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The Mediating Role of Science Knowledge in Linking Digital Well-Being and Media Literacy to Critical Thinking Skills: A PLS-SEM Analysis

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Abstract: This study aims to analyze the influence of digital well-being, knowledge of learning media, and teaching material satisfaction on students' science knowledge and critical thinking skills through an integrative approach using Partial Least Squares Structural Equation Modeling (PLS-SEM). Data were collected through an online questionnaire administered to 366 respondents, followed by construct validity and reliability testing. The results show that digital well-being has a significant positive effect on science knowledge, but is nonsignificant and even tends to be negative in its relationship with critical thinking skills. In contrast, knowledge of learning media and satisfaction with teaching materials were found to have positive, significant effects on both science knowledge and critical thinking skills. In addition, scientific knowledge is an important predictor of critical thinking skills. Effect size analysis indicates that digital well-being, learning media knowledge, and teaching material satisfaction explain 32.7% of the variance in science knowledge ($R^2 = 0.327$). In comparison, satisfaction with science knowledge and teaching materials explains 25.6% of the variance in critical thinking skills ($R^2 = 0.256$), indicating a model with moderate predictive strength. These findings confirm that media literacy, satisfaction with teaching materials, and digital well-being work simultaneously to strengthen the foundation of science knowledge while promoting higher-order thinking skills. However, the influence of digital well-being on critical thinking is indirect. This study can serve as a reference for educators and policymakers in designing science learning strategies that balance technology use, strengthen media literacy, and provide relevant teaching materials.

Keywords: digital well-being, knowledge of learning media, teaching materials satisfaction, science knowledge, critical thinking skills.

▪ INTRODUCTION

In the digital era, the integration of technology into education has transformed the way students interact with learning resources, teachers, and peers. The development of digital platforms has opened up significant opportunities for students to access diverse sources of knowledge, but it also presents challenges related to digital well-being. Digital well-being refers to the balanced use of technology to support learning without compromising psychological health, focus, or academic performance (Moola et al., 2024). Several studies have shown that digital well-being is a critical factor in determining student learning effectiveness, particularly amidst the rise of online learning practices (Jiang, 2024; Kohler et al., 2024). In science education, balanced technology use not only impacts conceptual understanding but is also closely related to critical thinking skills, key 21st-century competencies (Chieng & Tan, 2021; Kustantia et al., 2023). Recent review studies also emphasize that digital well-being influences students' cognitive engagement, emotional regulation, and capacity to manage digital learning environments holistically, making it an essential component when examining learning

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effectiveness in the digital era (Avsec & Savec, 2021; Henrie et al., 2015; Kaddouri, 2025; Sakka et al., 2022).

Furthermore, students' ability to understand and utilize learning media plays a crucial role in improving learning outcomes. Learning media, both digital and traditional, have been shown to increase student engagement, deepen conceptual understanding, and foster analytical skills in science content (Naharuddin et al., 2023). Previous research confirms that students who are more skilled at using learning media demonstrate better mastery of science and are encouraged to think at a higher level (Alie et al., 2021). This becomes even more effective when supported by student satisfaction with the learning materials used. Satisfaction arises when learning materials are deemed relevant, engaging, and aligned with students' learning needs, thereby increasing motivation, persistence, and learning outcomes (Babajani et al., 2023; Corneja & P. Mendoza, 2023). Review-based evidence also indicates that learning media literacy, content quality, and learner satisfaction are interdependent components that collectively influence cognitive load, conceptual mastery, and metacognitive development, highlighting the need to analyze them as an integrated system rather than as isolated predictors.

Several previous studies have highlighted the role of digital well-being, knowledge of learning media, and satisfaction with learning materials in supporting the learning process. However, most of these studies have examined these three aspects separately, thus failing to provide a complete picture of how they interact to shape scientific knowledge and develop students' critical thinking skills. However, within the framework of science learning, critical thinking skills are often indirectly influenced by strong scientific knowledge acquisition (Suhirman & Khotimah, 2020; Worachak et al., 2023). This research gap highlights the need for a more comprehensive study that examines the interrelationships between these three factors simultaneously within an integrated model. This indicates the theoretical plausibility of an integrated model, as digital well-being may shape cognitive readiness, and learning media knowledge may influence how learners process information. Teaching material satisfaction may reduce extraneous cognitive load, aligning with both Cognitive Load Theory and social constructivist perspectives that view learning as the result of continuous interaction between cognitive, technological, and contextual factors.

