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Global Education: Computational thinking's role and relationships explored

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Abstract
This research investigates the correlation between students' Computational Thinking Skills (CTS) and their performance on the Computational Thinking Test (CTT) in the context of 21st-century education, aiming to align the Malaysian education system with global standards. Emphasizing creativity, critical thinking, and problem-solving, the study, conducted with Form 3 (15 years old) students at a local public secondary school, reveals significant correlations between CTT outcomes and CTS. Despite limitations, the findings underscore the importance of computational thinking skills in academic success, advocating for educational shifts to cultivate these skills for students' meaningful contributions to Malaysia's global development.

Keywords: Computational Thinking skills, Computational Thinking Test, Problem Solving

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1.0 Introduction
The Malaysian education system has undergone significant transformations to align its curriculum with the rapid evolution of technology. This adaptation is particularly critical in preparing students for the Malaysia 5.0 vision, where digital and physical spaces converge. Fostering computational thinking (CT) skills from early education stages is crucial to successfully transition into this vision. Additionally, initiatives in Science, Technology, Engineering, and Mathematics (STEM) are essential for preparing students for the demands of the 21st century (Fajrina, 2020).

Emphasizing CT and basic mathematics early on is integral to improving students' critical thinking skills. Enhanced critical thinking motivates students to tackle problems effectively, improving their CT skills and increasing engagement in STEM fields (Yin., 2020). The Malaysian Education Blueprint (MEB) 2013–2025 incorporated STEM and 21st-century education in the Standard Curriculum for Secondary Schools (SCSS), but challenges remain in fully implementing high-order thinking skills (HOTS) and CT in classrooms.

The success of a nation is tied to the capabilities of its youth. Technology plays a pivotal role in shaping the future, but challenges persist in transferring classroom-acquired knowledge, especially HOTS, to real-world situations (Howard, (2002). International assessments, like PISA, indicate fluctuations in Malaysian students' mathematics performance (Wong, 2019). The shortage of competent engineers and technicians underscores the need for a workforce equipped with problem-solving, creative thinking, and innovative skills (Nordstrom, 2011;Tracey Pieterse, 2023).

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The study emphasizes that the job market of the 21st century demands workers proficient in problem-solving, creativity, and teamwork. Computational thinking (CT) skills are crucial for generating a skilled workforce that aligns with STEM educational methods and active learning approaches. However, challenges arise in understanding and incorporating CT into the curriculum, with some misconceptions likening it to Information and Communications Technology (ICT) (Waterman,2019; Yang,2021).

Effectively integrating computational thinking requires a critical evaluation of both the competency in computational thinking and the factors influencing the resulting outcomes. Recognizing students' CT skills is essential for organizing activities that facilitate efficient CT application. This research aims to raise awareness among students and teachers about the dynamic nature of the Malaysian education system. By adapting to changing educational landscapes, Malaysia aims to produce students who remain competitive across various sectors.

The research further seeks to measure students' levels of computational thinking skills, addressing shortcomings in applying HOTS and problem-solving skills in the Malaysian educational syllabus. The researcher aims to understand the relationship between computational thinking and test performance, shedding light on potential errors made by students in CT tests. In essence, the study contributes valuable insights into the ongoing improvement of the Malaysian education system, ensuring its ability to meet the challenges of the contemporary world and produce individuals equipped with the necessary skills for success. Thus, the objectives of this study are:

i) To investigate the level of computational thinking among students.
ii) To investigate the relationship between computational thinking scale and computational thinking test scores among student
iii) To explore the errors in computational thinking tests made by students.

2.0 Literature Review

In educational contexts, students undergoing computational thinking (CT) development benefit from examples and guidance. Webb and Rosson (2013) stress the significance of scaffolded examples and simple workbooks for introducing CT concepts like problem-solving, abstraction, and computational vocabulary. Despite these efforts, challenges persist, including a lack of foundational understanding and the need for more student-centered education (Sadler, 2012).

The exploration of Computational Thinking (CT) in the following section underscores its importance in 21st-century education. According to Wing (2006), CT is a thinking model involving problem-solving, systems creation, and understanding human behavior using computer science principles. This thinking model finds applications in diverse disciplines, particularly in science and mathematics within STEM education. However, a systematic review by Tang et al. (2020) reveals gaps in CT assessment, especially in informal and non-STEM contexts. Zaharin et al. (2018) stress the role of CT skills in overcoming mental barriers.

