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Strengthening Computational Thinking Skills through Blended Learning, Digital Literacy and Learning Environment: The Role of Learning Motivation as a Mediating Variable

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Abstract: This study aims to examine the effects of blended learning, digital literacy, and the learning environment on students' computational thinking skills, with learning motivation as a mediating variable. A quantitative approach was employed, employing Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS. The study involved 215 high school students selected through purposive sampling, specifically students with experience in digital and blended learning environments. Data were collected using a questionnaire covering indicators of blended learning, digital literacy, learning environment, learning motivation, and computational thinking skills. Data analysis included external model testing for validity and reliability using Confirmatory Factor Analysis (CFA) and model testing using path coefficients, R-squared, and mediation analysis. The findings indicated that blended learning significantly influenced computational thinking skills ($\beta = 0.059$; $p = 0.009$) and learning motivation ($\beta = 0.167$; $p = 0.001$). The learning environment also showed a significant influence on computational thinking ($\beta = 0.199$; $p = 0.008$) and learning motivation ($\beta = 0.471$; $p < 0.001$). Learning motivation had the strongest direct influence on computational thinking ($\beta = 0.509$; $p < 0.001$). The SEM-PLS model showed adequate predictive power, with R-square values of 0.541 for computational thinking and 0.464 for learning motivation. Mediation analysis showed that learning motivation significantly mediated the relationship between blended learning and computational thinking ($\beta = 0.085$; $p < 0.001$), as well as the learning environment and computational thinking ($\beta = 0.240$; $p < 0.001$). However, the mediation effect between digital literacy and computational thinking was not significant ($\beta = 0.023$; $p = 0.752$), indicating that digital literacy directly influences computational thinking through students' cognitive and information processing abilities. This finding highlights the importance of integrating technology-based learning, a supportive learning environment, and motivational factors to strengthen computational thinking skills.

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Introduction

The rapid advancement of digital transformation in the era of the Industrial Revolution 4.0 has led to significant changes across various aspects of life, including the field of education. This transformation requires the education system to prepare students with 21st-century competencies relevant to technological developments and global dynamics. One competency that is receiving increasing attention in this context is computational thinking skills (Sunendar et al. 2020; Andrian & Hikmawan, 2021). This skill is seen as a crucial

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ability that enables individuals to solve problems systematically, logically, and data-driven in various scientific fields.

The concept of computational thinking was first popularized by Jeannette M. Wing, who explained that computational thinking is a problem-solving process that involves several stages: problem decomposition, pattern recognition, abstraction, and algorithm design. In recent developments, computational thinking is no longer understood narrowly as computer programming skills, but rather as a systematic and structured thinking approach that can be applied to various disciplines, including social sciences and economics. Yeni Anistyasari et al. (2020) emphasized that these skills play a crucial role in improving analytical skills, complex problem-solving, and data-driven decision-making.

Although the importance of computational thinking skills is increasingly recognized in modern education, various empirical findings indicate that these skills are still relatively low among Indonesian students. Research conducted by George-Reyes et al. (2021) shows that students still experience difficulties in abstracting and developing systematic steps to solve problems. This condition is influenced by learning practices that are still oriented towards memorizing concepts and solving routine problems, thus providing little space for students to explore, conduct in-depth analysis, and integrate technology into their thinking processes. Yet, educational policies such as the Independent Curriculum and digital education transformation emphasize the importance of developing critical, creative, and adaptive thinking skills in response to technological developments.

However, previous studies generally only partially analyzed the direct influence between variables, thus failing to explain the simultaneous and multilevel causal relationships between the research variables. Several studies also showed different results regarding the factors influencing students' computational thinking skills. This situation indicates a continuing research gap, particularly in comprehensively explaining the direct and indirect influences between variables. Therefore, this study uses a path analysis approach to analyze the causal relationships between variables simultaneously, thus providing a more comprehensive understanding of the factors influencing students' computational thinking skills.