Based on this, this study aims to analyze the influence of digital well-being, knowledge of learning media, and satisfaction with learning materials on students' scientific knowledge and critical thinking skills. The novelty of this research lies in its integrative approach, which brings these three variables together within a single structural framework rather than treating them separately as in previous studies. Positioning these variables within an established learning theory framework strengthens the theoretical contribution of this study; specifically, Cognitive Load Theory explains how media knowledge and material satisfaction optimize cognitive processing, while social constructivism underscores how digital well-being supports learners' ability to engage meaningfully within digital learning environments. This research is expected to provide empirical evidence regarding the direct and indirect relationships between the studied variables. The results are expected not only to enrich the literature on educational technology and pedagogy but also to serve as a practical reference for teachers, curriculum developers, and policymakers in designing effective science learning strategies and supporting the strengthening of 21st-century skills.

Conceptual Framework and Hypothesis Development

H1: Digital Well-Being Positively Influences Students' Science Knowledge

Digital well-being is defined as a balanced state of digital technology use that supports mental health, concentration, and learning effectiveness (Mohebeldin Zaky, 2023). Students with good digital well-being tend to be better able to utilize technology as a means of exploring knowledge, including in science (Shao et al., 2024). Previous research shows that healthy technology use can improve students' focus on learning content, reduce distractions, and foster better conceptual understanding (Mardianti et al., 2023; Mavrikis et al., 2022). Therefore, digital well-being is expected to contribute positively to students' science knowledge.

H2: Digital Well-Being Positively Influences Students' Critical Thinking Skills

Critical thinking skills require students to analyze information, evaluate evidence, and make decisions based on logic. Digital well-being enables students to manage technology use productively, enabling them to focus on higher-order thinking processes (Hikmahwati Arif, 2024). Several studies confirm that good digital well-being improves reflective capacity, concentration, and engagement in problem-based learning, ultimately strengthening critical thinking skills (Cintamulya et al., 2023; Nawawi et al., 2020). Specifically, components of digital well-being, such as the ability to regulate screen time, minimize digital distractions, and manage emotional responses to digital stimuli, are theoretically aligned with key elements of critical thinking, including sustained attention, cognitive flexibility, and reflective judgment. Students with higher digital well-being are better positioned to allocate cognitive resources efficiently, avoid cognitive overload, and engage deeply in analytical tasks, which are foundational for developing critical thinking skills. Therefore, it can be assumed that digital well-being positively influences students' critical thinking skills.

H3: Knowledge of Learning Media has a positive influence on students' Science Knowledge

Knowledge of learning media refers to students' ability to recognize, understand, and use various media to support the learning process (Rosalia Putri et al., 2023). The better students understand the function and potential of learning media, the more effective they will be in exploring complex science concepts (Dianta et al., 2021). Previous studies have shown that mastery of learning media increases learning effectiveness because students can adapt learning strategies to the characteristics of the material (Aboe et al., 2024; Manurung & Simaremare, 2022). Therefore, knowledge of learning media is expected to positively contribute to students' science knowledge.

H4: Knowledge of Learning Media has a positive influence on students' Critical Thinking Skills

The use of learning media not only serves as a cognitive aid but also as a trigger for active student engagement in analyzing and evaluating information (Sofiasyari & Indrianti, 2024). When students have a good understanding of learning media, they are better able to utilize learning resources to develop critical thinking skills (Sopandi et al., 2022). This aligns with research emphasizing that learning media literacy correlates with students' analytical and evaluative abilities, particularly in understanding science material that requires logical thinking (Manurung & Simaremare, 2022). Therefore, a positive relationship between knowledge of learning media and critical thinking skills can be assumed.

H5: Teaching Materials Satisfaction Positively Influences Students' Science Knowledge

Satisfaction with learning materials reflects the extent to which students perceive the materials used as relevant, engaging, and supportive of their learning process (Saucier et al., 2023). High-quality learning materials typically increase student interest in learning while strengthening conceptual understanding (Jamain et al., 2022). Several studies have shown that student satisfaction with learning materials is associated with increased motivation and academic achievement (Alwafi, 2023; Kartinah & Prasetyowati, 2022). Therefore, satisfaction with learning materials is hypothesized to positively influence students' science knowledge.

H6: Teaching Materials Satisfaction Positively Influences Students' Critical Thinking Skills

In addition to improving understanding of the material, satisfaction with learning materials also encourages student engagement in deeper learning activities (Yu, 2022). Well-designed learning materials can stimulate students to ask questions, reflect, and reassess the information received, activities that are at the heart of critical thinking (Nicholson et al., 2021; Shin, 2023). Empirical studies show that contextual and problem-solving-based learning materials encourage students to develop analytical and decision-making skills (Budi Asih et al., 2022; Trianawati et al., 2023). Therefore, student satisfaction with learning materials is expected to positively impact their critical thinking skills.

