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The Technological Literacy Profile of Physics Education Students in Utilizing Digital Applications To Support Quality Education

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Abstract

Technological literacy has become one of the essential competencies for university students in the digital era, particularly in supporting the achievement of Sustainable Development Goal (SDG) 4 on quality education. This study aims to analyze the technological literacy profile of physics education students at Universitas Sriwijaya in utilizing digital devices and applications for learning purposes. Data were collected through interviews with 30 respondents. The dimensions in the interview instrument included technology access, technology understanding, and technology production. The data were analyzed qualitatively using coding analysis with the Quirkos application. The findings reveal that students predominantly rely on smartphones and laptops to support learning activities, although unstable network quality remains a significant obstacle. Students' experiences in utilizing digital learning media and accessing scientific journals are still relatively limited. Various digital applications, such as Google Drive, PhET Colorado, Microsoft Word, Canva, and CapCut, are commonly used to facilitate learning. Technological literacy is supported by the availability of internet access, conducive learning environments, and campus facility support, yet it is hindered by limited technological understanding, data security risks, network instability, and the persistence of plagiarism practices. The findings imply that enhancing technological literacy is crucial for preparing students to engage in innovative and ethical digital learning environments. Therefore, universities should integrate digital literacy programs through educational technology training, project-based learning, and the habituation of digital ethics to foster adaptive and sustainable physics learning.

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INTRODUCTION

The development of digital technology has influenced almost every aspect of life, including education (Carstens et al., 2021; Hidayatullah et al., 2024; Raja & Nagasubramani, 2018). One of its impacts is that university students, as prospective teachers and scientists, are required to possess adequate technological literacy in order to utilize digital devices effectively and efficiently (Chen, 2025; Haleem et al., 2022; Nurzhanova et al., 2023). Technological literacy is not limited to technical abilities in operating devices but also includes critical thinking skills, the ability to validate information, data security awareness,

and an understanding of ethical issues in technology use (Albardía et al., 2025; Febliza et al., 2023; Iskandar et al., 2025). Thus, technological literacy is an essential competency that supports students' success in facing challenges in the digital era.

In the context of higher education, technological literacy has become one of the key skills that must be developed to support students' mastery of 21st-century competencies. Universities are not only expected to produce graduates with high academic competence but also to equip them with sufficient technological literacy to support learning, research, and community engagement (Damayanti et al., 2025; Khan et al., 2022; Putri et al., 2025). Technological literacy affects students' adaptive abilities in using various digital devices and applications for accessing learning resources, academic collaboration, and innovation in learning (Ika et al., 2024; Pangestu et al., 2024; Zhou et al., 2025). This indicates that technological literacy is an essential aspect of improving education quality.

Technological literacy in physics education holds high importance (Albardía et al., 2025; Cahyanto et al., 2024; Putri et al., 2025). For instance, the use of simulations, virtual laboratories, e-learning platforms, and interactive learning media can help students better understand abstract concepts in physics (Handayani & Purwanta, 2024; Liswar et al., 2023; Rusnayati & Ariantara, 2024). Furthermore, technological literacy can enhance learning motivation, broaden access to learning resources, and foster more meaningful learning experiences (Millah et al., 2025; Riyadi & Sudiyatno, 2023; Tabasi et al., 2024). In physics education, technological literacy is particularly crucial because physics concepts are often abstract, mathematical, and phenomenon-based, requiring digital tools to support visualization, experimentation, and data analysis that cannot always be achieved through conventional instruction alone (Tabasi et al., 2024). Therefore, the integration of technology in physics education aligns with the efforts to achieve Sustainable Development Goal (SDG) 4 to ensure inclusive, equitable, and quality education and promote lifelong learning opportunities for all.

