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From Digital Literacy to Computational Thinking in Economics Education: The Mediating Role of Self-Regulated Learning

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Abstract: This study aims to examine the effect of digital literacy (DL) on students' computational thinking (CT) in Economics Education, with self-regulated learning (SRL) serving as a key explanatory factor. A quantitative explanatory survey design was employed with 210 junior high school students from North Sulawesi and Central Kalimantan, Indonesia, who were selected through proportional sampling. Data were collected using Likert-scale questionnaires measuring DL, SRL, and CT and were analyzed using descriptive statistics and univariate linear regression. The results showed that DL significantly predicted SRL ($\beta = 0.75$, $p < .001$) and CT ($\beta = 0.71$, $p < .001$), while SRL significantly predicted CT ($\beta = 0.76$, $p < .001$). The significant direct relationship between DL and CT, together with the significant relationships between DL and SRL and between SRL and CT, suggests that SRL may play an explanatory role in the relationship between DL and CT. Because the direct relationship between DL and CT remained significant, the relationship was not fully accounted for by SRL. These findings highlight the importance of integrating digital literacy with SRL strategies, including goal setting, learning monitoring, strategy use, and self-evaluation, to support the development of students' computational thinking skills in Economics Education.

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Introduction

One of the cognitive abilities that has received widespread attention in the global educational literature is computational thinking. This ability is seen as an essential ability that is essential to deal with the complexity of modern problems that demand systematic and structured thinking (Shute et al., 2017a). Computational thinking encompasses several interconnected cognitive processes, including decomposition, pattern recognition, abstraction, and algorithm design. These processes are applicable across disciplines and are particularly relevant to economic learning, where students are expected to interpret data, establish causal relationships, and make rational decisions based on available information (Akiba, 2022; Bocconi et al., 2019).

Various international reports affirm that computational thinking is not only relevant in the field of informatics, but also contributes to improving students' problem-solving and logical reasoning skills. These competencies are an important part of learning economics in the era of the digital economy, which is loaded with data and information (Fei et al., 2025). At the secondary education level, mastery of computational thinking is an important foundation for students' readiness to face advanced learning and a technology-based work world. However, various studies show that the level of computational thinking mastery of secondary school students is still not optimal. Empirical findings indicate that these

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capabilities are generally in the medium to low category, especially in developing countries (Kim et al., 2021; Markandan et al., 2022).

The results of the Programme for International Student Assessment show that the reasoning and problem-solving skills of Indonesian students are still below the average of OECD countries. This condition reflects the weakness of the ability to think systematically and logically, which is closely related to computational thinking, including in understanding contextual economic problems (OECD, 2023b; Schlauch et al., 2025). This gap confirms the difference between the demands of 21st-century competencies and the actual achievement of students in high school. This shows the need for systematic efforts to improve high-level thinking skills in economic learning.

Various approaches have been applied to improve computational thinking, such as the integration of programming and problem-based learning (Ji & Wong, 2025). The use of digital technology is also a strategy that is widely used in the learning process in the 21st-century. However, recent research shows that the success of this approach is highly dependent on the ability of students to utilize technology meaningfully and strategically. Without these capabilities, the use of technology does not necessarily have a positive impact on the development of computational thinking (Fagerlund et al., 2021). Within this learning environment, digital literacy becomes an important enabling competence. Digital literacy refers to students' capacity to access, evaluate, organize, and utilize digital information in a critical and productive manner (Celik, 2023; Maddatuang et al., 2025). In economic learning, this competence is particularly relevant because students frequently encounter information and data that must be interpreted and evaluated before being used for academic decision-making. Digital literacy also extends beyond the technical operation of digital devices, encompassing cognitive and metacognitive capacities that enable students to understand, evaluate, analyze, and produce information within digital environments (Chen, 2025; Li et al., 2025).

