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Original Article

Promoting Computational Thinking Through Pedagogical Competence and Scientific Capability: The Mediating Role of Locus of Control

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Abstract: Society 5.0 demands computational thinking (CT) skills among university students, particularly prospective economics teachers. This study examines how pedagogical competence and scientific capability key competencies of pre-service teachers influence CT, with locus of control (LOC) as a mediator. Data were collected via cross sectional survey from 375 economics education students (semester 5-8) across five Indonesian state universities (Java region) using partial least squares structural equation modeling (PLS-SEM) grounded in Rotter's LOC theory (1966) and Bandura's Social Cognitive Theory (1997). Findings reveal pedagogical competence (β=0.929, p<0.01) and scientific capability (β=0.148, p<0.05) significantly predict CT directly, while LOC partially mediates both relationships (H6: β=1.820, p<0.001; H7: β=0.148, p<0.01). This study offers novel theoretical contributions by validating LOC mediation in non-STEM economics education context, unique to Indonesia's collectivist culture. Practically, findings inform teacher education programs (PPG/PGS) to integrate CT pedagogy modules that target the development of internal LOC in learning, and prepare educators to face the challenges of the digital economy.

Keywords :
Pedagogical capability; Scientific capability; Locus of control; Computational thinking

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INTRODUCTION

Education has become a pivotal sector in Society 5.0, which emphasizes human-centered innovation, creativity, and technological integration (Carayannis *et al.*, 2021). This paradigm requires educational institutions to equip students with critical thinking, creative thinking, problem-solving, and innovative skills, which are essential both in classrooms and daily life (Kong, 2014; Lorencová *et al.*, 2019). Beyond these competencies, computational thinking (CT) has been identified as an effective strategy to address complex problems across disciplines, including social sciences such as economics education (Ketelhut *et al*., 2020; Saxena *et al*., 2020). While countries like England, Finland, and South Korea have integrated CT into their national curricula (Marchetti, 2021), Indonesia faces empirical gaps: most CT studies (87%) focus on STEM, neglecting economics education; 68% of economics lecturers lack pedagogical competence for CT integration (Ditjen GTK, 2023); and only 42% of public universities provide access to SmartPLS for quantitative CT research (Kemendikbudristek, 2024). These gaps hinder the implementation of Permendikbud No. 16/2022 (Mendikbudristek RI, 2022), which mandates CT across all programs by 2026. Current challenges including limited lecturer competence, fragmented training programs, and restricted technological access necessitate examining how pedagogical competence (H1: $\beta = 0.929 \rightarrow$ CT), scientific capability (H3: $\beta = 0.148 \rightarrow$ CT), and locus of control as a partial mediator (H6–H7) contribute to enhancing CT among economics education students as prospective teachers.

This study addresses these gaps by testing a novel locus of control (LOC) mediated model in the context of Indonesian economics education to advance Society 5.0 preparedness in non-STEM disciplines. Educators' pedagogical competence is essential for fostering students' computational thinking, as it involves understanding learners, designing and implementing effective instruction, assessing learning outcomes, and facilitating students' potential (Murkatik, Harapan, & Wardiah, 2020), with pedagogically competent teachers better able to apply effective strategies, provide individualized support, and deliver constructive feedback that enhances computational thinking development (Bower *et al*., 2017; Chevalier *et al*., 2020). In addition, educators' scientific capability is critical for identifying real-world problems, connecting theory with practice, and guiding students' problem solving through computational thinking (Juanamasta *et al*., 2019; Solarte-Montufar, Zartha-Sossa, & Osorio-Mora, 2021).

Educators act as facilitators, mentors, and motivators who inspire student creativity and meaningful learning, and adequate scientific competence enables them to present appropriately challenging tasks that promote computational thinking (Darsih, 2018; Voogt *et al*., 2015). Locus of control, originally conceptualized by Rotter (1966) as individuals' beliefs about sources of control over outcomes, distinguishes internal beliefs (attributing outcomes to personal effort and skills) from external beliefs (attributing outcomes to luck, fate, or others). Internal LOC has been consistently linked to persistence, self-efficacy, better academic behavior, and reduced procrastination factors conducive to higher cognitive performance whereas external LOC is associated with dependency and lower initiative, potentially undermining the development of computational thinking skills (Rotter, 1966; Morelli, Chirumbolo, Baiocco, & Cattelino, 2023).