H7: Science Knowledge Positively Influences Students' Critical Thinking Skills

Science knowledge is not simply the accumulation of information, but rather the foundation for students to conduct logical reasoning and evidence-based argumentation (Ekiz-Kiran & Boz, 2020). Students with a strong mastery of science tend to be better able to connect concepts, test hypotheses, and evaluate information, which are indicators of critical thinking skills (Guilfoyle et al., 2020; Muhibbuddin et al., 2023; Sidiq et al., 2021). Previous research confirms that understanding science concepts strengthens students' capacity to critically evaluate scientific and social phenomena (Amanda et al., 2022; Muhibbuddin et al., 2023). Therefore, it can be hypothesized that scientific knowledge positively influences students' critical thinking skills.

▪ METHOD

Types and Design of Research

This study used a quantitative explanatory approach to test causal relationships between variables through a structural model (Syamsiah et al., 2024). The quantitative approach was chosen to measure the strength and direction of the relationship between Digital Well-Being (DWB), Learning Media Knowledge (KLM), and Teaching Material Satisfaction (TMS) as exogenous variables, and Science Knowledge (SKE) and Critical Thinking Skills (CTS) as endogenous variables (Figure 1). The study used a cross-sectional survey design. Data were collected over time from respondents who met the inclusion criteria.

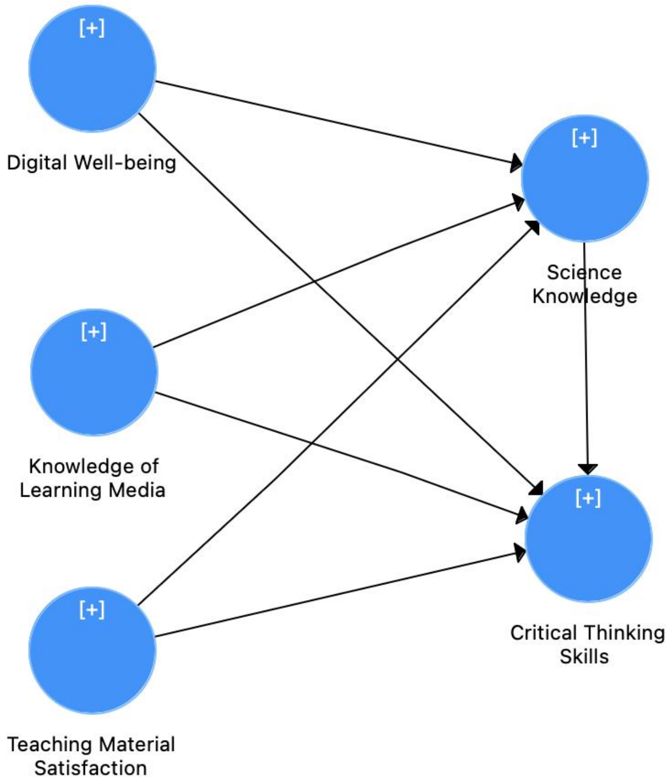

Figure 1. PLS-SEM analysis diagram

Research Subjects

The research population consisted of students at SMP Negeri 3 Lubuk Sikaping. The sampling technique used was purposive sampling. The criteria for students eligible to complete the instrument were: 1) active students in science subjects; 2) willingness to complete the questionnaire; and 3) basic access to digital learning media. The PLS-SEM analysis used a minimum of 5 respondents per item, resulting in a minimum of 150 students (30 items). A total of 440 students completed the questionnaire; only 366 were deemed valid according to the criteria.

Research Instrument

The instrument was a structured questionnaire comprising several reflective scales for the construct. A 4-point Likert scale was used (1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree) according to the initial collection instructions (Jamaluddin et al., 2025). The questionnaire was developed by adapting items from previously validated instruments related to digital well-being (Ghai et al., 2023), media literacy (Schilder & Redmond, 2019), satisfaction with learning materials (Alwafi, 2023), science knowledge (Sun et al., 2024), and critical thinking skills (Teng & Yue, 2022a), with adjustments made to suit the context of science learning in junior high schools.

Digital Well-Being (DWB) is a student's ability to manage the use of digital devices in a balanced manner so that it does not interfere with concentration, psychological health, or the learning process. Learning Media Knowledge is a student's understanding of the function and use of learning media, and the ability to choose the right media to help understand science concepts. Teaching Material Satisfaction (TMS) refers to students' subjective assessment of the relevance, clarity, attractiveness, and usefulness of science teaching materials used in learning activities. Science Knowledge (SKE) is defined as a student's ability to understand, explain, and apply science concepts as they relate to the material being studied. Meanwhile, Critical Thinking Skills (CTS) is a student's ability to analyze information, evaluate evidence, and draw logical conclusions in the context of science learning.