However, several challenges remain in implementing digital technology among university students. These include limited network infrastructure, insufficient skills in operating digital applications, and low awareness of digital ethics (Aleca & Mihai, 2025; Dwivedi et al., 2020). Previous studies on technological literacy have largely focused on general education contexts or emphasized access and usage levels without deeply examining discipline-specific needs, particularly in physics education, where technological tools play a strategic role in conceptual understanding and scientific inquiry (Fitriyani et al., 2020). Moreover, limited research has explicitly linked students' technological literacy profiles with the SDGs framework, especially SDG 4, as a foundation for sustainable and inclusive physics education in higher education settings.

This gap indicates the need for empirical evidence that maps the technological literacy profile of physics education students by considering access, understanding, and production aspects of technology within the context of digital learning and sustainability goals. Therefore, this study aims to analyze the technological literacy profile of physics education students at Universitas Sriwijaya in utilizing digital devices and applications for learning. The results are expected to contribute to the development of effective learning strategies and to support the achievement of SDG 4 on quality education.

METHODS

This study employed a qualitative research approach. Data were collected through interviews. The sampling technique used was purposive sampling, with the rationale that the selected participants were actively enrolled students who had experienced digital-based learning and regularly used digital devices in physics courses, making them relevant informants for exploring technological literacy in an educational context.

The dimensions of the interview instrument included technology access, technology understanding, and technology production (Livingstone, 2004). The interview instrument

was semi-structured, allowing flexibility for probing deeper responses while maintaining consistency across participants. Instrument validation was conducted through expert judgment involving two experts in physics education and educational technology to ensure content relevance, clarity, and alignment with the research objectives. Revisions were made based on expert feedback before data collection.

The examples of key interview questions included "What digital devices and applications do you commonly use to support physics learning? How do you access e-learning platforms and scientific e-journals, and what difficulties do you encounter? How do you evaluate the reliability and ethical use of digital information in completing academic tasks? and have you ever created digital learning products such as presentations, videos, or simulations in physics courses?"

The respondents consisted of 30 undergraduate students from the Physics Education Study Program at Universitas Sriwijaya, comprising male and female students from different academic years who had varying levels of experience with digital learning platforms and applications. The interview data were analyzed qualitatively using coding analysis with the Quirkos application.

This study addresses several interrelated research questions concerning the technological literacy of physics education students at Universitas Sriwijaya in supporting learning in the digital era. Specifically, the study explores students' levels of technological literacy and examines how the use of digital devices and applications contributes to the effectiveness of physics learning. It also investigates the extent to which internet network quality influences students' access to e-learning platforms, e-journals, and other digital learning resources. Furthermore, the study identifies factors that support and hinder students in utilizing digital media, including ethical considerations and data security issues. Finally, the study analyzes how technological literacy contributes to the development of students' creativity and innovation in producing digital physics learning media.

RESULTS AND DISCUSSION

The level of technological literacy among physics education students at Universitas Sriwijaya indicates a functional tendency, meaning that students are capable of utilizing basic digital tools to support learning but have not yet optimized their analytical and scientific competencies. Referring to Livingstone's (2004) framework, functional technological literacy is characterized by the ability to operate digital devices and applications for routine tasks, without deeper engagement in critical evaluation, scientific analysis, or creative knowledge production.

The findings reveal that the most frequently used digital devices in learning are laptops and smartphones, as shown in Figure 1. These devices serve as the primary means for students to access e-learning platforms, SPSS (Statistical Product and Service Solution), Zoom, and Google Meet as essential learning tools.

Figure 1 Quirkos visualization related to the use of digital devices

This finding confirms that students' technological literacy remains at the functional literacy stage, emphasizing the ability to operate personal devices that are flexible and easily accessible. Empirically, this functional level is demonstrated by students' dominant use of devices for accessing materials, attending online classes, and submitting

assignments, rather than for conducting data-driven analysis, scientific simulations, or research-based digital inquiry. Figure 1 illustrates the distribution of digital devices used by physics education students, showing that smartphones and laptops dominate learning activities compared to other digital tools. This pattern indicates that students primarily rely on personal devices that support mobility and ease of access in daily academic tasks. This aligns with Pangestu (2024), who explained that students tend to choose devices that are convenient and available anytime, anywhere. Similarly, Izquierdo (2024) found that nearly all university students in the United States use smartphones for academic purposes. Hasan (2025) also emphasized that laptops and smartphones dominate online learning, especially when classes are conducted via Zoom or Google Meet.