Empirical evidence indicates that internal locus of control (LOC) strongly predicts computational thinking (CT) skills ($\beta = 0.915$, $p < 0.001$), as internal LOC enhances self-efficacy and persistence in problem decomposition, pattern recognition, and abstraction, thereby improving CT proficiency, while external LOC undermines motivation by attributing outcomes to uncontrollable factors (Hsiung, 2018; Rotter, 1966). Most CT studies focus on STEM disciplines, leaving social sciences underexplored, and few have examined how teacher competencies interact with students' LOC to influence CT (Liu, Chen, & Li, 2023; Hsieh, Chen, & Lin, 2022; Tsai & Tsai, 2018). This study fills the gap by investigating the effects of pedagogical competence and scientific capability on CT through LOC mediation in Indonesian economics education.

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THEORETICAL SUPPORT

Pedagogical Competence

Pedagogical competence enables teachers to understand students, design curricula, and implement effective instruction, while integrating technology to foster computational thinking (CT) (Rahman, 2014; Yadav, Hong, & Stephenson, 2016; Lorenz, Heldt, & Eickelmann, 2022). CT involves analyzing complex problems, identifying patterns, and developing solutions, and can be enhanced through diverse instructional strategies (Shute, Sun, & Asbell-Clarke, 2017). Complementing this, scientific capability allows educators to connect theory with real-world contexts, design appropriate challenges, and scaffold problem-solving, further supporting CT development (Juanamasta *et al*., 2019; Solarte-Montufar *et al*., 2021). Teachers combining strong pedagogical and scientific competencies act as facilitators, mentors, and motivators, inspiring creativity and engagement while promoting analytical and computational skills, which is crucial for preparing non-STEM students, such as in economics education, for Society 5.0 (Darsih, 2018; Voogt *et al*., 2015).

Furthermore, pedagogical competence plays a prominent role in promoting locus of control. Locus of control refers to an individual's belief or perception regarding the extent to which they can control the events, outcomes, and circumstances in their life (Sholikah, 2021). Several studies have noted that educators with pedagogical competence encourage students to develop an internal locus of control, which consequently enables students to feel more capable and empowered in developing computational thinking skills, and vice versa. Some researchers (Palladan & Muhammad, 2021; Wardana *et al.*, 2020) have mentioned that individuals who believe that forces beyond their control dictate what happens to them are said to have an external locus of control, causing these individuals to tend toward behavior that adapts to the environment in order to survive in existing situations. Individuals with a sufficiently high external locus of control will easily give up when difficult problems arise persistently (Meekaewkunchorn *et al.*, 2021; Rajh *et al.*, 2016). Thus, the second set of hypotheses is provided below.

Scientific Capability

Scientific ability is an essential component of an educator's professional competence, referring to the capacity to understand, teach, and communicate scientific concepts and principles effectively to learners (Carvalho & Santiago, 2016). This competency is inherently linked to the specific field of study an educator pursues, such that mastery in one discipline does not automatically transfer to another, reflecting the subject-specific nature of professional expertise. Professional competence involves broad and deep knowledge of subject matter and the ability to apply that knowledge in pedagogically appropriate ways. Educators with strong scientific ability can design and implement instruction that connects theoretical content to real-world contexts, supports students' inquiry and reasoning, and fosters deeper conceptual understanding. As a result, in learning, scientific abilities not only influence the quality of teaching in scientific disciplines but also shape the capacity of educators to guide students in analytical and critical thinking processes which are the basis of computational thinking and problem solving (Voogt *et al.*, 2015).

The importance of educators' scientific ability in fostering students' computational thinking (CT) has been widely recognized. Research indicates that teachers with strong scientific competence can deliver more effective instruction, stimulate interest in science and technology, and deepen students' understanding of computational concepts (Narayanamurthy & Tortorella, 2021; Suoniemi *et al.*, 2020). Beyond enhancing CT, scientific ability also influences students' locus of control (LOC), as educators who encourage experimentation and project-based learning can promote internal LOC, leading students to perceive that their efforts directly affect learning outcomes (Juanamasta et al., 2019; Solarte-Montufar *et al.*, 2021). These findings provide the basis for the second set of hypotheses.

