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Integration of Digital Literacy into the Development of Students' Science Process Skills in Straight Line Motion Dynamics

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Abstract - *The integration of digital literacy into physics education is becoming increasingly important as students need to access, evaluate, interpret, and utilize digital information for scientific inquiry. This study examined the impact of digital literacy on students' science process skills in learning straight-line motion dynamics and how digital tools support experimental activities. A mixed methods design with an explanatory sequential approach was used. Quantitative data were collected from 40 grade XI students at SMA Negeri 11 and SMA Negeri 12 in Jambi City using a digital literacy questionnaire and a science process skills observation sheet. The questionnaire assessed technical, cognitive, and ethical competencies in the use of digital technology, while the observation sheet evaluated skills such as observing motion phenomena, hypothesizing, identifying variables, designing experiments, analyzing data, interpreting kinematic graphs, and drawing conclusions. Qualitative data were collected through semi-structured interviews with selected students to contextualize the quantitative findings. Data analysis included normality and linearity tests, followed by simple linear regression using SPSS 25.0 for quantitative data, and Miles and Huberman's interactive model for qualitative analysis. Results demonstrated that digital literacy significantly influences students' science process skills, with a p-value of 0.000 (< 0.05). The R-square value of 0.523 indicated that digital literacy explained 52.3% of the variation in science process skills. Interviews revealed that digital tools such as PhET simulations, motion analysis apps, instructional videos, sensors, and digital graphs helped students understand uniform and accelerated motion more concretely. This study's novelty lies in positioning digital literacy as an active, measurable component of straight-line motion learning rather than just supplementary media. It concludes that systematically integrating digital literacy can enhance students' science process skills and supports the development of technology-supported inquiry learning in secondary physics education.*

Keywords: *digital literacy; inquiry learning; motion dynamics; physics education; science skills.*

I. INTRODUCTION

The rapid development of digital technology in the 21st century has transformed education, particularly in the way students access, process, evaluate, and use scientific information (Dennis

& Harrison, 2020; Parenti, 2016; Tor & Gordon, 2020). In secondary education, digital literacy has become an essential competency that enables students to participate effectively in technology-supported learning environments (Ashrafi et al., 2022; Jeynes, 2017; ten Dam & Volman, 2004). Digital literacy is not limited to the technical ability to operate digital devices; it also involves critical, ethical, and creative thinking in selecting, interpreting, and applying information to support science learning (Dwidarti et al., 2025; Gutiérrez-Martín et al., 2022; Mokhtari et al., 2025). Therefore, integrating digital literacy into science learning is a strategic effort to prepare students to address global challenges that require higher-order thinking, scientific reasoning, and problem-solving.

Science process skills are also a fundamental component of science learning. These skills include observing, classifying, interpreting data, formulating hypotheses, conducting experiments, and drawing conclusions based on empirical evidence (Akhmedova, 2022; Elvanisi et al., 2018; Ningsi & Nasih, 2020). SPS helps students understand scientific concepts and train them to think and work scientifically (Darmaji et al., 2022; Şahintepe et al., 2020; Sari et al., 2023). However, many students still have difficulty connecting theoretical concepts to experimental practice, particularly in abstract physics topics such as dynamics of straight-line motion (Ambarwati et al., 2023; Tiastiti et al., 2024). This condition indicates the need for learning approaches that can connect digital literacy with the development of students' science process skills.

Straight-line motion dynamics in physics requires conceptual understanding and the ability to observe, measure, and analyze motion phenomena through experiments (Liu et al., 2022; Tiastiti et al., 2024; Retnani et al., 2024). However, learning activities on this topic are often teacher-centered and rely heavily on theoretical explanation, with limited support from digital visualization and data-based inquiry (Jarrett et al., 2022; Ramly et al., 2022). As a result, students may become passive and have difficulty understanding the relationships among distance, time, velocity, and acceleration in the dynamics of motion (Jurkaninová et al., 2019). The integration of digital literacy through interactive simulations, experimental videos, motion-analysis applications, and virtual-laboratory activities can help students observe physical phenomena more clearly, analyze data more accurately, and strengthen their science-process skills.

