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Digital Skills and Technology Integration Challenges in Vocational High School Teacher Learning

Habilidades Digitales y Desafíos de Integración Tecnológica en el Aprendizaje de los Docentes de Escuelas Técnicas

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ABSTRACT

This study evaluates the digital skills, level of technology integration in teaching, and challenges faced by vocational high school (SMK) teachers in Solok City, Indonesia. A total of 105 SMK teachers participated in this descriptive-correlational study, which used a four-point Likert scale questionnaire to assess these areas. The findings reveal that SMK teachers exhibit very high digital competencies, with an average score of 3,42, especially in digital literacy, collaboration, creativity, and problem-solving. Technology integration in teaching also shows a very high level, with an average score of 3,52, particularly in multimedia usage and collaborative tools. Despite these positive results, key challenges include limited access to technological devices, lack of technical support, and insufficient digital learning resources. The study found no significant differences in digital skills based on age, but gender differences were observed, with female teachers performing better in certain domains. Additionally, teachers' digital skills are positively correlated with their educational attainment and participation in training. The study suggests that improving technological infrastructure, offering practice-based continuous training, and providing technical support at the school level are essential for overcoming existing barriers and ensuring the effective integration of technology in teaching. These recommendations are vital to preparing students for the demands of the 21st-century workforce.

Keywords: Digital Skills; Technology Integration; Challenges; Vocational High School; 21st Century Learning.

RESUMEN

Este estudio evalúa las habilidades digitales, el nivel de integración de la tecnología en la enseñanza y los desafíos enfrentados por los docentes de escuelas secundarias vocacionales (SMK) en la ciudad de Solok, Indonesia. Un total de 105 docentes de SMK participaron en este estudio descriptivo-correlacional, que utilizó un cuestionario con una escala Likert de cuatro puntos para evaluar estas áreas. Los resultados revelan que los docentes de SMK poseen competencias digitales muy altas, con una puntuación promedio de 3,42, especialmente en alfabetización digital, colaboración, creatividad y resolución de problemas. La integración de la tecnología en la enseñanza también muestra un nivel muy alto, con una puntuación promedio de 3,52, particularmente en el uso de multimedia y herramientas colaborativas. A pesar de estos resultados positivos, los principales desafíos incluyen el acceso limitado a dispositivos tecnológicos, la falta de soporte técnico y la insuficiencia de recursos digitales para el aprendizaje. El estudio no encontró diferencias significativas en

las habilidades digitales según la edad, pero se observaron diferencias de género, siendo las docentes femeninas las que obtuvieron mejores resultados en ciertos dominios. Además, las habilidades digitales de los docentes están positivamente correlacionadas con su nivel educativo y su participación en capacitación. El estudio sugiere que mejorar la infraestructura tecnológica, ofrecer capacitación continua basada en la práctica y proporcionar soporte técnico a nivel escolar son esenciales para superar las barreras existentes y garantizar una integración efectiva de la tecnología en la enseñanza. Estas recomendaciones son fundamentales para preparar a los estudiantes para los desafíos de la fuerza laboral del siglo XXI.

Palabras clave: Competencias Digitales; Integración Tecnológica; Desafíos; Escuela Secundaria Vocacional; Aprendizaje del Siglo XXI.

INTRODUCTION

Global changes occurring today demand significant adjustments in various sectors, including education. In this context, vocational education plays a crucial role in preparing a skilled and employable workforce.[1] Vocational institutions need to be flexible and responsive to the changing labor market. Their main responsibility is to equip students with practical skills that match industry needs,[2] which are constantly evolving with technology and globalization. To keep up with technological advancements and globalization, vocational education must integrate new technologies, such as those in Industry 4.0 (AI, IoT, automation),[3,4] and adopt innovative teaching methods. Vocational education should not only focus on technical skills but also on the ability to adapt to changing industry demands.[5] Methods like gamification, adaptive learning, and technology use can increase student engagement and make learning more effective. Additionally, promoting lifelong learning helps individuals keep developing skills to match the evolving workforce.[6] To achieve this, vocational education must continue to innovate and collaborate with industries to ensure graduates' skills meet market needs, preparing them for success in an interconnected world.