However, unlike several previous studies that reported a gradual shift toward higher-level technological literacy involving data analysis, digital research skills, and scientific inquiry tools (Albardia, 2025; Putri, 2025), the present study reveals that students' technology use remains concentrated at a functional and operational level. This gap explicitly indicates that students have not yet reached the critical literacy level, which requires the ability to evaluate, interpret, and analyze digital scientific information, nor the creative literacy level, which involves producing original, research-based digital artifacts. This distinction indicates that device availability alone does not automatically lead to advanced technological literacy in physics education.

Laptops and smartphones enable flexible access to e-learning platforms, including downloading materials, completing quizzes, and joining discussion forums (Akpen et al., 2024; Izzati et al., 2024; Nikolopoulou, 2022). As shown in Figure 1, the limited use of other supporting devices suggests that students' technological engagement is still focused on basic operational needs rather than advanced or specialized digital tools. Moreover, for data analysis, applications such as SPSS operate more efficiently on laptops, making laptop availability crucial for successful data processing (Fitriyani et al., 2020; Guntur, 2023; Handayani & Purwanta, 2024). Nevertheless, despite access to laptops, students rarely use analytical software for independent research tasks, indicating limited analytical readiness rather than mere device constraints. Therefore, personal, flexible, and easily accessible digital devices remain students' primary choice for supporting the learning process.

Internet network quality is another factor that significantly affects access to digital information. Most students reported weak internet connectivity, which disrupted online learning, e-journal access, and participation in digital collaboration, as depicted in Figure 2.

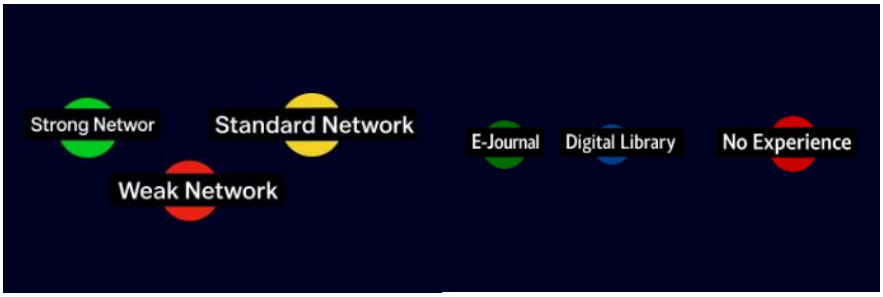

Figure 2 Quirkos visualization related to internet network quality for digital access

This finding highlights that network infrastructure has a substantial impact on the effectiveness of technology-based learning. Figure 2 depicts students' perceptions of internet network quality in supporting digital learning activities, indicating that a significant proportion of students experience weak or unstable network conditions, while only a small number report having strong and reliable internet access. Compared with studies conducted in institutions with stronger digital infrastructure (Aleca, 2025; Khan, 2022), the present findings demonstrate that infrastructure disparities remain a critical barrier to achieving equitable digital learning in physics education.

Cause-and-effect analysis shows that weak internet connectivity directly discourages students from accessing data-intensive academic resources such as e-journals and digital libraries, which typically require stable connections, institutional logins, and extended reading time. This condition reflects uneven digital readiness among students and directly influences their learning engagement. Putri (2022) asserted that poor network accessibility reduces online learning effectiveness, slows information literacy processes, and decreases students' motivation to seek academic references independently. Riyadi (2023) also noted that low network quality directly affects students' motivation to learn. As illustrated in Figure 2, unstable internet connections limit students' ability to access e-learning platforms, download learning materials, and participate in synchronous learning activities, thereby constraining the optimal use of digital technology in physics education. Thus, internet quality not only determines access to information but also serves as a key indicator of students' digital readiness for technology-enhanced learning.

