JISAE
https://doi.org/10.21009/JISAE
JISAE (Journal of Indonesian Student Assessment and Evaluation)
ISSN : P-ISSN: 2442-4919 | E-ISSN: 2597-8934
Website : http://journal.unj.ac.id/unj/index.php/jisae
Vol 12 No 1 (2026)

Measurement Invariance and Latent Mean Differences in Computational Thinking, Cultural Insight, and Numeracy Skills among Thai and Indonesian University Students

Afifi Lateh[1]
Prince of Songkla University

Yeni Rakhmawati[2]
Universitas Negeri Yogyakarta

Meechai Wongdaeng[3]
Prince of Songkla University

Chatthida Yukong[4]
Prince of Songkla University

Tawatchai Sritep[5]
Prince of Songkla University

Mohammad Archi Maulyda[6]
Universitas Mataram

Nawang Sulistyani[7]
Universitas Muhammadiyah Malang

Address for Correspondence:
[1]afifi.l@psu.ac.th

ABSTRACT
This study examines the measurement structure and cross-national differences of university students' computational thinking, cultural insight, and numeracy skills in Thailand and Indonesia. It has 624 respondents including 338 Thai and 286 Indonesian undergraduate students. Data were analysed using the multi-group confirmatory factor analysis to test for measurement invariance between both national groups prior to latent means comparison. The results showed that the three-factor measurement model yielded an acceptable fit to the data. Tests of measurement invariance supported configural and metric invariance, with partial scalar invariance found between the two groups. Cross-national differences were significant according to latent mean comparisons. Thai students showed more computational thinking and cultural insight, while Indonesian students displayed better numeracy skills. The results show the need for analytical, intercultural and quantitative skills in higher education educational systems to channel the development of future generations into effective solutions.

Keywords:
Computational thinking; Cultural insight; Numeracy skills; Measurement invariance; Cross-national comparison

INTRODUCTION

Higher education systems are responding to a world that is shifting at an increasing rate — as technology moves more quickly, global connections grow stronger and interconnected problems emerge in the twenty-first century. Universities are no longer responsible only for transmitting disciplinary knowledge, but also preparing students with a multitude of skills that enable them to think critically, tackle complex problems, and communicate effectively in diverse cultural contexts (OECD, 2019; UNESCO, 2021). Computational thinking, cultural insight and numeracy skills are just some of the competencies identified as key capabilities in a globalised knowledge economy that increasingly rewards digitalisation.

Over the past few years, computational thinking has received considerable attention as a foundational cognitive framework to tackle problems of any kind in the digital age. Although initial articulations focused on the processes through which it was manifested (i.e., decomposition, abstraction, algorithmic thinking), more recent work has suggested that computational thinking is a valuable skill-set across disciplines (Shute et al., 2017; Denning, 2017). This is supported by more recent empirical work that suggests the incorporation of computational thinking within higher education benefits students in both technical and nontechnical content areas such as analytical reasoning, creativity, and problem-solving performance (Tang et al., 2020; Lockwood & Mooney, 2018). Consequently, computational thinking is now widespread in curricula around the world as a necessary element within twenty-first century competencies.

In addition to analytical skills, cultural insight has emerged as an essential competency in modern higher education. Because students will be learning in increasingly multicultural environments, they need to be able to make sense of cultural differences and respond appropriately. Recent studies highlight the fact that cultural insight goes beyond communication to encompass collaboration, adaptability and global citizenship (Deardorff, 2020; Matsumoto & Hwang, 2019). On the other hand, new educational environments that foster interaction and people working together can be highly effective in increasing students' cultural awareness and intercultural sensitivity (Hargreaves & O'Connor, 2018).

It is relevant to note the emergence of collaborative school culture with shared aims, mutual trust and normative attitudes toward joint learning in educational institutions. Modern research shows that social solidarity, and higher cognitive skills like reflection, creativity, intercultural understanding are facilitated with collaborative spaces (Fullan et al., 2020; Hargreaves & O'Connor, 2018). Such ecosystems offer meaningful opportunities for students to interact with diverse viewpoints and thus develop both cognitive and socio-cultural competencies.

A second critical dimension of student capacity is numeracy skill, or numeracy — that is, the ability to understand and use quantitative information effectively. Recent studies point to the key role of numeracy for data-informed decision making, information literacy and risk appraisal (Peters, 2020). Numeracy in higher education has continually been correlated with academic learning, scientific literacy, and the ability to solve problems across data-rich environments.

