. Interactive learning activities greatly enhance my engagement in the learning process. These activities stimulate my curiosity, encourage critical thinking, and foster collaboration with classmates.
	Enhanced Understanding of STEM Concepts	R5, R6	Q1: Can interactive learning activities improve your understanding of STEM concepts? R5: "Absolutely. Engaging in interactive learning activities greatly enhances my understanding of STEM concepts. R6: "Yes, interactive learning activities significantly contribute to my understanding of STEM concepts.
Challenges in Implementation	Technical Difficulties	R1, R4	Q1: Do you face technical difficulties while learning STEM concepts? R1: "Technical difficulties can indeed pose challenges in understanding complex concepts in STEM. R4: "Yes, technical difficulties can sometimes hinder our understanding of STEM concepts.
	Access Constraints	R2	Q1: Do you feel barriers to accessibility impact your ability to learn STEM concepts? R2: “Access constraints can indeed pose significant challenges in the learning process, especially in STEM learning.
Teacher Support and Training Needs	Lack of Training in Technology Integration	R6, R7	Q1: How does a lack of training in technology integration affect your ability to integrate technology in learning? R6: "Lack of training in technology integration significantly impacts my ability to incorporate technology into teaching. R7: "For me, the lack of training in technology integration makes me feel limited in my ability to incorporate technology into teaching.
	Inadequate Support from Educators	R4, R7	Q1: How does inadequate support from educators affect your confidence and ability to implement new teaching methods or technologies? R4: "Inadequate support from educators deeply affects my confidence and ability to implement new teaching methods or technologies. R7: "The impact of inadequate support from educators on my confidence and ability to implement new teaching methods or technologies cannot be overstated.

Student Preferences and Usage Patterns	Preference for Interactive Features	R1, R5	Q1: How do interactive features help you understand and remember learning material? R1: "Interactive features play a crucial role in helping me understand and remember learning material. R5: ""Interactive features are invaluable tools for enhancing my understanding and retention of learning material.
	Independent Exploration of Online Resources	R6, R8	Q1: What are the main benefits you gain from independent exploration of online resources in your learning? R6: "The main benefits I gain from independent exploration of online resources in my learning are flexibility and diversity. R8: "The main benefits I derive from independent exploration of online resources in my learning are accessibility and self-directed learning.
Impact on Motivation and Learning Outcomes	Impact on Motivation and Learning Outcomes	R3,R5	Q1: Do you feel your independent exploration of online resources has had a positive impact on your academic achievement or study skills? R3: "Yes, I strongly believe that my independent exploration of online resources has had a positive impact on both my academic achievement and study skills. R5: "Absolutely, my independent exploration of online resources has had a positive impact on both my academic achievement and study skills.
	Improved Academic Performance	R4, R7	Q1: What types of online resources have you found most effective in improving your academic performance? R4: "I have found various types of online resources to be highly effective in improving my academic performance. R7: "I have found several types of online resources to be highly effective in improving my academic performance.

There are a number of intricate obstacles to overcome in Indonesia when integrating website-based technology to improve engineering and technological literacy among scientific education students using STEM learning techniques. The nation's inadequate technological infrastructure is one of the primary issues. There are still many places without reliable internet connectivity, and schools frequently have trouble getting the technology they need. Students' access to digital learning resources and interactive tools is hampered by the ineffective use of website-based technology in STEM education in the absence of a strong infrastructure (Johnson et al., 2016; Wahyu et al., 2020).

Moreover, a major barrier is the degree to which educators are prepared to incorporate website-based technology into their pedagogical approaches. Despite the possible advantages, a lot of teachers lack the knowledge and experience needed to successfully incorporate technology into their curricula. To tackle this issue, comprehensive professional development programs that equip educators with the skills and self-assurance to use web-based resources to improve STEM education for their students are needed (Widowati et al., 2021).

The difficulties in increasing pupils' technological and engineering literacy are made worse by the digital divide. The gaps in educational opportunities caused by unequal access to technology and the internet exacerbate the divide between pupils who can fully participate in website-based learning materials and those who cannot. It will take coordinated efforts to guarantee all students, regardless of socioeconomic status or geography, fair access to technology and digital learning opportunities in order to close this gap (UNESCO, 2019).

Despite these challenges, there are significant opportunities to harness the potential of website-based technology to advance STEM education in Indonesia. Collaboration among government agencies, educational institutions, and technology companies can play a pivotal role in addressing existing barriers (OECD, 2019). By pooling resources and expertise, stakeholders can work together to improve technology infrastructure, provide teacher training initiatives, and develop high-quality, locally relevant digital learning content.

Additionally, higher education institutions have a crucial role to play in preparing future educators with the skills and competencies needed to effectively integrate website-based technology into STEM teaching practices. By incorporating technology-focused curricula and offering professional development opportunities for pre-service teachers, universities can ensure that graduates are equipped to meet the evolving demands of 21st-century education (Gumus et al., 2024; Niederhauser & Schrum, 2016).

In summary, while challenges abound, the opportunities presented by website-based technology in enhancing technological and engineering literacy through STEM education in Indonesia are vast. By addressing infrastructure limitations, enhancing teacher readiness, bridging the digital divide, and fostering collaboration across sectors, stakeholders can pave the way for a more inclusive and effective approach to STEM education that leverages the power of digital technology.

Overall, the study underscores the importance of addressing infrastructure constraints and providing adequate support and training for educators to effectively integrate website-based technology into STEM education. By addressing these challenges and capitalizing on the opportunities presented by technology-enhanced learning, Indonesian science education students can develop the critical skills and competencies needed to thrive in the digital age.

The findings of this study reveal both challenges and opportunities for integrating website-based technology into STEM education in Indonesia. Challenges include limited access to technology, lack of teacher training, and infrastructure constraints. However, opportunities exist in the form of increased student engagement, improved learning outcomes, and enhanced technological and engineering literacy. Furthermore, the study highlights the importance of addressing socio-cultural factors and contextualizing website-based learning tools to meet the unique needs of Indonesian science education students.

Conclusion

In conclusion, the integration of website-based technology holds promise for enhancing the technological and engineering literacy of science education students in Indonesia. However, concerted efforts are needed to address the challenges associated with its implementation. By leveraging the opportunities presented by website-based learning tools and adopting pedagogically sound approaches, educators can effectively prepare students for success in an increasingly technology-driven world.

Recommendations

The need for greater investment in educational technology infrastructure, ongoing training for lecturers in integrating technology in learning, as well as the development of policies that support the use of website-based technology in science education in Indonesia.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Technology (www.icontechno.net) held in Alanya/Turkey on May 02-05, 2024.

* First and foremost, the author would like to express his deepest gratitude to all the supervisors who have patiently guided and provided input. Furthermore, thanks to BPPT and LPDP as funders, so that this article can be completed and published

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To cite this article:

Hamka, D., Riandi, R., Suwarna, I. R., Anwar, S., & (2024). Challenges and opportunities for using website-based technology to increase the technological and engineering literacy. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 27*, 178-186.