Each construct consists of several statements, such as: Digital Well-Being (DWB) "I can control the use of digital devices so that it does not interfere with my learning."; Knowledge of Learning Media (KLM) "I understand how to use learning media to help me understand science concepts."; Satisfaction with Learning Materials (TMS) "The science materials provided are interesting and easy for me to understand."; Science Knowledge (SKE) "I can explain the science concepts I learn in class."; Critical Thinking Skills (CTS) "I can evaluate the accuracy of the information I receive in science lessons." All items underwent a language modification process to simplify and adapt them to the context of junior high school students in Indonesia. For example, technical terms such as "digital self-regulation" were simplified to "managing gadget use," and examples of complex learning media were replaced with learning apps or videos familiar to students. Content validation was conducted by three experts in science education, research methodology, and learning media using the Content Validity Index (CVI) approach. The experts assessed the relevance and clarity of each item using a scale of 1–4. The I-CVI values for all items ranged from 0.80 to 1.00, thus meeting the content validity criteria for the three experts.

All variables were measured using questionnaires completed simultaneously by students; the potential for Common Method Bias (CMB) was addressed from the outset. To minimize procedural bias, respondents were guaranteed anonymity, instructed that there were no right or wrong answers, and questionnaire items were randomized to prevent respondents from predicting construct patterns. Furthermore, all statements were structured in a neutral and understandable manner to reduce comprehension bias. CMB was tested for statistical significance using Harman's Single-Factor Test, and the results showed that the first factor accounted for less than 50% of the total variance. Additional testing was conducted using Full Collinearity VIF (Hair et al., 2019), and all constructs had VIF values < 3.3, indicating that the model did not exhibit Common Method Variance.

Data Collection and Analysis Techniques

Data collection was conducted using an online questionnaire survey distributed via Google Forms. All data collected was kept confidential to maintain research ethics. Incoming questionnaire data were screened, and respondents with unreasonable answers (straight-lining), many blank items (>20%), or very short response times were excluded. Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to handle the reflective model, aiming to maximize predictive capacity (Mahande et al., 2025). Evaluation was conducted on the measurement model to ensure the quality of the reflective construct (Hair et al., 2019). The first test was indicator reliability, which assesses the strength of the relationship between each item and the latent construct. An indicator is considered reliable if its outer loading is≥ 0.70. Next, internal reliability was assessed using Cronbach's alpha and CR values, with a minimum threshold of >0.70 indicating consistency between items in measuring the construct. Convergent validity is achieved when the AVE value exceeds 0.50, meaning more than half of the indicator's variance can be explained by the latent construct (Hair et al., 2021; Henseler, 2012; Syamsiah et al., 2024). Discriminant validity is tested using the Fornell-Larcker criterion, where the square root of a construct's AVE must be higher than its correlation with other constructs (Fornell & F. larcke, 1981).

Once the measurement model meets the criteria, the analysis proceeds to the structural model to assess the strength of the relationships among variables. The first test is path coefficients to determine the direction and strength of the influence between constructs. The significance of the path coefficients is tested using a bootstrapping procedure with 5,000 resamples, and results are reported as coefficients, t-values, and p-values at $\alpha = 0.05$ (two-sided). Model strength is evaluated through the explained variance (R^2) of the endogenous construct, where a value of 0.75 is considered substantial, 0.50 moderate, and 0.25 weak (Henseler et al., 2015).

▪ RESULT AND DISSCUSSION

Convergent Validity

The results of the outer loadings test in Table 1 indicate that all indicators forming the construct have loadings above 0.70. Indicators in the Critical Thinking Skills (CTS) construct ranged from 0.703 to 0.807, indicating consistent item contributions to explaining the construct. The Digital Well-being (DWB) construct had loadings ranging from 0.752 to 0.803, indicating strong indicator strength in reflecting the latent variables. Similarly, Knowledge of Learning Media (KLM) had loadings of 0.738-0.811, indicating the stability of its contribution. At the same time, Science Knowledge (SKE) showed relatively high loadings of 0.754-0.819, indicating a strong indicator of the construct. Meanwhile, Teaching Material Satisfaction (TMS) showed loadings of 0.720-0.821, which, overall, met the indicator reliability standards. All reflective constructs in the model can be declared valid by an indicator.

Table 1. Outer loadings

Item Variable	Digital Well-being	Knowledge of Learning Media	Teaching Material Satisfaction	Science Knowledge	Critical Thinking Skills
CTS2					0.703
CTS3					0.712
CTS4					0.807
CTS5					0.807
CTS6					0.781
DWB1	0.768				
DWB2	0.752				
DWB4	0.786				
DWB6	0.803				
KLM1		0.781			
KLM2		0.769			
KLM3		0.738			

KLM4	0.811		
KLM5	0.769		
SKE1			0.814
SKE2			0.754
SKE3			0.819
SKE4			0.805
SKE5			0.755
TMS2		0.720	
TMS4		0.821	
TMS6		0.766	

Internal Reliability

Table 2 shows that the measurement model meets the required psychometric quality criteria, so the internal consistency of the indicators for each construct is assessed as good. Specifically, Science Knowledge has the highest reliability and AVE (0.624), while Teaching Material Satisfaction has the lowest alpha and CR (0.755; CR = 0.813), but is still adequate. Critical Thinking Skills shows the lowest AVE (0.583) but remains above the convergent validity threshold. The reflective instrument is sufficiently reliable and valid to proceed with the structural model analysis.