The subsequent discussion highlights the positive impacts of Computational Thinking Skills (CTS) at both individual and societal levels. Katai et al. (2021) argue that existing courses inadequately support students' CT development, necessitating efforts to implement and acquire these skills. The importance of introducing computational thinking early to enhance cognitive skills is underscored by the role of creativity in mathematics, as emphasized by Kim, Lee & Cho (1999) and Walia (2017).

Moreover, the study emphasizes the critical role of problem-solving and critical thinking in daily life and academic pursuits. Pambudi (2018) emphasizes the need for math teachers to impart knowledge, enabling students to identify and apply mathematical concepts in problem-solving contexts. Tau han (2019) underscores that strong math grades alone do not contribute to improved mathematical reasoning, advocating for the integration of computational thinking skills early in the academic system to enhance cognitive abilities. Sian Hoon (2020) reported that it is crucial to engage students in a classroom activity to develop their mathematical thinking skills.

In essence, computational thinking involves breaking down complex problems into smaller parts, employing algorithms, and comprises components such as decomposition, pattern recognition, abstraction, and algorithmic thinking (Rey, 2020). There is a significant overlap with mathematical thinking, which involves logical reasoning, problem-solving, and critical thinking using mathematical concepts (Su, 2015). The shared components include logical reasoning, abstraction, algorithmic thinking, pattern recognition, and problem decomposition. Overall, the skills developed in computational and mathematical thinking are transferable between the two areas, emphasizing systematic problem-solving, logical reasoning, and abstraction.

3.0 Methodology

This study utilizes a non-experimental research design that employs a quantitative method and error analysis to determine the level of computational thinking among form 3 students, as well as its relationship with the computational thinking test taken and the errors made by the students in the CT test.

3.1 Sample

The respondents of this study are seventy-three Form 3 (15 years old) students from three classes. They were selected using purposive sampling techniques for an exploration case study.

3.2 Research Instrument

The researcher has adopted the questionnaire from Özgen, Recep, & Yaşar (2017), the Computational Thinking Scales (CTS). The Computational Thinking Skills (CTS) were specifically designed to assess the extent of computational thinking abilities in students.. In this study, the questionnaire is used to measure the level of students' computational thinking and its correlation with their CT test scores. The questionnaire contains 15 items including five items for critical thinking, six items for creativity, and four items for problem statement. Students responded to a Likert-format scale with ten potential responses, ranging from 1 (Strongly Disagree) to 10 (Strongly Agree).

CT test: In this study, the instrument used was a pen and paper test consisting of 8 questions. These questions were adopted and adapted from 3 different research studies. The researcher adopted three items from Tauhan, Hoon, & Sing (2019),four items from Akgul & Kahveci (2016), and one item from Pambudi, Budayasa, & Lukito (2018). The eight items in the test were focused on critical thinking, creativity, and problem-solving.

4.0 Findings

Table 1: Grades in Mathematics Test Form 3

Grade	Frequency	Percent (%)
A (85%-100%)	2	2.74
B (70%-84%)	11	15.07
C (60%-69%)	14	19.18
D (50%-59%)	8	10.96
E (40%-48%)	33	45.21
F (0%-39%)	5	6.85
Total	**73**	**100.0**

Table 1 provides an overview of the grades obtained by Form 3 students in their most recent mathematics test. The predominant grade among students was E, constituting 45.21% (n = 33), while the least frequently attained grade was A, accounting for only 2.74% (n = 2) of respondents. The table reveals that more than 60% of students did not achieve creditable results, encompassing grade D (10.98%), grade E (45.21%), and grade F (6.85%), totaling 46 students. The remaining distribution comprises 15.07% for grade B and 19.18% for grade C.

