Letters in Information Technology Education (LITE)
Vol 6, No 2, 2023, pp. 16-21
e-ISSN: 2654-5667

An Analysis of Cybersecurity Subject and Vilanets Learning Media Towards Vocational School Students' Digital Skills

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Article Info

Article history:
Received: Jan 05, 2023
Revised: Feb 2, 2023
Accepted: Mar 07, 2023

Keyword:
Cybersecurity Subject
Digital Skills
Innovative Learning Media
Virtual Learning Environments
Virtual Laboratory
SWOT
SLR

ABSTRACT

Digital skills are crucial to accessing jobs, business opportunities, and information. The vocational school is vital in fulfilling Human Resources (HR) and future workforce candidates. Therefore, subjects and learning media are needed to accommodate students' digital skills. The analysis methods are Strength, Weakness, Opportunity, and Threat (SWOT) and Systematic Literature Review (SLR). Cybersecurity is a desirable talent area of the future and is one of the digital skills competency areas. The results map the alignment of the scope of the Cybersecurity subject material and Vilanets learning media. These results can be used as a reference for the digital skills of students in vocational schools.

I. INTRODUCTION

Along with the rapid development of technology, digital skills are becoming increasingly important now and in the future. Today, almost all jobs and sectors require good digital skills. The COVID-19 pandemic has accelerated digital transformation and forced many people to work, study and communicate online. Therefore, digital skills are not only a necessity but also mandatory skills needed in the job market. In the future, digital skills will be increasingly required as technology development and digitalization will continue. Digital skills are crucial to accessing jobs, business opportunities, and information. Apart from that, digital skills will also be the key to adapting to changes and finding solutions to complex problems.

Digital skills include using and utilizing digital technology for various purposes, such as work, study, communication, and access to information. Eight competency areas support digital skills: (1) operating hardware and software; (2) information and data literacy; (3) creation of content or digital products; (4) cloud computing competency; (5) digital communication and collaboration; (6) digital problem solving; (7) digital security and ethics; (8) and digital project management. Desired future talent targets large-scale data modeling and data science expertise, cloud computing, and cybersecurity [1].

Vocational schools are vital in fulfilling Human Resources (HR) and prospective future workers to accommodate the demand for digital skills. The vocational school needs to conduct a subject analysis to match the latest technological trends and ensure students are ready to face challenges in the future. The vocational school must also expand cooperation with various parties, including industry and government organizations, to ensure their graduates have skills that match the labor market demands.

Indonesia's current vocational school curriculum is the 2013 Curriculum (K13) and the Merdeka Curriculum. The transition between K13 and the Merdeka Curriculum raises problems, especially in adjusting subjects at each level. Changing subjects at each level is urgent, considering that the current subjects must be in harmony with the demands of the Merdeka Curriculum and digital skills. On the other hand, the Merdeka Curriculum can

determine subjects adapted to the internal conditions of vocational schools in their respective regions [2]. Merdeka Curriculum provides an opportunity to be able to make adjustments regarding subjects that are aligned with the digital skills desired today. Technology-based learning media is also essential to support the smooth learning of these subjects. For this reason, an analysis of the Cybersecurity subject and Vilanets learning media is needed, which can be a future reference to accommodate global demands that lead to digital skills, which cover eight competency areas towards digital skills.

Cybersecurity subject and Vilanets learning media is something that must be done. The Cybersecurity subject covers materials that lead to eight competencies in digital skills. Vilanets learning media results from innovative thinking derived from the concept of Virtual Learning Environments (VLEs) combined with the concepts of virtualization, simulation, and cloud [3]. These concepts can accommodate availability, accessibility, and scalability problems in learning media so that the learning process can occur effectively and efficiently.

