

Impact of Computational Thinking in Achieving High Order Thinking Skills at Selected Schools in Sarawak

Nor Iqbal bin Mohd Sait^{1*}, Noor'ain binti Aini¹, Kartinah binti Zen²

¹Faculty of Social Sciences and Humanities, Universiti Malaysia Sarawak,
94300 Kota Samarahan, Sarawak, Malaysia

²Faculty of Computer Science and Information Technology, Universiti
Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

*Corresponding author: noriqbalmohdsait@gmail.com

Received Date: 11 Mar. 2026

Accepted Date: 20 Jun. 2026

Publish Date: 29 Jun. 2026

ABSTRACT

Computational thinking (CT) is a six-step approach that involves the processes of decomposition, pattern recognition, abstraction, algorithm, evaluation and logical reasoning that promotes greater levels of thinking and the development of soft skills such as critical thinking and problem solving. This approach was introduced by the Malaysian Ministry of Education (MOE) in 2017 as a component for achieving Higher Order Thinking Skills (HOTS) in its efforts of improving the quality of education in the country. Between 2017 and 2019, the Faculty of Computer Science and Information Technology (FCSIT) of Universiti Malaysia Sarawak (UNIMAS) organized the Computational Thinking and Computer Sciences (CTCS) teaching course across Sarawak to prepare teachers for this transition in the MOE's efforts of improving the quality of education on primary and secondary levels. From a population of 57 teachers, a select of 4 teachers involved in the course were interviewed to provide further insight into the effectiveness of CT in achieving HOTS.

Keywords: Computational thinking; Education; High Order Thinking Skills; Problem-solving skills; Soft skills development

Copyright: This is an open access article distributed under the terms of the Creative Commons Attribution-Non-Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0) license which permits unrestricted use, distribution, and reproduction in any medium, for non-commercial purposes, provided the original work is properly cited.

INTRODUCTION

Computational thinking (CT) is a process initially exclusive to computer scientists in complex problem solving during their encounters, then stressed as “a fundamental skill for everyone, and not just for computer scientists” that is to be taught at all education levels (Wing, 2006). Guzdial

(2008) cites that the natures of CT were believed to first exist in the 1960s through Alan Perlis' initiative of making programming a topic that must garner the attention of everyone due to its ability on the 'theory of computation', followed by the ideas of Seymour Papert in the 1980s that explored the idea of 'soap-sculpture mathematics'. These theories have since evolved into what Jeanette Wing introduced as computational thinking.

In the modern times, CT has established itself as a core element in many educational systems across the globe (Lockwood & Mooney, 2017) and as an approach in developing Higher Order Thinking Skills (HOTS) through nurturing a student's ability to create, evaluate and analyse (Zaharin et al., 2018). High-performing countries have made it integral to its education such as Finland and Singapore which passed with flying colours during its participation in the latest international large-scale assessment known as the Programme for International Student Assessment (PISA).

Numerous studies suggest that CT is an essential skill that must be applied for all backgrounds (Wing, 2006) in any subject (Hsu et al., 2018) that helps in fostering creativity and problem-solving abilities (Yadav et al., 2017). Influenced by the implementation of CT by high performers in PISA, Malaysia has followed suit through its integration of CT through the introduction of subjects in the primary and secondary level and the initiative of the Computational Thinking and Computer Sciences (CTCS) teaching program held nationwide.

For this study, its focus was directed towards the CTCS course held between 2017 and 2019 in Sarawak. Studies conducted about CT in Sarawak highlighted the changes of implementing CT in the teaching-learning process (Anuar et. al, 2020), the influence of CT towards performance (Shariman et. al, 2024) and the effectiveness of CT within STEM subjects (Hamid et. al, 2024), yet studies that observe the impact of CT towards HOTS are limited. This study asked the following questions; what are the teachers' perspectives towards the application of CT in the teaching-learning process, and what is the impact of CT towards the development of Higher Order Thinking Skills (HOTS) among students in Sarawak from the teacher's perspective?

To answer these questions, the study explored the teachers' perspective of applying CT in the teaching-learning process and explored the impact of CT towards the development of HOTS among students in Sarawak by observing why applying CT for teachers is a key component in achieving HOTS among their students. This study hopes to provide greater understanding in developing rationales for continuing CT as part of a key component in the syllabus specially designed for students in Sarawak. This is due to the diverse background setting of schools in urban and rural areas with each coming with unique circumstances. Moreover, this study hopes to provide deeper insight towards the CTCS teaching programme to increase its influence in the teaching-learning process.