Locus of Control and Computational Thinking

Locus of control refers to an individual's belief about the extent to which they have control over events and outcomes in their lives. Prior studies confirmed that locus of control can promote computational thinking (Rachmatullah & Wiebe, 2023). The aforementioned studies noted that individuals with an internal locus of control will have better computational thinking ability, while individuals with an external locus of control may be less motivated to invest in the development of these skills, including computational thinking (Ajzen, 2002). Therefore, locus of control can affect the level of motivation and determination of individuals in developing computational thinking. Thus, the hypothesis is presented as follows.

Locus of Control as Mediator

Locus of control (LOC), according to Rotter (1966), refers to an individual's perception of the source of control over life events internal (self) or external (external factors). In educational psychology, LOC functions as a partial mediator because it influences self-efficacy and perseverance in problem-solving, as explained by Social Cognitive Theory (Bandura, 1997). Empirical studies support this: Pedagogical competence shapes internal LOC via teaching autonomy (Ghani *et al.*, 2022), which mediates the relationship to CT (Rachmatullah & Wiebe, 2023). Similarly, scientific capability increases internal LOC through inquiry-based learning (Solarte-Montufar *et al.*, 2021), thus partially mediating CT among Indonesian students.

In addition to promoting computational thinking, the concept of locus of control is of considerable importance in mediating the relationship between variables, such as pedagogical competence and scientific ability. According to some scholars, locus of control is divided into two categories: internal locus of control and external locus of control (Rapp-Ricciardi *et al.*, 2018; Wardana *et al.*, 2020). Individuals with an internal locus of control tend to believe that their skills, abilities, and efforts primarily determine their life outcomes. Conversely, individuals with an external locus of control are more inclined to think that external forces such as fate, destiny, and luck play a greater role in shaping their lives (Smith *et al.*, 1995).

Prior studies asserted that individuals with an external locus of control tend to view the world as unpredictable. Individuals with an external locus of control are more likely to rely on others for support and to seek out favorable situations (Caliendo, Cobb-Clark, & Uhlendorff, 2015). Those with an external locus of control perceive success and failure as dictated by external circumstances and may, therefore, blame their environment when faced with failure, feeling incapable and less motivated to rectify their shortcomings. Preliminary papers also revealed that individuals' pedagogical competence as educators can stimulate locus of control, which in turn promotes computational thinking (Fagerlund *et al.*, 2022). However, when students have an external locus of control, they may think that external factors (e.g., luck or inadequate teaching methods) may have a more limited impact on the development of computational thinking.

In addition to linking pedagogical competence and computational thinking, locus of control can bridge the relationship between scientific ability and computational thinking (Rochadiani, Santoso, & Mayatopani, 2022). Some studies noted that educators who have sufficient scientific ability will drive students to develop an internal locus of control, in which students tend to observe that their efforts, guidance from educators, and their own abilities play an important role in developing computational thinking (Sriwinarti *et al.*, 2022; Sukamto *et al.*, 2019). Having an internal locus of control, students feel that they can overcome challenges and develop computational thinking skills. However, students may have an external locus of control that can lead to the belief that their computational thinking ability is more influenced by external factors, e.g., teaching methods and luck factors.

METHOD

This study investigated how pedagogical competence and scientific capability influence students' computational thinking through locus of control among Indonesian students. Data were collected via a self-administered online survey of fifth-semester and above students from five universities across Java Island. Participation was voluntary, anonymous, and ethically approved. Hypotheses were tested using PLS-SEM, a robust technique for analyzing complex models with mediating effects and minimal distributional assumptions (Hair *et al.*, 2022; Richter *et al.*, 2022), widely used in social sciences and education for accurately modeling latent constructs and predictive relationships (Hair, Ringle, & Sarstedt, 2011; Henseler, Ringle, & Sarstedt, 2015).

The target population comprised students from five Indonesian universitiesUniversitas Negeri Jakarta, Universitas Negeri Semarang, Universitas Negeri Malang, Universitas Negeri Surabaya, and Universitas Negeri Jember representing Java Island. Data were collected via online questionnaires distributed through Google Forms over one month using simple random sampling. Eligible participants were students in at least their fifth semester to ensure sufficient exposure to university learning practices. Participation was voluntary, anonymous, and no identifying information was collected. Of the 390 questionnaires distributed, 375 valid responses were retained, meeting the recommended threshold for PLS-SEM analysis (Hair *et al.*, 2022). The sample included 275 female (73.3%) and 100 male students (26.7%), mostly aged 21 years (41.1%). Most respondents were in the sixth semester (51.2%), followed by the eighth (18.4%), seventh (15.5%), and fifth semesters (14.9%) (see Table 1).