Cybersecurity courses at the Polytechnic of Leiria—a public higher education institution in Portugal describe the roadmap and general milestones that lead to the course and the identification of strengths and opportunities and student learning outcomes [4]. There is also research on a series of recommendations for preparing advanced cybersecurity courses covering what to teach and how to do it [5]. This research was accomplished by selecting topics from 35 free online courses and analyzing them using NIST's NICE reference framework. Regarding digital learning media, WebEx tools HandsOn-Labs were conducted to close the instructional gap between offline, mixed, and online meetings [6]. There are also research results on developing learning media using technology by adding automatic scoring and scoring functions to learning media. These results can reduce costs and maximize scalability [7].

II. METHODS

Cybersecurity subject analysis is carried out manually using several data in documents. The documents related to digital skills, competency areas, target areas of future talent desired, existing curriculum, and the materials from the international cybersecurity technical certification body. The data and documents are collected, summarized, and aligned. Alignment was carried out to gain relevance between digital skills, competency areas, target areas of talent, curricula, and international certification bodies to determine Cybersecurity courses in the vocational school. Furthermore, the thematic analysis is carried out on opportunities (opportunities) and threats (challenges) [8]. All data and documents are read and understood to familiarize oneself with the data. Relevant information supported by the experience of researchers identified to set the theme of strengths, weaknesses, opportunities, and threats, as well as mapping the alignment of the scope of cybersecurity material.

An analysis of Vilanets learning media uses previous research data [3], Scopus-indexed, and Google Scholar-indexed articles. The search was done through Harzing's Publish or Perish apps the manual investigation aimed to find a more specific context about technology integration in cybersecurity learning. A manual search returned five articles. A search through the application yielded 200 Scopus-indexed articles and 200 Google Scholar-indexed articles with the keywords virtual learning environments and virtual laboratories. The investigation was narrowed down to 15 pieces. The total number of papers used includes articles from previous research used to describe the concept of learning media used in cybersecurity in vocational schools.

III. RESULTS AND DISCUSSION

A. Cybersecurity Subject

Cybersecurity knowledge and skills continue to grow as life becomes more integrated with the digital world. To meet these demands, educational institutions must continue to innovate in the field of cybersecurity education and make this educational process as effective and efficient as possible [7].

Cybersecurity is a rapidly growing field of study. The industry needs more and more professionals in terms of the cybersecurity field. This situation has prompted higher education institutions to develop subjects and curricula to accommodate cybersecurity topics and skills. An analysis of strengths, weaknesses, opportunities, and threats, abbreviated as SWOT, relates to cybersecurity has been done. Strengths supporting the Cybersecurity subject are high market demand, focus on technology, and potential for career advancement. Weaknesses that arise are limited resources, a curriculum that still needs to be specific, and a need for more awareness. Opportunities include market growth, opportunities for lifelong learning, and opportunities to demonstrate leadership. Meanwhile, the threats that arise are related to curriculum renewal, qualified teachers in the field of cybersecurity, and technological developments that are constantly changing [1].

1) Strengths

On the strength side, high market demand is a condition with many demands or market needs for a product or service. In the context of the Cybersecurity subject at vocational school, high market demand can be interpreted as increased demand from industry and society for workers who have competence in the field of cybersecurity. There is ample opportunity for vocational school graduates equipped with knowledge and skills in cybersecurity to be absorbed in a large and rapidly growing labor market. There is a high demand for a workforce in the cybersecurity field, which can provide benefits for vocational school students who choose to study cybersecurity [1].

Vocational schools focus more on technology than other educational institutions. It can accelerate the adoption of cybersecurity subject and related technology integration and provide opportunities for students to learn and master technology relevant to market needs to increase the workforce's competitiveness in the future. In addition, by focusing on technology, the vocational school can prepare students to work in technology-related fields, such as cybersecurity, big data, and artificial intelligence, which are now increasingly needed in the job market. This strength can also positively impact the national economy due to the existence of a reliable workforce skilled in the technology required by industry.