Limited internet connectivity has also resulted in low student access to e-journals and digital libraries. E-journals are rarely used because students perceive them as difficult to access and time-consuming to read and requiring advanced academic skills such as critical reading, data interpretation, and reference management, skills that align more closely with critical technological literacy rather than functional literacy. This finding contrasts with prior research reporting increased student engagement with scholarly digital resources following structured digital literacy training (Putri, 2025; Kunz, 2024), suggesting that the absence of systematic training at the institutional level contributes to the observed literacy gap in this study. Most students admitted they had never directly used these resources for learning. Instead, they preferred social media over credible academic databases (Basar et al., 2021; Falahuddin et al., 2025; Ren et al., 2024).

This demonstrates limited ability among students to identify, evaluate, and integrate academic information (Kunz, 2024; Ratri, 2025). Thus, the rare use of e-journals is not only a technical issue but also a reflection of students' limited critical technological literacy. Consequently, poor internet infrastructure not only hinders learning but also weakens students' technological literacy in accessing digital academic sources effectively.

Students' experience with digital media remains confined to basic activities, such as attending online classes, submitting assignments, and participating in discussions through collaborative platforms. The limited use of e-journals and digital libraries indicates low academic information literacy, as shown in Figure 3.

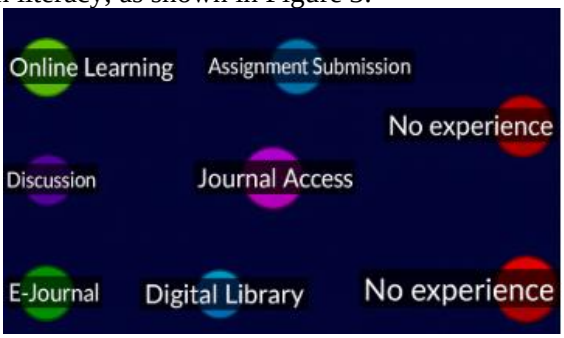

Figure 3 Quirkos visualization related to students' experiences with digital media

These findings suggest that students' learning habits tend to rely on quick and practical sources, such as social media or general platforms, rather than more complex scholarly resources. This behavior reflects functional literacy, where technology is used for efficiency and task completion, rather than critical literacy, which requires evaluation of scientific credibility and evidence-based reasoning. Figure 3 illustrates students' experiences in utilizing digital media for academic purposes, showing that the use of digital platforms is dominated by general learning media, while access to e-journals and digital libraries remains relatively low.

This pattern indicates that students prioritize ease and speed over academic depth when searching for learning resources. This aligns with Putri (2025), who noted that low academic digital literacy among students stems from limited training in scientific information retrieval and restricted access to journal databases. Hasan (2025) reported similar challenges, noting students' difficulty in critically selecting and utilizing scientific information. As reflected in Figure 3, the limited engagement with scholarly digital resources constrains students' ability to develop critical reading, analytical skills, and evidence-based reasoning in physics learning. Hence, the limited experience in using digital media for academic purposes necessitates enhanced digital literacy through training in scientific information retrieval and expanded access to credible reference sources.

In terms of digital application use, students predominantly employ creative and content-based tools such as Canva, Microsoft PowerPoint, YouTube, CapCut, podcasts, animation software, and TikTok, as illustrated in Figure 4. Analytical applications such as SPSS and IoT-based technologies are less popular because they demand higher-order skills, including statistical reasoning, data interpretation, and experimental design, which students have not been sufficiently trained to master. While previous studies have emphasized the potential of digital tools to support scientific inquiry and data-driven experimentation in physics learning (Rusnayati, 2024), the current findings indicate that students' technological literacy is more strongly developed in communication and visualization than in analytical reasoning and data processing.