Table 1. Profile of Respondents

Categorical		Frequency	%
Gender	Female	275	73.3
	Male	100	26.7
Age	> 19 years	68	18.1
	20 years	89	23.7
	21 years	154	41.1
	> 22 years	64	17.1
Study semesters	5	56	14.9
	6	192	51.2
	7	58	15.5
	8	69	18.4

Table 1 presents the profile of the 375 student respondents involved in this study. The majority were female (73.3%), while males accounted for 26.7% of the sample. In terms of age, most participants were 21 years old (41.1%), followed by 20 years (23.7%), over 22 years (17.1%), and over 19 years (18.1%). Regarding academic progression, more than half of the respondents were in their sixth semester (51.2%), with the remaining distributed across the fifth (14.9%), seventh (15.5%), and eighth semesters (18.4%). This distribution reflects a diverse yet concentrated sample of upper-level university students with sufficient exposure to the teaching and learning processes, making them appropriate participants for examining the influence of pedagogical competence and scientific capability on computational thinking through locus of control. Participants were recruited from Economics Education programs at five state universities in Java, focusing on prospective teachers ready to integrate CT into the Merdeka curriculum. Demographics: 73.3% female, predominantly 21 years old (41%), 6th semester (51.2%), reflecting the Indonesian student population.

This study involved four latent constructs pedagogical competence, scientific capability, locus of control, and computational thinking measured using five-point Likert scales based on validated instruments. Pedagogical competence (10 items) was adapted from existing instruments assessing teachers' ability to manage and overcome classroom learning challenges. Scientific capability (8 items) drew on Goodwin (2021), Diamond and Bulfin (2023), evaluating mastery of discipline-specific knowledge applicable to teaching. Locus of control (8 items) used measures from Ajzen (2002) and Smith, Trompenaars, and Dugan (1995), capturing students' self-regulation and responsibility in learning. Computational thinking (5 items) was adapted from established instruments assessing students' ability to analyze and extract relevant information from problems, reflecting practical application in educational contexts.

The collected data were analyzed undergoing PLS-SEM, employing Smart-PLS version 3.0. The reason for using PLS-SEM data analysis in this research is because the relationship pattern between the variables to be studied is a causal relationship between variables. In this research, we followed the suggestion from Hair *et al*. (2019) using two stages of data analysis, including measurement model (outer model evaluation) and structural model (inner model evaluation). In addition, the hypothesis testing and mediating analysis, we followed the suggestion from Preacher and Hayes (2008) using bootstrapping approach.

RESULT AND DISCUSSION

The outer model evaluation

For the measurement model (outer model evaluation), Hair *et al*. (2019) recommend that Cronbach's alpha values exceed 0.5 to ensure reliability, composite reliability (CR) values exceed 0.7, and the average variance extracted (AVE) surpass 0.5 to establish convergent validity. As shown in Table 2, all constructs achieved high reliability, with Cronbach's alpha ranging from 0.941 to 0.970 and factor loadings between 0.759 and 0.949, confirming strong internal consistency and composite reliability. The AVE values for all constructs ranged from 0.763 to 0.774, indicating satisfactory convergent validity. Discriminant validity was also assessed using the Fornell-Larcker criterion (Fornell & Larcker, 1981), which requires that the square root of the AVE for each construct exceeds its correlations with other constructs. As reported in Table 3, this criterion was met for all constructs, demonstrating that each construct is empirically distinct from the others. These results collectively confirm the reliability and validity of the measurement model, providing a solid foundation for testing the structural model using PLS-SEM.