In an effort to support computational thinking skills, various technology-based learning approaches have been developed, one of which is blended learning. Mulenga Robert and Helvi Shilongo (2025) define blended learning as the systematic integration of face-to-face and online learning designed to improve the well-being and effectiveness of the learning process. This approach allows students to gain more varied learning experiences and encourages active engagement in the learning process. Research by Xingyu Geng and Yu-Sheng Su (2025) shows that blended learning can improve higher-order thinking skills when designed interactively and collaboratively. Furthermore, Miranda Yula et al. (2021) found that the implementation of blended learning significantly improved students' analytical skills. However, the success of blended learning implementation is inseparable from students' digital competency readiness.

In the context of technology-based learning, digital literacy is a crucial factor influencing the effectiveness of the learning process. Alakrash and Razak (2021) define digital literacy as an individual's ability to access, stream, manage, and create information through digital technology critically and ethically. Students with high levels of digital literacy tend to be better able to navigate various information sources, analyze data, and develop solutions systematically. Research by Sari and Nugroho (2022) shows that digital literacy has a positive influence on technology-based problem-solving skills. Thus, digital literacy not

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only functions as a technical skill in using technology but also contributes to shaping students' computational mindset.

In addition to pedagogical factors and digital competencies, the learning environment also plays a crucial role in supporting the development of students' thinking skills. Based on the ecological development proposed by Urie Bronfenbrenner (1977), individual development is influenced by the interactions between the various environmental systems surrounding them. A conducive learning environment, both physically, socially, and psychologically, can create a learning atmosphere that supports exploration, collaboration, and students' courage in trying various problem-solving strategies. Lee et al. (2021) showed that a supportive learning environment positively impacts students' critical and creative thinking skills. Therefore, strengthening these skills is crucial.

Among these external factors, learning motivation plays an internal role that determines the intensity and persistence of students in participating in the learning process. Within the framework of Self-Determination Theory developed by Edward Deci and Richard M. Ryan, intrinsic motivation emerges when individuals feel they have autonomy, competence, and connectedness in the learning process. Research by Putri et al. (2023) shows that learning motivation mediates the relationship between the use of learning technology and student learning outcomes. This indicates that blended learning, digital literacy, and a positive learning environment do not automatically improve computational thinking skills if students lack strong learning motivation. Thus, learning motivation is suspected to play a significant mediating role in strengthening the influence of external factors on computational thinking skills.

Although various previous studies have examined blended learning, digital literacy, learning environments, and learning motivation separately, there is limited research integrating these four variables into a comprehensive conceptual model to explain computational thinking skills, particularly in non-informatics learning contexts such as economics education. The novelty of this research lies in the development of an integrative model that examines the simultaneous influence of blended learning, digital literacy, and the learning environment on computational thinking skills, with learning motivation as a mediating variable. This approach provides a theoretical contribution by combining pedagogical, digital, environmental, and psychological perspectives within a unified analytical framework relevant to the digital transformation of education in Indonesia. Theoretically, this research is expected to enrich the study of computational thinking skills by integrating blended learning theory, digital literacy, educational ecology theory, and Self-Determination Theory into a single structural model. Practically, the results of this study are expected to provide an empirical basis for teachers and lecturers in designing blended learning strategies that can enhance students' motivation and computational thinking skills.

Research Method

This study employed a quantitative research design, specifically a correlational approach using Structural Equation Modeling (SEM), to investigate the relationships among Blended Learning, Digital Literacy, Learning Environment, Learning Motivation, and Computational Thinking skills. The design was chosen to examine both the direct and indirect effects among variables and to analyze the mediating role of learning motivation in strengthening students' computational thinking skills. Structural Equation Modeling allows the simultaneous analysis of multiple relationships among latent variables and provides a comprehensive understanding of the proposed conceptual model (Hair et al., 2021).