Table 2. Mean Score of Items in Computational Thinking Scale for Critical Thinking

	Items	Mean	Std. Deviation
1	I am good at preparing regular plans regarding the solution of the complex problems	5.56	2.176
2	It is fun to try to solve the complex problems.	6.72	2.237
3	I am willing to learn challenging things.	7.08	2.109
4	I am proud of being able to think with a great precision.	7.64	2.191
5	I make use of a systematic method while comparing the options at my hand and while reaching a decision.	7.00	1.912
	Overall Critical Thinking	6.80	1.704

Table 2 presents the mean scores and standard deviations for items related to Critical Thinking in the Computational Thinking Scale (CTS). The overall mean for Critical Thinking is 6.80 (SD = 1.704), indicating a favorable response from participants. Notable items include the enjoyment of solving complex problems (Item 2), with a mean of 6.72, and the systematic method in decision-making (Item 5), with a mean of 7.00.

Table 3. Mean Score of Items in Computational Thinking Scale for Creativity

	Items	Mean	Std. Deviation
6	I like the people who are sure of most of their decisions.	7.51	2.144
7	I believe that I can solve most of the problems I face if I have sufficient amount of time and if I show effort.	7.83	2.111
8	I have a belief that I can solve the problems possible to occur when I encounter with a new situation.	6.92	2.034
9	I trust that I can apply the plan while making it to solve a problem of mine.	7.00	1.912
10	I trust my intuitions and feelings of “trueness” and “wrongness” when I approach the solution of a problem	7.07	1.937
11	When I encounter with a problem, I stop before proceeding to another subject and think over that problem.	6.28	2.192
	Overall Creativity	7.10	1.542

In Table 3, the mean scores for items related to Creativity in the CTS are detailed. The overall mean for Creativity is 7.10 (SD = 1.542), showcasing a positive inclination toward creative thinking. Notably, Item 7, indicating belief in problem-solving with sufficient time and effort, scored the highest mean of 7.83. Conversely, Item 11, reflecting a tendency to proceed to other problems without dwelling on the current one, received the lowest mean of 6.28.

Table 4. Mean Score of Items in Computational Thinking Scale for Problem Solving

	Items	Mean	Std. Deviation
12	I have problems in the demonstration of the solution of a problem in my mind.	5.49	2.634
13	I cannot apply the solution ways I plan respectively and gradually.	5.85	2.095
14	I cannot produce so many options while thinking of the possible solution ways regarding a problem.	5.51	2.360
15	I cannot develop my own ideas in the environment of cooperative learning.	6.11	2.315

Overall Problem Solving	5.74	1.848

Table 4 highlights the mean scores and standard deviations for items related to Problem Solving in the CTS. The overall mean for Problem Solving is 5.74 (SD = 1.848), indicating a comparatively lower level of agreement. Item 15, expressing difficulties in developing personal ideas in a cooperative learning environment, received the highest mean of 6.11, while Item 12, suggesting challenges in demonstrating problem solutions mentally, scored the lowest mean of 5.49.

The overall mean for CTS is 6.55 (SD = 1.204), with Creativity having the highest mean of 7.10 (SD = 1.542) and Problem Solving having the lowest mean of 5.74 (SD = 1.848). The highest individual item mean is attributed to Item 7, emphasizing confidence in problem-solving with time and effort, while the lowest mean items are associated with Problem Solving (Items 12 and 14). These findings suggest that participants exhibit higher levels of Critical Thinking and Creativity compared to Problem Solving in the context of computational thinking.

Table 5: Components included in the Computational Thinking Test (CTT).