Students with high levels of digital literacy tend to be better able to understand technology-based problem representations. This ability supports the development of systematic computational solutions, including in analyzing simple to complex economic problems (Archer & Sterling, 2024; Mee et al., 2025). Therefore, digital literacy is seen as an important prerequisite for the development of computational thinking in the modern learning environment. This is becoming increasingly relevant in the context of economic learning that utilizes digital data and information. However, a number of studies show that the influence between digital literacy and computational thinking is not always direct. Diverse research results indicate that there are other variables that affect the influence between the two constructs (Gümüş et al., 2024; Siddiq et al., 2024).

In digital learning environments that require substantial independence, students' ability to manage their own learning becomes particularly important. This condition is also relevant to technology-based economic learning. Self-regulated learning describes the process through which students actively manage their learning by planning learning activities, monitoring their progress, and evaluating the outcomes they achieve. It also involves the regulation of cognitive, motivational, and behavioral aspects of learning (Mejeh et al., 2024; Panadero, 2017). Recent research shows that self-regulated learning has a crucial role in technology-based learning. This ability allows learners to manage digital information more effectively and reflectively. Students who demonstrate stronger self-regulated learning are generally better equipped to establish learning goals and select appropriate learning strategies. Such capabilities can help them manage the demands of complex digital learning

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environments and support more effective learning outcomes. (Broadbent et al., 2023; Rusdi et al., 2023).

From the perspective of computational thinking, self-regulated learning may function as an internal regulatory mechanism through which students translate their digital capabilities into problem-solving activity. In Economics Education, computational thinking is manifested through students' ability to decompose economic problems, identify patterns in economic data, select relevant information, and develop systematic steps to analyze economic problems and make decisions. For example, students may apply these processes when analyzing market equilibrium or economic trends based on numerical and graphical data (Wing, 2019). This process is important in the development of systematic reasoning and algorithmic thinking. Empirical studies show that students who are able to manage their learning process independently are more effective in developing higher-level thinking skills. This ability is relevant to the process of economic analysis and decision-making (Mejeh et al., 2024; Shute et al., 2017b). In digital learning, digital literacy provides learning resources and tools, while self-regulated learning functions as an internal process of learning management. Computational thinking represents the high-level cognitive outcomes expected in economic learning. Against this background, the present study examines Indonesian secondary students within the context of Economics Education. This group is in a strategic phase of cognitive development in the formation of higher thinking skills.

The novelty of this study is the examination of the structural relationship between digital literacy, learning motivation, and computational thinking specifically among secondary school students in Economics Education in a developing-country context. This extends previous evidence that has largely examined these constructs among university students and in general technology-based learning settings (Nirmala et al., 2024). This study investigates the relationship between digital literacy and computational thinking while examining self-regulated learning as a potential mediating mechanism. The study is expected to provide an empirical contribution to the development of technology-based economic learning in secondary schools.

Research Method

This study employed a quantitative explanatory survey design to examine the relationship between digital literacy (DL) and computational thinking (CT), with self-regulated learning (SRL) examined as a mediating variable in Economics Education. The study involved 210 junior high school students from Bitung City and North Minahasa Regency in North Sulawesi and Palangkaraya City in Central Kalimantan, Indonesia. Participants were selected from an accessible population of approximately 2,200 students using proportional sampling to ensure representation across the participating schools.

Data were collected using a 49-item self-report questionnaire comprising 24 items for DL, 15 items for SRL, and 10 items for CT. All items were rated on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). DL was assessed through technical, cognitive, and social-emotional skills; SRL covered learning planning, motivation and self-efficacy, cognitive strategies, self-control, and self-evaluation and reflection; and CT included decomposition, pattern recognition, abstraction, algorithmic thinking, and debugging. The instruments were adapted and contextualized for secondary Economics learning based on established measures (Chen, 2025; Li et al., 2025; Mejeh et al., 2024; Shute et al., 2017b). Details of the indicators, item numbers, sample items, and sources are provided in the Instrument Matrix (Table 1). Content validity was assessed through expert review,

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while construct validity and reliability were evaluated using factor loadings, Average Variance Extracted (AVE), Cronbach's alpha, and composite reliability (CR).