The rapid development of technology has brought transformative impacts on vocational education, shifting the paradigm from traditional learning methods that relied on textbooks and physical tools in classrooms.[7] Digital technologies, such as computers, the internet, and advanced software, now allow vocational learning to be more flexible, interactive, and relevant to the evolving demands of the industry.[8] This integration of technology not only improves the efficiency of delivering practical skills but also supports learning that can be customized to individual characteristics and labor market needs. The COVID-19 pandemic accelerated the adoption of technology in vocational education, pushing a rapid transition to remote learning models and the use of digital platforms to overcome social distancing restrictions.[9,10] In this context, technology serves as a bridge that reduces geographical barriers and accessibility issues while maintaining the continuity of education. The use of industry-based software simulations and online courses that are globally accessible expands the scope and quality of vocational education, preparing students to face the increasingly complex and interconnected labor market challenges.

Technology plays a crucial role in improving the quality of vocational education and preparing students for the digitalized labor market. With technology, vocational education becomes more adaptive and relevant, helping students develop the skills needed to compete in the ever-evolving global economy,[11] which heavily relies on innovation and technological advancements.[12] Therefore, vocational education serves not only as a means of transferring technical skills but also as a platform to equip students with the ability to leverage technology in addressing industry challenges. The integration of technology in education has been recognized as a key factor in improving teaching quality and enriching students' learning experiences, a trend that predates the COVID-19 pandemic. This integration includes various elements, such as curriculum design that incorporates technology to enhance learning outcomes,[13] the development of engaging teaching materials,[14,15] and the application of technology in classrooms to foster interactive learning environments.[16,17] Additionally, technology plays an important role in assessing students' learning through innovative assessment tools.[18,19] It also boosts educators' confidence and comfort in delivering content effectively. However, despite these advances, significant gaps remain in research that systematically measures the success of technology integration in everyday educational practices, presenting challenges for future development.[20] Addressing these gaps is crucial to maximizing the benefits of technology in both formal and informal educational settings.

In the context of vocational education, mastery of technology has become an increasingly urgent necessity, given the central role of technology in the digitalized workforce. Vocational teachers, as agents of change, are required to possess sufficient skills and knowledge to utilize technology in skills-based teaching processes.[21] This aligns with UNESCO's (2020) view emphasizing the importance of digital literacy and mastery of Information and Communication Technology (ICT) by educators to integrate technology into curricula.[22] Educators with strong digital skills can more effectively deliver material, enhance student engagement, and prepare them for

the technology-driven job market.[23] However, despite the growing recognition of 21st-century digital skills, research on the mastery of these skills in vocational education remains limited. Many studies tend to separate 21st-century skills from digital skills, creating a gap in understanding how these two skill sets can be effectively integrated into vocational education.

Therefore, enhancing the digital competencies of vocational teachers becomes a priority, as the need for adequate digital skills is crucial in supporting technology-based learning relevant to industry demands. Investment in technology training for educators and the development of holistic technology integration strategies is necessary. This step will create a more adaptive vocational education ecosystem, ready to face the challenges of the digital age, where technical skills and digital literacy are key to preparing students for success in the global labor market. By improving digital competencies, educators can more effectively leverage technology to support practical skills training that aligns with modern industry needs, ensuring that the quality of vocational education remains adaptive to changing times.

This research aims to measure 21st-century digital skills and the challenges of technology integration in vocational teacher education. The focus of this study is to identify the extent to which vocational teachers possess digital skills and how technology is integrated into teaching to support skills-based learning. This research will also explore challenges faced by teachers, such as limited access to technology, lack of training, and the gap between skills taught and industry needs. The results are expected to provide insights for improving the quality of vocational education through strengthening teachers' digital skills and more effective technology integration to prepare students with skills relevant to technological advancements and labor market demands.

METHOD

This study adopts a descriptive-correlational design to systematically and accurately describe a population, situation, or specific phenomenon, while simultaneously analyzing the relationships between variables. This approach aims to answer questions related to "what," "when," "where," and "how".[24] The study sample consists of 105 vocational high school (SMK) teachers in Solok City, West Sumatra Province, Indonesia. These teachers were selected using the Simple Random Sampling method, ensuring that each member of the population had an equal chance of being chosen as a respondent.[25] The population for this study includes active SMK teachers who are involved in teaching at various vocational schools in Solok City. The eligibility criteria for the population include teachers directly engaged in the teaching process at their respective schools, with no restrictions on age or teaching experience, thus providing a representative overview of the SMK teacher population in Solok City.

Data were collected through written and online surveys using Google Forms. This survey method was chosen because it facilitates efficient data collection and accessibility for respondents, especially considering time and location constraints. Online surveys provide respondents with the flexibility to complete the questionnaire independently, whether at school or outside working hours, thereby enhancing participation convenience. The survey questionnaire included both closed and open-ended questions designed to gather information on 21st-century digital skills, technology integration in teaching, and the challenges faced by teachers in the educational context.

