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Research Article

Technology and Digital Literacy in Mathematics Learning at Vocational High School Muhammadiyah 3 Metro

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ABSTRACT

Background: Digital literacy is a critical competency for vocational students; however, its integration into mathematics instruction at SMK Muhammadiyah 3 Metro remains limited, as evidenced by low student engagement and insufficient use of technological resources. **Objective:** This study seeks to characterize the mathematics learning process and analyze the alignment between theoretical frameworks and classroom implementation. **Method:** A descriptive-quantitative approach was employed, using a 40-item Likert-scale questionnaire addressing student motivation, digital media use, teacher roles, and school facilities. The instrument was administered to 31 students and one mathematics teacher during the odd semester of 2024/2025. Data analysis involved index score calculations. **Results:** Student motivation was reported as very high (85.80%), whereas engagement (59.35%) and enjoyment (54.19%) were moderate. Teacher involvement and school facilities achieved full scores (100%), resulting in a 40-percentage-point disparity between system readiness and student participation. These findings suggest that infrastructure and teacher readiness alone are insufficient to ensure active student learning. **Conclusion:** The principal challenge is not related to facilities or teacher competence, but rather to adopting pedagogical strategies that promote interactive and enjoyable learning experiences. Digital literacy can enhance learning quality when integrated into student-centered instructional methods. It is recommended that schools prioritize pedagogical innovation over mere technological provision to foster meaningful student engagement. The study's limitations include a small sample size from a single school, which necessitates caution when generalizing the findings.

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INTRODUCTION

The ongoing advancements of the Fourth Industrial Revolution have prompted significant changes in graduation requirements, particularly at the vocational high school (SMK) level. These changes necessitate that students remain responsive to current developments to successfully transition into the workforce. Within this context, digital literacy has emerged as a critical skill, defined as the capacity to access, process, evaluate, and use digital information ethically and critically (Muliawanti & Kusuma, 2019; Fadhillah et al., 2023; Ministry of Education and Culture, 2017). The implementation of digital literacy is expected to enable vocational school graduates to become adaptable and productive workers who can compete in the global market (Jayantika & Namur, 2022). In this study, digital literacy is operationally defined as students' ability to use digital technology in mathematics learning, encompassing four dimensions: student motivation and activity, use of digital media, teacher roles, and school facilities.

Technology plays a pivotal role in mathematics education by facilitating the presentation of material that is often perceived as difficult and abstract. Information and Communication Technology (ICT) provides solutions through visualization and simulation, thereby enhancing the effectiveness and efficiency of instruction (Hibatulloh et al., 2023; Dewi et al., 2023). Empirical studies have demonstrated that digital literacy positively influences students' cognitive abilities in problem-solving and critical thinking (Munif et al., 2024; Putri et al., 2024; Septia & Wahyu, 2023). Widana (2020) reported that digital literacy significantly enhances teachers' capacity to develop higher-order thinking skills (HOTS)-based assessments, as indicated by an F value of 60.594 and a significance value of 0.000. This finding suggests that teachers with advanced digital literacy are better prepared to design assessments targeting higher-order thinking. Additionally, students' affective domains, such as motivation and interest in learning, are significantly enhanced when teachers use interactive digital media creatively (Hamin et al., 2025; Murip et al., 2024; Hasanah et al., 2021).

Although digital literacy has demonstrated positive effects, prior research has identified significant gaps in its development and application within educational settings. These gaps are primarily attributed to disparities in mastery across various dimensions of digital literacy. For example, Artiyani (2022) found that while 85% of vocational students demonstrated high proficiency in operating digital devices, only 45% could critically assess the credibility of digital information. Similarly, Septia and Wahyu (2023) observed that students' digital collaboration skills were moderate (score 60 out of 100), despite high operational literacy (score 85). Afifah and Lestari (2024) corroborated these findings, reporting that vocational students achieved high scores in Internet Search (76.73) and Hypertext Direction Guide (79.53), but scored considerably lower in Information Content Evaluation (52.94). These discrepancies contribute to suboptimal learning processes and hinder students' knowledge acquisition. The lack of comprehensive digital literacy and the inability of digital literacy initiatives to foster engaging, participatory learning experiences underscore persistent challenges in its implementation. These challenges are further exacerbated by shifts in resource availability and foundational teacher competencies, which complicate the optimization of pedagogical strategies to promote active and meaningful student engagement (Artiyani, 2022).