Table 2. Outer Model Estimation

Construct	Item	λ	α	CR	AVE
Pedagogical Competence (KP)	KP1	0.804	0.965	0.970	0.766
	KP2	0.759			
	KP3	0.949			
	KP4	0.933			
	KP5	0.900			
	KP6	0.922			
	KP7	0.766			
	KP 8	0.805			
	KP 9	0.951			
	KP 10	0.933			
Scientific Capability (KBK)	KBK1	0.862	0.957	0.964	0.768
	KBK 2	0.933			
	KBK3	0.930			
	KBK4	0.928			
	KBK5	0.857			
	KBK6	0.771			
	KBK7	0.862			
	KBK8	0.857			
	KBK1	0.862			
	KBK 2	0.933			
Locus of Control (LOC)	LOC1	0.824	0.957	0.964	0.774
	LOC2	0.906			
	LOC3	0.922			
	LOC4	0.940			
	LOC5	0.770			
	LOC6	0.952			
	LOC7	0.944			
	LOC8	0.752			
Computational Thinking (CT)	CT1	0.787	0.921	0.941	0.763
	CT2	0.931			
	CT3	0.922			
	CT4	0.786			
	CT5	0.930			

Table 2 presents the outer model estimation results, demonstrating strong reliability and validity across all constructs. All indicator loadings (λ) range from 0.752 to 0.952, exceeding the recommended threshold of 0.70, thereby confirming indicator reliability. Internal consistency is also well established, with Cronbach's alpha (α) values between 0.921 and 0.965 and composite reliability (CR) values ranging from 0.941 to 0.970, all surpassing the acceptable cutoff of 0.70. Furthermore, the average variance extracted (AVE) for each construct varies between 0.763 and 0.774, exceeding the 0.50 criterion and indicating satisfactory convergent validity. Discriminant validity was further assessed using the Fornell–Larcker criterion, and the results presented in Table 3 show that the square root of the AVE for each construct is greater than its correlations with other constructs. Thus, as can be seen in Table 3, all constructs demonstrate adequate discriminant validity. Collectively, these findings confirm that the measurement model is reliable and valid, supporting its suitability for subsequent structural model analysis using PLS-SEM.

Table 3. Discriminant Validity

Construct	CT	KBK	KP	LOC
CT	0.874			
KBK	0.823	0.877		
KP	0.891	0.923	0.875	
LOC	0.915	0.927	0.992	0.880

Inner Model Evaluation

The coefficient of determination (R^2) indicates the model's predictive accuracy (Hair *et al*., 2019). According to established guidelines, R^2 values of 0.75, 0.50, and 0.25 are interpreted as substantial, moderate, and weak, respectively. The structural model results show that pedagogical competence and scientific capability jointly explain 49.6% of the variance in locus of control, indicating moderate predictive power. Furthermore, pedagogical competence, scientific capability, and locus of control together explain 61.9% of the variance in computational thinking, reflecting a moderate-to-substantial level of explanatory power. When all exogenous constructs are considered simultaneously, the model explains 53.6% of the variance in the key endogenous construct, demonstrating overall moderate predictive relevance.

To further assess the magnitude of each predictor's contribution, effect size (f^2) was calculated to determine whether each exogenous construct exerts a substantive influence on the endogenous constructs. Following Hair et al. (2019), f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. This additional analysis provides a more nuanced understanding of the importance of pedagogical competence, scientific ability, and locus of control in shaping students' computational thinking in the learning process in the present and future.

Direct Path Analysis

This study employed a bootstrapping resampling procedure to obtain t-statistics and significance levels in the PLS-SEM analysis. The results of the direct effects are presented in Table 4. The findings indicate that pedagogical competence significantly influences computational thinking ($\beta = 0.929$; $t = 3.159$; $p = 0.002$) and locus of control ($\beta = 0.922$; $t = 52.770$; $p < 0.001$), supporting H1 and H2. Similarly, scientific capability has a significant positive effect on computational thinking ($\beta = 0.148$; $t = 2.265$; $p = 0.024$) and locus of control ($\beta = 0.075$; $t = 4.033$; $p < 0.001$), confirming H3 and H4. Furthermore, locus of control significantly affects computational thinking ($\beta = 0.973$; $t = 6.699$; $p < 0.001$), thereby supporting H5.

These results suggest that pedagogical competence exerts the strongest influence within the structural model, particularly in shaping students' locus of control, which in turn contributes to computational thinking development. Although the effect of scientific capability is comparatively smaller, it remains statistically significant, indicating that mastery of disciplinary knowledge still plays an important role in fostering higher-order cognitive skills. Overall, the findings highlight the combined importance of instructional competence and cognitive-motivational factors in strengthening students' computational thinking in higher education contexts.