Table 1. Instrument Matrix

Variable Name	Indicator/Dimensions	No. of Items	Sample Item
Digital Literacy	Technical skills; cognitive skills; social-emotional skills	24	I can distinguish between accurate and unreliable information found on the internet.
Self-Regulated Learning	Learning planning; motivation and self-efficacy; cognitive strategies; self-control; self-evaluation and self-reflection	15	I set clear learning goals before starting an Economics learning activity.
Computational Thinking	Decomposition; pattern recognition; abstraction; algorithmic thinking; debugging	10	I can divide a large problem into several smaller parts to make it easier to solve.

Before the main data collection, a pilot test was conducted with respondents outside the study sample to evaluate the clarity and consistency of the questionnaire items. Necessary revisions were made based on the pilot results. The main survey was administered online over a one-month period with assistance from school administrators and teachers. Participation was voluntary, and respondents were informed about the purpose and procedures of the study before completing the questionnaire. The final dataset consisted of 210 complete responses with no missing values.

Data were analyzed using SPSS. Descriptive statistics were first calculated to summarize the distributions of DL, SRL, and CT. Data screening and assumption testing were subsequently performed before inferential analysis. Three univariate linear regression models were used to examine (1) the relationship between DL and CT, (2) the relationship between DL and SRL, and (3) the relationship between SRL and CT. Each model was evaluated using the standardized regression coefficient (β), coefficient of determination (R^2), and significance level ($p < 0.05$). The mediating role of SRL was assessed based on the pattern of relationships among DL, SRL, and CT. Significant relationships between DL and SRL and between SRL and CT, together with a significant direct relationship between DL and CT, were interpreted as evidence that SRL contributes to the relationship between DL and CT. Because the direct DL–CT relationship remained significant, the relationship was not considered fully mediated by SRL.

Results and Discussion

Results

This section reports the findings of the study based on data obtained from 210 high school students across North Sulawesi and Central Kalimantan, Indonesia. The results are organized sequentially, beginning with the sociodemographic profile of the respondents, followed by descriptive statistics of the three study constructs, and concluding with the inferential analysis examining the direct and indirect relationships among digital literacy, self-regulated learning, and computational thinking. All findings are presented through tables accompanied by narrative descriptions to facilitate accurate and systematic interpretation of the data.

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Table 2. Distribution of the studied students according to sociodemographic data (n=210)

Sociodemographic profile of the respondents	N	%
Age (Years)		
12-14	170	80.95
15-17	40	19.05
Gender		
Male	65	30.95
Female	145	69.05
Province		
North Sulawesi	162	77.14
Central Kalimantan	48	22.86

Table 2 presents the sociodemographic profile of the 210 respondents participating in this study, encompassing three descriptive dimensions: age group, gender, and province of origin. With regard to age distribution, the sample was predominantly composed of students within the 12–14 year age range, representing 170 respondents (80.95% of the total sample), while the remaining 40 respondents (19.05%) belonged to the 15–17 year age group. This distribution is consistent with the demographic characteristics of the target population, namely junior high school students in Indonesia, wherein the majority of enrolled students fall within the early adolescent bracket. In terms of gender composition, female students constituted the larger proportion of the sample (n = 145 = 69.05%), while male students accounted for the remaining 30.95% (n = 65). This gender distribution reflects the natural demographic composition of the participating schools and was not the result of deliberate selection criteria.

Regarding geographical representation, the majority of respondents originated from North Sulawesi Province (n = 162 = 77.14%), while the remaining 48 respondents (22.86%) were drawn from Central Kalimantan Province. The proportional difference between the two provinces corresponds to the relative size of the student population in each participating school and is consistent with the proportional sampling technique applied in this study, wherein the allocation of respondents from each region was determined based on the population composition of each school. The larger representation of North Sulawesi respondents reflects the higher number of participating schools and enrolled students from that province relative to Central Kalimantan. Overall, the sociodemographic distribution of the sample across age, gender, and region is presented to ensure transparency and to provide an accurate descriptive portrait of the studied population.