The need for these competencies is especially felt in Southeast Asia, where higher education systems are undergoing major transformations to consolidate global competitiveness and digital readiness. Reforms in countries across the region have focused on fostering analytical ways of thinking, cultural competence and digital literacy among students (UNESCO, 2021). But past studies have tended to consider computational thinking, cultural competence, and numeracy in isolation rather than as integrated dimensions of student development.

As a matter of fact, complex problems in the real world demand that individuals use many competencies at once. Whether such challenges are overcome through analytical reasoning backed by computational thinking, interpretation of quantitative data facilitated by numeracy skills or effective collaboration across cultural contexts grounded in cultural insight. We might therefore gain richer insights into how students' cognitive and intercultural capacities develop by understanding how these competencies coexist in individuals. A second overarching problem is cross-national variation. Differential curriculum design, pedagogical practices and environments may be determinants regarding how students acquire these competencies (OECD, 2019). Comparative research can thus inform us on how educational systems structure student outcomes. Nevertheless, empirical studies on these competencies in conjunction with each other across countries are still limited particularly in Southeast Asian higher education contexts.

Due to the potential differences in responding across groups in cross-national studies, measurement invariance is crucial for ensuring that constructs are interpreted similarly. In the absence of such equivalence, differences observed may be measurement artifacts rather than substantive (Putnick & Bornstein, 2016; Davidov et al., 2018). Establishing measurement invariance is therefore a prerequisite for valid comparisons across groups. Previous studies have examined computational thinking, cultural insight, and numeracy skills separately, but limited research has tested whether these constructs are measured equivalently across Southeast Asian countries. In response to these gaps, the current study aims at exploring computational thinking, cultural insight and numeracy skills of university students in a cross-national setup. In particular, it examines the measurement invariance of these constructs across Thailand and Indonesia using multi-group confirmatory factor analysis, followed by comparisons of latent means. The study adds to the growing field of comparative education research and provides insights into how the four key competencies develop at different educational settings in Southeast Asia by combining these approaches.

This study addresses three research questions: whether the measurement model of computational thinking, cultural insight, and numeracy skills demonstrates an acceptable fit among university students; whether the measurement structure of these three constructs is invariant across students from Thailand and Indonesia; and whether significant latent mean differences exist in computational thinking, cultural insight, and numeracy skills between students from the two countries.

METHOD

Participants were university students from Thailand and Indonesia. A total of 338 and 286 students were from each country respectively (total number = 624). The sample size was relatively large and balanced across the two national groups providing adequate statistical power for multi-group structural equation modelling analyses (Kline, 2016). The study included measurements for three latent constructs: computational thinking – the students' capabilities in creativity, algorithmic thinking, cooperativity, and problem solving. Items were rated by respondents on a four-point Likert-type scale, from 1 (strongly disagree) to 4 (strongly agree). Higher scores denote a greater ability in computational thinking. Participants' computational thinking was adapted from Junpho et al., (2022). The average reliability coefficient was 0.86 from the instrument. Details are presented in Table 1.

Cultural insight in this study refers to the students' ability to understand, interpret, and respond to social interactions and learning environments within culturally diverse contexts. It encompasses awareness of cultural differences, sensitivity to interpersonal dynamics, and the capacity to engage collaboratively across different cultural settings. This survey is based on the Collaborative School Culture Survey (CSCS) by Gumuseli and Eryilmaz (2011). While the original instrument was meant to explore collaborative dimensions in school culture, these underlying dimensions—Professional Development, Collegial Support, Collaborative Leadership, Teacher Collaboration, Learning Partnership and Unity of Purpose—signal patterns of social interaction, shared beliefs and collective engagement that are strongly connected to intercultural awareness and cultural interpretation within education. The items were contextually customized from school-based organizational contexts to pre-service teachers' higher education learning environments in Thailand and Indonesia for the purpose of this study. The adaptation was not intended to measure school culture as such, but rather to show how the students experienced, interpreted and interacted with their cultural ecologies in these contexts. For each item, a four-point Likert scale (1–4) was used; higher scores indicate more cultural awareness and intercultural understanding. The reliability coefficient of the instrument was 0.89 on average. Details are presented in Table 2.