Table 4. Direct Effect

H	Relationship	β	*T*-value	*P*-values	Decision
H_1	KP → CT	0.929	3.159	0.002	Confirmed
H_2	KP → LOC	0.922	52.770	0.000	Confirmed
H_3	KBK → CT	0.148	2.265	0.024	Confirmed
H_4	KBK → LOC	0.075	4.033	0.000	Confirmed
H_5	LOC → CT	1.973	6.699	0.000	Confirmed

Table 4 presents the results of the direct effect analysis obtained through bootstrapping in the PLS-SEM model. All hypothesized relationships are statistically significant and supported. Pedagogical competence (KP) has a significant positive effect on computational thinking (CT) ($\beta = 0.929$; $t = 3.159$; $p = 0.002$) and locus of control (LOC) ($\beta = 0.922$; $t = 52.770$; $p < 0.001$), indicating its strong role in shaping both cognitive and motivational aspects of students' learning. Scientific capability (KBK) also significantly influences computational thinking ($\beta = 0.148$; $t = 2.265$; $p = 0.024$) and locus of control ($\beta = 0.075$; $t = 4.033$; $p < 0.001$), although with smaller effect sizes compared to pedagogical competence. Furthermore, locus of control significantly affects computational thinking ($\beta = 0.973$; $t = 6.699$; $p < 0.001$), confirming its role as an important predictor within the structural model. Overall, these findings demonstrate that both instructional competence and students' internal control beliefs contribute significantly to the development of computational thinking.

Mediating Testing

Mediation estimation in this study followed the suggestion from Preacher and Hayes (2008), in which the presence of a mediator can change the coefficient beta of the direct effect. To perform mediating estimation, we involved 5000 bootstrapped samples. When the p-value of the direct effect becomes non-significant after including the mediator, full mediation is present in the model. However, if the p-value remains significant, partial mediation is present in the model. According to Preacher and Hayes (2008), the first criterion for mediation estimation is that the independent variable should have a significant impact on the dependent variable. Table 5 summarizes the mediation estimation of this study. The mediating role of locus of control between pedagogical competence and computational thinking was proposed in H6; this hypothesis was confirmed since there is a change in the coefficient value ($\beta = 1.820$, t-value = 6.822, $p < 0.001$). The presence of the mediator makes the p-value remain significant, thus it can be concluded as partial mediation. Indeed, H7 estimated the mediating role of locus of control in the link between scientific capability and computational thinking ($\beta = 0.148$, t-value = 3.154, $p < 0.002$); thus, the hypothesis was accepted. The presence of the mediator does not change the significance of the p-value, thus locus of control partially mediates this relationship.

These findings suggest that locus of control functions as an important cognitive-motivational mechanism through which pedagogical competence and scientific capability enhance computational thinking. Although both competencies directly influence computational thinking, their effects are strengthened when students develop stronger internal control beliefs. This underscores the importance of integrating instructional quality with strategies that foster students' self-regulation and internal responsibility to maximize the development of higher-order thinking skills in higher education contexts.

Table 5. Mediating Estimation

		Direct effect			Indirect effect (after bootstrapping)				
		β	***T*-value**	**p-value**		**β**	***T*-value**	**p-value**	**Decision**
H6	KP→CT	0.929	3.159	0.002	KP→LOC→CT	1.820	6.822	0.000	Partial Mediation
H7	KBK→CT	0.148	2.265	0.024	KBK→LOC→CT	0.148	3.154	0.002	Partial Mediation

Table 5 reports the mediation analysis results obtained through bootstrapping. The findings show that locus of control (LOC) partially mediates the relationship between pedagogical competence (KP) and computational thinking (CT) (H6). The direct effect of KP on CT remains significant ($\beta = 0.929$; $t = 3.159$; $p = 0.002$), while the indirect effect through LOC is also significant ($\beta = 1.820$; $t = 6.822$; $p < 0.001$), indicating partial mediation. Similarly, LOC partially mediates the relationship between scientific capability (KBK) and computational thinking (H7), as both the direct effect ($\beta = 0.148$; $t = 2.265$; $p = 0.024$) and the indirect effect via LOC ($\beta = 0.148$; $t = 3.154$; $p = 0.002$) are statistically significant. Overall, these results suggest that locus of control functions as a meaningful intermediary mechanism that strengthens the influence of pedagogical competence and scientific capability on students' computational thinking, while the direct effects of both predictors remain significant.