Table 3. Mean Percent Scores of Digital Literacy, Self-Regulated Learning, and Computational Thinking (n = 210)

Study Variables	Mean ± SD	Low (< 33.33%)		Moderate (33.33 – < 66.67%)		High (≥ 66.67%)	
		Yes	%	Yes	%	Yes	%
Digital Literacy (DL)	**64.58 ± 21.42**	**17**	**8.10**	**89**	**42.38**	**104**	**49.52**
Technical Skills	65.12 ± 22.08	16	7.62	86	40.95	108	51.43
Cognitive Skills	66.47 ± 23.15	15	7.14	82	39.05	113	53.81
Communication Skills	62.16 ± 21.96	20	9.52	91	43.33	99	47.14
Self-Regulated Learning (SRL)	**63.02 ± 16.27**	**12**	**5.71**	**98**	**46.67**	**100**	**47.62**

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Learning Planning	64.31 ± 17.04	13	6.19	93	44.29	104	49.52
Motivation and Self-efficacy	65.48 ± 17.89	11	5.24	89	42.38	110	52.38
Cognitive Strategies	62.77 ± 16.58	14	6.67	101	48.10	95	45.24
Self-Control	61.94 ± 15.92	15	7.14	99	47.14	96	45.71
Self-evaluation and Self-reflection	63.12 ± 16.11	10	4.76	101	48.10	99	47.14
Computational Thinking (CT)	**65.36 ± 18.94**	**14**	**6.67**	**86**	**40.95**	**110**	**52.38**
Decomposition	66.02 ± 19.88	13	6.19	84	40.00	113	53.81
Pattern Recognition	64.83 ± 18.31	15	7.14	89	42.38	106	50.48
Abstraction	65.71 ± 19.04	14	6.67	85	40.48	111	52.86
Algorithmic Thinking	64.92 ± 18.67	16	7.62	87	41.43	107	50.95
Debugging	63.88 ± 18.12	17	8.10	90	42.86	103	49.05

Descriptive analysis of the three study constructs revealed generally moderate-to-high score distributions across all variables. Digital literacy yielded a mean score of 64.58 ± 21.42, with 49.52% of respondents classified in the high category and 42.38% in the moderate category. At the indicator level, cognitive skills recorded the highest mean (M = 66.47, SD = 23.15), followed by technical skills (M = 65.12, SD = 22.08), while communication skills yielded the lowest mean (M = 62.16, SD = 21.96). Self-regulated learning demonstrated a mean of 63.02 ± 16.27, with 47.62% of respondents in the high category and 46.67% in the moderate category. Motivation and self-efficacy recorded the highest indicator mean (M = 65.48, SD = 17.89), whereas self-control yielded the lowest (M = 61.94, SD = 15.92), with 7.1% of respondents falling in the low category.

Computational thinking scores produced a mean of 65.36 ± 18.94, with more than half of the respondents (52.38%) classified in the high category and 40.95% in the moderate category. Among its indicators, decomposition recorded the highest mean (M = 66.02, SD = 19.88), followed by abstraction (M = 65.71, SD = 19.04), while debugging yielded the lowest mean score (M = 63.88, SD = 18.12), with 8.10% of respondents in the low category. Across all three constructs, the proportion of respondents in the low category remained below 10%, indicating a consistently moderate-to-high distributional pattern throughout the sample.

Table 4. Univariate linear regression analysis for the effect of digital literacy on self-regulated learning and computational thinking (n = 210)

Dependent Variables	R^2	F (p)	B	Beta	T	p	B (LL – UL 95% C.I)
Self-Regulated Learning	0.56	265.38 (< 0.001*)	1.21	0.75	16.29	< 0.001*	(1.07 – 1.36)
Computational Thinking	0.49	206.12 (< 0.001*)	1.09	0.71	14.36	< 0.001*	(0.94– 1.24)

Table 4 presents the results of the univariate linear regression analyses examining the relationships of digital literacy and self-regulated learning and computational thinking among 210 respondents. Digital literacy significantly predicted self-regulated learning (F = 265.38, p

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< 0.001), explaining 56% of its variance ($R^2 = 0.56$; B = 1.21; $\beta = 0.75$; t = 16.29; $p < 0.001$; 95% CI [1.07–1.36]). Digital literacy also significantly predicted computational thinking (F = 206.12, $p < 0.001$), accounting for 49% of its variance ($R^2 = 0.49$; B = 1.09; $\beta = 0.71$; t = 14.36; $p < 0.001$; 95% CI [0.94–1.24]). These findings indicate positive relationships between digital literacy and both self-regulated learning and computational thinking.