LITERATURE REVIEW

The turn of the new millennium saw the topic of computational thinking (CT) making a resurgence in the modern era, one that aligns the ideas of Perlis and Papert. Wing (2006) defines CT as a concept that can be applied at all levels of education, providing one with the avenue of problem solving. CT involves a four-stage approach in its application which are:

1. Decomposition: The scenario is broken down into smaller sub-scenarios,
2. Pattern Recognition: Similar characteristics are searched within the sub-scenarios,
3. Abstraction: Critical details are extracted from analysed sub-scenarios,
4. Algorithms: Also known as creation of algorithm, a solution fitting criterion of scenarios is designed.

Over the years, the four key stages have been a mainstay in many iterations of CT and over time have developed to include an additional two new stages (Shute et al., 2017) which were:

5. Evaluation: The constructed algorithm was assessed, and
6. Logical Reasoning: The feasibility of the created algorithm is justified.

In the educational technology space, most scholars agree that CT is an important 21st-century skill that develops the skills and abilities of complex problem-solving (Voogt et al., 2015) that can be applied in many fields, predominantly in mathematics, science and engineering (Angraini et al., 2024) and even in non-STEM subjects through a cross-disciplinary manner (Hsu et al., 2018). CT can be used and benefited by anyone of any background as it is considered a 21st century literacy (Mohaghegh & McCauley, 2016). The elements and components of CT has been adopted by numerous countries around the globe in its educational systems based on its track record of developing students' abilities to think critically and solve complex problems (Lockwood & Mooney, 2017), in addition to CT growing in global prominence of being both defined and applied in a classroom setting (Ogebo & Ramnarain, 2022).

Examples of said countries includes Finland and Singapore, both of which are high-performing countries that scored above the global average (OECD, 2023) in PISA, the triannual international large-scale assessment organised by the Organisation for Economic Co-operation and Development (OECD) that provides countries a perspective on the quality of education in their respective countries. PISA assesses 3 key competencies that are crucial in the modern day which are reading, mathematics and sciences (Goczek et al., 2021).

Finland's reform of its two-track education system kept in mind the nature of CT when it introduced its compulsory nine-year education system called peruskoulu that stressed on the importance of developing 21st century skills such as critical thinking, problem solving and communication to adapt to the 21st century competency (Lavonen & Korhonen, 2017). Furthermore, the roles of teachers are now being redefined where the boundaries of teaching are no longer limited within the school setting and have begun to expand into external networks (Tiippana et al., 2024). Finland establishes a knowledge-based society that encourages learning far beyond the 9-year compulsory system which has proven to be effective as it produced a very low dropout rate (Morgan, 2014).

Singapore is another example where its implementation of CT elements in the primary and secondary levels of education that observes the development of problems solving, critical thinking and algorithmic thinking, with the addition of adding programming subjects into its curriculum (Seow et al., 2019). This shift along with Singapore's approach on establishing 'thinking schools'

also changed the dynamics of parties involved in the school system where students are more active and engaged in the teaching process (Al-Thani, 2024) and brought with it the need of quality over quantity (Ng, 2021).

The main similarity that can be observed through the implementation of CT of the two high-performing countries are the development of 21st century skills in critical thinking and problem solving as the foundation in their education systems. Studies indicate that CT has shown positive results regarding its implementation into the teach-learning process due to its ability in developing competencies in problem-solving as it acts as a process in helping to create and analyse (Kale et al., 2018).

Its implementation is not just exclusive to the STEM field through multiple subjects (Weintrop, 2016; Rich et al., 2019), but it can also be applied in the non-STEM field through certain stages of CT (Hsu et al., 2018). Making CT as a key component in the teaching-learning process enables teachers to foster creativity (Yadav et al., 2017) that can be further applied for an individual (Angeli et al., 2016). Moreover, Zaharin et al.'s (2018) taxonomy model shows that CT shares many similarities with Higher Order Thinking Skills (HOTS) as the nature of both are thinking processes that support one another (See Figure 1).

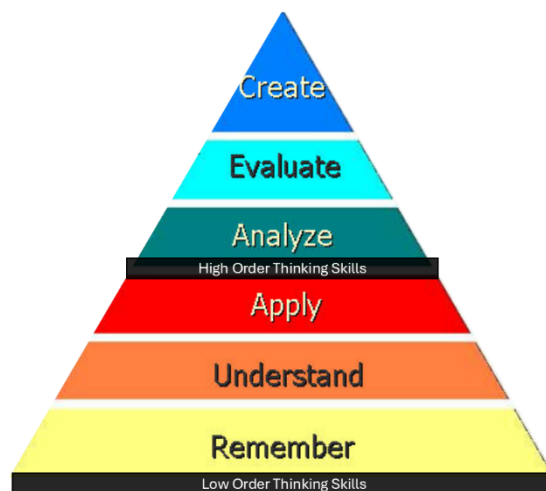


FIGURE 1. Zaharin et al.'s Iteration of Bloom's Taxonomy Model on HOTS (2018)

On the other hand, there are a set of challenges that must be noted to successfully adopt and implement CT. Several studies point out that teachers tend to find the lack of proper support and materials in implementing CT becoming a major deterrent in limiting the widespread adoption of CT in the classroom (Isharyadi and Juandi, 2020; Wahab et al, 2021) that ranges from resources to exposure towards CT. Changes to the curricula may also be a challenges to some as Rebeiro et al. (2013) notes that curricula change becomes a hurdle when it comes to implementing CT as there lays the need in understanding and change of disciplines.