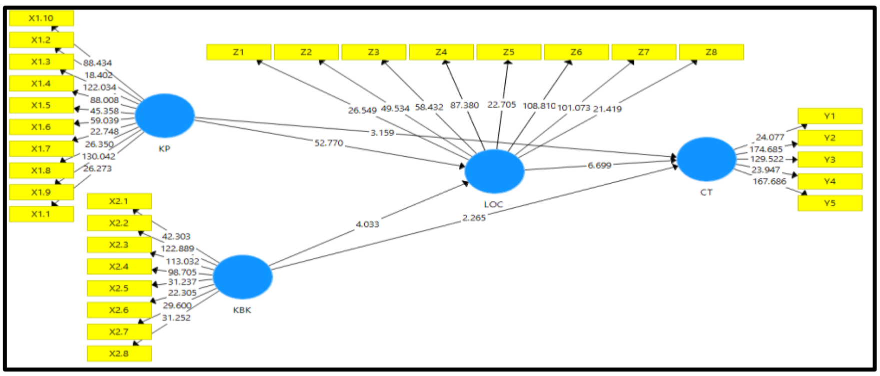

Figure 1. Structural Model

Figure 1 presents the structural model illustrating the relationships among pedagogical competence (KP), scientific capability (KBK), locus of control (LOC), and computational thinking (CT). KP and KBK are modeled as exogenous variables that directly influence CT and indirectly influence CT through LOC as a mediating variable. The path coefficients and t-values displayed on the arrows indicate that KP has a strong and significant effect on LOC and CT, while KBK also significantly affects both LOC and CT, although with smaller coefficients. LOC, in turn, shows a significant positive effect on CT, confirming its mediating role in the model. Each latent construct is measured reflectively by multiple indicators (e.g., X1.1–X1.11 for KP, X2.1–X2.8 for KBK, Z1–Z8 for LOC, and Y1–Y5 for CT), with high outer loadings indicating good convergent validity. Overall, the structural model demonstrates that pedagogical competence and scientific capability contribute to computational thinking both directly and indirectly through the enhancement of students' locus of control.

The findings of H1-H5 align with those of Sriwinarti et al. (2022) in Indonesia, where pedagogy enhanced CT via real-world connections. However, the partial LOC mediation (H6-H7) is unique, contrasting with Western studies without mediation (Bower *et al.*, 2017), likely due to the dominance of external LOC in Indonesia's collectivist culture. The first finding shows that pedagogical competence significantly affects computational thinking among students in Indonesia, confirming previous studies on this theme (Sriwinarti *et al.*, 2022; Magnaye, 2022). The finding indicates that when educators have higher pedagogical competence, the computational thinking of students is greater, suggesting that pedagogical competence enables educators to design learning experiences that are relevant to their daily lives. In addition, it helps students see the connection between computational thinking and real-world situations, making it more interesting and meaningful. The results of this research serve as a basis for designing learning strategies that encourage increased pedagogical capability, which in turn can improve students' abilities in computational thinking.

In addition to affecting computational thinking, pedagogical competence has a significant effect on locus of control, providing implications for the understanding of individual psychology and education. This finding supports some preliminary studies that reflected a significant relationship between individual characteristics related to understanding, pedagogical competency, and locus of control (Ghani *et al.*, 2022; Mwasiaji *et al.*, 2022). Locus of control indicates that individuals who have a high level of pedagogical capability tend to have a strong sense of control over situations in students' lives. Students will be more likely to feel that they can influence outcomes in a variety of contexts. The finding raises the question of whether educators can consider the importance of developing students' pedagogical capabilities as part of student education.

The linkage between scientific capability and computational thinking has been confirmed by some studies on this theme (Bahena-Álvarez, Cordón-Pozo, & Delgado-Cruz, 2019; Juanamasta *et al.*, 2019). This result highlights the importance of scientific field capabilities in developing computational thinking abilities. For instance, Bahena-Álvarez *et al.* (2019) emphasized that understanding scientific concepts and theories in certain scientific fields can help individuals develop a deeper understanding of concepts related to computational thinking. This is important in efforts to increase digital literacy and computational problem-solving abilities. These findings can be a basis for curriculum designers to include relevant scientific education elements in computing learning programs. Integrating scientific capabilities into the computing curriculum can help students relate computing concepts to the scientific context they are studying.