The integration of digital literacy in science learning is also consistent with the Independent Learning (*Merdeka Belajar*) paradigm, which emphasizes learner autonomy, collaboration, and the use of information technology to improve the learning process (Asrial et al., 2024; Bashori, 2018; Rudge, 2021). As secondary education institutions, SMA Negeri 11 and SMA Negeri 12 Jambi City have the potential to implement innovative learning approaches that support students' cognitive, affective, and psychomotor development. Nevertheless, the implementation of digital literacy to develop science process skills still requires empirical investigation, especially in experimental physics learning on straight-line motion dynamics (Mokhtari et al., 2025; Oktavia et al., 2024; Santos & Serpa, 2017). Therefore, this study is important because it examines how digital literacy can be integrated into physics learning to support students' scientific inquiry and experimental competence.

Previous studies have shown a positive relationship between digital literacy and students' scientific thinking skills. Ardianti et al. (2021) found that the use of interactive digital media can improve students' science process skills and learning motivation in physics learning. Digital literacy also supports the development of scientific thinking and problem-solving skills in science learning contexts (Bellová et al., 2017; Kamid et al., 2023). In addition, virtual laboratories and augmented reality have been reported to improve students' analytical skills and conceptual understanding (Kamid et al., 2022; Mellawaty et al., 2023). However, most previous studies have not specifically examined the integration of digital literacy in straight-line motion dynamics learning or its impact on science process skills at the senior high school level, particularly in SMA Negeri 11 and SMA Negeri 12 Jambi City.

The novelty of this study lies in the systematic integration of digital literacy into straight-line motion dynamics learning, using a mixed-methods approach that combines quantitative and qualitative analyses. This study not only measures the influence of digital literacy on students' science process skills but also explores students' perceptions, experiences, and challenges in using digital tools during physics learning. Thus, the findings are expected to contribute to the development of contextual and technology-based science learning models that integrate digital literacy in senior high school physics learning, particularly in SMA Negeri 11 and SMA Negeri 12 Jambi City.

This study aims to analyze the influence and role of digital literacy integration in developing students' science process skills in straight-line motion dynamics at SMA Negeri 11 and SMA Negeri 12 Jambi City. The study is expected to provide an empirical basis for developing adaptive physics learning strategies that are relevant to technological advancement and support the achievement of 21st-century competencies in secondary education. The research questions are formulated as follows: (1) What is the level of students' digital literacy in learning straight-line motion dynamics? (2) How do students' science process skills develop after the integration of digital literacy in straight-line motion learning? and (3) What is the relationship between digital literacy and students' science process skills in the topic of straight-line motion dynamics?

II. METHODS

This study employed a mixed-methods approach, which systematically combines quantitative and qualitative methods to obtain comprehensive, in-depth, and valid findings on the phenomenon under investigation (Creswell & Creswell, 2017; Taherdoost, 2022; Zinn et al., 2021). The study used an explanatory sequential design. In this design, quantitative data were collected and analyzed first, followed by qualitative data collection and analysis to explain and strengthen the quantitative findings (Ernawati et al., 2022; Majuddin et al., 2022).

This design was selected because the study aimed not only to statistically examine the relationship between digital literacy and students' science process skills but also to understand how digital literacy was integrated into the learning process of straight-line motion dynamics in physics. The study involved two main variables: digital literacy as the independent variable and students' science process skills as the dependent variable. The relationship between these variables was examined through digital-based physics learning activities on straight-line motion dynamics, particularly experimental activities related to uniform motion and uniformly accelerated motion. These activities used interactive digital learning media and virtual simulation tools to support students' exploration of kinematic concepts.