In the local context, the Ministry of Education (MoE) implemented CT in its syllabus starting in 2017 by offering subjects such as Information Communication Technology (ICT known as Teknologi Maklumat Komputer @ TMK) for the primary level and Basic Computer Science (known as Asas Sains Komputer @ ASK) for the secondary level that exposes students to CT

(Lapawi & Husnin, 2020a). Malaysia followed the trend of applying CT by Finland and Singapore by making CT as a foundation for developing 21st century skills in critical thinking and problem solving, where this transition was a continuation of the HOTS initiative introduced in 2012 (Zaharin et al., 2018) which involved preparation for teachers for this shift through the CTCS teaching program; a comprehensive course held nationwide to provide teachers the knowledge and guidance on how to apply the CTCS teaching techniques in the classroom with the main objective of improving their teaching approach to increase the effectiveness of the teaching-learning process.

METHODOLOGY

The study aimed at exploring first-hand experiences of carrying out computational thinking (CT) in the classroom through the lens of teachers and perspectives from past literature discussing the subject, thus establishing itself as an exploratory study surrounded by themes involving CT which includes CT in countries around the world, the impact of applying CT in education and challenges around CT.

The study took a qualitative approach to best obtain answers from descriptive answers (Tenny et al., 2017) which mainly relied on participants' (who are teachers) opinions on CT. Semi-structured interviews guided by an interview protocol were utilised to allow more expression and freedom. This was the main instrument utilised where four teachers of various backgrounds, experience and education levels from primary to tertiary who participated in the courses and practised CT in their classrooms shared their perspectives of CT in the classroom, the perspective of CT in achieving HOTS and challenges faced in implementing CT. Interviews were conducted digitally through Zoom as the platform to enable accessibility to teachers who had difficulties based on their location, with an average duration of 35 minutes per teacher interviewed. Prior to conducting the interview, teachers were informed that the interviews were being recorded to accurately note their perspectives.

Purposive sampling was applied to ensure the validity of the data as data provided must at least be from individuals or groups that are knowledgeable or experienced (Palinkas et. al., 2015), hence individuals eligible for this study must be participants of the CTCS teaching course between 2017 to 2019 and were currently teaching at the time the interviews were conducted. Once the teachers have been selected and invited for the interviews, teachers who participated were informed that the interviews were recorded.

To ensure the accuracy of data provided by teachers, the study practiced the Interviewee Transcript Review (ITR) suggested by Rowlands (2021) to ensure the validity of the data provided by the teachers. Each interview conducted was transcribed in verbatim to ensure any verbal expressions were not omitted to capture positive or negative reactions by teachers, which were then processed for teachers to review. Upon obtaining the teachers' approval towards the transcription, the study commenced initial coding of transcripts and utilised the NVivo 12 software to highlight similar key words and phrases from the teachers to establish baseline themes regarding questions asked regarding their experiences of CT.

Morgan (2022) suggests that a reflexive approach is better suited for studies that are completely qualitative, and subjectivity as an added advantage for findings. This approach in thematic analysis was utilised as the study relied on similar keywords and phrases provided by

teachers and past literatures. Prior to the final themes established, initial codes were pre-applied based on the literature review and interview protocol that were identified as ‘CT and Its Components’, ‘The Correlation of CT and HOTS’, and ‘Challenges of CT’.

Upon the completion of triangulation based on the literature review and processed transcription from the interviews, the study established ‘Teachers’ Understanding of CT and Its Components’, ‘Teachers’ Perspective on HOTS and Its Relationship to CT’ and ‘Challenges of Applying CT in the Classroom’ as the final themes which were established for this study based on key words and phrases within these themes were common throughout the interviews and literatures referenced in the study.

SCOPE AND LIMITATION

A set of research limitations were experienced during the performance of this study. One prominent limitation is the low turnout of teachers who were willing to participate in the study which significantly reduced the potential opportunities for deeper insights. Of the 57 teachers who responded to our approach, only 4 teachers managed to participate in the interviews citing connectivity (particularly network issues) and unavailability of participating. Despite this, the limited number of participants provided vast perspectives on the impact of computational thinking (CT) towards their classroom and how their students perceived their lessons.

Another limitation experienced by the study is the period gap between the study and when the CTCS teaching course was conducted. The study began in 2022, and the teaching course took place between 2017 to 2019. This 3-year gap limited the exploration of ideas as teachers either had been transferred or retired since then.