Additionally, storage and collaboration applications like Google Drive and OneDrive are frequently used to support academic tasks. The use of these applications significantly contributes to the effectiveness of physics learning by promoting active engagement, concept visualization, and peer communication. However, the use of data analysis and information-processing applications remains limited, for instance, SPSS and IoT-based technologies, although Microsoft Word and AI-based platforms are increasingly used for assignments and innovative learning exploration. This indicates that students' technological literacy is still concentrated on presentation and communication rather than on complex scientific data analysis.

Figure 4 Quirkos visualization related to students' use of digital applications

Students utilize various digital applications to produce physics learning media, such as Canva and PowerPoint for designing interactive presentations, and CapCut and TikTok for creating simple experiment videos. Figure 4 presents the distribution of digital applications used by students in developing physics learning media, indicating that creative and presentation-oriented applications are used more frequently than analytical or data-processing tools. Furthermore, several students reported using PhET Simulation and Augmented Reality (AR) applications to visualize abstract physics concepts such as harmonic motion, waves, and electromagnetism. The use of these tools demonstrates innovative efforts to develop technology-based learning resources that enhance conceptual understanding—particularly for abstract phenomena that are difficult to explain through conventional methods (Rusnayati, 2024). As shown in Figure 4, the dominance of design and visualization tools suggests that students' technological literacy is more developed in

the communicative and creative dimensions than in scientific data analysis. While these applications significantly support physics learning through engagement, visualization, and communication, the limited use of data-analysis tools reflects students' focus on presentation and communication rather than scientific inquiry.

This suggests that students are more comfortable using technology for communication and content presentation than for data analysis and research. Scientifically, this finding implies that analytical skills require more intensive training, whereas collaborative applications are easier to access and comprehend. Students prefer visual and collaborative platforms because they foster creativity and active learning engagement (Handayani & Purwanta, 2024; Hasan et al., 2025; Mhlanga, 2024).

Moreover, the findings reveal a technological literacy gap—students tend to favor instant, easy-to-use applications rather than analytical tools that require longer learning curves. This is significant because it shows that digital learning effectiveness depends not only on device availability but also on students' readiness to develop deeper analytical skills (Hariyanto et al., 2022; Pangestu et al., 2024; Zou et al., 2025). While basic device mastery is adequate, limited use of analytical applications restricts students' abilities in quantitative research and digital data management.

From the perspective of supporting and inhibiting factors, environmental support, device availability, and internet access serve as key enablers for digital media use in learning, as shown in Figure 5. However, low technological understanding, weak digital ethics awareness, and vulnerability to data security breaches are the main obstacles. Instances of account hacking and unsafe digital practices illustrate students' limited cybersecurity literacy. Many students neglect data privacy, fail to activate two-factor authentication, and store personal information in unsecured cloud services (Megouache et al., 2021; Ntloedibe et al., 2024; Taufik & Agus Juhana, 2025). These conditions highlight the urgent need to strengthen digital ethics and data security awareness as integral components of technological literacy.

Figure 5 Quirkos visualization related to supporting and inhibiting factors in digital media use

Based on Figure 5, several students reported experiencing security issues, such as hacked social media or email accounts, indicating weak data protection practices and limited awareness of digital security. Unlike studies that reported increasing student awareness of cybersecurity and digital ethics (Megouache, 2021), this study reveals persistent vulnerabilities such as account hacking and unsafe data storage practices,

indicating that digital ethics has not yet been fully internalized as part of students' technological literacy. This is often caused by unsafe digital habits, such as failing to validate information sources, neglecting privacy and verification settings, and using weak passwords (Adeosun, 2025; Ahmadiar & Muchallil, 2015; Cahyanto et al., 2024). Moreover, storing data in cloud services like Google Drive without additional protection increases vulnerability to data breaches (Ntloedibe et al., 2024; Sasi et al., 2024; Vardakis et al., 2024). These findings suggest that students' digital security literacy remains limited, leading to reduced confidence in using digital platforms. Therefore, strengthening digital ethics and cybersecurity awareness is essential to ensure students can use technology responsibly and remain protected from potential threats.