Learning about cybersecurity can lead to careers in a rapidly expanding field and offers an excellent opportunity for career progression. As the demand for cybersecurity experts increases, the opportunities for getting a job in this field also increase, providing

options for vocational students to choose promising careers. In addition, with good cybersecurity skills, vocational students can benefit from finding jobs in various industries that require this expertise, such as banking, telecommunications, and technology companies. In this industry, cybersecurity skills will become an in-demand and highly valued skill. This career advancement potential also allows vocational school students to become entrepreneurs in cybersecurity, such as opening a cybersecurity company or a cybersecurity consultant. It can open up new opportunities for vocational school students to develop their careers and create new jobs in the field of cybersecurity [1].

2) Weaknesses

As for weaknesses, vocational schools often need more resources, including budgets, qualified teaching staff, and access to the latest technology. Limited resources have resulted in a lack of laboratory space, a lack of practicum tools and materials, and a lack of school technicians who can manage network infrastructure. Learning activities can only run effectively and efficiently if these weaknesses are anticipated. What can be done is to adopt technology-based learning media into subjects that can minimize obstacles.

The Merdeka curriculum currently implemented in vocational schools is very general because it must adequately provide the cybersecurity knowledge needed to prepare students for careers in that field. Fortunately, the structure of the Merdeka Curriculum provides flexibility in adjusting subjects according to the conditions of vocational schools in their respective regions. Merdeka Curriculum provides an advantage because the school can adapt various things, such as alignment to digital skills that are currently demanded [2].

Another area for improvement is the need for more awareness about the importance of cybersecurity and the lack of knowledge about cybersecurity risks. Not everyone or educational institutions realize these skills are vital in today's digital world. It can result in a lack of support or attention to the Cybersecurity subject in the vocational school. In addition, a lack of awareness can also lead to a lack of interest from students or parents in choosing majors or study programs related to cybersecurity in the vocational school. This lack of awareness can also affect acceptance and support from the government, industry, or the broader community in the Cybersecurity subject at vocational school.

3) Opportunity

When it comes to opportunities, there is a growing cybersecurity market and career opportunities in the industry will continue to grow the potential for market growth and ever-increasing demand for cybersecurity, especially in today's digital age. The rapid development of technology, including the Internet and mobile devices, has created new challenges in cyber security, such as online fraud, hacking, and cyber-attack. It allows the vocational school to develop relevant and practical cybersecurity subjects to meet the increasing market needs. The increased demand for cybersecurity has created opportunities to pursue lucrative careers. The cybersecurity subject that refers to international and industry standards can open up job opportunities in multinational companies and meet the needs of an increasingly global market. In addition, the vocational school can work with technology companies and related industries to provide training and practical experience for students in dealing with cybersecurity challenges in the real world. Vocational schools can also take advantage of opportunities to develop relationships with tertiary institutions and professional training institutions to improve students' qualifications in cybersecurity and prepare them for future challenges and opportunities. In a global context, there are also opportunities for a vocational school in Indonesia to become part of an international network of schools that focus on developing digital skills and cybersecurity. It can be an opportunity for students to participate in student exchange programs and internships at global companies engaged in information technology and cybersecurity, which can provide valuable experience and enhance their skills. In this way, the vocational school can play an essential role in increasing cybersecurity awareness and skills in Indonesia and preparing students for successful careers in the future.

When the vocational school has many materials on cybersecurity, the vocational school can become a content provider to support lifelong learning for students and the public to learn about technology and cybersecurity. This opportunity also makes it easy for professionals and workers to keep abreast of the latest developments in the field of cybersecurity and update their skills independently. With lifelong learning opportunities, individuals can continually update and improve their knowledge and skills to remain relevant in an ever-evolving job market.

Vocational schools can also serve as examples of leadership in preparing students to enter this growing industry and play an essential role in mitigating cybersecurity risks. The cybersecurity subject in vocational schools allows schools to show educational leadership and prepare a reliable workforce in information technology and cybersecurity. Schools can become leaders in information technology and cybersecurity education in Indonesia by implementing a comprehensive curriculum, adequate facilities, and appropriate teacher training.

