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Exploring the Role of Digital Literacy as a Predictor of Self-Regulated Learning in Physics Education

Riswanto[1)*], Dedy Hidayatullah Alarifin[1)], Arif Hidayat[2)]

[1)]*Department of Physics Education, Universitas Muhammadiyah Metro, Metro, 34112, Indonesia*
[2)]*Department of Computer Science, Universitas Muhammadiyah Metro, Metro, 34112, Indonesia*

**Corresponding author: rumbiariswan@gmail.com*

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Abstract – *The rapid integration of digital technologies into education highlights the critical importance of digital literacy in developing self-regulated learning (SRL), particularly among physics education students. This study aims to investigate the influence of digital literacy on SRL by (1) assessing the digital literacy levels of physics students, (2) examining their SRL profiles, (3) analyzing the predictive power of digital literacy on SRL, and (4) identifying which digital literacy indicators significantly impact different SRL dimensions. A quantitative, cross-sectional approach was employed with 28 undergraduate students using validated instruments: the Digital Literacy Scale and the Online Self-Regulated Learning Questionnaire. The results revealed high digital literacy levels, especially in media utilization (M = 4.17), but lower performance in evaluating digital information (M = 3.96). SRL was strongest in planning (M = 3.3) and monitoring-evaluation (M = 3.2), while autonomy (M = 2.5) and motivation-discipline (M = 2.8) were less developed. Regression analyses confirmed digital literacy as a significant predictor of SRL (β = 0.50; p = 0.016), explaining 58.9% of the variance. Among the digital literacy indicators, digital technology skills emerged as the most influential factor across all SRL dimensions. Furthermore, gender was found to moderate the relationship, with a stronger effect observed in female students. This study contributes to physics education by demonstrating the importance of integrating digital literacy training, particularly in technology skills and information evaluation, into curriculum design to support students' independent learning capabilities in digital learning environments.*

Keywords: *digital literacy; online learning strategies; physics education; self-regulated learning; technology skills*

I. INTRODUCTION

The digital revolution has fundamentally reshaped the landscape of education worldwide by presenting new opportunities and challenges for learners, educators, and educational institutions alike. Digital literacy, defined as the ability to access, evaluate, and effectively use digital information, has become a crucial competence for success in the 21st century (Arono et al., 2022; Audrin & Audrin, 2022). As the educational system increasingly integrates digital technologies,

students are expected to not only be proficient in basic technological skills but also in higher-order skills such as critical thinking and independent learning (Bahri et al., 2024). For higher education, particularly in science and technology fields like physics, digital literacy is indispensable, enabling students to engage in complex learning tasks, conduct research, and collaborate in virtual environments. In Indonesia, the transition towards a more digital learning environment has been accelerated by government policies that encourage the integration of technology in education. Despite this, studies indicated that the digital literacy index in Indonesia remains in the medium category, suggesting significant room for improvement in key areas, including critical digital skills such as information evaluation and digital content creation (Agustini, 2021; Simanjuntak et al., 2025).

At the same time, self-regulated learning (SRL) has emerged as a critical determinant of academic success, particularly in the digital era where students are required to independently manage their learning processes. SRL involves the ability to set learning goals, monitor progress, evaluate outcomes, and adjust strategies as needed, making it essential for mastering complex subjects like physics. Research has consistently shown that SRL is linked to better academic performance and deeper learning, particularly in digital science education (Bahri et al., 2024). However, despite its significance, many students struggle with developing strong SRL skills, particularly in contexts where digital tools and resources are integral to the learning experience. This gap in SRL skills, coupled with varying levels of digital literacy, calls for a deeper investigation into how these two constructs interact, particularly in fields such as physics education. In this context, understanding the relationship between digital literacy and SRL is not only crucial for improving educational outcomes but also for designing more effective educational interventions that foster both technical proficiency and independent learning.

The main issue addressed by this study is the lack of empirical evidence on how digital literacy influences SRL, particularly in the context of Physics Education in Indonesian universities. While both digital literacy and SRL have been studied extensively, their interaction remains underexplored, especially in the context of Indonesian students. Some studies have established that digital literacy positively impacts SRL in various academic settings. Still, few have examined how specific dimensions of digital literacy, such as digital technology skills, information evaluation, and media utilization, relate to distinct dimensions of SRL, such as planning, autonomy, and motivation (Saregar et al., 2024; Wijayati et al., 2023). Understanding these relationships is critical for developing tailored interventions that address the specific challenges faced by students in mastering SRL in a digitally mediated learning environment.

The problem of inadequate SRL skills in digital contexts has been compounded by the rapid shift to online and hybrid learning environments, which demand a new set of competencies. In

response to this challenge, recent research has suggested various strategies to enhance SRL, such as integrating metacognitive training, providing automated feedback, and encouraging collaborative learning through digital tools (Bellhäuser et al., 2023; Boudjedra, 2024; Dekker, 2023; Kumar, 2022). However, there is a lack of consensus on which components of digital literacy most effectively promote SRL, and how these components should be integrated into educational practices. Additionally, the role of gender as a moderating factor in the relationship between digital literacy and SRL has received little attention in the existing literature, despite evidence suggesting that digital literacy might impact male and female students differently (Martzoukou et al., 2020). Given the complexity of these factors, a more comprehensive approach is needed to identify the key elements of digital literacy that most significantly influence SRL and to explore how these elements can be enhanced through educational interventions.