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The participants consisted of 178 senior high school 1 Tondano students who had experience in technology-based learning environments. The participants were selected using a purposive sampling technique to ensure that respondents were familiar with digital learning platforms and blended learning practices. The selection criteria included students who had participated in learning activities that integrated both face-to-face and online instruction, ensuring that the data collected were relevant to the objectives of the study. Data were collected using a structured questionnaire developed based on relevant theoretical frameworks related to blended learning, digital literacy, learning environment, learning motivation, and computational thinking.

The instrument consisted of several indicators for each variable: five indicators for Blended Learning (BL1–BL5), five indicators for Digital Literacy (DL1–DL5), six indicators for Learning Environment (LE1–LE6), five indicators for Learning Motivation (LM1–LM5), and six indicators for Computational Thinking (CT1–CT6). The validity and reliability of the instrument were evaluated through Confirmatory Factor Analysis (CFA) to ensure that the measurement model met the required standards of construct validity and internal consistency (Byrne, 2016). Data collection was conducted through the distribution of questionnaires to the selected respondents. Prior to data collection, respondents were informed about the purpose of the study and provided their consent to participate voluntarily. The questionnaires were administered during the data collection period, and all responses were collected and recorded for further analysis. The research design illustrating the relationships among variables is presented in Figure 1.

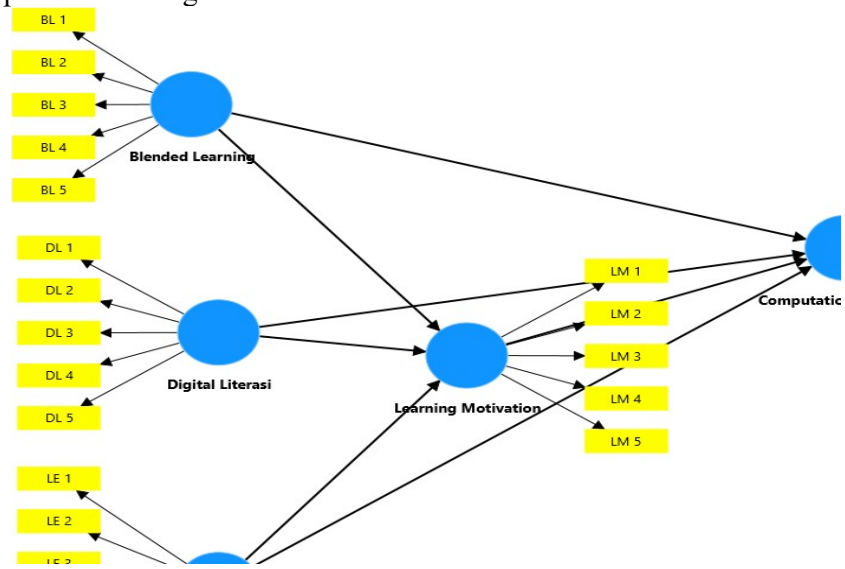

Figure 1. Research Design

Quantitative data were analyzed using the Partial Least Squares (PLS)-based Structural Equation Modeling (SEM) method with the help of SmartPLS software to test the hypothesized relationships between research variables. The analysis was carried out in two stages: testing the measurement model (outer model) to assess the validity and reliability of the constructs, and testing the structural model (inner model) to examine the influence between latent variables. The SEM-PLS approach was chosen because it is capable of analyzing complex relationships, can be used on relatively small sample sizes, and is suitable for predictive research and development theory. The analysis included measurement model evaluation and structural model testing to assess the validity, reliability, and predictive relationships among constructs. The SEM approach enabled the researcher to evaluate both

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direct effects and mediating effects among variables, particularly the role of learning motivation as a mediator between blended learning, digital literacy, learning environment, and computational thinking skills.

Results and Discussion

Outer Model Evaluation

Convergent Validity

Convergent validity is a component of the measurement model in SEM-PLS, commonly referred to as the outer model, whereas in covariance-based SEM it is known as Confirmatory Factor Analysis (CFA). The assessment of convergent validity on reflective constructs is based on two main criteria: indicator loading values above 0.7 and a significant p-value (<0.05). However, in some studies, especially those using new instruments, loading values between 0.40 and 0.70 can still be considered for retention.