FINDINGS

TABLE 1: *Summary of Participants*

Teacher	Gender	Teaching Experience	Teaching Level
A	Male	10-19 years	Primary
B	Male	20-29 years	Secondary
C	Male	20-29 years	Tertiary
D	Male	10-19 years	Primary

Teachers’ Understanding of CT and Its Components

Teachers were asked questions regarding their understanding and experiences of CT in the classroom to their current recollection. This would observe the processes used in the classroom ranging from decomposition to logical reasoning. One teacher shared an insight that decomposition and algorithm are his favoured techniques as it easier for his students.

“For me, I have better understanding of Decomposition and Algorithm. They are the most frequent I apply for the students. Just applying one concept is actually great because it’s easier for the kids.” (Teacher A)

One teacher shares a more elaborate use of CT concepts, correlating with Teacher A’s idea on CT stating that decomposition is more favoured, however favouring pattern recognition with an example of its application in the teaching-learning process especially in Science.

“There are basic concepts such as decomposition and pattern recognition; those are the ones I often use because among the students they understand more if we apply these concepts. So, there are parts which we will use these CT aspects to provide or improve a student’s understanding in food preservation in that chapter. It is because if we want to, we can use it (to help in) memorizing and analysing.” (Teacher D)

The use of decomposition is a commonly used and preferred process amongst the teachers. One teacher provides a more advanced understanding of CT concepts by providing elaboration of each concept, where one of them that favours decomposition and algorithm provides a highly detailed explanation of each concept.

“CT specifically has a lot of activities that is not necessarily computer-based, but then anything related to other subjects can also using CT. Actually, CT is there in our daily lives (only) just that we don’t name it as CT and so on. Decomposition of course has to break up the problem and then there’s the large number (and) all that; smaller compartments in order to solve the problem. Pattern recognition is a bit difficult even though the methods are basically same (to the others). Abstraction is an aspect of important and unimportant. Algorithm is where we need to make a solution. I feel like the most I used were decomposition and algorithm.” (Teacher B)

In addition, one teacher suggests that CT can be applied in not just teaching particular subjects but can be applied universally in all subjects as it is more of a thinking process.

“Using the methods in CT such as decomposition, pattern recognition, abstraction and also algorithm; these are used for solving problems. For me, CT isn’t just for (certain) subjects or technique. It can be expanded to other subjects because it undergoes a thinking process.” (Teacher C)

Application of CT in the Classroom

When asked about the impact of its implementation in their classrooms, teachers had a lot of positives regarding its implementation particularly in helping them during class. One teacher pointed out that in theory it can help to attract the students’ attention and solidified the theory when testing through a particular subject (being physical education) which students find boring but changed when CT was applied. This being the elaboration of the teacher’s concern when CT was first introduced.

“For example, in moral education and PE (physical education), sometimes the students (find it) boring. When divided into groups they undergo (activities involving) processes like decomposition the students are interested, wanting to find the answer at the end. It was acceptable by them.” (Teacher A)

One teacher suggests that CT is not only just a means of an essential problem-solving skill, but it also helps to understand human behaviour through its approaches, along with supporting that CT can be applied to any subject due to its nature of being both a problem-solver and thinking process.

“CT is an essential skill in problem solving, and understanding human behaviour is a basic concept in computer science. Besides that, my students have the chance to apply steps in arranging, analysing, and also presenting data or idea, logically and systematically. Using the methods in CT such as decomposition, pattern recognition, abstraction and also algorithm; these are used for solving problems. For me, CT isn’t just for certain subjects or technique. It can be expanded to other subjects because it undergoes a thinking process.” (Teacher C)

Teachers also found that because CT is naturally a part of daily life and believe it to be an approach that can easily be applied to any subject, the core elements of CT can easily be applied to their teaching methods.

“If we observe problem-solving, it is there in add maths, in maths, in various subjects... Even in computer sciences it’s actually there, but the characteristics of problem-solving itself is specific to a subject like Physics and so on, but the CT that’s there is generalized. The process is applicable to any subject.” (Teacher B)

“Teaching sciences have always stressed on using textbooks completely. Any activities related to science for example; conducting an experiment. We instantly use the stated experiment materials to teach a topic and from there we’re stressed on using CT in the experiment. It’s because it’s not far from it, so for me it’s no problem.” (Teacher D)

When asked about the best way to summarise their opinion on CT, teachers had nothing but positive summaries on their experience on CT.