The population of this study consisted of students from SMA Negeri 11 and SMA Negeri 12 Jambi City who had studied straight-line motion dynamics in physics. Students in this population were assumed to have basic knowledge of kinematic concepts and relevant learning experiences for the research topic. The sample was selected using purposive sampling. This technique was used because the participants needed to meet specific criteria aligned with the study's objectives. The criteria included: (1) grade XI students who had studied straight-line motion dynamics; (2) students who had participated in physics learning activities related to kinematic concepts, including uniform motion and uniformly accelerated motion; and (3) students who were willing to participate in all stages of the study, including learning activities, observations, questionnaire completion, and interviews. Based on these criteria, the study involved 40 students, consisting of 25 female students and 15 male students from SMA Negeri 11 and SMA Negeri 12 Jambi City. This sampling technique was considered appropriate because it enabled the researchers to gather information from participants with direct experience of the learning process under examination.

The instruments used in this study comprised quantitative and qualitative measures. The quantitative instruments measured students' digital literacy and science process skills, while the qualitative instrument explored students' experiences and perceptions regarding the integration of digital literacy into physics learning.

a. Quantitative instruments

The first quantitative instrument was a digital literacy questionnaire. This questionnaire was used to measure students' digital literacy levels, including technical, cognitive, and ethical competencies in the use of digital technology for learning activities. The questionnaire was developed based on the European Commission's Digital Competence Framework (DigComp) and used a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Before data collection, the questionnaire was tested for internal consistency using Cronbach's alpha. The reliability test showed a Cronbach's alpha of 0.76, exceeding the acceptable threshold of 0.70. This result indicated that the questionnaire was reliable for measuring students' digital literacy.

The second quantitative instrument was a science process skills observation sheet. This instrument was used to assess students' science process skills during laboratory activities on straight-line motion dynamics, particularly in experiments involving uniform and uniformly accelerated motion. The observed aspects included observing motion phenomena, formulating hypotheses, identifying variables, designing experiments, collecting and analyzing data, and drawing conclusions based on motion graphs and measurement results. The observation sheet was completed by two observers, namely a physics lecturer and a laboratory assistant, to improve objectivity and reduce assessment bias. The reliability of the SPS observation sheet was also tested using Cronbach's alpha, resulting in a coefficient of $\alpha = 0.78$. This value indicated good internal consistency and confirmed that the observation sheet was appropriate for assessing students' science process skills in learning activities on straight-line motion dynamics.

b. Qualitative instrument

The qualitative instrument used in this study was a semi-structured interview guide. The interview guide was designed to explore students' perceptions, experiences, and challenges with using digital tools in learning straight-line motion dynamics. The semi-structured format allowed the researchers to ask predetermined questions while also providing opportunities for follow-up questions based on students' responses. The interview data were used to deepen the quantitative findings and provide a broader understanding of how digital literacy was implemented in physics learning.

c. Quantitative data analysis

Quantitative data were analyzed using inferential statistics to determine the relationship and influence between digital literacy (X) and science process skills (Y). Before hypothesis testing, prerequisite tests were conducted to ensure that the data met the assumptions for parametric analysis. These tests included a normality test and a linearity test. After the assumptions were fulfilled, a simple linear regression analysis was conducted to examine the influence of digital literacy on students' science process skills. All statistical analyses were performed using SPSS version 25.0 to obtain accurate and systematic results.

d. Qualitative data analysis

Qualitative data were analyzed using the Miles and Huberman (1994) interactive analysis model. This model consists of three main stages: data reduction, data display, and conclusion drawing/verification. Data reduction involved selecting, focusing, and simplifying relevant interview data. Data display was conducted by organizing the interview findings into narrative descriptions and thematic matrices. Conclusion drawing and verification were carried out by comparing the qualitative findings with the quantitative results to obtain a more comprehensive interpretation. To enhance the trustworthiness of the qualitative data, member checking and source triangulation were conducted during the analysis.

The research procedure was carried out in four main stages. In the first stage, the researchers conducted a literature review on digital literacy, science process skills, mixed-methods research, and physics learning in straight-line motion dynamics. Based on this review, the research instruments were developed, including a digital literacy questionnaire, an SPS observation sheet, and a semi-structured interview guide. The instruments were then validated by three experts: a physics education lecturer, a digital literacy expert, and a research methodology expert. This validation process was conducted to ensure that the instruments were relevant to the research objectives and appropriate for the learning context.