Previous studies have explored various aspects of digital literacy and their impact on SRL, but few have examined the specific indicators of digital literacy and their direct relationship with the dimensions of SRL. For instance, Saregar et al. (2024) found that digital literacy was positively correlated with SRL, but their study did not break down the individual components of digital literacy. Similarly, Bahri et al. (2024) demonstrated a link between digital literacy and academic performance in science education, but the relationship between digital literacy and SRL specifically was not addressed. Furthermore, studies examining the influence of gender on this relationship are scarce, and most focus on generic correlations between digital tools and academic outcomes, without delving into the mechanisms that connect digital literacy to independent learning skills. This study aims to fill these gaps by analyzing the relationship between digital literacy and SRL among physics students in Indonesia, focusing on the specific dimensions of digital literacy and their impact on the various facets of SRL.

This study draws on the body of literature that links digital literacy to SRL and extends this work by focusing on the three main dimensions of digital literacy: digital technology skills, information evaluation, and media utilization. It also considers the five key dimensions of SRL: planning, autonomy, monitoring and evaluation, motivation and discipline, and technology use. By employing a mixed-methods approach, including quantitative analysis and regression modeling, this study aims to provide a nuanced understanding of how digital literacy influences SRL in the context of physics education (Alfakhry et al., 2024; Burro et al., 2022). Specifically, it will test the hypothesis that digital literacy, particularly digital technology skills, is a significant predictor of SRL across all dimensions, with a particular focus on planning and monitoring-evaluation, where students have shown the most significant gaps in previous research. Furthermore, this study will investigate the moderating role of gender in this relationship, offering insights into how interventions can be tailored to meet the needs of male and female students.

The primary goal of this research is to investigate how digital literacy affects SRL in Physics Education students, with a focus on understanding which dimensions of digital literacy are most strongly correlated with specific aspects of SRL. The novelty of this study lies in its comprehensive analysis of the three core dimensions of digital literacy and their unique contributions to SRL, as well as its exploration of gender as a moderating factor. The findings of this study are expected to inform the design of interventions aimed at enhancing digital literacy and SRL among physics students, with implications for educational practice and policy in Indonesia and beyond. Specifically, the study aims to provide evidence-based recommendations for improving digital literacy curricula in higher education, which can lead to better student outcomes in terms of both technical skills and independent learning capabilities. This is particularly important as the higher education sector continues to adapt to the increasing prevalence of digital learning environments.

II. METHODS

This study employs a quantitative, descriptive correlational design with a cross-sectional survey approach to examine the relationship between digital literacy and SRL among physics education students. The rationale behind this methodological choice is rooted in the need to capture data at a single point in time and to explore the relationship between the two constructs, digital literacy and SRL using statistical analysis. Given that this study aims to test the predictive power of digital literacy on SRL dimensions, this research design is particularly suitable as it allows for the measurement of latent variables and the examination of their relationships in a naturalistic educational setting (Creswell, 2014).

The participants in this study were undergraduate students from the physics education study program at the University of Muhammadiyah Metro, Indonesia. A stratified proportional random sampling technique was applied to ensure that students from different academic years were represented in the sample. This method was used to maintain the diversity of the sample, as students in different years of study may have varying levels of exposure to digital tools and educational technology, which could influence their digital literacy and SRL. Based on the Cochran formula for sample size calculation, the study included 28 participants, ensuring a 5% margin of error and a 95% confidence level. Although this sample size is relatively small, it is sufficient for the study's purposes, given its exploratory nature and focus on generating insights into the relationship between the variables (Cochran, 1977).

Two main instruments were used in this study to measure digital literacy and SRL: the digital literacy scale (adapted from Nikou et al., 2022) and the online self-regulated learning

questionnaire (OSLQ) (Barnard et al., 2009). These instruments were adapted to fit the context of the study, which focused on Indonesian physics education students. The digital literacy scale was designed to measure three core indicators of digital literacy: (a) digital technology skills, (b) understanding and evaluation of digital information, and (c) media utilization. The scale includes 24 items in total, with 8 items for each indicator, assessed on a 5-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5). The scale has been validated in previous studies (Nikou et al., 2022) and has demonstrated good reliability and validity in similar contexts. For this study, the scale was translated into Bahasa Indonesia and pre-tested with a small group of students to ensure its appropriateness and clarity.

The SRL was measured using the online self-regulated learning questionnaire (OSLQ), which assesses five dimensions of SRL: (a) planning, (b) autonomy, (c) monitoring and evaluation, (d) motivation and discipline, and (e) technology utilization. The OSLQ includes 30 items, with six items for each dimension, also measured on a 5-point Likert scale. The OSLQ has been widely used in research on SRL in online and blended learning environments and has proven to be a reliable and valid instrument for assessing self-regulation strategies (Barnard et al., 2009).

The data collection process involved distributing the two questionnaires to participants via Google Forms, which enabled the easy and efficient collection of responses in an online format. The questionnaires were administered over a period of two weeks, during which participants were asked to complete the surveys in a quiet, distraction-free environment to ensure accurate and thoughtful responses. Given the growing reliance on digital tools for learning in higher education, the online format of the survey was deemed appropriate for capturing the students' perceptions of their digital literacy and SRL skills. The data was automatically recorded and stored in a CSV format for further analysis.