“For example, we give a task to a student, I will use (the) decomposition technique and this is easy for the kids.” (Teacher A)

“It is systematic, most importantly (for) problem solving.” (Teacher B)

“It has really helped me particularly in guiding students better to find a new solution for problems that seem impossible to solve.” (Teacher C)

“CT can be applied in many things. Meaning, if we want to, we can use it for memorizing and can also for analysing.” (Teacher D)

Teachers’ Perspective on HOTS and Its Relationship to CT

Venturing towards the teachers’ perspective of CT and its ability towards achieving HOTS. This avenue was initially discovered by observing the teachers’ perspective towards HOTS. The participating teachers found that the introduction of HOTS into the syllabus in 2012 was a great addition stating that HOTS reflects daily life; an ability that endorses thinking and capable of developing students’ ability in thinking:

“HOTS is great because it encourages thinking. It is good if we do not stress it as an exam. HOTS is part of daily life; it can be anywhere. In fact, sometimes HOTS is also implemented into the co-curriculum but of course not all (in its entirety).” (Teacher B)

“HOTS for me is an ability to apply knowledge, ability to assess in reasoning and reflection to solve a problem. Making innovative decisions and ability to create something. HOTS is also a good and positive initiative where it has various advantages which are improving the abilities and capabilities that exists in a student. Students will be able to control, guide and measure the learning that they have empowered.” (Teacher C)

“HOTS is inserted and implemented in the daily teaching plan. This means that the teacher will plan every daily lesson and must use HOTS, though it’s not compulsory. They must state which part of HOTS they have applied to the day’s lesson. Currently, the usage of HOTS is very important.” (Teacher D)

In addition, one teacher notes that the use of HOTS can be difficult for students as it becomes complex for students that are not as independent which becomes a cause for struggle for them:

“HOTS might be quite difficult for (certain) students because (if) we want to break it down; the teacher needs to do it one-by-one. Only competent and skilled students can answer HOTS questions. For very weak students, they cannot answer. In groups, maybe they can answer HOTS questions. Individually in a test, weak students will not be able to answer.” (Teacher A)

Teachers were then asked when they were first introduced to CT, and teachers stated that the nature of CT shared many similar outlooks towards developing the thinking abilities of a person. The concepts covered in CT are essential skills for HOTS. The close relation between the two were explored from the teachers’ experience and discovered that CT acts as a tool that helps a student to achieve the level of HOTS. In other words, they work in parallel with CT acting as the approach and HOTS as the status. In this scenario, CT acts as they key to achieve HOTS.

“CT is a tool in the direction of high order thinking (skills). That’s exactly what it is. If we are to directly go to high order thinking, while weak students do not get it; these students will jump around in thoughts. CT will guide students to the level of high order thinking.” (Teacher A)

“CT can cause HOTS to be carried out systematically. Before this we press on HOTS’ end product; it should be mind-mapping, the 8 mind maps. To have that as a product, we need to have a process... With CT, we can promote it as a way to obtain the product, it definitely supports our efforts to cultivate HOTS to obtain students that practice HOTS... For me it is something that support each other.” (Teacher B)

“I strongly agree. Both have their own strengths, both shape the thinking capabilities and cultivate thinking abilities among students. Besides that, they also help teachers to improve a certain practice, in teaching and learning activities.” (Teacher C)

“I agree from what I understand. For me, CT can be used in many things. If we wanted to use it for remembering we could, for analysing it can be used in many places, (and) that’s why I use CT a lot in teaching.” (Teacher D)

Challenges of Applying CT in the Classroom

Challenges of practising CT by the teachers were then explored. The study found that class size plays a role in the development of students’ abilities, as teachers found that a small class size provides a great environment for the development of their students as they can provide full supervision to the class simultaneously. Bigger classes prove to be a greater challenge for teacher to be able to control and provide adequate supervision to their students.

“I once had 41 students here (in a class). We are not able to control the class (better). The important part here is class control. If there is no (control) then it can’t be done. I’ve tried it, however, if the class is too full it is difficult to do.” (Teacher A)

“A moderate group of students however needs time.” (Teacher C)

In addition to class size, a couple of teachers suggest that the lack of facilitation pose as a challenge in practicing and applying CT successfully in the class. This includes responsibilities, exposure of students, and support in schools. One teacher noted that commitment is an issue where the number of tasks they have on top of teaching made this challenging and not as manageable.

“It is rarely touched except if the administration followed this course. We have to explain to the PPD that some teachers followed the same course. This is what the administration may not have noticed.” (Teacher A)

“At the initial stages, of course the workload was there, but we make an effort with an open mind prioritising the students. Still, it becomes a problem.” (Teacher C)

“One challenge is the exposure to students at the early stages. In the house, they are not exposed to well-equipped CT tools. Many schools still face problems, even us where at the end the results differ. Also, if the head of department does not support, there is nothing we can do about it.” (Teacher D)

One teacher suggests that certain teachers may be content with what they have learnt and have decided to not explore better opportunities in expanding their knowledge.