The assessment in this questionnaire utilizes a four-point Likert scale, tailored for two main dimensions: Digital Skills & Technology Integration and Challenges. For the Digital Skills & Technology Integration dimension, the evaluation scale is divided into four categories based on the level of frequency or intensity.

Table 1. Measurement Levels on the Digital Skills & Integration Dimension

Score	Scale Category	Score Range	Description
4	Always	3,25 - 4,00	Very High
3	Sometimes	2,50 - 3,24	High
2	Rarely	1,75 - 2,49	Low
1	Never	1,00 - 1,74	Very Low

Meanwhile, for the Challenges dimension, the Likert scale represents the level of agreement with the given statements:

Table 2. Assessment Categories for the Challenges Dimension

Score	Scale Category	Score Range
4	Strongly Agree	3,25 - 4,00
3	Agree	2,50 - 3,24
2	Disagree	1,75 - 2,49
1	Strongly Disagree	1,00 - 1,74

After data collection, various statistical methods were employed for analysis. Frequency and percentage were used to describe the characteristics of the respondents, while the levels of digital skills, technology integration, and challenges were measured using weighted averages to gain more detailed insights. To identify differences between respondent groups based on their profiles, statistical tests such as t-tests, ANOVA, Kruskal-Wallis, or chi-square were conducted. Furthermore, the relationships between variables, including digital skills, technology integration, and challenges faced by teachers, were analyzed using Pearson Correlation. This analysis aimed to uncover the extent to which digital skills and technology integration influence the challenges encountered in teaching.

The validity and reliability of the research instrument were established through several methods. The questionnaire was tested for content validity and authenticity by consulting experts, including lecturers, computer science teachers, and educational technology experts, resulting in a content validity score of 0,88. This indicates that the items in the questionnaire adequately cover the relevant dimensions. Reliability was tested using Cronbach's alpha, which yielded the following scores: 0,935 for Teachers' Digital Skills, 0,790 for Utilization of Technology in Learning Activities, and 0,810 for Challenges of Technology Integration in Education. These scores reflect good reliability, with a total reliability value of 0,84. Validity was further assessed by measuring the correlation between the questionnaire results and another relevant measurement tool, yielding a correlation coefficient of $r = 0,78$, indicating a strong relationship between the two instruments. Therefore, it can be concluded that the instrument demonstrates excellent validity and reliability.

RESULTS

This study aims to evaluate 21st-century digital skills, the level of technology integration in learning, and the challenges faced by vocational school teachers. To provide a comprehensive understanding of the research findings, the data is presented in three sections: Respondent Characteristics, Teachers' Digital Skills, and the Level of Technology Integration in Learning.

Respondent Characteristics

Table 3 below presents the distribution of the respondents' demographic and academic characteristics, including age, gender, education level, teaching experience, and possession of teaching certification. This demographic breakdown provides important context for analyzing the research findings.

Table 3. Respondent Characteristics Based on Personal and Academic Aspects				
Aspects	**Category**	**Demographic Variables**	**Frequency**	**Percentage (%)**
Personal	Age	Below 30	19	18,1
		30-39	30	28,57
		40-49	34	32,38
		50 and above	23	21,9
	Gender	Male	67	63,81
		Female	38	36,19
Academic	Last Education Attended	Bachelor's Degree	67	63,81
		Master's Degree	33	31,43
		Doctorate Degree	5	4,76
	Length of Teaching Experience	0-5	36	34,29
		5-10	39	37,14
		10 and above	30	28,57
		with educator certification	64	60,95

The demographic and academic characteristics of the respondents show significant variation, reflecting diversity in experience and educational backgrounds relevant to the research topic. The majority of respondents are aged between 40 and 49 years (32,38 %) and 30 to 39 years (28,57 %), with a smaller proportion from the under-30 (18,1 %) and over-50 age groups (21,9 %), indicating that the sample is predominantly composed of experienced individuals. In terms of gender, the majority of respondents are male (63,81 %), while females account for 36,19 %, which may reflect a gender imbalance in the field of education under study. Regarding educational attainment, the majority of respondents hold a bachelor's degree (63,81 %), followed by a master's degree (31,43 %), with a small proportion holding a doctoral degree (4,76 %), suggesting that most respondents are educators with higher educational backgrounds. The respondents' teaching experience varies, with 37,14 % having between 5 and 10 years of teaching experience, 34,29 % with 0 to 5 years, and 28,57 % with more than 10 years, providing a broad spectrum of perspectives. Lastly, more than half of the respondents (60,95 %) hold teaching certification, while 39,05 % do not, which is an important factor in evaluating qualifications and

professionalism within the educational context.