In the second stage, learning activities on straight-line motion dynamics were implemented by integrating digital resources and media, such as PhET Interactive Simulations, motion analysis applications, and instructional videos on uniform and uniformly accelerated motion. During these activities, students conducted physics practicum activities supported by digital literacy. They explored kinematic concepts, analyzed motion graphs, and interpreted experimental data using digital tools.

In the third stage, quantitative data were collected using the digital literacy questionnaire and SPS observation sheet during the straight-line motion laboratory activities. After the quantitative data were obtained, in-depth interviews were conducted with selected students. The interview participants represented high, medium, and low achievement categories based on the quantitative results. This selection was intended to provide a broader explanation of the statistical findings.

In the fourth stage, the quantitative data were analyzed using SPSS to determine the statistical relationship between digital literacy and science process skills. The qualitative data were analyzed using the Miles and Huberman model to explore students' learning experiences and explain the quantitative findings. Finally, the quantitative and qualitative findings were integrated to provide a comprehensive understanding of the effectiveness of integrating digital literacy in enhancing students' science process skills in learning straight-line motion dynamics. The overall sequence of the research procedure is presented in Figure 1.

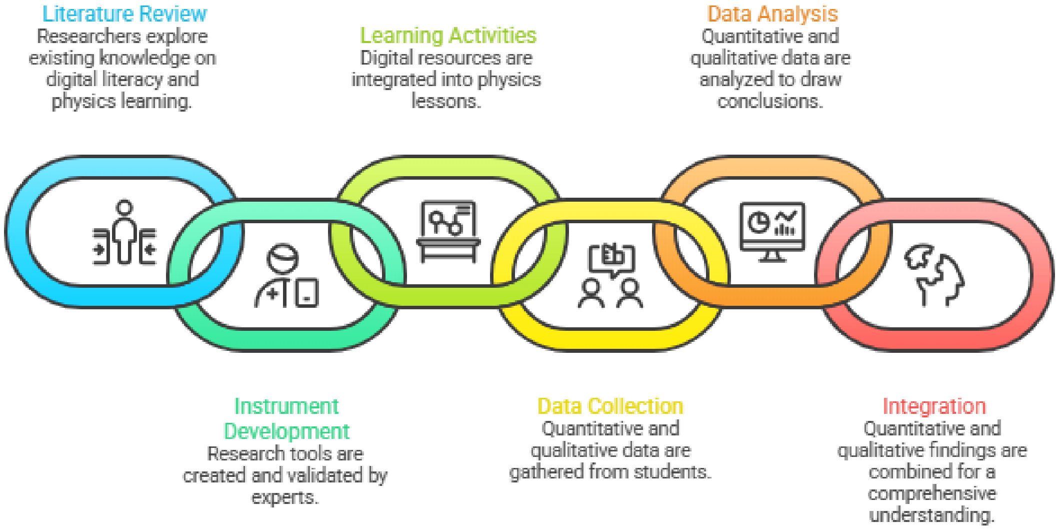

Figure 1. Research procedure

III. RESULTS

Quantitative data analysis was conducted to examine the effect of digital literacy (X) on students' science process skills (Y) in learning straight-line motion dynamics. Before hypothesis testing, assumption tests were conducted to ensure that the data met the requirements for simple linear regression. These tests included normality and linearity tests. The normality test was conducted using the Kolmogorov-Smirnov test to determine whether the data for both variables were normally distributed. The results of the normality test are presented in Table 1.

Table 1. Results of the Kolmogorov-Smirnov normality test

Variables	N	Sig. (p)	Description
Digital literacy (X)	40	0.168	Normal
Student science process skills (Y)	40	0.200	Normal

Table 1 shows that the significance values for digital literacy (p = 0.168) and science process skills (p = 0.200) were greater than 0.05. These results indicate that the data for both variables were normally distributed. Therefore, the normality assumption required for simple linear regression analysis was fulfilled. The next assumption test was the linearity test, which was conducted to determine whether the relationship between digital literacy and science process skills was linear. The results of the linearity test are presented in Table 2.