This study involves four main variables: (1) student activity and motivation, (2) use of digital media, (3) teacher roles and school facilities, and (4) teacher digital literacy reinforcement. The novelty of this research lies in its quantitative examination of the hypothesis that the main challenge in digital literacy implementation is not infrastructure or teacher competence, but rather pedagogical strategies. Ardiansyah, Hardhienata, and Suhendra (2025) found that digital literacy is the strongest predictor of teacher innovativeness in mathematics instruction, with a significant

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direct impact (β = 0.965, $p < 0.002$), demonstrating that digital competence is a vital strategic resource for pedagogical innovation. Unlike previous studies that have focused more on the impact of digital literacy on learning outcomes, this study specifically highlights the gap between system readiness and student engagement in the context of vocational mathematics education in Indonesia.

The objectives of this study are as follows: (1) to assess the level of student motivation and learning activity in digital-based mathematics instruction at SMK Muhammadiyah 3 Metro; (2) to quantitatively identify the gap between system readiness, including facilities and teacher roles, and student engagement; and (3) to determine the primary challenges in digital literacy implementation by comparing index scores across relevant aspects. The indicators of success for this research include: (1) post-test scores exceeding pre-test scores, (2) an N-Gain score classified at least as moderate, and (3) teaching skills observation scores rated as good.

This study seeks to answer two primary research questions: (1) What is the level of digital literacy implementation in mathematics learning at SMK Muhammadiyah 3 Metro, considering student motivation, digital media use, teacher roles, and school facilities? (2) What are the main challenges in implementing digital literacy? The research is based on two central assumptions: first, that digital facilities and teacher competencies at the school are sufficient; and second, that the principal challenge is related to pedagogical strategies rather than infrastructure. This premise is supported by Ferawati, Royadi, and Saputri (2025), who demonstrated that integrating educational games and the quality of learning management significantly affect digital literacy competence in mathematics ($R^2 = 0.611$), highlighting the importance of structured pedagogical approaches. The hypothesis posited is that there is no significant gap between system readiness and student engagement.

The findings of this study are anticipated to inform the development of more effective, participatory, technology-based instructional methods by providing strategic recommendations. These recommendations aim to address the disconnect between operational technology proficiency and active student participation. Hu (2025) asserts that fostering digital literacy in vocational education elevates it from a supplementary skill to a fundamental empowerment, supporting students' lifelong learning and career advancement, and enabling them to become active contributors to digital transformation.

METHOD

Research Design

A cross-sectional survey design with a descriptive-quantitative approach was employed in this study. The cross-sectional design was chosen because data collection occurred at a single point in time to describe the current condition of digital literacy implementation in mathematics learning at SMK Muhammadiyah 3 Metro. This approach is suitable for capturing a snapshot of existing phenomena without manipulation or intervention, making it appropriate for descriptive research that aims to portray the status of digital literacy across multiple aspects (Creswell & Creswell, 2018). Pre- and post-test measurements were not utilized, as the study was not intended to measure change over time but to provide a comprehensive description of the current state of digital literacy implementation from the perspectives of both teachers and students.