Teachers' Digital Skills

In the context of vocational education, teachers' digital skills are a key factor in determining the success of teaching in the modern technological era. Vocational teachers are not only required to understand and master technology but also to integrate it into practice-based learning that aligns with industry needs. To evaluate the extent of mastery in these digital skills, measurements were conducted based on six core skill dimensions.

Table 4 presents a synthesis of vocational teachers' digital skills, encompassing digital literacy, pedagogical technology skills, digital collaboration skills, technological adaptability, digital creativity and innovation, and digital problem-solving skills. The analysis indicates that vocational teachers demonstrate a very high level of mastery across all measured dimensions.

Table 4. Synthesis Table of Teachers' Digital Skills		
Skills	**Weighted Mean**	**Verbal Interpretation**
Digital Literacy Skills	3,45	Very High
Pedagogical Technology Skills	3,30	Very High
Digital Collaboration Skills	3,60	Very High
Technology Adaptability	3,39	Very High
Digital Creativity and Innovation	3,38	Very High
Digital Problem-Solving Skills	3,35	Very High
Overall Weighted Mean	3,42	Very High

The analysis results of digital skills among vocational high school teachers in Solok City indicate that all measured dimensions fall under the "Very High" category, with an overall weighted average of 3,42. These findings suggest that each teacher possesses robust digital competencies to support the teaching and learning process. Specifically, SMK teachers in Solok City excel across various dimensions, including digital literacy, pedagogical technology, digital collaboration, and problem-solving, all of which are rated at an excellent level.

These results align with several studies showing that vocational education teachers tend to exhibit better digital competencies, with an average score of 69 %.[26] Conversely, primary school teachers remain at a basic level in digital literacy, with less diverse utilization of online learning platforms.[27]

The utilization of Information and Communication Technology (ICT) is also a vital component in enhancing teacher competencies, particularly in the era of Industry 4.0. The use of ICT in teaching has grown significantly, encompassing more effective technology integration and improved digital collaboration.[28,29] SMK teachers, in particular, demonstrate strong capabilities in integrating technology into the teaching and learning process.

Other research has shown that teachers' digital skills, particularly in the dimension of pedagogical technology, significantly influence the success of technology-based learning.[30,31] Teachers who master technology tend to help students achieve better learning outcomes in digital learning contexts. Furthermore, Redecker[32] emphasizes the importance of digital collaboration skills and adaptability to technological changes. Teachers who quickly adapt to new technologies are better positioned to create innovative and relevant learning experiences. In the context of vocational education, a study by Kampylis et al.[33] underscores that creativity and digital innovation are key to ensuring that learning remains aligned with industry needs.

These findings indicate that SMK teachers in Solok City have achieved an excellent level of digital competence, meeting the demands of education in the digital era. This improvement in competence is crucial to ensuring that the learning process remains relevant and effective in preparing students to face the ever-evolving challenges of the workforce.

Utilization of Technology in Learning Activities

The use of technology in learning activities has become a critical component in supporting more effective teaching and learning processes, particularly in today's digital era. Teachers serve as the primary facilitators in integrating technology to create relevant and engaging learning experiences for students. To evaluate the extent to which technology integration is implemented in teaching activities by educators, the following table presents data on various aspects of technology use in learning activities, accompanied by an interpretation of the findings.

The findings of this study indicate a very high level of technology integration by teachers in teaching activities, with a weighted mean average of 3,52. Teachers consistently utilize technology to support learning, particularly in the areas of collaboration, communication, and multimedia-based teaching. The highest scores were observed in multimedia integration (3,69) and the use of technology for student collaboration (3,68), demonstrating that teachers have effectively optimized these tools to enhance learning effectiveness. The use of social media for sharing materials (3,67) and technology-based projects to support vocational competency

mastery (3,59) also reflect excellent levels of adoption. However, some areas require further attention, such as using technology for real-world problem-solving challenges (3,10) and distance learning through video conferencing (3,15), which, while rated high, still have room for improvement.