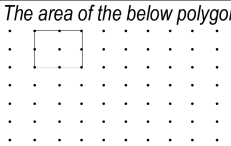
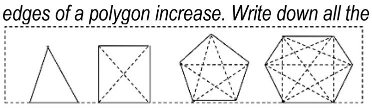
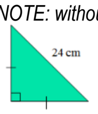
	Items	Mark
1	*The area of the below polygons equals 4-units square.*  Draw polygons whose areas equal 4 units square in the given space. Make sure the polygons you draw are not the same.	2
2	Ali is three times older than Ahmad. The sum of the two is 48. So, what are their ages?	3
3	*In the below figure, there are some polygons and diagonals belonging to them (dotted lines). Find out what properties change as the number of edges of a polygon increase. Write down all the changes you find.* 	2
4	*Write down problems the solutions of which follow the same arithmetic operations. Write as many problems as you can. First, decide on the solution and then set up questions suitable for the solution.* *Solution: 10 – 5 =*	3
5	Mr. Amir had a square plot of land with a size of 21m x 8m. A year later this land was hit by a road widening project, so Mr. Amir sold a part of this land in a corner with a right triangle shape with 6m and 8m sides with a price of RM30 per m^2. The income from the sale of the land was used by Mr. Amir to create a fence around his present land. The cost of making a fence of RM15 per meter while for the iron gate along the 4m, the cost was RM300. How much money did Mr. Amir need?	3
6	*Find the area of the isosceles right-angle triangle shown below. Please explain.* *[*NOTE: without the aid of trigonometry or Pythagoras theorem]* 	2
7	Jaspreet's and Sharanpreet's alarm clock rang at 7.30 a.m. For the remainder of the day, Jaspreet's alarm clock will ring every 45 minutes, and Sharanpreet's alarm clock will ring every one hour. What will the time be when both the alarm clocks ring together again?	3
8	*What is the next three numbers for:* 10, 40, 90, 61, 52, 63, ___, ___, ___	3
	Total	21

Table 6 Students Performance in Computational Thinking Test

	N	Mean	Std. Deviation
Computational Thinking Test (CTT)	73	8.21	2.147

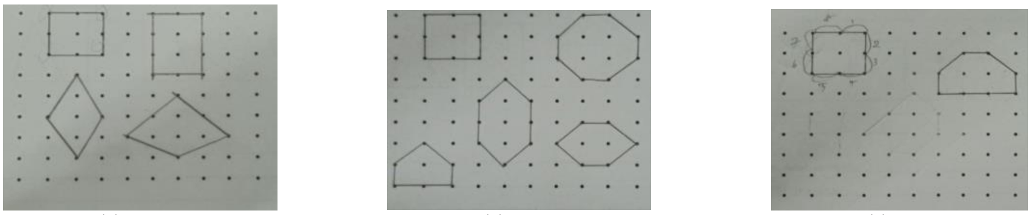
The analysis of students' performance on the Computational Thinking Test (CTT) is presented in Table 6. The mean score on the CTT is 8.21 out of a maximum score of 21, with a standard deviation of 2.147. This equates to a percentage score of 39.09%, suggesting that the overall performance is poor.

Table 7 Results of Pearson Correlation of Computational Thinking Scale (CTS) and Computational Thinking (CT) Test Score

			CTS
Pearson	CT Test Score	Correlation Coefficient	-.251*
		Sig. (2-tailed)	.034
		N	73
		N	73

The correlation between students' Computational Thinking Scale (CTS) levels and CT test scores was examined using Pearson correlation (Table 7). The analysis reveals a weak negative relationship (r = -0.251, p = 0.034) between students' CT test scores and their computational thinking scale levels. Despite the weak correlation, the relationship is statistically significant ($p < 0.05$), leading to the rejection of the null hypothesis. Consequently, it is concluded that a decrease in students' computational thinking test scores significantly correlates with an increase in their levels of computational thinking scale.

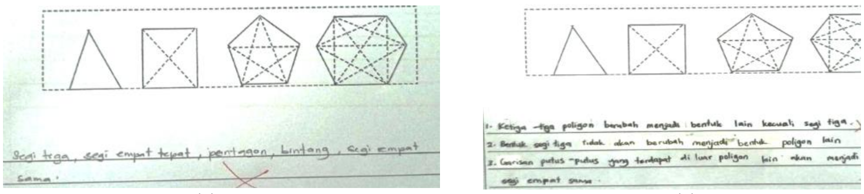
According to Akgul and Kahveci (2016), students can demonstrate their problem-solving abilities by utilizing this item to think spatially, modify shapes, and think analogically. In addition to these skills, this task requires a high degree of intuitive thinking, which is referred to as mathematically creative thinking. The results of looking at the first item in the CTT indicate that only 12 students answered correctly. Most of the correct answers depicted a rectangular shape, while only one student drew a triangle. Other responses showed students drawing various polygons in the provided answer space, some with different areas than the original question.