Population, Sample, and Sampling Technique

The population comprised all students and the mathematics teacher at SMK Muhammadiyah 3 Metro who participated in digital-based mathematics learning during the odd semester of the 2024/2025 academic year. The student sample comprised 31 students from a single class (Class X), selected via total sampling (saturation sampling), in which all students in the class were included as respondents. This technique was employed because the class represented the only group engaged in

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digital-based mathematics learning at the school, resulting in the entire population serving as the sample. The mathematics teacher who taught the class was also included as a supporting respondent, selected purposively due to direct involvement in implementing digital literacy in mathematics instruction. This sampling approach ensures representation of all relevant subjects within the defined context, consistent with the study's descriptive nature (Sugiyono, 2023).

Research Instruments

Three sets of research instruments were employed to collect data comprehensively:

1. Digital Literacy Questionnaire (for Students)

The student questionnaire comprised 40 items addressing four primary domains: Student Activities and Motivation (A1-A10), Use of Digital Media (B1-B10), Role of Teachers and School Facilities (C1-C10), and Strengthening Teachers' Digital Literacy (D1-D10). Instrument development was informed by a review of relevant literature and adaptation from established digital literacy research instruments (Artiyani, 2022; Septia & Wahyu, 2023). Each item utilized a four-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree).

2. Teacher Questionnaire

The teacher questionnaire included the same 40 items as the student version, modified to capture teachers' perspectives on the implementation of digital literacy. It incorporated self-assessment of digital competence and evaluation of school facility readiness.

3. Observation and Documentation Sheets

Observation sheets served to corroborate questionnaire responses through direct classroom observation. Documentation was collected to provide supporting evidence, including lesson plans, teaching materials, and photographs of learning activities.

Validity and Reliability of Instruments

Before data collection, the questionnaire instruments underwent validity and reliability testing. A pilot test involving 20 students from another class was conducted to assess the instrument's quality. Content validity was determined through expert evaluation by two university lecturers specializing in educational research, and one experienced vocational school teacher, who assessed the relevance, clarity, and appropriateness of each item. Items achieving a Content Validity Index (CVI) of 0.80 or higher were retained.

Construct validity was evaluated using Pearson Product-Moment correlation. The pilot test indicated that 36 of 40 items had correlation coefficients (r) exceeding the critical value of 0.361 ($\alpha = 0.05$), confirming their validity. Four items were excluded due to low correlation. Reliability analysis using Cronbach's Alpha produced a coefficient of 0.87 for the overall questionnaire, reflecting very high internal consistency. The reliability coefficients for the four subscales were as follows: Student Activities and Motivation ($\alpha = 0.84$), Use of Digital Media ($\alpha = 0.82$), Role of Teachers and School Facilities ($\alpha = 0.85$), and Strengthening Teachers' Digital Literacy ($\alpha = 0.83$).

Data Collection Procedures

Data collection took place in September 2024, during the odd semester of the 2024/2025 academic year. The procedures were implemented in three stages:

Stage 1: Preparation

The research instruments were prepared and validated. Approval was obtained from the school principal and the class teacher. Students were informed about the research purpose and assured of the confidentiality of their responses.

Stage 2: Questionnaire Administration

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The student questionnaire was administered in the classroom during a 40-minute session. The researcher and a trained assistant provided guidance and ensured clarity of all items. Students were encouraged to respond honestly, and anonymity was guaranteed to reduce social desirability bias. The mathematics teacher completed the questionnaire privately, also requiring approximately 40 minutes.

Stage 3: Observation and Documentation

Classroom observation was conducted over two lesson periods (2 × 45 minutes) to verify questionnaire findings and document the implementation of digital literacy in mathematics instruction. Observations emphasized student engagement, teacher-student interaction, and the use of digital media during lessons.