In relation to the Sustainable Development Goals, particularly SDG 4 on quality and inclusive education, these findings imply that technological literacy development in physics education must go beyond access and basic usage. Equitable and sustainable education requires not only digital infrastructure but also the cultivation of analytical skills, ethical awareness, and scientific inquiry competencies. Without addressing these dimensions, digital learning risks reinforcing inequality rather than promoting inclusive and high-quality education.

Overall, this study concludes that students' technological literacy in physics learning is still functional, focusing on mastery of basic devices and collaborative applications, but has not yet evolved toward scientific and analytical competencies such as e-journal use, data analysis, and innovative media development. The key contribution of this study lies in demonstrating that, despite widespread digital device use, physics education students' technological literacy remains uneven and insufficiently aligned with the goals of sustainable, high-quality education. These findings highlight serious challenges in both infrastructure and skills. Therefore, enhancing technological literacy requires a strategic focus on facilities, technical training, and digital ethics development to support the realization of quality education as emphasized in SDG 4.

This study recommends that technological literacy directly contributes to improving the quality of physics education in higher education through digital access, digital understanding, and digital production. Digital access broadens students' learning resources, digital understanding supports critical evaluation of scientific information and ethical technology use, and digital production reflects students' creativity in developing interactive physics learning media.

Overall, these findings demonstrate that technological literacy is a key driver in supporting the achievement of Sustainable Development Goal (SDG) 4 by promoting inclusive access, ethical digital practices, and innovative learning in physics education. Unlike previous studies that generally emphasize technology access or general digital literacy, this research highlights a discipline-specific profile of technological literacy in physics education, revealing that students' competencies remain predominantly functional rather than analytical and research-oriented.

This distinction underscores the importance of targeted technological literacy development aligned with the analytical and scientific demands of physics learning. Although analytical technological literacy still requires strengthening, these findings provide an essential foundation for advancing effective, innovative, and sustainable physics education in the digital era.

CONCLUSION

This study reveals that technological literacy among physics education students at Universitas Sriwijaya plays a crucial role in learning within the digital era. Students utilize laptops and mobile phones to access e-learning platforms, engage in digital collaboration, and perform data processing. However, their proficiency in data analysis, e-journal utilization, and the development of innovative learning media remains limited. The main

challenges include internet connectivity, analytical skills, digital ethics, and data security. Nevertheless, students are capable of producing digital physics learning media, such as experimental videos and interactive simulations that enhance conceptual understanding. Technological literacy contributes to the quality of learning through access to learning resources, critical understanding, and digital media production. Therefore, the enhancement of facilities, technical training, and digital ethics is essential to achieving more effective and innovative physics learning. However, this study has several limitations. The findings are limited to a single institution and may not represent the broader context of physics education students in other universities or regions. In addition, the data were obtained through self-reported responses, which may lead to subjective bias. Future research should involve larger and more diverse samples, integrate quantitative performance measures, and include longitudinal studies to capture changes in digital literacy over time. The implications of this study highlight the need for curriculum redesign that integrates digital literacy and ethics into physics education. Educators and policymakers should focus on strengthening digital competencies through project-based learning, training in data analysis tools, and the responsible use of technology to foster critical and creative thinking among future teachers.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, FIS; Research design, FIS; Data collection, FIS.; Drafting manuscript, FIS; Supervised, KW; Review paper, KW and AK; Data analysis, EAP; Literature review, EAP.

AI DISCLOSURE STATEMENT

The authors declare that this research was designed, conducted, written, and edited entirely by the authors without the use of any artificial intelligence (AI) tools, services, or techniques. The authors take full responsibility for the content of this publication.

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