Tabel 1. Computational Thinking Scale

No	Dimension	Amount	Example
1	Creativity	6	I can discover new ways to solve problems using technology
2	Algorithmic thinking	6	I can construct logical steps to solve problems
3	Cooperativity	4	I can collaborate with others to solve computational problems
4	Critical thinking	4	I can actively contribute to a team in addressing technological challenges

5	Problem solving	3	I regularly seek references or additional resources to aid in problem-solving
	Total	**23**	

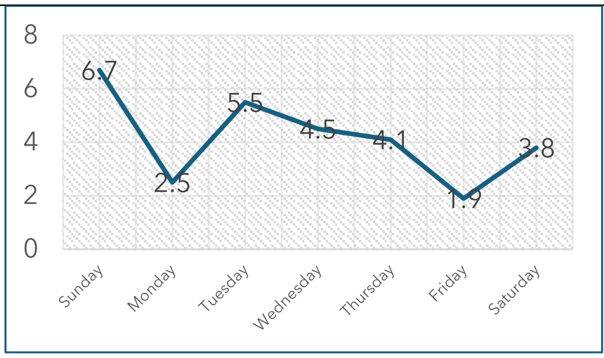
Tabel 2. Collaborative School Culture Survey (CSCS)

No	Dimension	Amount	Example
1	Professional Development	6	I regularly participate in training to enhance my teaching skills.
2	Collegial Support	4	I felt supported by my friends when I faced challenges in teaching.
3	Collaborative Leadership	11	I felt heard when I presented my feedback to administrators and faculty.
4	Teacher Collaboration	6	Friends in the faculty often share teaching materials and learning strategies with each other.
5	Learning Partnership	4	My faculty fosters strong relationships with parents to support students' learning.
6	Unity Of Purpose	5	We are committed to improving students' academic performance.
Total		**36**	

The numeracy skill was measured by means of objective items in which the respondents selected the right answer from several options to questions of numeracy. Each question scored 1 when correctly answered and 0 when incorrectly answered, thus coding dichotomously. The entire direct scoring process is objective, allowing interpretation of the students' quantitative reasoning ability. The numeracy test for teachers was borrowed from Australian Council for Educational Research, (2015) in this study. The test items were modified to ensure an appropriate cultural insight, computational thinking, and educational contexts in Indonesia and Thailand The instrument consists of three dimensions (Numbers and Algebra; Measurement and Geometry; Statistics and Probability) which consists of a total of 10 item. The mean reliability coefficient of this instrument was 0.92. Details of the numeracy test are presented in Table 3.

Tabel 3. Numeracy Skills Scale

No	Dimension	Amount	Example
1	Deep inquiry of mathematic	2	Percentage Calculation: A shirt originally priced at $80 is on sale with a 25% discount. What is the sale price of the shirt?
2	Mathematical content knowledge	3	If you invest $1,000 at an annual interest rate of 5% for 3 years, how much interest will you earn?
3	Mathematical engagement	2	Probability: A bag contains 4 red balls, 5 blue balls, and 6 green balls. What is the probability of randomly selecting a blue ball?
4	Mathematical knowledge in everyday life	3	A line graph shows the temperature over a week.

		 On which day did the temperature reach its highest point?
Total	**10**	

The variables in the study were cross-culturally adapted from the original questionnaires, as participants come from two different countries, Thailand and Indonesia. Thai and Indonesian versions of original English-version instruments, where relevant, were translated to ensure conceptual consistency and linguistic clarity across contexts as well. Bilingual experts in education and intercultural studies examined the translated instruments before disseminating them to determine if the items were appropriate, clear, and culturally relevant for pre-service teachers from either country. Five experts assessed all the translated instruments using Item-Objective Congruence (IOC), with all items exceeding a cut-off of .50. The instruments were then piloted with 30 pre-service teachers to test for item clarity, comprehensibility and contextual appropriateness prior to implementation of the instruments in the main study.

Data were analysed in the R statistical environment using the lavaan package for structural equation modelling. The analysis carried out in four stages.

Stage 1: Descriptive Statistics

Descriptive statistics (mean ± standard deviation) for every latent construct were calculated in order to investigate the distribution of our study variables.

Stage 2: Measurement Model

To test the measurement model of these three latent constructs, a confirmatory factor analysis was performed. Fit of the models was assessed using widely accepted indices such as Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR). According to the recommendations of Rex B. Kline, standard indicators of acceptable model fit are CFI and TLI values close to or above. 90, RMSEA below. 08, and SRMR below. 08 (Kline, 2016).