Data Analysis

Descriptive statistical techniques were employed for data analysis. Index Scores were calculated to assess the level of implementation success for each aspect. The index score was determined by comparing the Total Score to the Theoretical Maximum Score using the following formula:

$$Index\ Score = \frac{Total\ Score}{Maximum\ Score} \times 100\%$$

The resulting score was then converted into descriptive categories based on the following criteria:

Table 1. Interpretation Criteria for Index Scores

No.	Score Range	Category
1	81% – 100%	Very High
2	61% – 80%	High
3	41% – 60%	Moderate
4	20% – 40%	Low
5	0% – 19%	Very Low

The analysis aimed to describe the current state of digital literacy implementation and identify gaps across its various aspects. To enhance the validity of the findings, data triangulation was performed by comparing questionnaire data with school observations. This approach is consistent with the study's objective of providing a comprehensive overview of digital literacy implementation rather than testing causal relationships.

RESULT AND DISCUSSION

1. Result

Readiness of Facilities and Teachers

Empirical findings demonstrate optimal readiness regarding system support, specifically in Teacher Roles and School Facilities (C1-C10) and Strengthening Teachers' Digital Literacy (D1-D10), both of which achieved index scores of 100% (Very High). These results suggest that schools have provided sufficient technological infrastructure and that teachers are proficient in utilizing digital media, selecting effective learning models, and employing technology to enhance student engagement. Teachers also demonstrate the capacity to guide students in developing digital literacy and to implement interactive, digital-based instructional methods.

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Table 2. Descriptive Statistics for System Readiness Aspects (N=31 Students)

No	Aspect	Index Score	SD	Min	Max	Category
1.	Teacher Roles and School Facilities (C1-C10)	100%	0.00	100%	100%	Very High
2.	Strengthening Teachers' Digital Literacy (D1-D10)	100%	0.00	100%	100%	Very High

Note: The zero standard deviation indicates unanimous agreement among respondents regarding the readiness of facilities and teacher competence.

These results confirm that the technical prerequisites for digital literacy implementation, including teacher adaptation and competence, have been ideally fulfilled (Muliawanti & Kusuma, 2019; Artiyani, 2023).

Increased Motivation and Independence in Learning

The data shows that the implementation of technology in learning has successfully provided positive benefits in terms of student attitudes and independence.

Table 2. Students' Perceptions of Motivation and Independent Learning (N=31 Students)

No	Key Indicators	Index Score	SD	Min	Max	Category
1.	Motivation through engaging learning methods	85.80%	8.20	70%	100%	Very High
2.	Seeking information through digital media for understanding	73.54%	10.50	55%	90%	High
3.	Utilization of digital technology for independent learning	69.97%	11.20	50%	85%	High
4.	Motivation due to the relevance of the material to daily life	70.96%	9.80	55%	90%	High

The standard deviation values (ranging from 8.20 to 11.20) indicate moderate variation in student responses, suggesting that while most students reported high motivation, there were some differences in individual experiences. The minimum and maximum scores show that no student scored below 50% in any aspect, confirming generally positive perceptions across the sample.

These high scores confirm that digital technology is effective in increasing students' extrinsic and intrinsic motivation, in line with previous findings that digital literacy positively influences students' motivation and interest in learning (Hamin et al., 2025; Murip et al., 2024).

Critical Gaps in Student Engagement

Although system readiness reached 100%, an in-depth analysis of students' perceptions showed a significant gap in three key indicators of learning experiences, all of which were in the moderate category.

Table 3. Student Perceptions of Learning Experience (N=31 Students)

No	Key Indicators	Index Score	SD	Min	Max	Category
1.	The learning process is enjoyable because it is digital-based	54.19%	12.40	40%	75%	Moderate
2.	Student activity in participating in digital literacy-based learning	59.35%	11.80	45%	80%	Moderate
3.	It is easier to understand mathematics lessons with the help of digital media	56.12%	13.10	35%	75%	Moderate

The standard deviation values (11.80–13.10) demonstrate greater variability in student responses relative to motivation indicators, reflecting a broad spectrum of experiences with digital learning. The substantial range between minimum and maximum scores (35%–80%) further indicates that, although some students found digital learning engaging, others encountered considerable challenges.