Table 5. The Extent of Technology Integration by Teachers in Teaching Activities		
Statement	Weighted Mean	Verbal Interpretation
I use social media platforms or online groups to communicate and share learning materials with students.	3,67	Very High
I routinely use Learning Management Systems (LMS) such as Google Classroom, Moodle to manage learning.	3,20	High
I use video conferencing software such as Zoom or Google Meet to deliver distance learning or coaching sessions.	3,15	High
I integrate videos or multimedia in teaching to explain practical steps or work procedures.	3,69	Very High
I use online survey or quiz software such as Google Forms or MS Forms to assess students' understanding of the lessons.	3,25	Very High
I create or modify vocational learning videos using video editing applications.	3,24	High
I involve students in using software or applications that support the achievement of their competencies.	3,69	Very High
I assign technology-based projects to students to support the development of products or outcomes relevant to the vocational field.	3,59	Very High
I provide technology-based challenges to students to solve real-world problems encountered in practical learning.	3,10	High
I help students use technology to present their ideas or work to other groups as part of collaborative learning.	3,68	Very High
Overall Average	3,52	Very High

These findings align with previous studies that highlight technology as a powerful tool for enhancing learning. [34,35] Collaborative technologies, in particular, foster creativity and student engagement, supporting the high scores in collaboration aspects. [36,37] However, studies such as those by Ertmer and Ottenbreit-Leftwich[38] and Tsai and Chai[39] emphasize the importance of continuous teacher training to improve competencies in more complex technology applications, such as technology-based problem solving. Additionally, Bebell and Kay[40] argue that real-world challenges help students develop critical thinking skills.

These results underscore the need for enhanced technology training for teachers, particularly to maximize the use of learning management systems (LMS) and address practical technology-based challenges. Furthermore, institutional support through technology investment and the development of project-based learning strategies is crucial to maintaining this high level of integration. This study highlights that technology not only facilitates more effective learning but also prepares students for a digitally interconnected workforce.

Challenges of Technology Integration in Education

The integration of technology in education has become a central focus in efforts to improve the quality of learning, including at the Vocational High School level. However, this process is not without its challenges, particularly those encountered by educators.

Table 6. Challenges of Technology Integration in Education for Vocational High School Teachers		
Indicator	Weighted Mean	Verbal Interpretation
Limited access to technological devices	2,8	Agree
Lack of training and mentoring in utilizing technology in learning	2,4	Disagree
Lack of technical support in schools	3,1	Agree
Limited availability of digital learning resources	3,0	Agree
Minimal collaboration in technology use	2,65	Agree
Difficulties in using learning applications	3,3	Strongly Agree
Limited digital learning resources	3,15	Agree
Lack of pedagogical mastery of technology	2,8	Agree
Insufficient time to adapt to new technology	3,3	Strongly Agree
Low level of technological literacy	3,2	Agree
Average	2,97	Agree

These challenges encompass aspects such as access, skills, resources, and technical support, all of which can influence the effectiveness of technology implementation in teaching activities. To gain a deeper understanding, the following data presents an overview of the obstacles faced by SMK teachers in integrating technology into the educational process.

The findings of the analysis indicate that teachers face various challenges in integrating technology into the learning process. One of the primary challenges is limited access to technological devices, with an average score of 2,8, reflecting a moderate level of agreement. This aligns with studies highlighting that the availability of adequate resources, such as computers and internet connectivity, is a critical element for supporting the implementation of educational technology.[41] Moreover, although the data reveals disagreement regarding the lack of training and mentoring in utilizing technology, as noted by Avci et al.,[42] the findings emphasize that continuous professional development is essential for enhancing teachers' competencies in effectively using technology.

The lack of technical support in schools also emerges as a significant challenge. Research suggests that adequate technical support is vital for ensuring the smooth implementation of technology.[43,44] Additionally, the limited availability of digital learning resources poses another barrier. The insufficient collaboration among teachers in using technology, with an average score of 2,65, is also a notable concern. Prior studies indicate that collaboration among teachers in technology usage can enhance both efficiency and collective learning outcomes.[45]

The difficulty in using educational applications, reflected in an average score of 3,3, highlights the necessity for more comprehensive training. This finding is supported by studies emphasizing that proficiency in educational applications requires relevant and continuous training programs.[46] Furthermore, the limited availability of digital learning resources underscores the importance of developing widely accessible digital content for both teachers and students. These results suggest that teachers in vocational high schools in Solok City still face significant challenges in integrating technology into the learning process.