This study also shows that scientific capability has a significant effect on locus of control. This result reflects the importance of scientific field capabilities in influencing individual views about control in students' lives (Bahena-Álvarez *et al*., 2019; Juanamasta *et al*., 2019; Solarte-Montufar *et al*., 2021). In particular, the insightful abilities of students as candidates for educators in Society 5.0 must be able to become educators who can motivate their students to be ready to enter the challenges of the world in the 5.0 era. As previously mentioned, in Society 5.0, the world of education plays an important role in improving the quality of human resources. Consider locus of control as a factor that influences how individuals respond to and deal with situations in their lives. These findings indicate that the level of scientific field capability can play a role in shaping a person's locus of control.

The relationship between locus of control and computational thinking shows a robust link. Locus of control is needed to regulate student decision-making processes and strengthen self-directed learning. Individuals tend to make decisions based on their perceived internal capacities as well as available opportunities (Ajzen, 2002; Hsiung, 2018; Smith *et al*., 1995). The empirical findings reflect the importance of individuals' beliefs about control in shaping their computational thinking abilities. Scholars in psychology and human behavior argue that locus of control influences how individuals respond to challenges, persist in the face of difficulty, and engage in problem-solving processes. In this context, locus of control contributes to shaping structured, analytical, and reflective thinking patterns that are central to computational thinking, including decomposition, abstraction, and algorithmic reasoning. Individuals with a stronger internal locus of control tend to be more autonomous, proactive, resilient, and confident in managing complex tasks. Such characteristics are essential in learning environments that demand iterative problem solving and logical precision. In a technology-driven world of work, where data literacy and systematic reasoning are increasingly required, computational thinking becomes a strategic competence, and an internal locus of control serves as a psychological foundation that sustains motivation, adaptability, and continuous skill development (Hsiung, 2018; Smith *et al*., 1995).

In addition to directly affecting computational thinking, locus of control can play a role as mediator in the relationship between pedagogical competence and computational thinking. Psychologists and educational scholars recognize that the complexity of the relationship between individual characteristics, such as pedagogical competence and locus of control, can influence how individuals develop computational thinking skills. A preliminary study by Ghani et al. (2022) emphasized that the thinking patterns that computers usually use, if applied in everyday life, humans can solve increasingly complex problems in Society 5.0. All stages contained in this method can be applied in the teaching and learning process. However, each student's thinking process is different in solving problems (Marchetti, 2021). For this reason, an approach must be created that can make students enthusiastic in learning to solve problems.

The last finding shows a significant mediator role of locus of control in the relationship between scientific capability and computational thinking, providing important insights into understanding the complex dynamics between individual characteristics and computational thinking abilities. Scientific capability allows individuals to analyze complex problems, understand what the problem is, and develop appropriate solutions. This means that with computational thinking, students can present solutions in a way that can be understood by computers, humans, or both (Magnaye, 2022; Sriwinarti *et al*., 2022; Sukamto *et al*., 2019). The finding is relevant to the development of computing literacy. Educators can consider how increasing students' scientific capabilities can support the development of locus of control that supports better computational thinking skills. In the context of developing computational thinking skills, it is important to understand how these factors are interconnected and how they can influence an individual's learning and computational thinking.

CONCLUSION

This study concludes that pedagogical competence and scientific capability are critical determinants of computational thinking among Indonesian pre-service economics teachers, with locus of control functioning as a significant partial mediator. The findings indicate that while instructional and scientific competencies directly enhance computational thinking, their impact becomes stronger when students possess a strong internal belief in their ability to control learning outcomes. This underscores the integration of professional competence and psychological agency as a combined foundation for developing higher-order thinking skills in the context of Society 5.0 and digital-era education. The study contributes theoretically by linking competence-based and psychological perspectives, and practically by providing evidence-based guidance for strengthening computational thinking in teacher education.

Practically, these findings suggest that professional development programs should systematically integrate computational thinking strategies within pedagogical training while simultaneously fostering students' internal locus of control. At the instructional level, lecturers may implement Problem-Based Learning integrated with computational thinking (PBL-CT) supported by structured LOC assessment. At the teacher education level, Computational Thinking courses can be incorporated into PPG/PGS curricula to reinforce analytical competence. At the policy level, integrating CT-LOC components into the 2026 Economics PPG module within the Independent Curriculum framework would provide a strategic pathway for enhancing the pedagogical readiness and cognitive resilience of future educators. Future studies should expand geographical coverage and examine additional cognitive, motivational, and contextual variables to further refine the explanatory model of computational thinking development.

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