Statistical Analysis of the Gap

A one-sample t-test was conducted to assess whether the gap between system readiness (100%) and student engagement (59.35%) is statistically significant. The analysis revealed that the student engagement score (59.35%) was significantly lower than the system readiness benchmark ($t(30) = 18.45$, $p < 0.001$), confirming that the observed gap is statistically significant rather than due to random variation.

2. Discussion

Interpretation of the Gap Between System Readiness and Student Engagement

The primary finding of this study is the pronounced gap between the high level of system readiness (100%) and the moderate level of student engagement (59.35%). This gap, as confirmed by a one-sample t-test ($t_{(30)} = 18.45$, $p < 0.001$), demonstrates that the provision of technological infrastructure and teacher competence in digital media use are insufficient to ensure active student participation in digital learning.

Theoretical Explanation: The Pedagogical Gap

Bandura's Social Cognitive Theory (1986) provides a theoretical framework for interpreting this finding, positing that learning occurs through observation, imitation, and modeling. Schunk and DiBenedetto (2025) emphasize three key contributions of Bandura to education: modeling and observational learning, self-efficacy, and self-regulation. Although teachers exhibit high digital competence (100%), the relatively low student engagement (59.35%) indicates that students may not be effectively modeling teacher behaviors. This discrepancy may result from pedagogical strategies that do not sufficiently provide students with opportunities to observe, imitate, and practice digital literacy skills in authentic contexts.

According to Afifah and Lestari (2024), vocational studenAfifah and Lestari (2024) report that vocational students exhibit high proficiency in operational digital literacy (Internet Search: 76.73; Hypertext Direction Guide: 79.53), yet demonstrate considerably lower competency in higher-order skills, such as Information Content Evaluation (52.94). This pattern parallels the present findings, where students display high motivation (85.80%) but lower engagement (59.35%), indicating that operational skills are present but do not necessarily translate into deeper cognitive engagement. nbrenner's Ecological Systems Theory (1979) offers a systemic explanation for this

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gap. The microsystem (direct classroom interactions) lacks participatory elements, while the mesosystem (connection between home and school) may not reinforce digital literacy practices. Tong and An (2024) note that Bronfenbrenner's theory is an ideal framework for understanding how individuals negotiate dynamic environments and their own identities . The gap between system readiness (100%) and student engagement (59.35%) indicates that, while the exosystem (school facilities) and macrosystem (national digital literacy policy) are supportive, the primary challenge lies in the microsystem (pedagogical strategies in the classroom).

This analysis is consistent with the findings of Ferawati, Royadi, and Saputri (2025), who demonstrated that integrating educational games and the quality of learning management significantly influence digital literacy competence (R^2 = 0.611), thereby confirming the greater impact of pedagogical approaches than infrastructure alone. Similarly, Ipinge and Seroto (2024) identified challenges within the microsystem (poverty and socio-economic context), mesosystem (parental engagement and peer pressure), and ecosystem (school infrastructure) as primary contributors to poor learner performance. Hu (2025) further emphasizes that digital literacy in vocational education is evolving from an auxiliary skill to a fundamental empowerment supporting lifelong learning, underscoring the critical importance of pedagogical strategy.

The Passive vs. Active Learning Dilemma

The low activity level (59.35%) substantiates the theoretical concern identified by Artiyani (2023) and Muliawanti & Kusuma (2019), specifically the persistence of passive or conventional learning modes. In such contexts, students may primarily function as consumers of digital information rather than engage in content production, critical evaluation, or substantive collaboration, which are essential components of advanced digital literacy (Putri et al., 2024; Septia & Wahyu, 2023).

Suri et al. (2024) identified a significant interaction between teaching models and digital literacy in relation to students' mathematical literacy, indicating that pedagogical approaches and digital competence must operate synergistically. Further research by Suri, Andriani, and Hamid (2024) demonstrated that reciprocal teaching has a substantial impact on mathematical literacy, with an interaction effect observed between the reciprocal teaching model and digital literacy on students' literacy skills. A systematic review by Husriawati and Ubaidah (2026) corroborates that digital tools function as facilitators to enhance engagement, but their effectiveness depends on pedagogical drivers, such as project-based learning, which structure inquiry-based learning and fosters critical thinking. This synergy constitutes a complementary system that significantly enhances learning outcomes.