Stage 3: Measurement Invariance

Multi-group confirmatory factor analysis was performed using the recommended hierarchical approach of David L. Putnick and Marc H. Bornstein to whether the measurement structure was equivalent between Thailand and Indonesia (Putnick & Bornstein, 2016). We tested the following invariance levels: 1) Configural invariance; 2) Metric invariance; and 3) Scalar invariance. We compared models based on changes in model fit indices, specifically ΔCFI with a decrease of ≤. 01 indicates acceptable invariance. The NS items were scored as dichotomous (correct = 1, incorrect = 0). Accordingly, CFA and measurement invariance analyses were estimated with the WLSMV estimator suitable for models consisting of categorical indicators.

Stage 4: Latent Mean Comparison

After determining that scalar invariance was achieved, latent mean differences were compared between Thailand and Indonesia. In the current analysis, we fixed the latent means for the reference group to zero which allowed us to estimate and interpret the latent means of each wave for comparison group relative to those in reference group.

RESULTS AND DISCUSSION

Descriptive statistics are shown for the pooled sample (N = 624) as follows: Computational thinking, M = 74.79, SD = 11.60; cultural insight, M = 118.16, SD = 18.29; and numeracy skills, M = 8.24, SD = 2.16. Visual inspection of skewness and kurtosis suggested that computational thinking (skewness = –0.74, kurtosis = 1.56), cultural insight (skewness = −1.08, kurtosis = 2.29), and numeracy skills (skewness = −1.87, kurtosis = 2.83) all showed acceptable distributional properties as to approximate normality for subsequent analyses. Pearson correlation analyses indicated that computational thinking and cultural insight were strongly correlated (r = .83, p <. 001). In contrast, computational thinking (r = .07, p = .20) and cultural insight (r = .05, p = .22) were not significantly related to numeracy skills. Despite the relatively high correlation between computational thinking and cultural insight, it did not surpass the often mentioned multicollinearity threshold of .85-.90. Furthermore, the two constructs are theoretically distinct, representing the social-cultural aspects versus cognitive approach to problem solving.

1. Measurement Model

Confirmatory factor analysis was performed to test the three factors measurement model, which included aspects of computational thinking, cultural insight and numeracy skills. The results suggested that the model demonstrated a marginally acceptable fit to the data according to established model fit criteria. All model fit indices indicated that the three-latent-variable measurement model fits the observed data well and, thus, supports the construct validity of those variables. As the measurement model showed acceptable fit, we subsequently performed a multigroup confirmatory factor analysis to test for measurement invariance across countries. Detailed in table 4.

Table 4. Model Fit Indices for the Measurement Model

Model	CFI	TLI	RMSEA	SRMR
Three-factor measurement model	.831	.825	.061	.056

2. Measurement Invariance

To test whether the measurement structure of the constructs was equivalent across students from Thailand and Indonesia, a multi-group confirmatory factor analysis was performed. With the aim of interpreting constructs comparably among different country contexts, measurement invariance across countries was tested through multigroup confirmatory factor analysis. We examined three more restrictive models, configural, metric and scalar invariance. Within this model, the configural invariance model—the least restrictive where parameters can take on any value across groups while retaining the same factor structure— exhibited acceptable fit (CFI = .801, TLI = .794, RMSEA = .067, SRMR = .060). The result suggests that the above-mentioned three-factor structure comprising computational thinking, cultural insight and numeracy skills in this study was essentially similar between Thai and Indonesian participants.

Subsequently, metric invariance was assessed by constraining factor loadings to be equal between groups. The metric model also showed adequate fit (CFI = .794, RMSEA = .067, SRMR = .078). Relative to the configural model, the improvement in model fit was trivial (ΔCFI = .007), suggesting that the factor loadings were fairly consistent across countries. Then, scalar invariance was tested by constraining items intercepts to equal across groups. The fit for the scalar model also significantly deteriorated (CFI = .773, RMSEA = .070, SRMR = .082), and change in CFI of .021, indicating the possibility of full scalar invariance was not supported.

To address this issue, score tests were examined to identify non-invariant intercepts across the Thai and Indonesian groups. Results showed that some items (CT18, CI1, CI9, CI25, CI27 and CI31) exhibited strong intercept non-invariance and were released as needed for attaining partial scalar invariance. Such items may align with linguistic interpretation differences, cultural educational aspects or specific collaborative and intercultural interaction practices between the two national contexts. In particular, some cultural insight items were adapted from dimensions of collaborative school culture that could be differently interpreted or understood as a function of sociocultural norms, communication styles and educational environments in Thailand and Indonesia. Equally, the non-invariant Computational Thinking item (CT18) could indicate contextual differences in technology-related learning experiences and what had been taught between students in both countries.