Table 2. Construct reliability and validity

Indicator	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Digital Well-being	0.782	0.784	0.859	0.605
Knowledge of Learning Media	0.834	0.840	0.882	0.599
Teaching Material Satisfaction	0.755	0.757	0.813	0.593
Science Knowledge	0.850	0.857	0.892	0.624
Critical Thinking Skills	0.820	0.828	0.874	0.583

Discriminant Validity

Table 3 shows that the Fornell-Larcker Criterion, with an AVE greater than 0.5, indicates that this model meets the requirements for convergent validity. Off-diagonal values describe correlations between latent variables or cross-loadings; they should be smaller than the corresponding diagonal values to ensure good discriminant validity. For example, the correlation between Digital Well-being and Knowledge of Learning Media is 0.420, which is lower than the diagonal value of 0.778, indicating that these variables are distinguishable. In addition, other values, such as 0.332 between Teaching Material Satisfaction and Knowledge of Learning Media, and 0.445 between Science Knowledge and Teaching Material Satisfaction, support the sustainability of good discriminant validity. The results indicate that this measurement model has adequate convergent and discriminant validity.

Table 3. Fornell-Larcker criterion

Indicator	Digital Well-being	Knowledge of Learning Media	Teaching Material Satisfaction	Science Knowledge	Critical Thinking Skills
Digital Well-being	0.778				
Knowledge of Learning Media	0.420	0.774			
Teaching Material Satisfaction	0.417	0.332	0.770		
Science Knowledge	0.470	0.402	0.445	0.790	
Critical Thinking Skills	0.207	0.373	0.359	0.416	0.763

Table 4 shows the diagonal values (0.768 for DWB1 in Digital Well-being), which reflect the factor loadings and indicate how well each indicator represents the measured latent variable. Off-diagonal values indicate relationships between the indicator and different latent variables, such as 0.374 between KLM1 and Digital Well-being, which is relatively low compared to its diagonal value (0.781 for Knowledge of Learning Media). Cross-loading values should be smaller than their diagonal values to ensure that each indicator is more strongly related to the intended latent variable than to the other variables, which indicates good discriminant validity.

Table 4. Cross loadings

Item Variable	Digital Well-being	Knowledge of Learning Media	Teaching Material Satisfaction	Science Knowledge	Critical Thinking Skills
CTS2	0.155	0.239	0.239	0.303	0.703
CTS3	0.199	0.274	0.256	0.273	0.712
CTS4	0.210	0.340	0.261	0.357	0.807
CTS5	0.083	0.323	0.296	0.325	0.807
CTS6	0.154	0.238	0.315	0.324	0.781
DWB1	0.768	0.210	0.298	0.381	0.170
DWB2	0.752	0.373	0.280	0.344	0.111
DWB4	0.786	0.321	0.337	0.373	0.216
DWB6	0.803	0.418	0.379	0.360	0.136
KLM1	0.374	0.781	0.209	0.326	0.241
KLM2	0.252	0.769	0.217	0.340	0.293
KLM3	0.217	0.738	0.249	0.227	0.216
KLM4	0.347	0.811	0.257	0.308	0.352
KLM5	0.410	0.769	0.344	0.334	0.315
SKE1	0.347	0.366	0.435	0.814	0.319
SKE2	0.364	0.169	0.263	0.754	0.320
SKE3	0.449	0.390	0.425	0.819	0.356
SKE4	0.314	0.338	0.271	0.805	0.290
SKE5	0.365	0.293	0.327	0.755	0.351
TMS2	0.425	0.148	0.720	0.359	0.231
TMS4	0.416	0.351	0.821	0.341	0.288
TMS6	0.127	0.262	0.766	0.328	0.308

H1: Digital Well-Being to Science Knowledge

H1 shows that Digital Well-Being (DWB) has a significant effect on Science Knowledge (SKE), with a coefficient of 0.277, t = 4.803, and p = 0.000 (Table 5). This finding indicates that students' digital well-being plays an important role in enhancing their understanding of scientific concepts. When students manage technology use in a balanced way, including reducing distractions, regulating screen time, and maintaining psychological stability during digital learning, their cognitive capacity to process scientific information is optimized. This is in line with Cognitive Load Theory, which states that cognitive load can be minimized through the regulation of learning environments that support focus and concentration (Sweller et al., 2011). A stable digital condition enables students to process science concepts more effectively. The studies of Thomas et al. (2022) and Ferrari et al. (2022) also show that individuals with higher digital well-being are better able to sustain attention and elaborate on academic material, including in science-related courses. Therefore, this finding strengthens the notion that digital well-being is not merely a mental health issue, but also an academic factor that directly enhances the acquisition of science knowledge.