The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics were first employed to summarize the participants' digital literacy and SRL profiles. The mean, standard deviation, and frequency distribution were calculated for each indicator of digital literacy and each dimension of SRL. These statistics provided an overview of the participants' strengths and weaknesses in both areas and highlighted any significant variations among the students. Visual representations, such as bar charts and box plots, were used to present the distribution of responses for each indicator and dimension, allowing for an intuitive understanding of the data.

For inferential statistics, multiple regression analysis was performed to test the relationship between digital literacy and SRL. Specifically, simple linear regression was used to assess whether composite digital literacy (i.e., the combined score of all three digital literacy indicators) could significantly predict SRL (composite score). The regression model examined the strength

and significance of the relationship between digital literacy and SRL, with the goal of determining whether digital literacy can be considered a predictor of SRL in this context. The R-squared value, as well as the beta coefficients, were computed to determine the proportion of variance in SRL explained by digital literacy, as well as the strength and direction of the relationships. To further explore the influence of individual digital literacy indicators on SRL dimensions, Pearson's correlation analysis was conducted. This analysis provided insight into the specific contributions of digital technology skills, information evaluation, and media utilization to the five dimensions of SRL. Standardized beta coefficients from multiple regression analysis were also used to identify which digital literacy indicators had the most significant influence on each SRL dimension.

The reliability and validity of the instruments used in this study were assessed through confirmatory factor analysis (CFA) and reliability tests. CFA was conducted using AMOS software to assess the fit of the data to the hypothesized factor structure of both the Digital Literacy Scale and the OSLQ. Items with factor loadings below 0.50 were excluded from further analysis to ensure that only the most reliable items were included in the final model. Cronbach's alpha and composite reliability were calculated to measure the internal consistency of the scales, with values greater than 0.70 indicating satisfactory reliability (Nunnally & Bernstein, 1994). All scales demonstrated adequate reliability and validity, ensuring that the instruments provided accurate and meaningful measurements of digital literacy and SRL in this study.

Ethical approval for this study was obtained from the Institutional Review Board (IRB) at the University of Muhammadiyah Metro. Informed consent was obtained from all participants, who were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without penalty. Confidentiality was maintained by anonymizing all responses and ensuring that data were stored securely. Participants were also given the opportunity to ask questions or seek clarification about the study before completing the surveys. The overall research procedure employed in this study, including sampling, data collection, and data analysis, is illustrated in Figure 1.

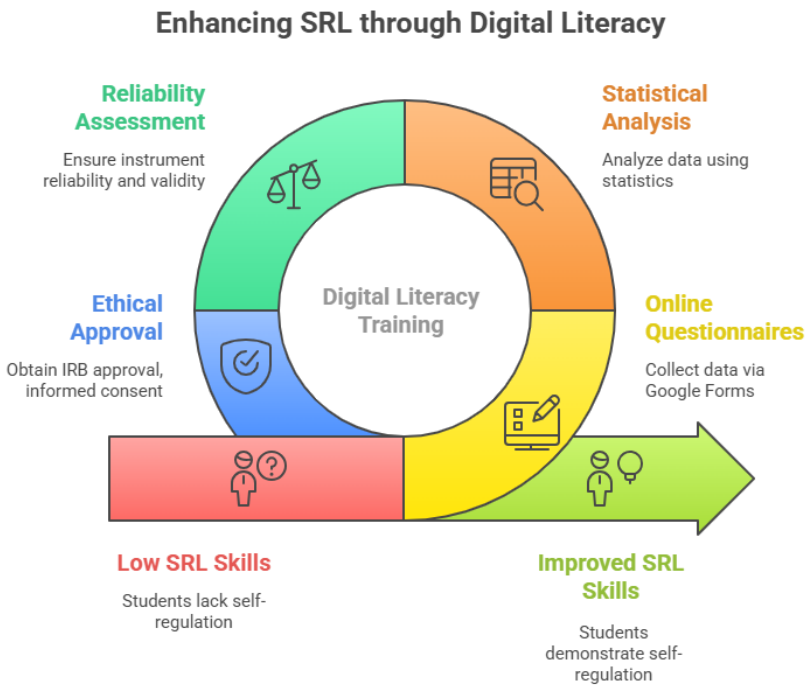

Figure 1. Flowchart of the research procedure

III. RESULTS AND DISCUSSION

The analysis of students' digital literacy, based on three primary indicators—digital technology skills, understanding and evaluation of digital information, and media utilization—provides a comprehensive picture of their strengths and weaknesses in this domain. The findings indicate that, overall, the students in this study exhibit a high level of digital literacy, with notable variation observed in specific areas. To illustrate the distribution of these results, we refer to Figures 2 and 3, which depict the mean scores and the standard deviations for each indicator.