Table 5. Univariate Linear Regression Analysis for the Effect of Self-Regulated Learning on Computational Thinking (n = 210)

Dependent Variable	R^2	F (p)	B	Beta	T	p	B (LL – UL 95% C.I)
Computational Thinking	0.58	289.47 (< 0.001*)	1.44	0.76	17.01	< 0.001*	(1.27 – 1.60)

Table 5 presents the univariate linear regression results examining self-regulated learning as a predictor of computational thinking among 210 respondents. The regression model was statistically significant (F = 289.47, $p < 0.001$), with self-regulated learning explaining 58% of the variance in computational thinking ($R^2 = 0.58$). The positive standardized coefficient ($\beta = 0.76$, t = 17.01, $p < 0.001$) indicates a significant positive relationship between self-regulated learning and computational thinking. The unstandardized coefficient was B = 1.44, with a 95% confidence interval ranging from 1.27 to 1.60, indicating a positive estimated association. Taken together, digital literacy significantly predicted self-regulated learning ($\beta = 0.75$, $p < 0.001$) and computational thinking ($\beta = 0.71$, $p < 0.001$), while self-regulated learning significantly predicted computational thinking ($\beta = 0.76$, $p < 0.001$). These findings indicate that self-regulated learning contributes to the relationship between digital literacy and computational thinking. However, because the direct relationship between digital literacy and computational thinking remained significant, the relationship was not fully mediated by self-regulated learning.

Discussion

The findings of this study revealed that digital literacy significantly predicted both self-regulated learning ($R^2 = 0.56$, $\beta = 0.75$, $p < 0.001$) and computational thinking ($R^2 = 0.49$, $\beta = 0.71$, $p < 0.001$) among junior high school students in North Sulawesi and Central Kalimantan, Indonesia. The explanatory power of digital literacy was marginally stronger for self-regulated learning than for computational thinking, suggesting that students with well-developed digital competencies tend to exhibit greater capacity for planning, monitoring, and regulating their own learning processes. Furthermore, self-regulated learning demonstrated a stronger predictive relationship with computational thinking ($R^2 = 0.58$, $\beta = 0.76$, $p < 0.001$), indicating that students with stronger self-regulated learning tend to demonstrate higher levels of computational thinking. The predominance of moderate-to-high score distributions across all three constructs, with low-category proportions consistently below 10%, further suggests that the studied sample possessed adequate foundational competencies across the measured domains.

The significant association between digital literacy and self-regulated learning is in line with previous empirical evidence indicating that students' ability to engage effectively with digital environments can support goal setting, purposeful use of digital resources, and metacognitive awareness. These capabilities are closely related to the processes involved in self-regulated learning (Broadbent et al., 2023; Panadero, 2017; Riswanto et al., 2025). The significant relationship between digital literacy and computational thinking is also consistent with previous research, which suggests that stronger digital competencies can support students in engaging with problem decomposition, pattern recognition, abstraction, and algorithmic thinking (Voogt et al., 2015). The comparatively stronger predictive contribution of self-regulated learning relative to digital literacy in explaining variance in computational thinking further aligns with recent empirical evidence suggesting that

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metacognitive and motivational factors occupy a more proximal role than technological proficiency in shaping students' higher-order cognitive performance. The descriptive patterns observed in this study are also broadly consistent with international education reports indicating that adolescent students in digitally active learning environments tend to demonstrate moderate-to-high levels of digital literacy and self-regulated learning, though regional and institutional variations remain considerable (Global Education Monitoring Report Team, 2023).