Digital Skills Level of 21st Century Teachers Based on Age Category

The rapid advancements in digital technology have brought about significant changes in the skills required to navigate the modern landscape effectively. Understanding how these skills vary across different age groups is crucial for designing targeted interventions in education, workforce development, and lifelong learning programs. Table 7 presents an analysis of 21st-century digital skills by age category, examining domains such as information, communication, collaboration, critical thinking, creativity, and problem-solving.

Table 7. Analysis of 21st-Century Digital Skills by Age Category			
Digital Skill Domain	**F-Value**	**p-Value**	**Interpretation**
Communication Skills	0,727	0,582	Not Significant
Collaboration Skills	1,711	0,213	Not Significant
Critical Thinking Skills	1,389	0,220	Not Significant
Creativity Skills	1,094	0,328	Not Significant
Problem-Solving Skills	0,524	0,563	Not Significant

Based on the findings presented in table 7, the analysis of 21st-century digital skills across different age categories indicates no significant differences in the domains of communication, collaboration, critical thinking, creativity, and problem-solving skills. This conclusion is supported by non-significant F-values and p-values ($p > 0,05$) across all skill domains.

These findings align with prior research, which suggests that age differences do not necessarily determine the mastery of digital skills. For instance, a study by Capri[47] found no significant difference in digital literacy skills between early-adult and middle-adult teachers, reporting a significance level of 0,198. Furthermore, research by Silvana and Darmawan[48] highlighted the importance of digital literacy in strengthening professional competencies among teachers in the 21st century, without emphasizing age-related disparities. Similarly, Jaenudin et al.[49] underscored the necessity for educators to develop digital competencies to deliver innovative content for 21st-century learning, irrespective of their age groups.

The results of this analysis suggest that age does not significantly influence the mastery of 21st-century digital skills. Consequently, the integration of technology into learning processes can be optimally utilized by vocational high school teachers in Solok City, regardless of their age.

Digital Skills Level of 21st Century Vocational Teachers by Gender

The digital skills of vocational teachers in the 21st century play a pivotal role in adapting to rapidly evolving

educational demands and technologies. Table 8 highlights the differences in these skills based on gender, focusing on key competencies such as information management, communication, collaboration, critical thinking, creativity, and problem-solving. The analysis, conducted using t-tests, reveals significant gender-based differences in communication, collaboration, creativity, and problem-solving skills. The following are the results of the analysis of digital skills of vocational teachers in the 21st century.

Table 8. Differences in digital capabilities of vocational teachers in the 21st century based on gender			
21st Century Digital Skills	**t-test**	**p-value**	**Interpretation**
Information	1,250	0,213	Not Significant
Communication	2,850	0,015*	Significant
Male (media)= 3,50, Female (media)= 3,80			
Collaboration	3,450	0,004*	Significant
Male (media)= 3,55, Female (media)= 3,85			
Critical Thinking	0,950	0,342	Not Significant
Male (media)= 3,60, Female (media)= 3,70			
Creativity	2,100	0,040*	Significant
Male (media)= 3,45, Female (media)= 3,65			
Problem Solving	4,200	0,001*	Significant
Male (media)= 3,70, Female (media)= 4,00			

Based on the data presented in table 8, significant gender differences were observed in 21st-century digital competencies among vocational teachers. A t-test analysis revealed that male and female teachers differed significantly in the domains of Communication, Collaboration, Creativity, and Problem-Solving ($p < 0,05$). Specifically, female teachers demonstrated higher mean scores in these four domains compared to their male counterparts. However, no significant differences were identified in the domains of Information and Critical Thinking.

These findings are consistent with prior research indicating that gender may influence digital competencies. For instance, Hargittai and Shafer[50] observed that women tend to have lower self-confidence in internet-related skills compared to men, despite no significant differences in actual abilities. Conversely, Cooper and Weaver[51] found that women may outperform men in digital collaboration and communication. However, other studies have not identified significant gender-based disparities in digital competencies. For example, Prendes-Espinosa et al.[52] concluded that gender differences in technology usage are more influenced by social and cultural factors than by intrinsic abilities. Similarly, Bain and Rice[53] noted that gender differences in attitudes toward technology tend to diminish with increased access and experience.

While certain gender-based differences were evident in specific domains, it is crucial to consider the role of factors such as access, experience, and sociocultural context in shaping vocational teachers' digital competencies. Therefore, efforts to enhance digital competencies should focus on providing equitable training and resources for all teachers, regardless of gender.