H2: Digital Well-Being to Critical Thinking Skills

H2 shows a pattern different from that predicted by the first hypothesis. Digital Well-Being does not have a significant effect on Critical Thinking Skills (CTS), as indicated by the coefficient of 0.110, t = 1.228, and p = 0.219. This result suggests that digital well-being does not automatically improve students' critical thinking abilities. Conceptually, digital well-being in this study is dominated by regulatory indicators such as controlling digital exposure, reducing device use, and maintaining emotional comfort. However, these components do not directly involve higher-order cognitive activities such as argument analysis, information evaluation, or the synthesis of evidence, which are core elements of critical thinking. Gómez et al. (2025) note that digital well-being serves more as a foundational condition for learning than as a primary driver of higher-order thinking skills. In addition, overly strict regulation of technology use may reduce students' opportunities to explore digital content in depth, even though such critical exploration is an important medium for developing CTS. The findings of this study also indicate that the effect of DWB on CTS is more indirect through Science Knowledge, which was found to be a significant mediator. Thus, although digital well-being is important for fostering a healthy learning environment, its effect on critical thinking skills is indirect and insufficient to independently influence CTS.

H3: Knowledge of Learning Media to Science Knowledge

The analysis of H3 shows that Knowledge of Learning Media (KLM) has a significant effect on Science Knowledge, with a coefficient of 0.198, t = 3.667, and p = 0.000. This finding confirms that students' mastery of digital learning media contributes tangibly to their understanding of scientific concepts. From the perspective of social constructivism, learning media function as mediating tools that facilitate the internalization of knowledge (Molloy et al., 2019). Students who can use digital media effectively can access visual representations, simulations, instructional videos, and scientific resources to construct deeper meaning from science content (Zhang et al., 2020).Click or tap here to enter text. As well as Panigrahi et al. (2020) Support this result by showing that digital media literacy is positively correlated with science learning outcomes, as learning media can simplify the understanding of complex concepts. Therefore, mastery of digital media is not only a technical skill but also an academic competence that strengthens scientific knowledge.

H4: Knowledge of Learning Media to Critical Thinking Skills

The H4 is also supported, indicating that KLM has a significant effect on CTS, with a coefficient of 0.240, t = 3.304, and p = 0.001. Digital media literacy enables students to search for information more critically, understand the structure of arguments, assess the credibility of sources, and compare across sources. These activities are core processes in the development of critical thinking skills. Previous studies have stated that media literacy is a strong predictor of critical thinking because students with higher media literacy tend to evaluate digital content more deeply (Joshi et al., 2024; Yeravdekar, 2022). Media literacy also enables students to identify information bias and validate data, making their analyses more accurate. Thus, this study's findings show that media literacy is not merely a technical aid but a cognitive component that is highly important for developing critical thinking skills.

H5: Teaching Material Satisfaction with Science Knowledge

H5 is supported based on the statistical results, with a coefficient of 0.264, t = 4.324, and p = 0.000. This finding indicates that students' satisfaction with teaching materials significantly contributes to increases in Science Knowledge. Engaging, relevant, easy-to-understand, and well-structured teaching materials can enhance students' motivation and involvement in the learning process. According to Henrie et al. (2015), positive perceptions of the quality of digital teaching materials can increase cognitive engagement, which ultimately strengthens the understanding of science concepts. In addition, teaching materials that successfully connect scientific concepts with real-world contexts can help students build more meaningful knowledge. The higher the students' satisfaction with the learning materials, the greater the likelihood that they will understand the content more deeply.

H6: Teaching Material Satisfaction to Critical Thinking Skills

The sixth hypothesis is accepted, with a coefficient of 0.200, t = 3.094, and p = 0.002. This finding confirms that students' satisfaction with teaching materials also affects the development of critical thinking skills. High-quality instructional materials typically include elements that promote analysis, evaluation, problem-solving, and reflection. Corazza et al. (2020) show that well-designed materials with rich contexts and appropriate levels of challenge can stimulate inferential abilities and encourage students to engage in higher-order reasoning. When students are satisfied with the teaching materials used, whether due to the clarity of structure, relevance of content, or interactivity, they are more motivated to participate in analytical and reflective activities. Therefore, satisfaction with digital teaching materials directly impacts the development of analytical and critical thinking skills during learning.