Indicators with loadings below 0.40 should be eliminated from the model. For indicators with loadings between 0.40 and 0.70, their impact on Average Variance Extracted (AVE) and Composite Reliability should be evaluated first. Such indicators may be removed if doing so increases the AVE above 0.50 and the Composite Reliability above 0.70. However, decisions to remove indicators should also take content validity into account, since indicators with lower loadings may still be retained if they play an important role in representing the construct being measured.

Table 1. Convergent Validity

Construct	Item	Outer Loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Computational Thinking	CT 1	0.765	0.792	0.852	0.890
	CT 2	0.919			
	CT 3	0.927			
	CT 4	0.860			
	CT 5	0.755			
	CT 6	0.981			
Learning Motivation	LM 1	0.849	0.748	0.832	0.799
	LM 2	0.961			
	LM 3	0.809			
	LM 4	0.938			
	LM 5	0.915			
Blended Learning	BL 1	0.825	0.888	0.917	0.689
	BL 2	0.945			
	BL 3	0.707			
	BL 4	0.988			
	BL 5	0.930			
Digital Literacy	DL 1	0.803	0.833	0.881	0.797
	DL 2	0.929			
	DL 3	0.960			
	DL 4	0.859			
	DL 5	0.937			
Learning Environment	LE 1	0.838	0.847	0.887	0.868
	LE 2	0.841			
	LE 3	0.705			
	LE 4	0.707			

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LE 5	0.954
LE 6	0.862

Based on the analysis results, all measured constructs showed outer loadings above 0.7, indicating that each item is valid in representing its construct. The Computational Thinking construct has a Cronbach's alpha of 0.792, composite reliability of 0.852, and AVE of 0.890; Learning Motivation alpha of 0.748, CR 0.832, AVE 0.799; Blended Learning alpha of 0.888, CR 0.917, AVE 0.689; Digital Literacy alpha of 0.833, CR 0.881, AVE 0.797; and Learning Environment alpha of 0.847, CR 0.887, AVE 0.868. These values indicate that all constructs have good internal reliability and adequate convergent validity, so that the research instrument can be trusted to measure the variables studied.

Validity Test

Table 2. Fornell Larcker Validity Test

	Blended Learning	**Computational Thinking**	**Digital Literasi**	**Learning Environment**	**Learning Motivation**
Blended Learning	0.830				
Computational Thinking	0.495	0.700			
Digital Literasi	0.858	0.534	0.773		
Learning Environment	0.581	0.609	0.699	0.754	
Learning Motivation	0.535	0.705	0.573	0.654	0.707

Based on the Fornell-Larcker Validity Test results table, it can be interpreted that the diagonal value indicating the square root of AVE for each construct is greater than the correlation value between constructs in its row and column. For example, blended learning has a value of 0.830, computational thinking 0.700, digital literacy 0.773, learning environment 0.754, and learning motivation 0.707, all higher than the correlation between related constructs. This indicates that each construct has good discriminant validity, meaning that the constructs are quite different from each other and each item measures its own construct more strongly than the other constructs. Thus, the research instrument meets the criteria for both convergent and discriminant validity.

Structural Model Evaluation Results (Inner Model)

In Structural Equation Modeling (SEM), a structural model is used to test causal relationships between latent variables in a study. One important measure in a structural model is the R-Square (R^2) value, which indicates the extent to which the independent variables can explain the variation in the dependent variable. This value provides an indication of the model's predictive power in explaining the relationships between the variables under study.

Table 3. Coefficient Test

	R-square	**R-square adjusted**
Computational Thinking	0.541	0.530
Learning Motivation	0.464	0.455

Based on Table 3, the coefficient test results show that the R-square for the Computational Thinking construct is 0.541 and the adjusted R-square is 0.530, while for Learning Motivation, the R-square is 0.464 and the adjusted R-square is 0.455. These R-square values indicate that 54.1% of the variation in Computational Thinking and 46.4% of the variation in Learning Motivation can be explained by the independent variables used in the model. In general, these values indicate a moderate to good level of predictive ability of

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the model, so that the independent constructs have a significant contribution to the dependent variable in this study.