4) Threats

The cybersecurity subject in vocational schools requires adjustments to the existing curriculum. It can be a threat and a challenge because the government has determined the vocational school curriculum and has a limited time limit for updating it. The vocational school curriculum may not capture the latest cybersecurity risks or adequately prepare students for the evolving challenges of the future. In addition, the development of a new curriculum also requires sufficient resources and qualified experts. A lack of understanding of the importance of cybersecurity can also make curriculum development easier to implement. Therefore, there is a need for collaboration between government, industry, and academia to ensure that the vocational school curriculum can be updated quickly and is relevant to the ever-changing developments in technology and cybersecurity.

The vocational school also faces threats in finding and retaining qualified teaching staff in cybersecurity. The challenge is how to make teaching vocational schools with qualifications and experience in cybersecurity have adequate training and support programs for teachers to develop their skills and knowledge in cybersecurity and retain qualified and skilled teachers due to competition in the increasing cybersecurity labor market. Strict, and the challenge of obtaining support and incentives from the government or educational institutions to attract and retain quality teachers. If this threat is not addressed, creating a good and

effective learning environment for students to develop their cybersecurity capabilities will not be easy.

Another threat lies in the ever-changing technological developments and increasing demand for cybersecurity knowledge, which can challenge vocational schools to ensure students have access to the latest technology and training. On the other hand, threats can occur if the Cybersecurity subject in vocational school is not in line with technological developments and market needs, so vocational school graduates must have competencies relevant to existing market demands. Alignment between the Merdeka Curriculum and the existing competencies required in the industry is needed. Existing competencies in the industry refer to the EC-Council, which includes international certification programs in the field of cybersecurity, such as the Certified Network Defender (CND).

B. Alignment of Cybersecurity Subject

EC-Council is the world's largest cyber security technical certification body in 145 countries globally. EC-Council is a Certified owner and developer ethical World renowned Hacker (C|EH), Computer Hacking Forensic Investigator (C|HFI), Certified Security Analyst (ECSA), Penetration Testing License (Practical), Certified Network Defender (CND), and many other certification programs. The agency has trained and certified more than 200,000 information security professionals globally who have influenced the cybersecurity mindset of many organizations worldwide. Material from CND is adopted into the Cybersecurity subject in vocational schools [9].

Cybersecurity subject follows the structure of the Merdeka Curriculum in the vocational school. The subject lies in several areas: 1) the area of Information Technology expertise, 2) Computer Network Engineering and Telecommunications expertise programs, and 3) Computer and Network Engineering concentration expertise (Teknik Komputer dan Jaringan/TKJ) as shown in Figure 1 [10]

C. The Cybersecurity subject's layout refers to the Merdeka Curriculum's structure.

Mapping the alignment of the cybersecurity subject refers to several components: 1) the network security component of the Merdeka Curriculum TKJ's expertise concentration [10]; 2) APAC Digital Skills Index [1]; and 3) CND EC-Council material [9]. The mapping can be seen in Table 1, including descriptions, targeted digital skill indexes, and material coverage.

D. Vilanets as an Innovative Cybersecurity Learning Media

The Internet is a source of information for educators, students, and parents for innovative learning [11]. The tremendous global explosion in the spread of Internet-based communication services [12]. Some people with different ages, geographical locations, and literacy abilities often feel they need to be included in the digital world that continues to grow [13]. Barriers to technology integration in school-based learning environments play an essential role in the digital divide [14]. Technology integration into the education system has changed teaching and learning styles [15]. The use of technology for education needs to include an adoption model and analyze possible barriers [16]. Efforts can be made to integrate technology into formal education and training [13]. Technology infrastructure is needed to accommodate learning so that it can be used evenly [11]. It is necessary to adopt technology such as computers and the Internet to enhance teaching and learning activities so that students benefit from developing the skills needed to use technological resources to improve their learning [15]. Educators must internally audit personal biases, attitudes, and perceptions regarding technology adoption [16].