“Sometimes teachers in schools they do not want (to) expand their knowledge anymore. It’s like ‘That’s enough’. They are satisfied with the level (they are at).” (Teacher B)

DISCUSSION

The discussion of the study focuses on the impact observed by teachers regarding the practising of CT in the classroom and what was experienced by teachers which may range from change in environment to student behaviour. In addition, this section also observed the close connection between CT and HOTS where both share the nature as thought processes that looks towards problem-solving where both works in parallel with each other. Finally, challenges in

implementing CT are also discussed in this section where difficulties in fully practising CT by teachers due to the dependency of support and facilitation.

The overall observation of CT by teachers highlighted the overwhelming positive support and perspectives of teachers when practising CT in the classroom. As Voogt *et al.* (2015) suggested; CT is a critical modern-day skill that develops skills and abilities in complex problem-solving which can be applied by any person of any background (Mohagheh & McCauley, 2016) as constantly outlined by Teachers B and C. The findings from the study align with these ideas as teachers would use select stages to assist in their teaching, yet a greater number of perspectives would significantly help in further establishing this idea where the positive feedback obtained would resonate with other teachers who were not involved in the interviews. In addition, due to CT's highly systematic process which gives clarity and structure on carrying out activities, this further helps in developing students' thinking abilities through the development of rationale and approach which is observable by all teachers involved in the interviews.

However, the limited number of perspectives of four creates questions regarding the validity and viability of the teachers' opinions. This was one of the study's major concerns as a bigger number of at least 10 teachers was the initial target, and the unfortunate low turnout was mainly contributed to the limited access of teachers to connectivity and internet stability which was also experienced during the interviews where stutters and freezes happened often. On the other hand, this study was focused on exploring the perspectives of teachers regarding their experiences towards CT and compensated the lack of participation through the depth of data provided by teachers as samples in qualitative studies are commonly small as the depth of data is a foundation for this type of inquiry (Vasileiou *et al.*, 2018).

Although CT can be predominantly applied in mathematics, science and engineering (Angraini *et al.*, 2024) yet it has been observed that CT can be applied in non-STEM subjects (Hsu *et al.*, 2018). This was highlighted by Teacher B where CT can be applied universally in any subject and through Teacher A provides additional examples such as Moral Education and Physical Education as it is a systematic process than just a set of concepts.

This allowed an avenue opening for discussions regarding the ability of CT in assisting teachers developing HOTS among their students as indicated by all teachers in the interviews. HOTS was an initiative introduced by the MOE in 2012 as their initiative in improving the national quality of education. CT was then introduced as the next step in improving quality, where a similarity was observed as both are processes that looked towards problem-solving (Zaharin *et al.*, 2018). The findings provided a better understanding towards the connection of CT and HOTS, and a revision represented by Figure 2.

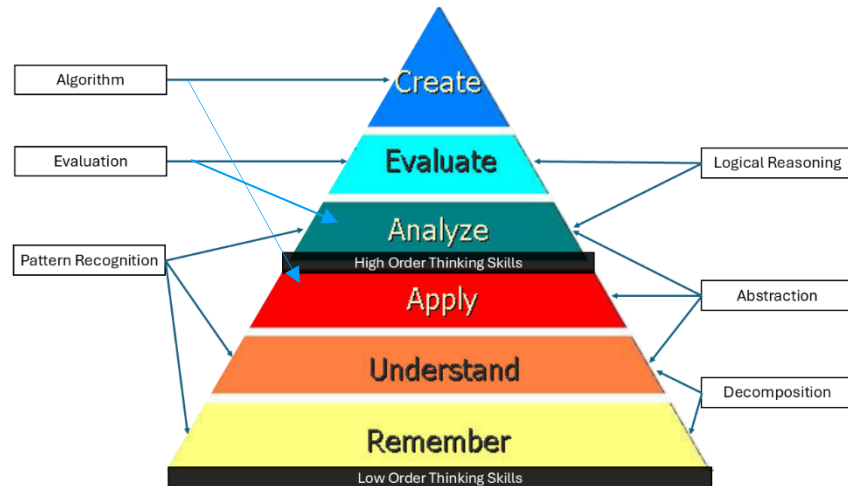


FIGURE 2. Connection of CT towards Zaharin et al.'s Iteration of HOTS Taxonomy Model

Based off the Bloom's Taxonomy Model by Zaharin et al. (2018), the study found that each component of CT supports HOTS from the bottom-up and plays multiple roles in every aspect. Before proceeding to the next levels, each step must be completed from the first step as it covers the first foundations from the Lower Order Thinking Skills (LOTS) starting by remembering. It is noticeable that few concepts are multidimensional and acts as a buffer to proceed to the next stages of thinking skills particularly decomposition, pattern recognition and abstraction.