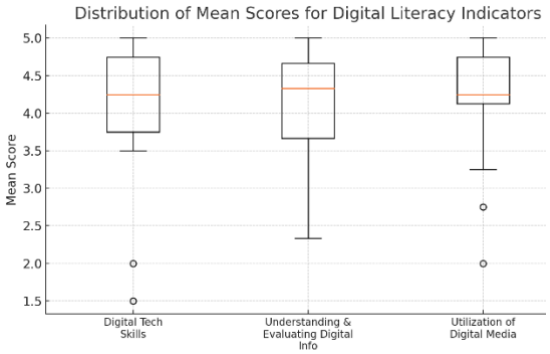

Figure 2. Distribution of mean scores for digital literacy indicators

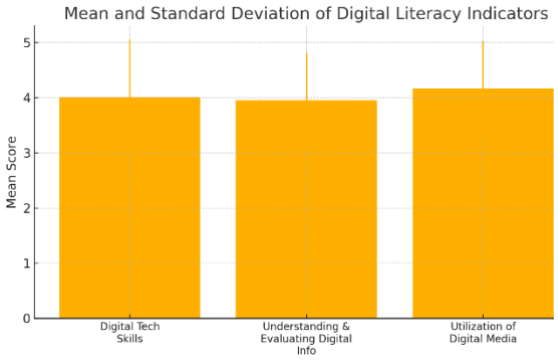

Figure 3. Mean and standard deviation of digital literacy indicators

Figure 2 presents the distribution of mean scores for the three digital literacy indicators. The data reveal that, on average, students exhibit strong proficiency in digital literacy, with all three indicators surpassing the threshold of 4.0 on a 5-point Likert scale. The highest average score was found in the utilization of digital media (M = 4.17), followed closely by digital technology skills (M = 4.02) and understanding and evaluating digital information (M = 3.96). The boxplot, shown in Figure 3, further substantiates these findings by indicating that the median scores for all three indicators are above 4.0, signaling that most students perform at a relatively high level.

Despite these overall high scores, notable variations were observed within each indicator. For digital technology skills, the interquartile range (IQR) spanned from approximately 3.75 to 4.75, with two low outliers around 1.5 and 2.0. These outliers suggest that a small subset of students still struggles with basic technical skills, indicating a potential area for improvement. In contrast, the understanding and evaluation of digital information indicators showed a wider IQR (around 3.65–4.75), with a lower whisker reaching approximately 2.33. This suggests that the ability to assess the credibility of online information critically is more varied and presents a particular challenge for some students. The utilization of the digital media indicator displayed the narrowest IQR (4.10–4.75), with only a few outliers below 3.0. This indicates that most students are highly proficient in using digital media platforms to support their learning, although a small group of students remains less active in utilizing these tools effectively.

These observations are reinforced by the bar chart in Figure 2, which shows that the mean score for utilization of digital media was the highest (M = 4.17) and the lowest variability (SD = 0.86) among the three indicators. This finding suggests that most students are quite adept at utilizing digital platforms, such as Google Classroom, Zoom, and YouTube, for their learning activities. On the other hand, digital technology skills exhibited a relatively higher standard deviation (SD = 1.05), indicating more variation in the students' technical abilities. The understanding and evaluating digital information indicator also showed a moderate level of variability (SD = 0.87), indicating that some students are struggling more than others with critical information evaluation skills. Therefore, targeted interventions, such as workshops focused on enhancing digital literacy in these specific areas, are recommended to address these gaps (Muhingi et al., 2021; Yaqin et al., 2023).

Students' open-ended responses further confirm the quantitative data. Around 80% of participants expressed confidence in their ability to use digital devices, including computers, laptops, and smartphones, to support their physics learning. However, some students reported difficulties with more advanced features, such as connecting simulation software or utilizing specific digital tools for data analysis (Marion & Fixson, 2021; Marwedel, 2021). While the average score for understanding and evaluating digital information was relatively high, some

students expressed uncertainty about assessing the validity of online academic sources, such as journal articles (Castro & Tumibay, 2021; Pennycook & Rand, 2020). These insights underscore the need for further development in students' ability to critically evaluate digital content.

The analysis of students' SRL abilities was based on five core dimensions: planning, autonomy, monitoring and evaluation, motivation and discipline, and the use of technology (Derlina, Harahap & Sinaga, 2021; Derlina et al., 2019). Figure 4 shows the distribution of individual scores for these SRL dimensions, and Figure 5 provides a histogram of the frequency distribution for each dimension. Both visualizations reveal a nuanced picture of students' SRL competencies.

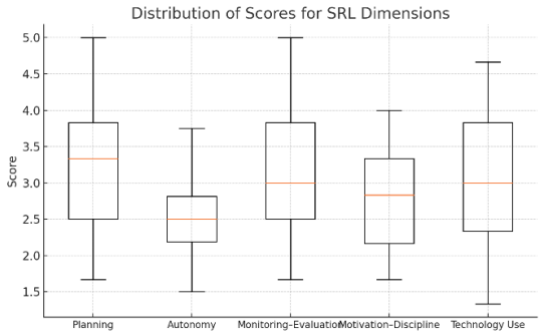

Figure 4. Distribution of scores for SRL dimensions

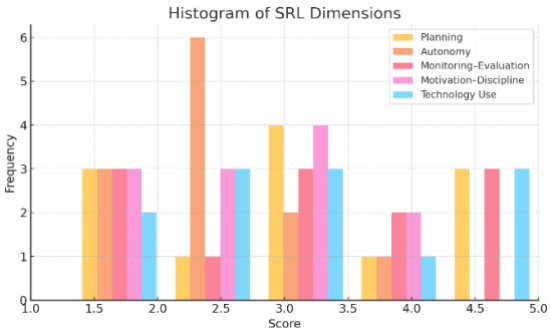

Figure 5. Histogram of SRL dimensions

For planning, the median score was 3.33, with an IQR ranging from 2.50 to 3.75. The upper whisker extends to 5.0, indicating that some students are very skilled at planning their learning activities, while others exhibit lower levels of competence (around 1.67). This suggests that while most students demonstrate at least moderate planning abilities, further support may be required for those struggling in this area. Autonomy, on the other hand, showed a much lower median of 2.50, with a narrow interquartile range (IQR) of 2.20–2.75 and no high outliers. This indicates that students generally lack strong independence in managing their learning, with a concentration of scores in the lower to moderate range. This finding highlights the need for interventions that promote greater autonomy among students. Monitoring and evaluation had a median of 3.00, with an IQR of 2.50–3.75, and a whisker extending to 5.0. This suggests that while many students are capable of monitoring and evaluating their learning progress, there is considerable variability, and some students still face challenges in consistently tracking their performance.