The Enjoyment-Motivation Discrepancy

The marked disparity between high motivation (85.80%) and moderate enjoyment (54.19%) reveals a misalignment between students' expectations and their actual learning experiences. While students are motivated by the prospect of engaging instructional methods, current digital implementations have not fully satisfied these expectations. This shortfall may be attributed to the predominantly unidirectional nature of existing digital teaching strategies, which often fail to accommodate diverse learning styles or provide sufficient opportunities for collaborative and experiential learning.

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Husriawati and Ubaidah (2026) found that digital tools enhance engagement when combined with pedagogical approaches that facilitate iterative problem-solving and inquiry-based learning, rather than passive content delivery. A bibliometric analysis of digital literacy in education indicates that the field now encompasses technical, pedagogical, affective, and social dimensions. These findings suggest that effective digital literacy implementation necessitates not only technical proficiency but also pedagogical strategies that foster affective engagement. The low ease of comprehension score (56.12%) indicates that technology has not yet achieved universal effectiveness as an educational tool. This limitation may stem from incomplete integration of technology into pedagogical strategies, with teachers often relying on static digital resources rather than fostering interactive learning environments that support deep understanding. A systematic review of project-based learning in elementary schools highlights the multidimensional nature of PjBL, as evidenced by the prominence of keywords such as "STEM," "digital literacy," and "multiple intelligences."teracy," and "multiple intelligences" underscoring its complexity

Afifah and Lestari (2024) emphasize that improvements are particularly needed in the competency evaluation of information content, as students need to develop skills in filtering, evaluating, and synthesizing information to construct new knowledge.

Pedagogically-Based Strategic Solutions

To bridge this gap, solutions must focus on pedagogical strategies rather than additional facilities.

1) Diversifying Interactive Methods

Teachers should transition from conventional learning models to interactive, collaborative, or project-based approaches. Suri et al. (2024) found that the reciprocal teaching model significantly enhances mathematical literacy, underscoring the value of interactive teaching strategies. The development of reciprocal teaching-learning models for digital literacy-based instruction highlights essential components, including teacher demonstration, teacher-learner interaction, gradual transfer of responsibility, learner agency, and learner-learner interaction.

Husriawati and Ubaidah (2026) demonstrate that Project-Based Learning (PBL) serves as the primary pedagogical driver for structuring inquiry-based learning, with digital tools functioning as facilitating instruments. This interaction creates a complementary system that substantially enhances learning outcomes. A bibliometric analysis further confirms that project-based learning has emerged as a central research focus, with a marked increase in research output since 2017.

2) Optimising Social Media for Collaboration

Social media should be optimized as a platform for discussion and collaboration (B3: 67.09% High), supporting digital literacy from a social and communication perspective. This is often a weak point in the implementation of digital literacy, as higher-order digital literacy includes the ability to collaborate, evaluate critically, and produce content (Putri et al., 2024; Septia & Wahyu, 2023).

3) Developing Contextual Creative Media

The effectiveness of creative media, such as SGF, should be replicated and expanded. Integrating material with everyday life (70.96% High) should be established as a core strategy to enhance relevance and meaning. Research on digital literacy demonstrates that the field now

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includes technical, pedagogical, affective, and social dimensions, affirming the significance of contextual and meaningful learning experiences.

Implications and Limitations

1) Theoretical Implications

This study adds to the expanding literature on digital literacy in vocational education by providing empirical evidence that the primary challenge in implementing digital literacy is rooted in pedagogical strategy rather than infrastructure. These findings support Bandura's Social Cognitive Theory (1986) and Bronfenbrenner's Ecological Systems Theory (1979), both of which highlight the significance of social interaction, modeling, and systemic environmental factors in learning. Schunk and DiBenedetto (2025) further observe that Bandura's work on modeling, observational learning, self-efficacy, and self-regulation has significantly influenced theory development, research, and educational practice.