By freeing these intercepts, the partial scalar invariance model fit improved (CFI = .780, RMSEA = .069, SRMR = .080). The change in CFI from the metric invariance model (ΔCFI = .014) was marginally above the usually recommended limit, previous research has indicated partial scalar invariance is acceptable when only a few parameters were freed and the overall measurement structure was consistent across groups. Thus, the findings have substantial evidence for cross country comparability and suitable comparison of latent constructs between Thailand and Indonesia. Detailed in Table 5.

Table 5. Measurement Invariance Across Countries (Thailand vs. Indonesia)

Model	**χ^2**	**df**	**CFI**	**TLI**	**RMSEA**	**SRMR**	**ΔCFI**
Configural invariance	10684	4548	.801	.794	.067	.060	–
Metric invariance	10947	4614	.794	.791	.067	.078	.007
Scalar invariance	11655	4680	.773	.773	.070	.082	.021
Partial scalar invariance	–	–	.780	–	.069	.080	.014

ΔCFI = change in Comparative Fit Index relative to the preceding model.

3. Latent Mean Comparison

Latent mean comparisons between Thailand and Indonesia were performed following the establishment of partial scalar invariance. Statistically significant differences were found between the two groups. When the comparison group was set to Thailand (latent mean = 0), The results indicate that the students from Indonesia performed better in numeracy skills, whereas those from Thailand score higher in both computational thinking and cultural insight.

Results showed notable cross-country variations on all three constructs. Indonesian participants showed much lower levels of cultural insight than Thai participants (Estimate = −.124, SE = .031, z = −4.003, p < .001). Likewise, the latent mean of computational thinking was significantly lower in Indonesian participants (Estimate = −.175, SE = .041, z = −4.288, p < .001). Participants from Indonesia, on the other hand, had significantly greater levels of numeracy skills compared with participants from Thailand (Estimate = .089, SE = .020, z = 4.446, p < .001). These findings reveal that there are significant differences in the distribution of these competences between the two national contexts. Detailed in table 6.

Table 6. Latent Mean Differences Between Thailand and Indonesia

Construct	**Thailand (Reference)**	**Indonesia**	**SE**	**Z**	**p**
Computational thinking	0	-.175	.041	-4.288	< .001
Cultural insight	0	-.124	.031	-4.003	< .001
Numeracy skills	0	.089	.020	4.446	< .001

The adequacy of the three-factor model was supported through confirmatory factor analysis, providing evidence that computational thinking, cultural insight and numeracy skills are theoretically distinct but related dimensions of students' competencies. This suggests the multidimensional nature of twenty-first century skills in higher education, as cognitive and analytical abilities are also considered to be an integrated element along with intercultural skills instead of distinct constructs (OECD, 2019; Shute et al., 2017). Hence, these competencies development has also been widely noted to be co-developed in integrated learning experiences (Tang et al., 2020) particularly in digitally enriched and globally-oriented education environments.

A multi-group comparison across countries depicted strong psychometric equivalence between Thailand and Indonesia. If configural and metric invariance is established, this implies that the underlying factor structure of the model (e.g., which latent constructs are common across groups) and the relationships between observed indicators and their associated latent constructs are similar across groups. Full scalar invariance was not achieved, yet partial scalar invariance was retained after releasing a number of non-invariant intercepts. This implies that the vast majority of items operate in a similar fashion across contexts, thus enabling meaningful comparisons in terms of latent means. But, especially in cross-cultural research, demonstrating such equivalence is critical to ensuring that actual differences observed in a given measure reflect substantive rather than measurement bias (Putnick & Bornstein, 2016; Davidov et al., 2018).

The cross-national differences in the latent means were statistically significant; Thai participants had higher levels of computational thinking and cultural insight while Indonesian participants showed better numeracy. As with the previous one, these findings should be interpreted cautiously because they may indicate tendencies in the current sample but not necessarily features of nations.