Table 2. Results of the linearity test between digital literacy and science process skills

Sources of variation	df	F count	Sig.	Description
Linearity	1	45.327	0.000	Linear
Deviation from linearity	38	1.296	0.167	Does not deviate from linearity

Based on Table 2, the significance value for linearity was 0.000, which was lower than 0.05. Meanwhile, the significance value for deviation from linearity was 0.167, which exceeded 0.05. These results indicate that the relationship between digital literacy and science process skills was linear and did not significantly deviate from linearity. Thus, the data met the linearity assumption required for simple linear regression analysis. After the assumptions were fulfilled, a simple linear regression analysis was conducted to examine the effect of digital literacy on students' science process skills. The analysis was performed using SPSS version 25.0. The results of the regression coefficient test are presented in Table 3.

Table 3. Results of the simple linear regression coefficient test

Model	Unstandardized coefficients (B)	Std. error	Standardized coefficients (beta)	t count	Sig. (p)
(Constant)	25.412	4.376	-	5.810	0.000
Digital literacy (X)	0.652	0.096	0.723	6.801	0.000

The results in Table 3 show that the regression coefficient for digital literacy was 0.652, with a significance value of 0.000. Because the p-value was less than 0.05, digital literacy had a positive and significant effect on students' science process skills. The regression equation obtained from the analysis was: $Y = 25.412 + 0.652X$. This equation indicates that each 1-unit increase in digital literacy score was associated with a 0.652-point increase in students' science process skills. Therefore, students with higher digital literacy tended to demonstrate stronger science process skills in learning about straight-line motion dynamics. To determine the strength of the relationship and the contribution of digital literacy to science process skills, the model summary was analyzed. The results are presented in Table 4.

Table 4. Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	0.723	0.523	0.512	4.218

Table 4 shows that the R value was 0.723, indicating a strong positive relationship between digital literacy and science process skills. The R-squared value was 0.523, indicating that 52.3% of the variation in students' science process skills was explained by digital literacy. The remaining 47.7% was influenced by other factors not examined in this study. These results indicate that digital literacy made a substantial contribution to the development of students' science process skills in learning about straight-line motion dynamics. The ANOVA test was conducted to determine whether the regression model was statistically significant. The results are presented in Table 5.

Table 5. ANOVA test results

Model	Sum of squares	df	Mean square	F count	Sig. (p)
Regression	705.256	1	705.256	46.278	0.000
Residual	642.744	38	16.914		
Total	1348.000	39			

Based on Table 5, the F value was 46.278 with a significance value of 0.000. Since the p-value was less than 0.05, the regression model was statistically significant. This result confirms that digital literacy had a positive and significant effect on the science process skills of grade XI students at SMA Negeri 11 and SMA Negeri 12 Jambi City in straight-line motion dynamics learning. The quantitative findings indicate that students with higher digital literacy showed better performance in observing motion phenomena, designing experiments, collecting and analyzing data, interpreting kinematic graphs, and drawing scientific conclusions. These findings were further supported by the qualitative data obtained from student interviews. The results of the interview analysis are presented in Table 6.

Table 6. Results of student interview analysis on the integration of digital literacy and science process skills

Main themes	Student statements	Theoretical interpretation	Support for quantitative findings
Utilization of digital literacy in straight-line motion experiments	Students stated that using mobile phone sensors, such as accelerometers, video analysis applications, and PhET simulations helped them observe and measure motion in straight-line dynamics, including velocity and acceleration in uniform motion and uniformly accelerated motion experiments.	Digital literacy enables students to connect theoretical physics concepts with real-time experimental data through digital tools, thereby improving the accuracy of observing motion phenomena.	Supports the improvement of observation and experimental skills shown in the regression results, with a significant value of $p < 0.05$.
Improving data analysis	Most students reported that video tracking	Digital integration supports higher-order	Strengthens the R Square value of 0.523,