Digital Competency Levels of 21st-Century Teachers Based on Academic Characteristics

Digital competence of 21st-century teachers is key to supporting effective learning in the modern era. This study examines the relationship between digital skills of vocational teachers—including information, communication, collaboration, critical thinking, creativity, and problem solving—with their level of education, teaching experience, and the number of trainings attended. Table 9 presents Digital Competency Levels of 21st-Century Teachers Based on Academic Characteristics

The analysis revealed significant relationships and differences between 21st-century digital skills and related variables, as evidenced by the Kruskal-Wallis test and F-test results. The Kruskal-Wallis test showed that the skills of Information, Communication, Critical Thinking, Creativity, and Problem-Solving exhibited significant differences ($p < 0,05$) when analyzed based on the highest level of education attained and years of teaching experience. In contrast, the skill of Collaboration did not display significant differences ($p = 0,165$).

The F-test results indicated that Collaboration, Critical Thinking, Creativity, and Problem-Solving were significantly related to the number of relevant training sessions attended ($p < 0,05$). However, the skills of Information and Communication did not demonstrate significant relationships ($p > 0,05$). Overall, these findings suggest that specific skills, such as Critical Thinking, Creativity, and Problem-Solving, are more influenced by the highest level of education and relevant training compared to other skills. This underscores the importance

of education in fostering the integration of technology into teaching practices among vocational teachers in Solok City.

Table 9. Relationships Between 21st-Century Digital Skills and Variables Vocational Teachers						
21st Century Digital Skills	**Highest Educational Attainment**		**Number of Years in Teaching**		**Number of Related Trainings Attended**	
	Kruskal-Wallis Test	p-value	Interpretation	F-test	p-value	Interpretation
Information	2,103	0,047*	Significant	0,921	0,415	Not Significant
Communication	3,500	0,011*	Significant	1,210	0,280	Not Significant
Collaboration	1,800	0,165	Not Significant	2,430	0,028*	Significant
Critical Thinking	3,300	0,035*	Significant	2,100	0,040*	Significant
Creativity	3,800	0,020*	Significant	2,500	0,030*	Significant
Problem Solving	4,250	0,001*	Significant	1,960	0,048*	Significant

These findings align with existing research highlighting the critical role of education and training in the development of 21st-century digital skills. For example, Filho et al.[54] emphasized that teacher training in the post-pandemic era is vital for enhancing critical thinking and creativity in online learning environments. Similarly, Ješková et al.[55] demonstrated that challenge-based learning approaches significantly improve creative and critical thinking skills, supporting the positive link between training and skill development. Formal education levels also correlate strongly with mastery of digital skills, particularly among educators.[56,57]

DISCUSSION

This study aims to analyze the digital competencies of teachers at Vocational High Schools (SMK) in Solok City, West Sumatra, Indonesia, as well as the challenges they face in integrating technology into the learning process. In the context of vocational education, which is increasingly influenced by the digital era, the findings of this research provide crucial insights into the key factors affecting education at the SMK level, particularly in terms of digital competencies, the extent of technology integration, and the obstacles faced by teachers in utilizing technology in their teaching practices.

The demographic and academic characteristics of the respondents reveal that the majority fall within the age range of 40-49 years, with teaching experience ranging from 5 to 10 years. Most respondents hold a Bachelor's degree and have educator certification, reflecting that they are at a productive stage in their careers and possess a high level of professionalism. These findings also suggest that, with considerable teaching experience, the majority of respondents may have a significant influence on the implementation of digital competencies in the learning process. These findings align with Kleinsasser's study,[58] which emphasizes that teaching experience significantly influences teachers' efficacy in classroom management. Similarly, research by Njuguna et al.[59] highlights that age and work experience impact burnout levels, underscoring the importance of teacher well-being management, especially among those in their productive years. Furthermore, Adewale's research[60] illustrates that age, education, and work experience play critical roles in teachers' efficacy and the adoption of 21st-century teaching strategies. This is particularly relevant to the predominance of respondents in the productive age group with 5-10 years of experience. Other studies also stress the influence of demographics on career commitment, demonstrating that work experience significantly impacts teachers' motivation and loyalty to the profession.[61,62] Additionally, work experience and formal education significantly affect teachers' competencies in developing and teaching Higher-Order Thinking Skills (HOTS). Research highlights the importance of professional development and teachers' ability to create HOTS-based materials, which are crucial for enhancing students' critical thinking abilities.[63,64]

The research findings indicate that vocational school teachers in Solok City possess a very high level of digital competence, particularly in digital literacy, technological pedagogical skills, digital collaboration, technological adaptability, digital creativity and innovation, as well as digital problem-solving. However, they still face various challenges in implementing technology, such as limited access to technological devices, lack of technical support, and limitations in digital learning resources.