H7: Science Knowledge to Critical Thinking Skills

The final hypothesis is supported, with a coefficient of 0.282, t = 3.789, and p = 0.000. This finding shows that understanding of science concepts plays a significant role in shaping students' critical thinking skills. Theoretically, science knowledge provides the conceptual foundation and cognitive framework that enable students to analyze problems, evaluate evidence, and construct logical arguments (Jamaluddin et al., 2024). Content understanding is a prerequisite for the development of higher-order thinking skills, as critical thinking cannot be carried out without sufficient knowledge of the domain being analyzed (Wale & Bishaw, 2020). Thus, Science Knowledge becomes a crucial foundation that allows students to apply critical thinking strategies effectively. This finding is reinforced by the mediation analysis, which shows that SKE serves as a significant mediator linking the exogenous variables (Digital Well-Being, Knowledge of Learning Media, and Teaching Material Satisfaction) to CTS.

Table 5. Mean, STDEV, T-Values, P-Values (direct)

Path	Original Sample (O)	Sample Mean (M)	Standard Deviation (SDEV)	T Statistics (|O/STDEV|)	P Values
Digital Well-being -> Science Knowledge	0.277	0.273	0.058	4.803	0.000
Digital Well-being -> Critical Thinking Skills	-0.110	-0.104	0.089	1.228	0.219
Knowledge of Learning Media -> Science Knowledge	0.198	0.205	0.054	3.667	0.000
Knowledge of Learning Media -> Critical Thinking Skills	0.240	0.234	0.073	3.304	0.001
Teaching Material Satisfaction -> Science Knowledge	0.264	0.261	0.061	4.324	0.000
Teaching Material Satisfaction -> Critical Thinking Skills	0.200	0.207	0.065	3.094	0.002
Science Knowledge -> Critical Thinking Skills	0.282	0.288	0.074	3.789	0.000

The results of the mediation analysis (Table 6) indicate that Science Knowledge acts as a significant mediator in the relationship between the three exogenous variables, Digital Well-Being (DWB), Knowledge of Learning Media (KLM), and Teaching Material Satisfaction (TMS), and Critical Thinking Skills (CTS). The indirect effect of Digital Well-Being on CTS was significant ($\beta = 0.078$, $p < 0.001$), indicating that although DWB does not demonstrate a strong direct influence on critical thinking skills, it still contributes to strengthening CTS by increasing science knowledge. This finding is consistent with the view that digital well-being plays a more important role in establishing optimal cognitive conditions, such as focus, attention regulation, and reduced distraction, which then enable students to understand science concepts more effectively (Ghai et al., 2023). Thus, science understanding is an important mechanism bridging digital well-being and critical thinking skills.

Furthermore, the indirect effects of Knowledge of Learning Media ($\beta = 0.056$, $p = 0.028$) and Teaching Material Satisfaction ($\beta = 0.074$, $p = 0.002$) on CTS were also significant, confirming that these two variables influence critical thinking skills through science understanding. These results strengthen the argument that mastery of learning media and satisfaction with teaching materials contribute to a more effective learning experience, enabling students to build a better conceptual understanding. This understanding then improves their ability to analyze, evaluate, and draw logical conclusions (Henrie et al., 2015; Panigrahi et al., 2020). Thus, these mediation findings emphasize the importance of Science Knowledge as a conceptual foundation that must be strengthened in science learning, as it serves as the main pathway connecting pedagogical and digital factors to the improvement of students' higher-order thinking skills.

Table 6. Mean, STDEV, T-Values, P-Values (indirect)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Digital Well-being -> Science Knowledge -> Critical Thinking Skills	0.078	0.077	0.022	3.488	0.000
Knowledge of Learning Media -> Science Knowledge -> Critical Thinking Skills	0.056	0.060	0.026	2.193	0.028
Teaching Material Satisfaction -> Science Knowledge -> Critical Thinking Skills	0.074	0.074	0.024	3.109	0.002

In Figure 2, Science Knowledge has an R^2 of 0.327, indicating that 32.7% of the variation in Science Knowledge is explained by independent variables such as Digital Well-being, Knowledge of Learning Media, and Teaching Material Satisfaction. Meanwhile, Critical Thinking Skills has an R^2 of 0.256, indicating that Science Knowledge and Teaching Material Satisfaction can explain 25.6% of its variation. The R^2 values found indicate that the model is quite good at explaining the variation in Science Knowledge and Critical Thinking Skills. However, several other factors not included in this model may explain the remainder. The lower R^2 value for Critical Thinking Skills also indicates that although there is a significant influence, other factors not measured in this model may play a greater role in influencing students' critical thinking skills.

These findings contrast with several studies referenced in the introduction, which indicated that technology-supported learning environments may enhance students' analytical and critical thinking abilities (Chieng & Tan, 2021; Cintamulya et al., 2023; Kustantia et al., 2023). While prior research often highlights the positive role of digital engagement in fostering higher-order thinking, the present study suggests that digital well-being does not equivalently translate into cognitively demanding digital behaviors. Previous studies that reported stronger associations were mostly conducted with older students or university populations whose metacognitive and evaluative capacities are more developed (Gómez et al., 2025; Michelot et al., 2022). Therefore, the non-significant relationship observed in this study may reflect developmental differences and the distinct nature of digital well-being, which emphasizes regulation and balance rather than analytical engagement with digital information.