Motivation and discipline showed a median score of 2.83, with an IQR of 2.17–3.33, and the whisker extending above 4.0. This indicates that some students experience challenges with motivation and maintaining discipline, though there is a subset of students who demonstrate strong commitment and self-discipline. Finally, technology use had a median of 3.00, with an

IQR of 2.33–3.83, and an upper whisker of 4.67. The variability in this dimension reflects that while most students use technology at a moderate level, some either use it extensively or very infrequently. These results suggest that while students are competent in some aspects of SRL, such as planning and monitoring, they face challenges in areas like autonomy, motivation, and consistent use of technology.

The histogram in Figure 5 further corroborates these findings, with autonomy, motivation, and discipline being the weakest dimensions. The majority of students scored in the lower range for autonomy (2.0–2.5), indicating a need for interventions to promote more independent learning. In contrast, planning, monitoring, and evaluation demonstrated a more balanced distribution, with some students excelling in these dimensions. The findings emphasize that, while students show a high degree of competence in managing their learning strategies, enhancing their autonomy and motivation is essential for improving overall SRL.

The histogram of SRL dimensions, shown in Figure 4, provides a clear overview of the distribution of scores across the five dimensions of SRL: planning, autonomy, monitoring and evaluation, motivation and discipline, and technology use. Autonomy emerged as the dimension with the most significant challenges. The majority of students scored in the lower range (2.0–2.5), reflecting a lack of self-directed learning. This concentration of scores in the lower to moderate range, coupled with a narrow interquartile range (IQR) of 2.20–2.75, indicated that students struggle significantly with independence in their learning. This finding aligns with the broader literature on self-regulation in digital learning environments, where autonomy often represents a critical area in need of intervention (Khodaei et al., 2022; Miastkovska et al., 2024).

The Planning dimension, conversely, exhibited a more even distribution, with a median score of 3.33 and a wider interquartile range (IQR) of 2.50–3.75. This suggests that while most students demonstrate reasonable planning abilities, there is room for improvement in helping students who are less consistent in their approach. Monitoring and evaluation revealed two distinct groups: one that regularly reviews its learning targets (scores between 4.5 and 5.0) and another group that lacks consistent monitoring (scores between 2.5 and 3.0). This bimodal distribution emphasizes the variability in students' ability to evaluate their progress and adjust their strategies effectively. Motivation and discipline, as well as technology use, both exhibited moderate scores, with motivation and discipline centered around 2.83 and technology use averaging 3.00. This suggests that while some students exhibit strong motivation and discipline, the majority still require support in maintaining consistent engagement and focus, particularly in an online learning environment (Shunkov et al., 2022; Zhu et al., 2020).

The boxplot of digital literacy scores (Figure 3) further revealed that, overall, the students demonstrated strong digital literacy skills. The utilization of digital media scored the highest, with

an average of 4.17, suggesting that most students are proficient in using digital tools such as Google Classroom, YouTube, and Zoom for educational purposes. This is further supported by students' open-ended responses, where they expressed confidence in using these tools to enhance their learning experiences. However, some students still faced challenges with advanced features, such as connecting simulation software, highlighting the need for further support in utilizing complex digital tools (Marion & Fixson, 2021).

Digital Technology Skills recorded an average of 4.02, but with substantial variability (SD = 1.05), indicating that while many students are proficient in basic technical skills, a small subset still requires additional training in fundamental areas. Understanding and evaluating digital information had a slightly lower average (M = 3.96) and a wider distribution, with a lower whisker reaching around 2.33. This indicates that evaluating the credibility and relevance of online information is the most challenging aspect of digital literacy for many students (Castro & Tumibay, 2021; Pennycook & Rand, 2020). The findings underscore the importance of emphasizing critical thinking and information literacy as essential components of the digital literacy curriculum.

The regression analysis, shown in Figure 6, indicates a strong positive relationship between composite digital literacy and composite SRL. The regression line has a slope of +0.50, suggesting that a one-point increase in digital literacy corresponds to a 0.5-point increase in SRL. This finding supports the hypothesis that higher digital literacy directly contributes to enhanced self-regulated learning abilities. Most data points cluster between digital literacy scores of 3.0–4.5 and SRL scores between 2.5–4.0, with a few students in the higher right quadrant showing both high digital literacy and SRL scores. The distribution of points around the regression line is relatively symmetrical, indicating a good linear relationship without extreme heteroscedasticity, and confirming that digital literacy is a significant predictor of SRL.