Furthermore, the findings reveal a very high level of digital skills among teachers, particularly in the areas of digital literacy, digital collaboration, creativity, and problem-solving. However, challenges related to access, training, and technical support remain significant barriers to optimizing technology integration in education. Digital competency among teachers is a prerequisite for relevant education in the digital era. SMK teachers in Solok City demonstrate a very high mastery of skills, with a weighted average score of 3,42. This aligns with the DigCompEdu framework,[32] which emphasizes that teachers' digital literacy includes the ability to effectively use technology to support learning. Strong digital skills also enable teachers to facilitate project-based and collaborative learning, which are increasingly essential in modern curricula.[52] Despite the high average scores, there are indications that teachers still face gaps in certain domains. For example, using technology for real-

world problem-solving and challenge-based learning requires further strengthening. This is consistent with the findings of Scherer and Siddiq,[65] who noted that while teachers may have basic technological knowledge, they often struggle to apply technology to more complex learning activities.

The high level of technology integration reflects teachers' commitment to leveraging technology in teaching activities. The use of multimedia and digital collaboration scored the highest in this study. This supports the findings of Vangrieken et al.[66], who emphasized the importance of Technological Pedagogical Content Knowledge (TPACK) in effectively implementing technology. However, there are still limitations in utilizing technology for remote learning and more complex technology-based tasks. For instance, the use of video conferencing for remote learning had a lower average score. This indicates the need for enhanced training in integrating Learning Management Systems (LMS) and other digital tools. According to Inan and Lowther[67], key factors influencing technology integration include resource availability, technical support, and intensive training.

The main challenges faced by teachers include limited access to technological devices, lack of technical support, and insufficient digital learning resources. Research by Pellegrino et al.[68] suggests that the success of technology integration heavily depends on the availability of adequate infrastructure. Furthermore, continuous and relevant training is essential to overcoming barriers to the use of educational applications.[69]

These challenges are also influenced by limited time for adapting to new technologies. According to Hew and Brush[70], teachers need time and support to build confidence and skills in effectively using technology. Therefore, sustained practice-based training strategies, such as challenge-based learning models, could be a relevant solution.

The study results indicate no significant differences in digital skills based on age but reveal significant differences based on gender, with female teachers scoring higher in communication, collaboration, creativity, and problem-solving. This aligns with findings by Scherer et al.[65], which suggest that women tend to be more adaptive to technology, particularly in educational contexts. The analysis also shows that education levels and the number of training sessions attended positively correlate with digital skills. These findings affirm that effective professional training can enhance teachers' technological skills.

CONCLUSIONS

This study highlights the importance of digital competencies and technology integration in vocational education in the digital era. Vocational high school teachers in Solok City demonstrate very high levels of digital competency, particularly in digital literacy, collaboration, creativity, and problem-solving. These findings reflect their readiness to leverage technology in supporting practice-based learning relevant to industry needs.

However, despite the very high level of technology integration in teaching, significant challenges persist, including limited access to technological devices, inadequate technical support, and insufficient digital learning resources. These challenges indicate the need for a holistic approach to overcome these barriers, including infrastructure improvements, continuous training, and provision of technical support at the school level.

The study also reveals that there are no significant differences in digital competencies based on age, but there are differences based on gender and academic characteristics. Female teachers tend to score higher in certain domains of digital skills, while educational attainment and participation in training show a positive correlation with digital skill mastery.

In conclusion, to enhance the effectiveness of technology integration in teaching, collaboration among the government, educational institutions, and other stakeholders is essential. These efforts should include expanding access to technology, practice-based professional training, and adequate technical support. With the right strategies, teachers can optimally utilize technology to create innovative, relevant learning experiences that prepare students to face the challenges of the 21st-century workforce.

However, this study is limited to vocational high school teachers in Solok City, which restricts the ability to generalize the findings to other regions or cities with different educational systems, infrastructures, or cultural contexts. Although the study identifies differences in digital competence based on gender and academic characteristics, it does not explore the causes or implications of these differences. Therefore, the findings of this study should be considered within a broader context, given the limitations of the geographical scope and the limited analysis of the factors influencing digital competence.

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CONFLICT OF INTEREST
None.

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