and interpretation skills	applications and digital graphs helped them understand the relationships among displacement, time, velocity, and acceleration. These tools also helped them interpret motion graphs more clearly.	thinking skills, including analyzing kinematic graphs, interpreting motion trends, and drawing scientific conclusions.	indicating that digital literacy contributed substantially to students' science process skills.
Independent and collaborative learning	Students felt more independent because they could access digital learning videos, e-modules, and simulation-based explanations of uniform motion and uniformly accelerated motion. They also discussed experimental results through WhatsApp groups and classroom platforms.	Digital literacy supports self-regulated learning and collaboration, which are essential competencies in 21st-century science education.	Explains the improvement in experimental design, data collection, and scientific communication skills observed in the SPS assessment.
Technical challenges and adaptation	Several students initially experienced difficulties in using video analysis applications and interpreting digital motion graphs. However, after repeated practice and guidance, they became more confident.	This finding reflects the digital adaptation process, in which learners gradually develop technological fluency in scientific inquiry.	Explains the variability in SPS scores and the residual variation in the regression analysis.
Perceptions of the effectiveness of digital integration	Students stated that learning straight-line motion dynamics became more interesting, easier to understand, and more contextual when supported by digital simulations and video analysis tools.	Digital learning enhances conceptual understanding through constructivist learning, where students actively build knowledge from experience.	Supports the overall positive relationship between digital literacy and science process skills development.

The interview results confirmed the quantitative findings that digital literacy positively supported students' science process skills in learning straight-line motion dynamics. Students reported that using video analysis applications, PhET simulations, and mobile device sensors helped them observe motion phenomena, collect experimental data, analyze motion graphs, and draw scientific conclusions. These digital tools enabled students to more clearly visualize kinematic concepts, such as displacement, velocity, and acceleration, in uniform and uniformly accelerated motion.

The qualitative findings also showed that digital literacy supported independent learning, collaboration, and data-based problem solving. Students were able to access digital learning resources, discuss experimental results through online platforms, and connect theoretical physics concepts with experimental data. Although some students initially experienced technical difficulties in using digital tools and interpreting motion graphs, repeated practice and guidance helped them become more confident. These findings indicate that digital literacy not only supports the technical use of digital devices but also strengthens students' scientific inquiry processes.

IV. DISCUSSION

The findings of this study confirm that digital literacy plays an important role in strengthening students' science process skills in learning straight-line motion dynamics. The quantitative results showed a positive and significant relationship between digital literacy and science process skills, indicating that students who were more capable of accessing, evaluating, and using digital resources also demonstrated stronger scientific inquiry skills. This finding is consistent with the view that digital literacy is not limited to the technical ability to operate digital devices but also includes critical, ethical, creative, and analytical capacities in processing scientific information for learning purposes (Dwidarti et al., 2025; Gutiérrez-Martín et al., 2022; Mokhtari et al., 2025). In the context of physics learning, these competencies are particularly important because students are required not only to understand concepts but also to observe phenomena, analyze data, interpret evidence, and construct conclusions based on empirical findings. Therefore, integrating digital literacy into straight-line motion dynamics learning provides a meaningful foundation for developing students' scientific reasoning and inquiry-based learning practices.

The positive effect of digital literacy on science process skills can be explained by the nature of physics learning, which requires students to connect abstract concepts with observable phenomena. Straight-line motion dynamics involves relationships among displacement, time, velocity, and acceleration, which are often difficult for students to grasp when taught solely through verbal explanations or static representations. Previous studies have emphasized that students frequently experience difficulties in connecting theoretical concepts with experimental practice, especially in physics topics that require conceptual abstraction and data interpretation (Ambarwati et al., 2023; Tiastiti et al., 2024). The present study shows that digital tools, such as simulations, motion analysis applications, mobile phone sensors, and instructional videos, can help students visualize motion phenomena and interpret kinematic relationships more concretely. This supports the argument that digital technology can enrich physics learning by providing visual, interactive, and data-based learning experiences that are difficult to obtain through conventional teacher-centered instruction (Jarrett et al., 2022; Ramly et al., 2022).