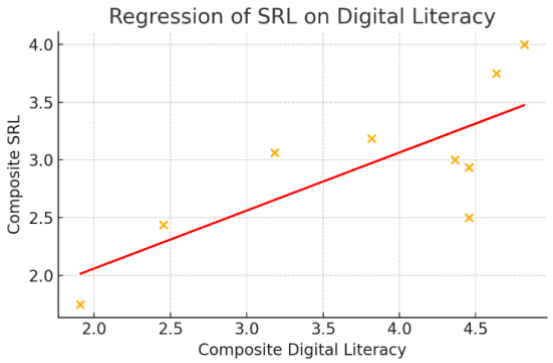

Figure 6. Regression of SRL on digital literacy

Further investigation into the individual dimensions of digital literacy revealed that digital technology skills exhibited the strongest correlation with SRL, particularly with planning (r =

0.82) and monitoring and evaluation (r = 0.75), as shown in Figure 7. This suggests that technical skills play a pivotal role in students' ability to plan and monitor their learning independently. Information evaluation had a strong correlation with planning (r = 0.77), but a weaker connection with motivation and discipline (r = 0.21), indicating that while the ability to evaluate information is crucial for planning, it does not significantly influence motivational aspects of SRL. Media use, although still contributing positively, showed a weaker correlation with SRL dimensions, particularly in areas such as motivation, discipline, and autonomy. These results highlight the primacy of digital technology skills in fostering effective SRL, followed by information evaluation and, to a lesser extent, media utilization.

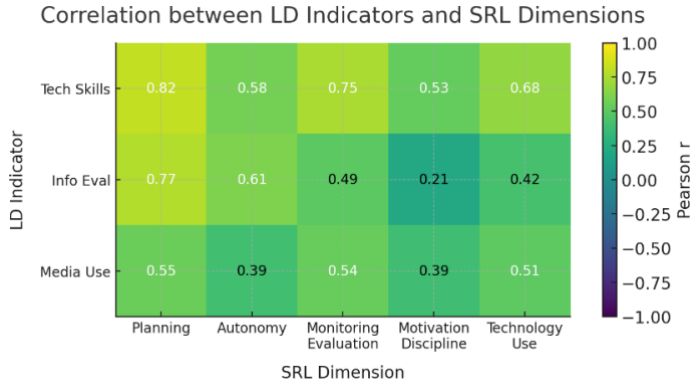

Figure 7. Correlation between digital literacy indicators and SRL dimensions

Based on these findings, it is clear that while planning and monitoring, and evaluation are relatively strong areas for most students, there is a critical need to focus interventions on improving autonomy, motivation, and discipline, and technology use. As digital literacy, particularly digital technology skills, has been shown to influence these areas positively, it is recommended that educational programs prioritize the development of these skills. Information evaluation also stands out as an area requiring targeted interventions, as it was found to be an important predictor of planning but had a limited impact on motivation and autonomy.

The findings from this study suggest that enhancing students' digital literacy, particularly in terms of technology skills and information evaluation, will significantly improve their SRL abilities. This could be achieved through tailored interventions that focus on fostering greater independence in learning, motivating students to engage consistently, and providing technical support for the effective use of digital tools in their learning activities. Such interventions would not only enhance students' academic performance but also equip them with the competencies needed to navigate an increasingly digital world. These results offer important insights into how digital literacy can be leveraged to support the development of self-regulated learning skills, providing valuable guidance for educators and policymakers in higher education, particularly within the context of science and technology education.

Multiple regression analysis was conducted, and the findings are presented in Figures 8 and 9, which provide insights into the contributions of digital literacy indicators to SRL dimensions. These visualizations reveal the dominance of digital technology skills (tech skills) in shaping SRL, with other indicators playing varying roles across the SRL dimensions.