From a theoretical standpoint, the results of this study carry significant implications for the conceptualization of digital literacy within the broader framework of 21st-century education (Acevedo-Borrega et al., 2022; van Laar et al., 2020). The findings provide empirical support for the proposition that digital literacy functions not merely as a technical skill set but also as a cognitive and motivational enabler that facilitates self-regulated learning behaviors among adolescent learners, thereby extending the conceptual boundaries of digital literacy beyond technological proficiency toward a more integrative framework encompassing its role in fostering autonomous and strategic learning (Y. Liu, 2024). Moreover, the stronger predictive contribution of self-regulated learning compared to digital literacy in explaining computational thinking highlights self-regulated learning as an important explanatory component in the relationship between digital competence and higher-order problem-solving capacities. The study further contributes to the theoretical discourse on the relationship between digital literacy and computational thinking by indicating that this relationship is not purely direct but is also associated with students' capacity for self-regulation, affirming the continued relevance of socio-cognitive theoretical frameworks in explaining technology-mediated learning outcomes (Anderson, 2016).

These findings have direct implications for Economics Education by supporting the integration of digital literacy, self-regulated learning, and computational thinking into authentic economic tasks. Teachers can engage students in analyzing inflation and unemployment data, preparing household budgets, interpreting market trends, and evaluating economic policy scenarios. Such tasks can develop self-regulation through goal setting, progress monitoring, self-control, and reflection, while fostering computational thinking through problem decomposition, pattern recognition, data analysis, abstraction, and systematic problem solving. Given the relatively low mean scores for digital communication and self-control, these dimensions require explicit instructional attention. In the context of North Sulawesi and Central Kalimantan, these practices can be supported through teacher professional development and context-sensitive learning resources that enable students to apply digital and computational skills to locally relevant economic issues. Accordingly, Economics Education should provide students with opportunities to use digital information critically, regulate their learning processes, and apply computational approaches to real-world economic problems (L. Liu et al., 2025; Panadero, 2017).

Conclusion

The findings demonstrate that digital literacy has significant predictive relationships with both self-regulated learning ($R^2 = 0.56$, $\beta = 0.75$, $p < 0.001$) and computational thinking ($R^2 = 0.49$, $\beta = 0.71$, $p < 0.001$). Self-regulated learning also significantly predicts computational thinking ($R^2 = 0.58$, $\beta = 0.76$, $p < 0.001$). The stronger explanatory contribution of self-regulated learning to computational thinking suggests that students' ability to plan, monitor, and evaluate their learning is closely associated with their capacity to engage in computational problem solving. Overall, the findings demonstrate the interconnected contribution of digital literacy and self-regulated learning to computational thinking in Economics Education.

The findings also indicate that self-regulated learning contributes to the relationship between digital literacy and computational thinking. Nevertheless, because the direct relationship between digital literacy and computational thinking remains significant, self-regulated learning does not fully account for this relationship. Thus, the findings provide an explanatory pattern consistent with a mediating role of self-regulated learning, while the present analysis does not establish a formally tested indirect effect. This distinction is important given that the analysis was based on univariate linear regression.

From a practical perspective, Economics Education should integrate digital literacy with self-regulated learning activities and computational problem solving. Teachers can use authentic tasks involving economic data, budgeting, market trends, and policy issues to encourage goal setting, learning monitoring, data analysis, problem decomposition, pattern recognition, and reflection. Such integration can provide students with opportunities to use digital resources strategically while developing computational thinking for real-world economic problems.

Recommendation

Based on the findings, Economics Education should integrate digital literacy and self-regulated learning through authentic, technology-supported economic tasks, with particular attention to digital communication and self-control. For example, students can collaboratively analyze economic data from credible digital sources, present their findings through digital platforms, and provide evidence-based feedback to peers. Self-control can be reinforced by requiring students to set learning targets, manage task deadlines, monitor their progress, minimize digital distractions, and reflect on their learning decisions. These competencies can be developed through age-appropriate economic activities, such as planning simple household spending, comparing prices and consumer choices, interpreting basic economic information from digital sources, and discussing economic issues relevant to students' daily lives. In North Sulawesi and Central Kalimantan, teacher professional development and locally relevant digital learning resources can support the implementation of these activities in Economics. Future research should further examine the mediating role of self-regulated learning using more advanced structural models.

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