(a) (b) (c)

Fig. 1. (a),(b),(c) Samples of answer item 1 from the students

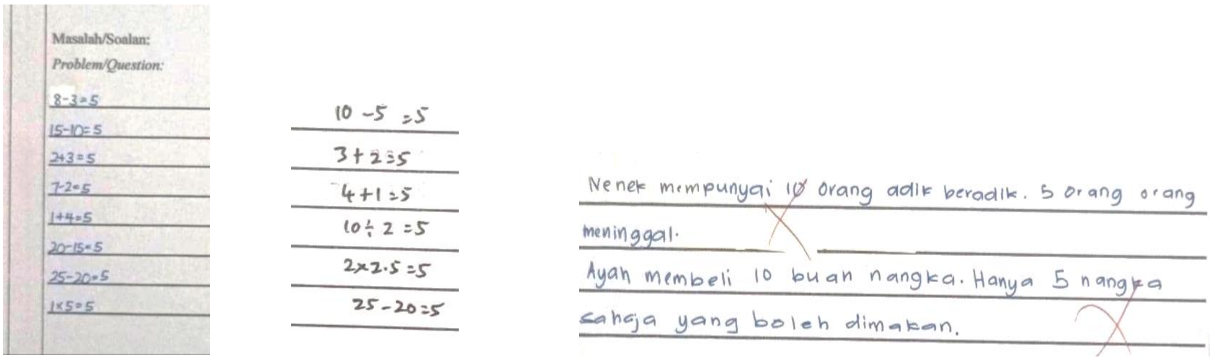
According to Akgul and Kahveci (2016), item 3 was used to assess mathematical creativity, and students were able to apply geometrical intuition through activities that involved "seeing in space" and "having the capability of seeing the end from afar." The results showed that 30 students answered incorrectly, with 17 students leaving the answer space empty. Some of the answers simply stated the names of the polygons.



(a) (b)

Fig. 2. (a),(b) Samples of answer item 3 from the students

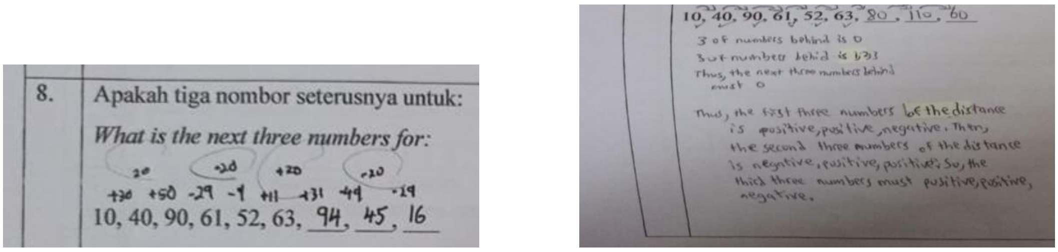
Akgul & Kahveci (2016) mentioned that students demonstrated their problem-solving, analytical, and analogical thinking skills in solving item 4. However, 40 people (54.8%) provided incorrect responses. It was observed that many students who did not answer item 3 also left item 4 unanswered. The results of these items suggest that some students may have misunderstood the question, as they listed down equations that resulted in 5, matching the given solution. Additionally, some students wrote statements of the solution instead of a problem or question.



(a) (b) (c)

Fig. 3. (a),(b) and (c) Samples of answer item 4 from the students

In item 8, only one student answered correctly. Most of the students were struggling to identify the pattern in the numbers, and some of them left the answer space blank. This indicates a lack of pattern analysis skills, as mentioned in computational thinking.



(a) (b)

Fig. 4. (a) and (b) Samples of answer item 8 from the students

5.0 Discussion & Recommendation

The research findings suggest a significant association between students' scores on the Computational Thinking Test (CTT) and their levels of the Computational Thinking Scale (CTS). Notably, the data from Table 1 reveal that students' mathematics knowledge is limited, as evidenced by a high percentage of failures in their Form 3 mathematics test, which contributes to a weak negative correlation.

The investigation into the level of computational thinking skills among Form 3 students reveals a focus on creativity, critical thinking, and problem-solving. Creativity has the highest mean, followed by critical thinking and problem-solving. The overall mean of students' CTS is 6.55, with problem-solving exhibiting the lowest mean value. Further research is recommended to explore the impact of Computational Thinking (CT) on problem-solving skills in mathematics, as the current findings suggest a need for additional studies to address existing gaps. The importance of CT as a fundamental skill in mathematics education is emphasized, highlighting the necessity of incorporating CT skills into instructional practices.