Learning computer networks in vocational schools, they still need to have adequate practicum infrastructure. Students also only have the equipment. Only some schools and students can do the practicum. It contributes to the digital skills gap in learning. Technology adoption and integration are required to implement a virtual laboratory that anyone can use anytime, anywhere. Virtual Laboratory Network Simulator (Vilanets) is a digital learning medium that is a combination of concepts between Virtual Laboratory (VL) and Virtual Learning Environments (VLEs).

TABLE I. MAPPING THE ALIGNMENT OF THE SCOPE OF CYBERSECURITY SUBJECT MATERIALS

Proposed subject name	**Subject Description according to the Merdeka Curriculum [11]**	**Digital Skills Competency targeted [1]**	**Coverage of material adopted from CND EC-Council [9]**
Cybersecurity	network usage policy;	hardware and software operation;	network security on Windows systems; network security on Linux systems; network security on mobile systems; network security on IoT systems;
	threats and attacks on network security; the function and workings of the authentication server;	information and data literacy;	network attack and defense strategy; network security technical; network security perimeter; data security;
	firewall concept and implementation on hosts and servers; analysis of functions and security procedures for service servers on the network;	digital communication and collaboration;	network traffic monitoring and analysis; monitoring and analysis of network records;
	determining the required network security system; firewalls on hosts and servers; how the system works to detect and contain threats/attacks that enter the network;	digital problem solving;	incident response and forensic investigations;
	procedures for securing data communication using	digital security and ethics;	enterprise virtual network security; enterprise cloud network security; enterprise

Proposed subject name	Subject Description according to the Merdeka Curriculum [11]	Digital Skills Competency targeted [1]	Coverage of material adopted from CND EC-Council [9]
	cryptographic techniques;		wireless network security; threat assessment by attack surface analysis; threat prediction with cyber threats intelligence;
	the need for tools requirements to build a firewall server, the requirements for the tools to build an authentication server;	digital project management;	network security administration; application security administration; business continuity and disaster recovery; anticipate risks with risk management;

VL is a simulation environment created using computer and internet technology that allows users to conduct experiments or practicums over the network. VL enables users to access the laboratory experience in a safe and controlled manner without having to be in the physical location of the laboratory. VL usually consists of software that provides interactive visualization and simulation experiences that can be tailored to the user's needs. VL is often used in education and scientific research, particularly in science and engineering. VL can improve technological literacy and problem-solving skills [17]. VL can be used to carry out practicum learning activities, is an exciting practicum activity, easy to implement, and able to overcome the implementation of expensive, challenging, and dangerous practicums [18]. VL effectively complements traditional teaching activities [19]. VL is better than no lab at all. VL can replace some real-world labs [20]. VL is the future when connected with e-learning systems: one of the best ways to teach; it allows students to do experiments instead of just looking at them; reduces costs and improves teaching efficiency; as well as modern and flexible teaching techniques so that they can keep up with technological developments [21]. VL can push through lab projects so students can practice with open-source and commercial tools widely used in the professional field [22].

VLEs are electronic systems that can provide complete administrative and didactic support for the learning process in vocational education and training environments [23]. VLEs feature all categories of technologies that enhance learning: e-learning and distance education systems. VLEs can be categorized into three according to the level of technology: ideal, linear non-adaptable, and linear adaptable. Vilanets is at the perfect level due to the complexity of using technology in it. The Vilanets development plan can be shown in a mockup of Figure 2. The ideal VLE [24] can accommodate availability and accessibility. Availability includes infrastructure, human resources, and technology equipment. Accessibility has ease of access, flexibility, and innovation. VLE provides assignment flexibility that can help increase learner engagement and adapt better to unexpected situations [25]. VLE can enhance learner pedagogy, engagement, and acceptance [26]. VLE encourages the application of innovative technology in a continuous process to increase the capacity of individual learners [27]. VLE increases the achievement of students' learning objectives [28].