Hypothesis Testing

Table 4. Path Coefficient Test

Hypothesis	Path Coefficient	T statistics	P values	Finding
BL -> CT	0.059	1.483	0.009	Significant
BL -> LM	0.167	1.435	0.001	Significant
DL -> CT	0.030	2.224	0.023	Significant
DL -> LM	0.046	1.326	0.005	Significant
LE -> CT	0.199	2.634	0.008	Significant
LE -> LM	0.471	5.737	0.000	Significant
LM -> CT	0.509	6.071	0.000	Significant
BL -> LM -> CT	0.085	1.281	0.000	Significant
DL -> LM -> CT	0.023	0.317	0.752	Insignificant
LE -> LM -> CT	0.240	3.861	0.000	Significant

The following is an interpretation of the results of Table 4 in point form:

1) Blended Learning → Computational Thinking: Path coefficient 0.059; p = 0.009 → Significant, indicating that blended learning has a direct effect on computational thinking.
2) Blended Learning → Learning Motivation: Path coefficient 0.167; p = 0.001 → Significant, indicating that blended learning increases learning motivation.
3) Digital Literacy → Computational Thinking: Path coefficient 0.030; p = 0.023 → Significant, indicating that digital literacy contributes to computational thinking.
4) Digital Literacy → Learning Motivation: Path coefficient 0.046; p = 0.005 → Significant, indicating that digital literacy also increases learning motivation.
5) Learning Environment → Computational Thinking: Path coefficient 0.199; p = 0.008 → Significant, learning environment influences computational thinking skills.
6) Learning Environment → Learning Motivation: Path coefficient 0.471; p = 0.000 → Significant, learning environment has a strong influence on learning motivation.
7) Learning Motivation → Computational Thinking: Path coefficient 0.509; p = 0.000 → Significant, learning motivation is a major factor in improving computational thinking.
8) Blended Learning → Learning Motivation → Computational Thinking: Path coefficient 0.085; p = 0.000 → Significant, learning motivation mediates the effect of blended learning on computational thinking.
9) Digital Literacy → Learning Motivation → Computational Thinking: Path coefficient 0.023; p = 0.752 → Weak/insignificant mediation effect
10) Learning Environment → Learning Motivation → Computational Thinking: Path coefficient 0.240; p = 0.000 → Significant, learning motivation mediates the effect of the learning environment on Computational Thinking.

The research results show that blended learning and digital literacy are interconnected in creating a more flexible, interactive, and technology-based learning experience, thereby enhancing student motivation. The integration of face-to-face and interactive learning provides students with opportunities to access a wider range of materials, tailor the learning process to their individual needs, and engage more actively in discussions and complete learning assignments. In this environment, students no longer merely receive information but become active individuals exploring learning resources and constructing their own understanding. This situation results in increased self-confidence, learning engagement, and

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intrinsic motivation in students participating in the learning process. These findings align with research by Asrori Ahmad et al. (2025), which states that the implementation of blended learning can increase learning motivation through more varied and flexible learning.

Field conditions demonstrate that the use of technology in learning encourages students to be more independent in acquiring information and deepening their understanding of the material. Many students utilize digital devices such as smartphones, laptops, learning videos, e-books, scientific articles, and digital learning platforms as additional learning resources beyond the material provided by the teacher. Easy access to various learning resources makes students more interested and active in the learning process because they gain a more diverse and easily understood understanding of the material. In this context, digital literacy relates not only to the ability to use technology but also to the ability to understand, disseminate, and utilize digital information effectively to support learning. This finding is supported by research by Kholid et al. (2024) and Tristiani et al. (2023), which explains that students with high levels of digital literacy tend to be more able to utilize digital learning resources effectively to expand their understanding.