Students with higher digital literacy were better able to analyze the relationship between distance, time, velocity, and acceleration using experimental data and digital simulations. This ability was reflected in their performance in designing simple experiments, identifying variables, interpreting motion graphs, and drawing scientific conclusions. These aspects are closely aligned with the core components of science process skills, which include observing, classifying, interpreting data, formulating hypotheses, conducting experiments, and making evidence-based conclusions (Akhmedova, 2022; Elvanisi et al., 2018; Ningsi & Nasih, 2020). The findings also support the idea that science process skills help students think and work scientifically rather than merely memorize scientific concepts (Darmaji et al., 2022; Şahintepe et al., 2020; Sari et al., 2023). Thus, digital literacy contributes not only to students' ability to use technology but also to their capacity to engage in scientific practices that are central to physics learning.

The qualitative findings strengthen the quantitative results by showing how digital literacy supported students' learning processes during straight-line motion dynamics activities. Students reported that experimental videos, interactive simulations, motion-analysis applications, and e-learning materials helped them better understand the dynamics of straight-line motion. In particular, these tools supported their understanding of uniform motion and uniformly accelerated motion, especially in interpreting the relationships among displacement, velocity, acceleration, and time through digital graphs and motion visualization (Lauc et al., 2020; Mazmurrini et al., 2023; Meulenbroeks et al., 2024). This indicates that digital media can function as a bridge between abstract physics concepts and students' empirical observations. When students can repeatedly observe motion, compare graph patterns, and analyze numerical data using digital tools, they have more opportunities to construct conceptual understanding through active learning.

The interview data also showed that digital learning activities increased students' engagement, curiosity, and participation in physics learning. The use of motion videos, mobile applications for collecting kinematic data, and spreadsheet software for processing experimental results encouraged students to become more involved in scientific activities rather than remain passive recipients of information (Maharani et al., 2025; Muzakki et al., 2022; Tor & Gordon, 2020). This finding is important because teacher-centered instruction and limited visualization support have been identified as factors that may make students passive and hinder their understanding of motion concepts (Jurkaninová et al., 2019). By integrating digital literacy into laboratory-based learning, students were given opportunities to observe, test, analyze, discuss, and communicate findings. These processes are essential for developing scientific habits of mind and improving the quality of physics learning.

The findings of this study are consistent with previous research indicating that digital literacy and interactive digital media can improve students' scientific thinking and science process skills. Ardianti et al. (2021) reported that interactive digital media can enhance science process skills and learning motivation in physics learning. Similarly, digital literacy has been associated with the development of scientific thinking and problem-solving skills in science learning contexts (Bellová et al., 2017; Kamid et al., 2023). The present findings also support studies showing that virtual laboratories and augmented reality can improve students' analytical skills and conceptual understanding (Kamid et al., 2022; Mellawaty et al., 2023). These consistencies suggest that digital literacy is increasingly relevant in science education because it enables students to interact with information, representations, and data in ways that support inquiry and conceptual development.

This study also supports prior evidence that integrating digital technology into laboratory-based learning can enrich students' learning experiences and strengthen conceptual understanding. Research has emphasized that digital technologies, including augmented reality, online resources, and technology-supported laboratory activities, can provide students with more flexible and meaningful learning opportunities (Dengel et al., 2022; Moghadas et al., 2023; Suroso et al., 2024). In the present study, this enrichment was achieved through motion analysis tools, simulations, mobile sensors, and digital graph interpretation. These tools enabled students to examine motion phenomena with greater accuracy and to connect experimental evidence with theoretical concepts. Therefore, digital literacy-based learning can support a more comprehensive form of scientific learning by integrating conceptual understanding, procedural knowledge, and data interpretation.