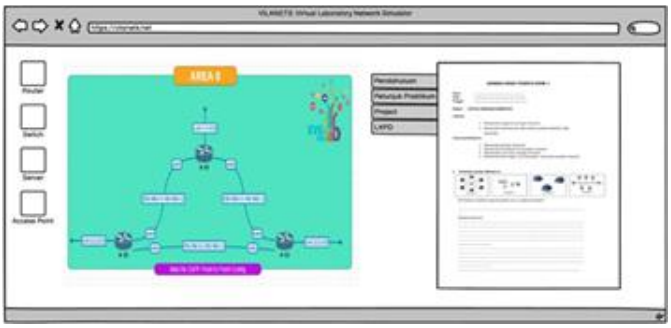

Fig. 1. Villanets Mockup

Vilanets is an advanced VLE in a virtual laboratory that accommodates availability, accessibility, and scalability. Vilanets is an innovative step for convergent and divergent thinking that can produce distance learning media with a combination of simulation, virtualization, and cloud concepts, as shown in Figure 3 [3].

Fig. 2. Vilanets concept

Vilanets is designed to accommodate a cybersecurity subject in the vocational school. Because it adopts the concepts of virtualization, simulation, and cloud, students can use it anytime, anywhere, without the need for high computer specifications, and it can be used collaboratively. Students can practice penetration tests in a simulated manner using network operating systems such as Linux and Cisco ASA. Students will be guided by modules and digital worksheets embedded in Vilanets so they do not have to switch media during practicum.

IV. DISCUSSION

Vocational school students today must have strong digital skills to be ready to face challenges in the world of work, which is increasingly connected to technology. The Cybersecurity subject integrates eight digital competency areas and is a vehicle for these skills. Vilanets digital learning media support can accommodate cybersecurity learning by presenting the concepts of virtualization, simulation, and cloud to minimize availability, accessibility, and

scalability problems so that learning can run effectively and efficiently.

References

[1] AlphaBeta, "Unlocking APAC's digital potential: changing digital skill needs and policy approaches." [Amazon Web Services], Seattle, Washington, 2021.

[2] Kementrian Pendidikan, "Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia Nomor 56/M/2022 tentang Pedoman Penerapan Kurikulum dalam Rangka Pemulihan Pembelajaran," 2022

[3] G. S. Santyadiputra and S. Hadi, "Vilanets: Inovasi Media Pembelajaran Jaringan Komputer," *J. Pendidik. Teknol. dan Kejuru.*, vol. 20, no. 1, pp. 57–67, 2023.

[4] M. Antunes and C. Rabadão, "Cybersecurity and digital forensics–course development in a higher education institution," in *Proceedings of the Tenth International Conference on Soft Computing and Pattern Recognition (SoCPaR 2018) 10*, Springer, 2020, pp. 338–348.

[5] L. G. Manzano and J. M. de Fuentes, "Design recommendations for online cybersecurity courses," *Comput. Secur.*, vol. 80, pp. 238–256, 2019.

[6] E. Troja, J. E. DeBello, and N. Roman, "Teaching efficient computer science and cybersecurity courses amidst the covid-19 pandemic," in *2021 IEEE Global Engineering Education Conference (EDUCON)*, IEEE, 2021, pp. 510–520.

[7] P. Ajjimaporn, M. Gibbons, B. Stoick, and J. Straub, "Automated Student Assessment for Cybersecurity Courses," in *2019 14th Annual Conference System of Systems Engineering (SoSE)*, IEEE, 2019, pp. 93–95.

[8] G. J. Longhurst, D. M. Stone, K. Dulohery, D. Scully, T. Campbell, and C. F. Smith, "Strength, weakness, opportunity, threat (SWOT) analysis of the adaptations to anatomical education in the United Kingdom and Republic of Ireland in response to the Covid-19 pandemic," *Anat. Sci. Educ.*, vol. 13, no. 3, pp. 301–311, 2020.

[9] EC-Council, *Certified Network Defender (Version 2)*, 2nd ed. New Mexico: EC-Council, 2020.