Higher computing thinking among the Thai, could be related to the effort recently made for digital literacy and coding in the education system (UNESCO, 2021). Prior studies, institutions have served as the primary vehicle in an effort to develop computational thinking and higher-order learning skills via problem-based and blended methodology in Thailand classrooms (Sukkamart et al., 2025). Likewise, the comparatively high cultural understanding seen among Thai participants may result from learning environments that promote collaborative learning, intercultural dialogue and student interaction (Jarusawat, 2020). These environments have been associated with the acquisition of intercultural knowledge and global citizenship competencies (Hargreaves & O'Connor, 2018; Fullan et al., 2020).

By comparison, the more favourable numeracy performance of Indonesian participants could be related to curricular and instructional emphases on mathematics and quantitative reasoning in some Indonesian learning contexts. Specifically, previous studies have indicated that structured mathematics lessons and problem-based learning approaches may assist Indonesian students to develop skills relating to mathematical literacy and reasoning (Priatna et al., 2020; Gufron et al., 2025). Another study has also emphasized the contributions of cognitive and technology-mediated learning methods to enhancing competencies associated with numeracy in Indonesia (Nur et al., 2021).

Importantly, these interpretations should be viewed not as immutable national differences but rather as contextual impressions or tendencies that may reflect a variety of institution- and learner-group differences in terms of curriculum, instructional practices, education experiences and sociocultural environments. Together, these findings highlight the need to cultivate countervailing capabilities that bridge computational thinking, cultural sensitivity and numeracy in order to prepare students for a world of deepening complexity and intersectionality.

A practical implication of the results is that higher education institutions should integrate all three areas to provide a greater emphasis on competency development rather than treating computational, cultural, and quantitative competencies as separate domains. A fresh approach is instead for universities to abandon the artificial distinction between humanities and STEM (science, technology, engineering, and mathematics), long understood as critical fields of knowledge that develop analytical reasoning, intercultural understanding and numeracy in isolation from each other.

In particular, Thai universities can capitalize on their strengths in using semantically oriented learning experiences across disciplines by emphasizing activity-driven mathematics through quantitative reasoning and creating supportive interdisciplinary and technology environments. Meanwhile, in Indonesia, it could be improved by more frequent digital problem-solving practices and greater intercultural learning opportunities through the use of team work approach and/or internationalisation. Regionally, university students from both countries can gain more from collaborating on joint programs based on shared study goals which integrate digital, cultural and quantitative expertise. Visiting interchange undoubtedly grants many students the possibility to partake in authentic intercultural, interdisciplinary opportunities in diverse educational contexts utilizing technology.

To provide a clearer overview of the findings, Table 7 summarizes the main results and their educational interpretations.

Table 7. Summary of Key Findings and Interpretations

Aspect	Main Finding	Interpretation
Measurement model	The three-factor model demonstrated acceptable model fit	Computational thinking, cultural insight, and numeracy skills represent distinct but related competencies.
Measurement invariance	Partial scalar invariance was achieved across Thai and Indonesian groups.	Cross-national comparisons were considered acceptable despite several non-invariant intercepts.
Computational thinking	Thai students reported relatively higher levels of computational thinking.	The findings may reflect greater exposure to digital learning, coding activities, and technology-integrated instruction.
Cultural insight	Thai students demonstrated relatively higher cultural insight.	Collaborative and intercultural learning environments may support intercultural awareness and social understanding.
Numeracy skills	Indonesian students demonstrated relatively higher numeracy skills.	Structured mathematics instruction and quantitative learning experiences may contribute to stronger numeracy performance.

CONCLUSION

The study investigated the measurement structure of computational thinking, cultural insight, and numeracy skills of university students in Thailand and Indonesia. Based on multi-group confirmatory factor analysis, the results showed that the measurement model reached an acceptable fit for cross-national invariance and allowed for meaningful between-nation comparisons of both national groups. The latent mean analysis also showed that students in Thailand reported significantly higher competencies in computational thinking and cultural insight while students in Indonesia significantly higher numeracy skills. This may indicate that types of educational experiences and environments lead to diverse pathways to competency development across contexts.

This also has important implications for higher education in Southeast Asia. Instead, universities must go beyond teaching one skill at a time and give students interdisciplinary learning environments that bring together digital, intercultural, and quantitative competencies. This interplay between interconnected competencies could better equip university students to face new and complex educational, technological, and global challenges.