The contribution of this study lies in its specific focus on straight-line motion dynamics learning at the senior high school level. Although previous studies have examined digital media, virtual laboratories, and science process skills in broader science learning contexts, fewer studies have specifically investigated how digital literacy functions as an active, measurable variable in learning about straight-line motion dynamics. This study addresses that gap by positioning digital literacy not merely as a supplementary tool but as an integral component of physics learning, influencing students' science process skills. This contribution is particularly relevant because learning straight-line motion dynamics requires students to interpret motion patterns, analyze kinematic graphs, and connect mathematical representations with physical phenomena. In this regard, the findings expand existing understanding of the relationship between digital literacy and science process skills in physics education, particularly in kinematics learning (Afnita et al., 2021).

The novelty of this research is reflected in the direct integration of digital literacy into straight-line motion dynamics learning activities and in the use of a mixed methods approach to understand both statistical relationships and learning experiences. By combining quantitative analysis with qualitative interpretation, this study provides a more comprehensive explanation of how digital literacy supports conceptual understanding, experimental competence, and reflective scientific thinking. This is consistent with the view that digital literacy can support broader learning capacities, including information evaluation, technological fluency, and evidence-based reasoning (Ollerenshaw et al., 2021). Furthermore, the use of real experimental activities and video-based motion observation strengthens the relevance of the findings for physics laboratory learning. Such an approach is consistent with research emphasizing the importance of inquiry-based learning, scientific process development, and hands-on or technology-supported exploration in science education (Gultepe, 2016; Ibrohim et al., 2020; Mawn et al., 2011).

The findings have practical implications for physics teachers and curriculum developers. Digital literacy should be considered a strategic component in designing physics instruction, particularly for topics that require visualization, measurement, and data interpretation, such as the dynamics of straight-line motion. Teachers can design experimental learning activities that integrate digital competencies with scientific inquiry, including analyzing motion videos, using simulation-based data-collection tools, interpreting kinematic graphs, processing experimental data, and presenting findings through digital platforms. This approach is also aligned with the Independent Learning (*Merdeka Belajar*) paradigm, which emphasizes learner autonomy, collaboration, and the use of information technology to improve learning processes (Asrial et al., 2024; Bashori, 2018; Rudge, 2021). When implemented systematically, digital literacy-based physics learning can help students become more active, independent, collaborative, and reflective in conducting scientific investigations.

V. CONCLUSION AND SUGGESTION

The results of this study show that digital literacy has a positive and significant influence on students' science process skills in straight-line motion dynamics learning at SMA Negeri 11 and SMA Negeri 12 Jambi City. The simple linear regression analysis indicated a significance value of 0.000 < 0.05, confirming that digital literacy significantly affected students' science process skills. The R Square value of 0.523 indicated that 52.3% of the variation in students' science process skills was explained by digital literacy, while the remaining 47.7% was attributed to other factors not examined in this study. Students with higher digital literacy demonstrated stronger abilities in observing motion phenomena, formulating hypotheses, identifying variables, analyzing kinematic graphs, interpreting experimental data, and drawing conclusions about uniform and uniformly accelerated motion. The interview and observation findings supported the quantitative results by showing that digital-based learning activities, such as motion video analysis, simulation applications, mobile device sensors, and digital data processing, helped students connect physics concepts to real motion phenomena and improved their engagement in experimental learning.

This study has several limitations. The sample was limited to 40 students from two senior high schools in Jambi City, so the findings should be interpreted carefully and may not fully represent students in broader educational contexts. In addition, the study focused solely on straight-line motion dynamics, so the results may not directly apply to other physics topics with different conceptual and experimental characteristics. Future research should involve larger, more diverse samples across different schools and regions, and examine the integration of digital literacy into other physics topics and learning models. Despite these limitations, this study contributes to the field of physics education by providing empirical evidence that digital literacy can be integrated systematically into experimental physics learning to strengthen students' science process skills. The findings offer practical guidance for physics teachers and curriculum developers in designing technology-supported inquiry activities that promote conceptual understanding, scientific reasoning, data interpretation, and student-centered learning in secondary physics education.

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