The integration of blended learning and digital literacy also creates a learning environment that encourages active student engagement in the learning process. Students with strong digital literacy skills adapt more easily to technology-based learning because they are able to search for relevant information, disseminate learning resources, and process information into new knowledge. This situation results in increased learning discipline, participation in classroom discussions, and student initiative in independent learning. The results of this study align with the findings of Mustanil et al. (2022) and Widyaningsih et al. (2025) who stated that technology-based learning can increase learning motivation because it provides opportunities for students to be more active, independent, and directly involved in the learning process.

However, the most interesting finding in this study was that learning motivation was unable to mediate the relationship between digital literacy and computational thinking, as indicated by a p-value of 0.752. This result suggests that the influence of digital literacy on computational thinking skills tends to occur directly rather than through psychological mechanisms such as learning motivation. Theoretically, this condition can be explained because digital literacy functions more as a technical-cognitive competency than an affective or emotional factor. Digital literacy relates to students' ability to systematically access, stream, manage, and use digital information. These abilities are directly related to the main components of computational thinking, such as information analysis, pattern recognition, abstraction, and developing problem-solving steps. In other words, when students possess strong digital literacy skills, they can directly develop logical and systematic thinking patterns without having to rely on high levels of learning motivation.

This condition suggests that the use of technology in learning does not always require motivational encouragement to develop computational thinking skills. Many students have become accustomed to using digital devices in their daily lives, so that information seeking, data processing, and technology exploration have become part of their cognitive habits. Consequently, the influence of digital literacy on computational thinking is more automatic and skill-based than based on internal psychological drive. This differs from blended learning and other learning environments, where success depends more on student engagement, comfort, and enthusiasm during the learning process.

This finding is novel in the research because it shows that not all technology-based factors require learning motivation as a mediating variable in improving computational thinking. Previous research generally places learning motivation as the primary mediator in

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the relationship between learning technology and learning outcomes. However, this study's results demonstrate that digital literacy has a direct influence on computational thinking because both fall within the domains of cognitive ability and information processing, which are intrinsically interrelated. Thus, this study provides a new perspective that the development of computational thinking skills is not only influenced by motivational factors but can also be formed directly through strengthening students' digital competencies.

Conclusion

The results showed that blended learning, digital literacy, learning environment, and learning motivation have a significant direct influence on computational thinking. In addition, learning motivation significantly mediated the relationship between blended learning and computational thinking, as well as between the learning environment and computational thinking. However, learning motivation was unable to mediate the relationship between digital literacy and computational thinking, indicating that digital literacy tends to influence computational thinking directly through students' cognitive and information processing abilities through motivational mechanisms. This finding is novel in the study because it shows that not all technology-based factors require motivational mediation to improve computational thinking skills. Therefore, strengthening students' digital competencies and creating a supportive learning environment are important strategies for developing computational thinking in the context of technology-based learning.

Recommendation

Based on the research findings, it is recommended that educators and schools pay more attention to the implementation of blended learning, which combines face-to-face activities with the effective use of digital technology. Teachers are expected to design more interactive, flexible, and varied learning experiences to increase student motivation and encourage them to think logically, systematically, and creatively in solving various learning problems. Furthermore, schools need to improve students' digital literacy through the use of various digital learning resources, training in technology use, and providing supporting facilities such as internet access and digital learning tools. These efforts are crucial for students to be able to optimally utilize technology in their learning, search for relevant information, and develop computational thinking skills. Furthermore, schools need to create a conducive learning environment by fostering positive interactions between teachers and students, providing adequate learning facilities, and encouraging collaboration among students. A supportive learning environment will increase student motivation and help them become more active in the learning process. For future research, it is recommended that researchers explore other factors that potentially influence students' computational thinking skills, such as innovative learning strategies, educational technology support, and individual student characteristics. Further research could also use a wider sample size or a different methodological approach to gain a more comprehensive understanding of the factors that influence computational thinking skills in a learning context.

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