The second finding highlights the significant predictive role of CT test scores in students' levels of CTS. Surprisingly, a negative relationship is observed, indicating that students with lower CT test scores exhibit higher levels of CTS which is like Doleck (2017) findings. This unexpected correlation may be attributed to the nature of the CTS questionnaire, where students may not consider CT problems when responding. Despite most students failing the CT test, their CTS levels are shown to be above moderate.

The exploration of errors in the computational thinking test reveals challenges faced by Form 3 students. Analysis of correct and incorrect responses indicates difficulties in several items, highlighting the need for a detailed examination of students' CTS factor by factor to understand variations and compare with the CT test.

Computational thinking exerts a profound influence on creativity, critical thinking, and problem-solving through its promotion of a structured and systematic approach to intricate challenges. The principles of abstraction and algorithmic thinking within computational thinking contribute significantly to creativity by encouraging individuals to deconstruct problems into manageable components, fostering creative ideation and the development of innovative solutions. However, a notable observation is that many students face challenges in questions 1, 3, and 4, indicative of struggles in creative thinking, where they encounter difficulty breaking down components and recognizing underlying patterns. Moreover, computational thinking plays a pivotal role in enhancing critical thinking, emphasizing logical reasoning and the evaluation of multiple solutions, facilitating informed decision-making. Question 6, for instance, tested students' capacity for critical thinking, assessing their ability to solve problems without relying on Pythagoras' theorem and evaluate solutions effectively. Furthermore, computational thinking equips individuals with problem-solving skills grounded in algorithm development and pattern recognition, enabling efficient resolution of diverse problems, as evidenced in questions 2, 5, 7, and 8. The integration of computational thinking into educational practices holds the promise of nurturing a generation of thinkers adept at navigating the complexities of the modern world, armed with creativity, analytical rigor, and effective problem-solving strategies.

The limitation of this data is a purposive study and is not for a generalization information.

6.0 Conclusion & Recommendations

In conclusion, this study successfully achieved its research objectives by establishing a significant relationship between students' levels of CTS and their performance on the CT test. The findings underscore the importance of addressing computational thinking in teaching and learning processes to foster better outcomes for students in the future. Recommendations for future research include exploring participants from different forms to investigate age-related knowledge increases. Additionally, researchers may consider examining other components of students' CTS, such as algorithms and cooperativity, to gain a comprehensive understanding. The study suggests investigating the relationship between CT skills and mathematics skills to enhance education at the secondary school level, particularly in science and engineering courses.

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References

Akgul. S., & Kahveci, N. G. (2016). A study on the development of a mathematics creativity scale. Eurasian Journal of Educational Research, 62, 57- 76 http://dx.doi.org/10.14689/ejer.2016.62.5

Doleck, T., Bazelais, P., Lemay, D., Saxena, A., & Basnet, R. (2017). Algorithmic thinking, cooperativity, creativity, critical thinking, and problem solving: exploring the relationship between computational thinking skills and academic performance. Journal of Computers in Education, 4, 355-369. https://doi.org/10.1007/S40692-017-0090-9.

Fajrina, S., Lufri, L., & Ahda, Y. (2020). Science, Technology, Engineering, and Mathematics (STEM) as A Learning Approach to Improve 21st Century Skills: A Review. *Int. J. Online Biomed. Eng.*, 16, 95-104. https://doi.org/10.3991/ijoe.v16i07.14101.

Howard, J. (2002). Technology-Enhanced Project-Based Learning in Teacher Education: Addressing the Goals of Transfer. The Journal of Technology and Teacher Education, 10, 343-364.

Katai, Z., Osztian, E., & Lorincz, B. (2021). Investigating the computational thinking ability of young school students across grade levels in two different types of Romanian educational institutions. NAER: Journal of New Approaches in Educational Research, 10(2), 214-233.