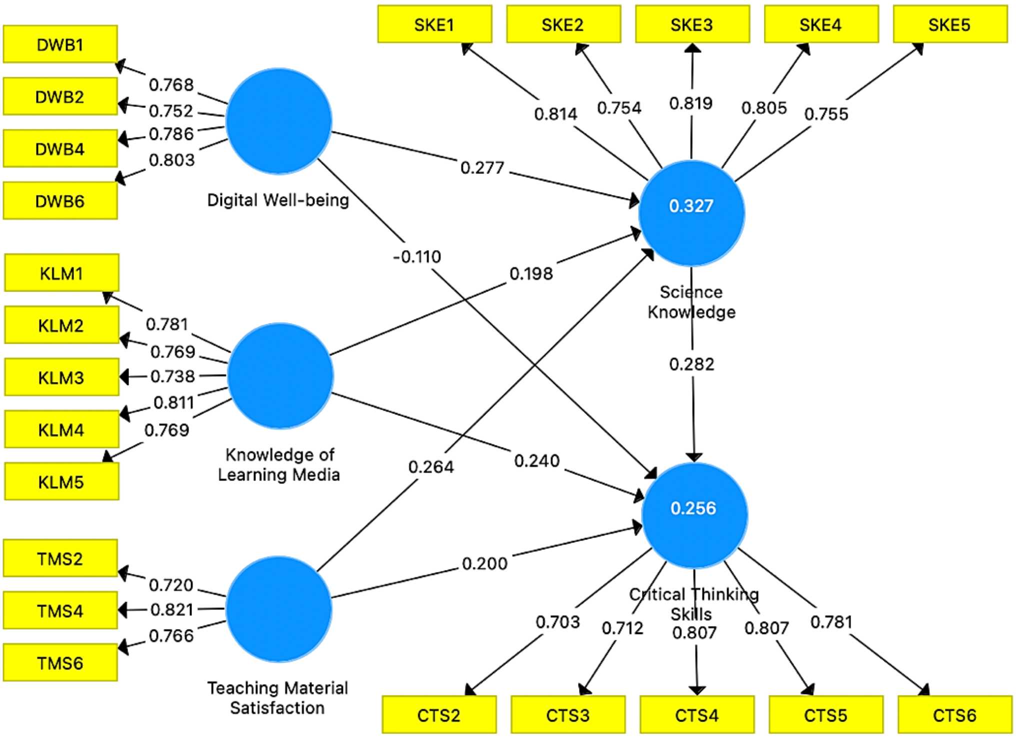

Figure 2. Results of PLS-SEM R2 analysis

The findings of this study are important because they provide empirical evidence of the simultaneous relationship between digital well-being, knowledge of learning media, satisfaction with teaching materials, science knowledge, and critical thinking skills. Scientifically, this study adds to the literature by demonstrating that these variables complement each other within an integrative model rather than acting independently as in previous research. Practically, these results can serve as a reference for teachers in designing science lessons that balance the use of technology, strengthen media literacy, and provide engaging teaching materials. The strength of this research lies in its comprehensive structural approach, which allows researchers not only to test direct relationships but also to assess the simultaneous effects among variables. This distinguishes it from and excels at previous research that has been limited to just one or two factors.

▪ CONCLUSION

This study found that most variables had positive, significant effects on students' science learning outcomes and critical thinking skills. Digital Well-Being (DWB) was shown to improve science knowledge, but did not significantly impact critical thinking skills. Conversely, knowledge of learning media and satisfaction with teaching materials consistently contributed to both improvements, while science knowledge was an important predictor of critical thinking skills. These findings confirm that digital well-being, media literacy, and the quality of teaching materials are not independent factors but work simultaneously to build a foundation of science knowledge and foster higher-order thinking skills.

The implications of these findings are both scientific and practical. Scientifically, this study adds to the literature by demonstrating the simultaneous interrelationship between digital factors, media, and teaching materials in science learning. In practice, these results provide a reference for teachers and policymakers in designing learning experiences that balance technology use, strengthen media literacy, and provide relevant teaching materials. However, this study has limitations, including its cross-sectional design, which cannot capture longitudinal dynamics, and its DWB measurement, which emphasizes regulating technology use rather than productive aspects relevant to critical thinking. Another limitation lies in the unrepresentative nature of the sample, drawn from a single school using purposive sampling. This limits the generalizability of the findings and may introduce contextual bias related to school culture, access to digital resources, or teaching practices. Therefore, further research is recommended to use a longitudinal design, expand the dimensions of DWB measurement, and include instructional factors such as inquiry learning strategies and metacognitive scaffolding to deepen understanding of the development of students' critical thinking skills.

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