These 3 concepts cover the first foundations in achieving HOTS as it develops the ability to remember, understand and apply which are identified as LOTS. Upon the mastery of LOTS, this takes students to the first step in HOTS where they develop the ability to analyse that first requires the CT concept of pattern recognition followed by logical reasoning. This would then allow students to proceed to the next stage of evaluate which involves the CT concept of evaluation. As the finale, with the development of all 5 concepts, this allows one the ability to create which can be nurtured by applying the CT concept of algorithm.

The concepts of CT applied towards the taxonomy model are based on the correlation that were discovered between the concepts of CT and HOTS. The study suggests decomposition being applied for the concepts of remember and understand are attributed to the need of breaking down ideas into smaller parts for an easier approach in recollecting ideas which can help students to understand a subject. Next, the study suggests that pattern recognition is well-applied for the concepts of remember, understand and analyse. Pattern recognition is the identification of repeated elements among ideas which overlaps with the three concepts as the use key points are foundational for the three.

Furthermore, the study suggests abstraction being applied for the concepts of understand, apply and analyse. Abstraction focuses on extracting important information from one or multiple sources, and this process is applied when an individual understands a subject. This requires them to apply what they have deduced and to an extent analyse whether the important point is suited to a problem. The study suggests algorithm (creation) is best applied towards the concept of create and apply which comes from the perspective that when a solution is designed, the concept of create and apply is present during the process. To determine the

effectiveness of a proposed solution, the study suggests evaluation is best applied to the concept of evaluate and analyse. This is where the process whether effectiveness of an applied solution is assessed is compatible with a problem or whether a more effective solution can be made, thus involving the process of evaluating and analysing the effectiveness of a solution. Finally, the study suggests that logical reasoning is best applied to the concept of evaluate and analyse. The function of logical reasoning looks towards justifying whether a solution is the best option possible that can be applied to a problem, and this process overlaps with the concept of evaluate and analyse. It is important to note that these concepts are highly cross-functional and may interlap more often than one may presume and can be adapted to suit unique circumstances.

However, despite the similarities of the two existing sets of challenges faced in implementing CT in the classroom. On top of change in curricula which acts as a starting challenge for teachers (Rebeiro et al., 2013) requiring changes of disciplines to teaching, additional challenges would include teachers faced in guiding students with no exposure to CT (Wahab et al, 2021) and teachers' preparedness towards the transition to CT covering materials, intervention with students and support for teachers (Isharyadi & Juandi, 2023). The findings of the study found that these are issues currently faced by teachers as bigger class sizes limit the amount of involvement that teachers can take during certain processes, teachers finding difficulty in guiding students who have limited exposure towards CT and the need of support for teachers in continuing to practise CT in the classroom.

CONCLUSION

The first major finding of the study is the overall positive reception of CT from teachers. One key theme observed is that teachers found CT as a thinking process that can be applied in many areas and not limited to a particular field. Decomposition has been noted as one of the most applied processes that has helped teachers in the classroom given the frequency of its application among teachers and have found increased interest in learning as it is easier for their understanding in the subject taught. On the other hand, this study also found that the limited number of interviewees due to the large geographical setting and limited accessibility to more participants confined the ability of further exploring potential challenges that other teachers may face when applying CT in the classroom.

Another major finding from the study is that teachers found CT as a key that aids in achieving HOTS. Some key points include CT as a systematic approach in achieving HOTS, shapes thinking capabilities of their students and as a universal approach that can be used in solving problems. CT acts as the missing link that enables HOTS to be achieved amongst students to its potential which supports the opinions of teachers that HOTS and CT were great initiatives when introduced and implemented.

In addition, there are several challenges faced when practising CT that most commonly involve class sizes and facilitation. Teachers cite that a large class of students consequently affects the effectiveness of its implementation as classroom control decreases for teachers. Facilitation covers the tasks that teachers are assigned, and the necessity of support from the school hierarchy to allow teachers to effectively practise CT. CT has established itself as an initiative that promotes the development of students' thinking skills and as an avenue for students to achieve HOTS. Future studies are recommended that further explore more perspectives of teachers in this area to help provide more evidence in supporting the initiatives

revolving around CT by obtaining larger samples that explore the perspectives of more teachers with more unique backgrounds and exploring the application of CT in schools with more diverse background such as urban or rural and accessibility to certain infrastructure such as materials and equipment.

ACKNOWLEDGEMENT

We would like to express our gratitude the Ministry of Education, Innovation and Talent Development (MEITD) and UNIMAS for allowing us to conduct and complete this research. Thank you very much.