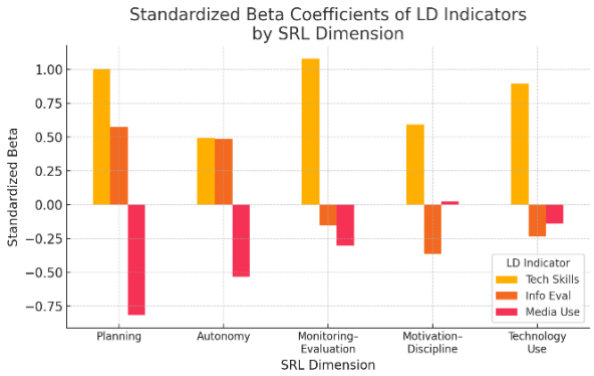

Figure 8. Standardized beta coefficients of LD indicators by SRL dimension

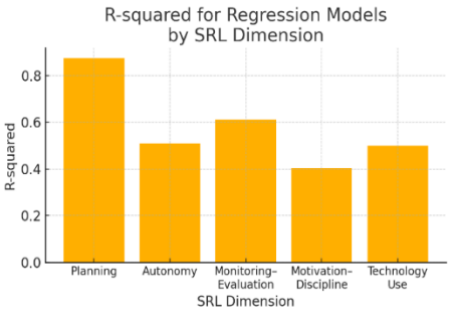

Figure 9. R-Squared for regression models by SRL dimension

Figure 8, the "grouped bar chart – standardized beta coefficients," shows the standardized beta coefficients (β) for three digital literacy indicators tech skills, info eval (information evaluation), and media use across the five SRL dimensions: planning, autonomy, monitoring-evaluation, motivation-discipline, and technology use. The results clearly indicate that tech skills are the dominant predictor in influencing all five SRL dimensions. In the planning dimension, tech skills have the highest beta coefficient (β = 1.00), significantly outperforming info eval (β = 0.58) and media use (β = –0.82). This suggests that students' technical abilities are the most critical factor in determining their success in planning independent learning tasks. Similarly, in autonomy, while there is a slight difference, tech skills (β = 0.50) still outperform info eval (β = 0.49), and media use shows a negative contribution (β = –0.82), emphasizing that independent learning is more reliant on mastering technical skills than on using digital media. In the monitoring and evaluation dimension, tech skills have an even greater contribution (β = 1.08), reinforcing the notion that the ability to monitor and evaluate one's learning is heavily dependent on digital technology proficiency. Motivation and discipline, however, were influenced solely by Tech Skills (β = 0.59), with info eval and media use contributing minimally or not at all. Lastly, in the technology use dimension, tech skills remained the strongest predictor (β = 0.90), albeit with a slightly reduced coefficient compared to its effect on other SRL dimensions. These findings demonstrate that digital technology skills are the most critical factor across all SRL dimensions, particularly in planning, monitoring, and evaluating one's learning process.

Figure 9, the "bar chart – r-squared per dimension," illustrates the explanatory power of the multiple regression models, showing the amount of variation in each SRL dimension that digital

literacy indicators can explain. The Planning dimension exhibits the highest R^2 value of 0.87, indicating that 87% of the variation in students' planning abilities can be attributed to the three digital literacy indicators. This confirms the strong predictive power of digital literacy, particularly tech skills, in fostering effective planning skills for independent learning. The monitoring and evaluation dimension comes next with an R^2 value of 0.61, followed by Autonomy with an R^2 of 0.51. These results suggest that more than half of the variation in students' ability to monitor and evaluate their learning, as well as their learning independence, is also influenced by their digital literacy levels. In contrast, the technology use ($R^2 = 0.50$) and motivation and discipline ($R^2 = 0.40$) dimensions explain relatively less variance, indicating that other factors, in addition to digital literacy, contribute to the development of these SRL aspects. These findings underline the critical role of digital literacy particularly tech skills in enhancing planning and monitoring and evaluation abilities. This further supports the idea that strengthening students' digital technology skills should be a priority for interventions aimed at improving SRL in the digital era (Arono et al., 2022; Zitierung et al., 2020).

The relationship between digital literacy and SRL was also examined in terms of gender differences, as shown in Figure 10, which visualizes the interaction between digital literacy and SRL by gender. The scatter plot indicates that male students (represented by blue dots) tend to have lower digital literacy (ranging from 2.5–4.0) and SRL scores (around 2.0–3.5), while female students (represented by red dots) demonstrate higher digital literacy scores (ranging from 3.0–4.5) and correspondingly higher SRL scores (ranging from 3.0–4.5).

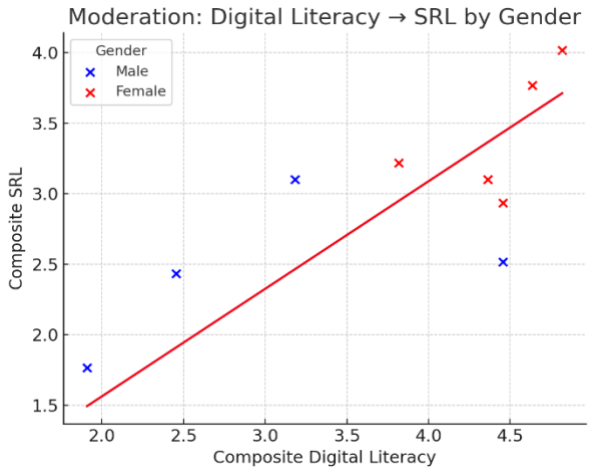

Figure 10. Moderation: Digital literacy → SRL by gender

The regression lines for male and female students show a marked difference in their slopes. For male students, the relationship between digital literacy and SRL appears moderate, with a less pronounced increase in SRL as digital literacy improves, as indicated by the flatter regression line. In contrast, the relationship for female students is steeper, suggesting a stronger correlation

between increases in digital literacy and improvements in SRL. This visual difference in regression slopes highlights that gender moderates the relationship between digital literacy and SRL, with female students being more effective at translating their digital literacy into improved independent learning strategies.

These findings of this study align with the literature suggesting that gender plays a role in how digital literacy impacts learning outcomes (Martzoukou et al., 2020; Vasilescu et al., 2020). The more significant effect of digital literacy on SRL among female students suggests that interventions designed to enhance digital literacy, and self-regulation might need to account for gender-specific needs. Specifically, tailored approaches to motivate male students to apply their digital skills more effectively in self-regulated learning contexts could help bridge this gap.

The findings of this study offer a comprehensive insight into the relationship between digital literacy and SRL among physics education students. The results demonstrate that students possess a relatively high level of digital literacy, with the digital media utilization indicator scoring the highest (M = 4.17). This suggests that most students are proficient in utilizing digital tools and platforms such as Google Classroom, YouTube, and Zoom, which are increasingly integral to modern education. However, the digital information understanding and evaluation indicator scored comparatively lower (M = 3.96), highlighting a significant gap in students' ability to critically assess and evaluate online information. This finding is particularly noteworthy because the ability to evaluate digital content is central to independent learning and academic success, especially in the digital age (Pennycook & Rand, 2020; Simanjuntak et al., 2025). These results align with studies by Muhingi et al. (2021) and Yaqin et al. (2023), which emphasize the need for greater focus on critical thinking and information literacy in educational curricula.