Several limitations of this study should be acknowledged. First, This included the fact that participants were only recruited from Thailand and Indonesia, leading to limitations in between-country comparisons and generalizability of findings outside Southeast Asia, or at an international level. Future study need more extensive cross-nation and also instructional settings to offer richer cross-cultural comparisons. Secondly, this study is cross-sectional in design so therefore it cannot conduct causal conclusions about the progression of computational thinking, cultural insight and numeracy development over time. Such longitudinal analysis may illuminate how these skills develop over the course of disparate educational experiences.

Third, some measures were based on self-reported responses—especially for computational thinking and cultural insight—which can be affected by social desirability, self-perception bias, or different response styles across cultures. Additional future studies that incorporate performance-based assessment or mixed-method approaches will enhance construct validity. Moreover, while partial scalar invariance was observed, full scalar invariance was not supported between the Thai and Indonesian groups. This means that some items may still operate differently in different cultural contexts because of language translation or sociocultural factors. Thus, more testing and fine-tuning to ensure cross-national measurement equivalence of the culturally adapted instruments is advisable in future research.

REFERENCE

Australian Council for Educational Research. (2015). *Literacy and numeracy test for initial teacher education students*(Vol. 1).

Davidov, E., Schmidt, P., Billiet, J., & Meuleman, B. (2018). *Cross-cultural analysis: Methods and applications* (2nd ed.). Routledge.

Deardorff, D. K. (2020). *Manual for developing intercultural competencies: Story circles*. Routledge.

Denning, P. J. (2017). Remaining trouble spots with computational thinking. *Communications of the ACM, 60*(6), 33–39.

Fullan, M., Quinn, J., & McEachen, J. (2020). *Deep learning: Engage the world change the world*. Corwin.

Gufron, A., Hidayah, I., Prabowo, A., Wardono, W., & Mariani, S. (2025). The effectiveness of problem-based learning in enhancing mathematical literacy: A systematic meta-analysis. *Jurnal Elemen, 11*(2), 483–501.

Gumuseli, A. L., & Erylmaz, A. (2011). The measurement of collaborative school culture (CSC) on Turkish schools. *New Horizons in Education, 59*(2), 13–26.

Hargreaves, A., & O'Connor, M. T. (2018). *Collaborative professionalism: Teaching together means learning for all*. SAGE.

Jarusawat, P. (2020). Students' satisfaction of the information literacy course using collaborative learning and collaborative teaching approaches to enhance the 21st century skills. *Chiang Mai University Journal of Humanities, 21*(3), 43–62.

Junpho, M., Songsriwittaya, A., & Tep, P. (2022). Reliability and construct validity of computational thinking scale for junior high school students: Thai adaptation. *International Journal of Learning, Teaching and Educational Research, 21*(9), 154–173.

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.

Lockwood, J., & Mooney, A. (2018). Computational thinking in secondary education: Where does it fit? A systematic literary review. *International Journal of Computer Science Education in Schools, 2*, 41–60.

Matsumoto, D., & Hwang, H. C. (2019). Culture and emotion: Integrating biological universality with cultural specificity. In D. Matsumoto & H. C. Hwang (Eds.), *The handbook of culture and psychology* (2nd ed., pp. 361–398). Oxford University Press.

Nur, A. S., Marlissa, I., Kamariah, K., Palobo, M., & Ramadhani, W. P. (2021). Mathematics education research in Indonesia: A scoping review. *Jurnal Tadris Matematika, 14*(2), 154–174.

OECD. (2019). *OECD future of education and skills 2030*. OECD Publishing.

Peters, E. (2020). *Innumeracy in the wild: Misunderstanding and misusing numbers*. Oxford University Press.

Priatna, N., Lorenzia, S. A., & Widodo, S. A. (2020). STEM education at junior high school mathematics course for improving mathematical critical thinking skills. *Journal for the Education of Gifted Young Scientists, 8*(3), 1173–1184.

Putnick, D. L., & Bornstein, M. H. (2016). Measurement invariance conventions and reporting: The state of the art and future directions for psychological research. *Developmental Review, 41*, 71–90.

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142–158.

Sukkamart, A., Chachiyo, W., Chachiyo, M., Pimdee, P., Moto, S., & Tansiri, P. (2025). Enhancing computational thinking skills in Thai middle school students through problem-based blended learning approaches. *Cogent Education, 12*(1), 2445951.

Tang, X., Yin, Y., Lin, Q., Hadad, R., & Zhai, X. (2020). Assessing computational thinking: A systematic review of empirical studies. *Journal of Educational Computing Research, 58*(2), 369–393.

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. UNESCO.