REFERENCES

- Al-Thani, G. (2024). Comparative analysis of stakeholder integration in education policy making: case studies of Singapore and Finland. *Societies*, 14(7), 104.
- Angraini, L. M., Susilawati, A., Noto, M. S., Wahyuni, R., & Andrian, D. (2024). Augmented reality for cultivating computational thinking skills in mathematics completed with literature review, bibliometrics, and experiments for students. *Indonesian Journal of Science and Technology*, 9(1), 225-260.
- Anuar, N. H., Mohamad, F. S., & Minoi, J. L. (2020). Art-integration in computational thinking as an unplugged pedagogical approach at a rural Sarawak primary school. *International Journal of Academic Research in Business and Social Sciences*, 10(17), 21-39.
- Goczek, Ł., Witkowska, E., & Witkowski, B. (2021). How does education quality affect economic growth?. *Sustainability*, 13(11), 6437.
- Guzdial, M. (2008). Education paving the way for computational thinking. *Communications of the ACM*, 51(8), 25-27.
- Hamid, M. S. A. A., Phang, E., & Zaini, F. (2024). Effectiveness Computational Thinking Techniques on Student Interest to STEM Subject.
- Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Computers & Education*, 126, 296-310.
- Isharyadi, R., & Juandi, D. (2023). A systematics literature review of computational thinking in mathematics education: Benefits and challenges. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 13(1), 69-80.
- Kale, U., Akcaoglu, M., Cullen, T., Goh, D., Devine, L., Calvert, N., & Grise, K. (2018). *Computational what? Relating computational thinking to teaching*. TechTrends, 62(6), 574-584.

- Lavonen, J., & Korhonen, T. (2017). Towards twenty-first century education: Success factors, challenges, and the renewal of Finnish education. In *Educating for the 21st century* (pp. 243-264). Springer, Singapore.
- Lockwood, J., & Mooney, A. (2017). Computational thinking in education: Where does it fit? A systematic literary review. *arXiv preprint arXiv:1703.07659*.
- Mohaghegh, D. M., & McCauley, M. (2016). *Computational thinking: The skill set of the 21st century*.
- Morgan, H. (2014). Review of research: The education system in Finland: A success story other countries can emulate. *Childhood Education, 90*(6), 453-457.
- Morgan, H. (2022). Understanding Thematic Analysis and the Debates Involving Its Use. *The Qualitative Report, 27*(10), 2079-2091. <https://doi.org/10.46743/2160-3715/2022.5912>
- Ng, P. T. (2021). Teach less, learn more. *Routledge Osiris World Education Summit Freebook 2021*.
- OECD (2023), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, PISA, OECD Publishing, Paris, <https://doi.org/10.1787/53f23881-en>.
- Ogebo, A. A., & Ramnarain, U. (2022). A systematic review of computational thinking in science classrooms. *Studies in Science Education, 58*(2), 203-230.
- Rich, K. M., Yadav, A., & Schwarz, C. V. (2019). Computational thinking, mathematics, and science: Elementary teachers' perspectives on integration. *Journal of Technology and Teacher Education, 27*(2).
- Rowlands, J. (2021). Interviewee transcript review as a tool to improve data quality and participant confidence in sensitive research. *International Journal of Qualitative Methods, 20*, 16094069211066170.
- Seow, P., Looi, C.K., How, M.L., Wadhwa, B., & Wu, L.K., (2019) Educational policy and implementation of computational thinking and programming: Case study of Singapore. In *Computational Thinking Education* (pp. 345-361). Springer, Singapore.
- Shariman, S., Mas'ud, F. H., Tarmizi, S., Zen, K., & Phang, E. (2024). Assessing the Influence of Computational Thinking Technique on STEM Based and Non-STEM Based Subjects in Sarawak Schools. *Journal of Borneo-Kalimantan. Vol, 10*, 1.
- Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142-158.
- Tenny, S., Brannan, G. D., Brannan, J. M., & Sharts-Hopko, N. C. (2017). Qualitative study. <https://europepmc.org/article/NBK/nbk470395>

- Tiippana, N., Korhonen, T., & Hakkarainen, K. (2024). Teachers' External Networking: Expanding Pedagogical Practices in Finland. *The Teacher Educator*, 59(4), 480-501.
- Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2018). Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period. *BMC medical research methodology*, 18(1), 148.
- Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies*, 20(4), 715-728.
- Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of science education and technology*, 25(1), 127-147.
- Wahab, N. A., Talib, O., Razali, F., & Kamarudin, N. (2021). The big why of implementing computational thinking In STEM education: A systematic literature review. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 6(3), 272-289.
- Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33-35.
- Yadav, A., Gretter, S., Good, J., & McLean, T. (2017). Computational thinking in teacher education. In *Emerging research, practice, and policy on computational thinking* (pp. 205-220). Springer, Cham.
- Zaharin, N. L., Sharif, S., & Mariappan, M. (2018). Computational thinking: A strategy for developing problem solving skills and Higher Order Thinking Skills (HOTs). *Int. J. Acad. Res. Bus. Soc. Sci*, 8(10), 1265-1278.