Kim, B. Y., Lee, J. S., & Cho, J. H. (1999). On the Practice of Creativity Development in Middle High School Mathematics. In: Proceedings of 1999 Spring Meeting of Mathematics Education held at Ewha Womans Univ., June 26, 1999 (pp. 523–542). Seoul: Korea Society of Educational Studies in Mathematics.

Nordstrom, K., & Korpelainen, P. (2011). Creativity and inspiration for problem solving in engineering education. Teaching in Higher Education, 16, 439 - 450. https://doi.org/10.1080/13562517.2011.560379.

Pambudi, D. S., Budayasa, I. K., & Lukito, A. (2018). Mathematical connection profile of junior high school students in solving mathematical problems based on gender difference. International Journal of Scientific Research and Management (IJSRM), 6(8), 73-78.

Rey, Y., Cambinda, I., Deco, C., Bender, C., Avello-Martínez, R., & Villalba-Condori, K. (2020). Developing computational thinking with a module of solved problems. Computer Applications in Engineering Education, 29, 506 - 516. https://doi.org/10.1002/cae.22214.

Sadler, I. (2012). The challenges for new academics in adopting student-centred approaches to teaching. Studies in Higher Education, 37, 731 - 745. https://doi.org/10.1080/03075079.2010.543968.

Sian Hoon Teoh , Parmjit Singh and Tau Han Cheong et al. Reflection in a Mathematics Classroom. E-BPJ. 2020. Vol. 5(SI1):163-168. DOI: 10.21834/ebpj.v5iSI1.2315

Su, H., Ricci, F., & Mnatsakanian, M. (2015). Mathematical Teaching Strategies: Pathways to Critical Thinking and Metacognition.. International Journal of Research in Education and Science, 2, 190-200. https://doi.org/10.21890/IJRES.57796.

Tang, X., Yin, Y., Lin, Q., Hadad, R., & Zhai, X. (2020b). Assessing computational thinking: A systematicreview of empirical studies. Computers & Education, 148, 103798.

Tauhan, C., Hoon, T.S., & Sing, P. (2019). Assessing college lecturers' mathematical thinking competence. Publishing Magazine , 6 (19), 24-3

Tracey Pieterse, Annie Temane and Charlene Downing. A model to facilitate critical thinking of radiography students. J Med Radiat Sci. 2023. Vol. 70(4):369-379. DOI: 10.1002/jmrs.697

Walia, P., & Walia, P. (2017). Developement and Standardisation of Mathematical Creativity Test. International Journal of Advanced Research, 5(7), 1293-1300.

Waterman, K., Goldsmith, L., & Pasquale, M. (2019). Integrating Computational Thinking into Elementary Science Curriculum: an Examination of Activities that Support Students' Computational Thinking in the Service of Disciplinary Learning. Journal of Science Education and Technology, 29, 53-64. https://doi.org/10.1007/s10956-019-09801-y.

Webb, H., & Rosson, M.B. (2013). Using Scaffolded Examples to Teach Computational Thinking Concepts. In Proceeding of the 44th ACM Technical Symposium on Computer Science Education, SIGCSE '13, (pp. 95–100).Denver, Colorado, USA.

Wing, J. M. (2006). Computational thinking. Communications of the ACM,49(3), 33-35.

Wong, S.L., Wong, S.L. Relationship between interest and mathematics performance in a technology-enhanced learning context in Malaysia. RPTEL 14, 21 (2019). https://doi.org/10.1186/s41039-019-0114-3

Yang, D., Baek, Y., Ching, Y., Swanson, S., Chittoori, B., & Wang, S. (2021). Infusing Computational Thinking in an Integrated STEM Curriculum: User Reactions and Lessons Learned. European Journal of STEM Education. https://doi.org/10.20897/EJSTEME/9560.

Yin, Y., Hadad, R., Tang, X., & Lin, Q. (2020). Improving and Assessing Computational Thinking in Maker Activities: the Integration with Physics and Engineering Learning. Journal of Science Education and Technology, 29, 189-214. https://doi.org/10.1007/s10956-019-09794-8.

Zaharin, N. L., Sharif, S., & Mariappan, M. (2018). Computational Thinking: A Strategy forDeveloping Problem Solving Skills and Higher Order Thinking Skills (HOTS). International Journal of AcademicResearch in Business and Social Sciences,8(10), 1265–1278.