[10] Kementrian Pendidikan, "Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 024/H/Kr/2022 tentang Konsentrasi Keahlian SMK/MAK pada Kurikulum Merdeka," 2022

[11] V. Soundrapandian and T. P. . O. Daniel, "Redefining digital divide in the Malaysian primary schools," *J. Adv. Res. Dyn. Control Syst.*, vol. 11, no. 1, pp. 1429–1436, 2019.

[12] H. Latchman, M. McNaughton, and S. Anderson, "Bridging the persistent digital divide digital literacy and customized open-source solutions," in *IMCIC 2021 - 12th International Multi-Conference on Complexity, Informatics and Cybernetics, Proceedings*, 2021, pp. 192–197.

[13] H. Cheng, K. Lyu, J. Li, and H. Shiu, "Bridging the digital divide for rural older adults by family intergenerational learning: A classroom case in a rural primary school in china," *Int. J. Environ. Res. Public Health*, vol. 19, no. 1, p. 371, 2021.

[14] N. Wilson, "Sociotechnical and pedagogical barriers to technology integration," in *Wealth creation and poverty reduction: Breakthroughs in research and practice*, IGI Global, 2020, pp. 80–98.

[15] S. T. Faloye, N. A. Ajayi, and R. Raghavjee, "Managing the challenges of the digital divide among first year students: A case of UKZN," in *2020 IST-Africa Conference (IST-Africa)*, IEEE, 2020, pp. 1–11.

[16] G. R. McWhorter, "Leveraging Educational Technology to Meet the Needs of 21st Century Learners," in *Handbook of Research on Barriers for Teaching 21st-Century Competencies and the Impact of Digitalization*, IGI Global, 2021, pp. 215–233.

[17] S. Supahar and E. Widodo, "The effect of virtual instrument system laboratory to enhance technological literacy and problem-solving skills among junior high school students," in *AIP Conference Proceedings*, AIP Publishing, 2023.

[18] A. Ardius, "Pemanfaatan Laboratorium Maya: Peluang dan Tantangan," *J. Teknodik*, vol. 24, no. 2, pp. 147–160, 2019.

[19] L. E. De Vries and M. May, "Virtual laboratory simulation in the education of laboratory technicians–motivation and study intensity," *Biochem. Mol. Biol. Educ.*, vol. 47, no. 3, pp. 257–262, 2019.

[20] N. Jones, *Simulated labs are booming*, vol. 562, no. 7725. Nature Publishing Group, 2018.

[21] K. Aljuhani, M. Sonbul, M. Althabiti, and M. Meccawy, "Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools," *Smart Learn. Environ.*, vol. 5, pp. 1–13, 2018.

[22] E. Li, "A Hands-On Mobile Device Forensics Course in Cybersecurity Education," in *2021 IEEE International Conference on Engineering, Technology & Education (TALE)*, IEEE, 2021, pp. 1–5.

[23] R. Mueller and J. Von Kempis, *Clinical Trials in Rheumatology*. Springer Science & Business Media, 2010.

[24] L. Caprara and C. Caprara, "Effects of virtual learning environments: A scoping review of literature," *Educ. Inf. Technol.*, pp. 1–40, 2022.

[25] W. L. Leite, W. Xing, G. Fish, and C. Li, "Teacher strategies to use virtual learning environments to facilitate algebra learning during school closures," *J. Res. Technol. Educ.*, pp. 1–15, 2022.

[26] S. Smith, D. Cobham, and K. Jacques, "The use of data mining and automated social networking tools in virtual learning environments to improve student engagement in higher education," *Int. J. Inf. Educ. Technol. Vol 12 4*, vol. 12, no. 4, pp. 263–271, 2022.

[27] R. A. Valentim *et al.*, "Virtual learning environment of the Brazilian health system (AVASUS): efficiency of results, impacts, and contributions," *Front. Med.*, vol. 9, p. 896208, 2022.

[28] E. Lacka, T. C. Wong, and M. Y. Haddoud, "Can digital technologies improve students' efficiency? Exploring the role of Virtual Learning Environment and Social Media use in Higher Education," *Comput. Educ.*, vol. 163, p. 104099, 2021.