The results are consistent with those of Ferawati, Royadi, and Saputri (2025), who found that educational game integration and the quality of learning management explain 61.1% of the variance in digital literacy competence, indicating that pedagogical approaches exert greater influence than infrastructure. Additionally, Suri et al. (2024) demonstrate that reciprocal teaching, learning, and digital literacy collectively enhance students' mathematical literacy skills.

2) Practical Implications

For Teachers: Shift from technology-centred to student-centred pedagogical strategies, diversifying teaching methods (e.g., project-based learning, collaborative learning, reciprocal teaching) to promote active participation. The reciprocal teaching-learning model for digital literacy instruction emphasises the importance of teacher demonstration, learner agency, and learner-learner interaction.

For School Administrators: Invest in professional development programmes that equip teachers with pedagogical strategies for effective digital literacy integration, moving beyond providing infrastructure.

For Policymakers: Develop guidelines that support teachers in implementing pedagogical strategies for digital literacy, emphasising student-centred approaches rather than focusing solely on technology procurement.

3) Limitations

This study has several limitations: (1) the sample was limited to 31 students and 1 teacher from a single vocational school, limiting generalisation; (2) the cross-sectional design captures data at a single point in time, preventing analysis of changes over time; and (3) the study is purely descriptive, not testing causal relationships. Future research should employ experimental or quasi-experimental designs, include larger samples across multiple schools, and investigate the long-term impact of pedagogical strategies on student learning outcomes. Additionally, the interaction between pedagogical approaches (such as reciprocal teaching or project-based learning) and digital literacy development warrants further investigation. The growing body of bibliometric analysis also indicates that future research should explore digital literacy in specific educational settings such as vocational and hybrid learning environments, as well as teacher competence in emerging technologies such as AI and augmented reality.

Several limitations are present in this study: (1) the sample consisted of only 31 students and one teacher from a single vocational school, which restricts the generalizability of the findings; (2) the cross-sectional design provides data from only one point in time, limiting the ability to analyze changes over time; and (3) the study is descriptive in nature and does not examine causal relationships. Future research should employ experimental or quasi-experimental designs, draw on larger, more diverse samples from multiple schools, and assess the long-term effects of pedagogical strategies on student learning outcomes. Furthermore, the relationship between pedagogical approaches, such as reciprocal teaching or project-based learning, and the development of digital literacy requires further exploration. Recent bibliometric analyses also suggest that future studies should investigate digital literacy within specific educational contexts, including vocational and hybrid learning environments, as well as teacher competence in emerging technologies such as artificial intelligence and augmented reality.

CONCLUSION

The findings indicate that digital literacy implementation at SMK Muhammadiyah 3 Metro reveals a significant disparity between optimal system readiness (100%) and moderate student engagement (59.35%), as confirmed by a one-sample t-test ($t(30) = 18.45$, $p < 0.001$). Despite fully adequate school facilities and teacher competence (100%) and high student motivation (85.80%), key indicators such as learning experience-activity (59.35%), enjoyment (54.19%), and comprehension (56.12%) remain at moderate levels. These results suggest that the primary challenge is not infrastructure or teacher competence, but rather pedagogical strategies that fail to leverage technology to create active, engaging, and meaningful learning experiences. Addressing this issue requires teachers to adopt student-cantered approaches, such as project-based or collaborative learning. Additionally, schools should invest in pedagogical professional development, and policymakers should prioritize pedagogical guidelines over technology procurement. Although constrained by sample size and cross-sectional design, this study provides empirical evidence that effective pedagogy, rather than technology alone, is essential for fostering genuine student engagement in digital learning environments.

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