Similarly, the results related to SRL show that students performed well in planning and monitoring and evaluation, indicating that most students are competent in organizing and reviewing their learning process. These skills are essential components of SRL, which have been positively associated with academic success (Bahri et al., 2024). However, the dimensions of independence and motivation-discipline revealed more significant challenges. The low scores in Independence suggest that students rely heavily on external guidance from instructors and are not fully confident in managing their learning independently. This finding is consistent with those of Bellhäuser et al. (2023), who highlighted that many students struggle with autonomy in online learning environments. The relatively low scores in motivation-discipline further indicate that students may lack consistent internal motivation to persist in their learning activities, a challenge that is particularly pronounced in digital learning contexts where self-regulation is crucial (Shunkov et al., 2022; Zhu et al., 2020).

Regression analysis confirmed that digital literacy, particularly digital technology skills, significantly predicted students' SRL ($\beta = 0.50$; $p = 0.016$). This finding supports the notion that technological proficiency plays a central role in fostering self-regulation in learning, as suggested by Saregar et al. (2024), who found a similar relationship between digital literacy and SRL in physics students. Moreover, Bahri et al. (2024) also affirmed that improving digital literacy enhances SRL, particularly in online environments, where the use of digital tools for managing and evaluating one's learning is essential. However, the results from this study also point to certain inconsistencies in the motivation-discipline dimension, where digital literacy showed a relatively low contribution. This finding contrasts with studies by Kumar (2022) and Bellhäuser et al. (2023), who posited that technology skills, when coupled with automated feedback mechanisms, can foster intrinsic motivation. The discrepancy in this study could be attributed to contextual factors such as inadequate internet access or limited exposure to technology-driven learning strategies, which may affect students' motivation to engage in self-regulated learning (Mirmoadi & Satwika, 2022).

This research makes an important contribution by mapping the specific influence of each digital literacy indicator, digital technology skills, information evaluation, and media utilization on each dimension of SRL. Such detailed analysis is still scarce in the context of Indonesian higher education, especially in the field of physics education. By demonstrating the dominant role of Digital Technology Skills in improving planning and monitoring-evaluation, this study highlights the necessity of strengthening technical competencies in students. This aligns with prior research by Zitierung et al. (2020), who emphasized the importance of digital technology in supporting independent learning. The study also suggests that while Media Utilization plays a supportive role in SRL, it is Information Evaluation that requires greater focus. Enhancing students' ability to assess digital content critically will significantly improve their ability to learn autonomously and engage in more meaningful learning experiences (Castro-Alonso et al., 2021).

The practical implications of these findings are particularly relevant for higher education institutions. First, the curriculum for Physics education programs should prioritize digital technology skills as the foundational component in developing SRL. Teaching students to use digital tools efficiently will provide them with the necessary skills to plan and evaluate their learning independently. Additionally, the curriculum should integrate information evaluation training, particularly through project-based courses that require students to critically assess scientific resources and data. As suggested by Kiemeneij et al. (2023) dan Hertel & Millis (2023), gamification, microlearning, and interactive learning platforms could be effective strategies to increase student engagement and foster SRL development. These approaches can help bridge the gap between students' high technical skills and their struggles with autonomy and motivation.

IV. CONCLUSION AND SUGGESTION

The findings of this study revealed that physics education students generally possess high levels of digital literacy, particularly in digital media utilization (M = 4.17), while the digital technology skills (M = 4.02) and comprehension and evaluation of digital information (M = 3.96) indicators also showed strong performance, albeit with some variation. The SRL dimensions, however, presented more varied results: Planning (M = 3.3) and monitoring and evaluation (M = 3.2) were adequately developed, while autonomy (M = 2.5) and motivation-discipline (M = 2.8) were notably weaker, indicating areas that need improvement. The regression analysis confirmed that digital literacy, particularly digital technology skills, significantly predicted students' SRL ($\beta = 0.50$, $p = 0.016$), explaining nearly 59% of the variation in SRL. The study also revealed that digital technology skills were the most dominant predictor for all SRL dimensions, especially planning, monitoring and evaluation. Gender differences were found to influence the relationship between digital literacy and SRL, with female students benefiting more from digital literacy in enhancing their SRL compared to male students. These findings underscore the importance of prioritizing digital technology skills in educational interventions to enhance students' SRL.

This study has several limitations that should be considered when interpreting the results. First, the small sample size (28 students) limits the generalizability of the findings to a larger population of physics education students. Additionally, the cross-sectional nature of the study only captures a snapshot of the relationship between digital literacy and SRL at one point in time, making it difficult to infer causal relationships. The use of self-report questionnaires may also introduce bias due to social desirability factors, and the study's focus on a single institution further restricts the representativeness of the results. Furthermore, this research solely considered digital literacy as a predictor of SRL, without accounting for other potentially influential variables, such as motivation, learning strategies, and access to technology. Future research should involve larger, more diverse samples, employ longitudinal designs to track changes over time, and explore additional factors that might contribute to SRL. Despite these limitations, this study makes a significant contribution to the field of physics education by highlighting the pivotal role of digital literacy, particularly digital technology skills, in enhancing SRL. It also emphasizes the need for targeted interventions to strengthen autonomy and motivation-discipline, with a particular focus on gender-sensitive approaches to maximize the effectiveness of digital literacy training in promoting independent learning.

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