

Comparison of Indonesian and Singaporean Senior High School Mathematics Textbooks in Developing Students' Computational Thinking Skills

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ABSTRACT

This study is motivated by the importance of CT skills as a basic literacy for problem-solving amid technological and information disruption. However, the integration of CT in Indonesian education remains suboptimal, as reflected in Indonesia's PISA scores, which are below the global average, while CT serves as a key framework in PISA 2022 alongside mathematical reasoning. One contributing factor is that mathematics questions and textbooks have not yet functioned as tools for thinking. In fact, textbooks serve as mediating variables in learning. This study employs a mixed-methods approach with an exploratory sequential design. Data were sourced from Indonesian and Singaporean high school mathematics textbooks with comparable learning outcomes. Analysis was conducted qualitatively and quantitatively using the chi-square test. The results showed a significant difference in the distribution of CT-based questions, where Singaporean textbooks more explicitly presented the four dimensions of CT, while Indonesian textbooks tended to be implicit. These findings underscore the importance of developing more exploratory and reflective textbooks to support 21st-century skills.

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INTRODUCTION

Computational thinking (CT) is an essential skill that students need to possess in the 21st century (Muhammad et al., 2024). CT involves the thinking process of formulating problems to arrive at effective and efficient solutions (Wing, 2006). This thinking process is not literal like computer programming. According to Wing (2006), human thinking is more creative and imaginative, enabling the resolution of various problems without relying on computers. This thinking process involves decomposition, algorithms, patterns, generalization, and abstraction much like how computers operate (Wing, 2006). Through these processes, problems can be solved more quickly and efficiently. Although it sounds complex, in reality, humans already use this thinking process in daily life, such as choosing clothes, packing the right items into a bag when heading to school, and evaluating routes while traveling.

CT can also be considered the fifth C skill alongside the other four 21st-century skills: critical thinking, communication, creativity and innovation, and collaboration (Rahmawati et al., 2024). Furthermore, CT not only supports higher-order thinking skills in the rapidly evolving era of technology and information but also enhances mathematical literacy skills such

as problem-solving and influences the affective domain, including self-confidence, creativity, and full engagement in the learning process (Fauzi et al., 2024). In line with this, as new fields emerge such as data science, data analysis, and biotechnology they increasingly demand the application of CT.

Globally, computer science has become mainstream in education policy. Many developed countries with high Programme for International Student Assessment (PISA) scores have integrated computer science into their core curricula using various approaches. The United Kingdom was the first country to do so, introducing a “computing” course for all levels of education starting in 2014. Finland, on the other hand, integrates CT across subjects, including mathematics, under the name “Ohjelmoinnin Perusteet.” Furthermore, the United States launched “Computer Science for All” to promote the integration of CT into K–12 education. In Asia, Singapore the comparison country in this study indirectly integrates CT by introducing it as early as preschool and elementary school, and offering it as an elective subject at the secondary level (Seow et al., 2019). Furthermore, other countries such as Lithuania, Japan, South Korea, and Australia have implemented similar approaches (Seow et al., 2019). In fact, the Organisation for Economic Co-operation and Development (OECD), the parent organization of the PISA assessment, has also recognized this by including CT as one of the assessment frameworks alongside mathematical reasoning in students’ thinking processes in 2022 (OECD, 2023).

In Indonesia, awareness of the importance of CT has actually been implicitly accommodated in national education policy. The government, through the Ministry of Education, Culture, Research, and Technology, has designated CT as one of the key elements in the Merdeka Curriculum. This is outlined in BSKAP Decision No. 033/H/KR/2022 regarding Learning Outcomes for Early Childhood, Elementary, and Secondary Education, particularly in the subject of Computer Science (BSKAP, 2022).

However, despite international recognition of the importance of CT and the existence of a legal framework to support it, its implementation in Indonesia still faces many challenges. This is reflected in the 2022 PISA assessment results for Indonesian students (359), which fell below the OECD average (472), particularly in mathematical literacy. Consequently, with the inclusion of CT as one of the assessment frameworks in PISA, there is an indication that Indonesian students’ CT skills need to be improved (OECD, 2023). One factor suspected to contribute to this challenge is highlighted in Setyaedhi’s (2025) research: the practice problems provided to students whether in textbooks or assigned by teachers fail to adequately represent the competencies intended to be achieved. In the context of education in Indonesia, these practice questions are primarily provided in mathematics textbooks, which include not only questions but also activities and materials designed to support the learning outcomes required by the curriculum (Ministry of Education and Culture, 2016).

It is this central role of textbooks that is the crucial focus. According to Fan (2013), textbooks serve as an intermediate variable linking dependent and independent variables. The dependent variables include the curriculum, culture, and educational policies, while the independent variables encompass students’ learning processes, learning outcomes, mindsets, and abilities. This assertion indicates that textbooks play a vital role, not merely as instructional materials, but as a crucial bridge for realizing quality education that positively impacts students. Therefore, it is essential to assess to what extent the quality of mathematics textbooks can foster 21st-century skills, particularly computational thinking (CT) abilities.

Unfortunately, research on Indonesian mathematics textbooks, particularly the Indonesian Government Textbooks in the context of CT, remains very limited. Based on a review conducted by Wijayanti et al. (2025), out of 42,672 articles indexed in SINTA between 2016–2024, only 80 articles (0.19%) addressed this topic. Furthermore, none specifically

analyzed CT content; the focus remained on spatial reasoning, non-routine problems, and mathematical creativity (Rahmawati, 2024; Manopo & Lisarani, 2021; Ummah et al., 2024). Additionally, comparative studies of Indonesian textbooks with those from high-PISA-scoring countries, such as Singapore, to examine how CT is integrated, remain scarce. Yet, such comparative studies could provide valuable perspectives and benchmarks for improving the quality of textbooks in Indonesia (Wijayanti et al., 2025). This gap constitutes the novelty and primary urgency of this study: the central role of textbooks, yet the scarcity of in-depth research on them and their capacity to foster CT in students.

To address this urgency, a comprehensive assessment of the quality of Indonesian textbooks necessitates a comparative approach with textbooks from other countries that have successfully integrated CT and achieved high PISA scores. Singapore was chosen not only because it is a neighboring country in ASEAN and achieved high PISA scores in 2022, particularly in mathematical literacy at 575, but also because the integration of CT in Singapore employs a distinct approach compared to other nations. There, CT is not a required subject as it is in Indonesia, but it is still introduced in preschool and elementary school, and there are elective courses in secondary school (Seow et al., 2019). This makes Singapore not only relevant as a comparison country in this study but also enriches the analytical perspective, especially since Indonesia has only recently implemented CT in the Computer Science curriculum.

However, the novelty and urgency of this research do not end there. There is a methodological gap in previous studies, namely the use of general CT frameworks—such as decomposition, pattern recognition, algorithms, generalization, and abstraction—with their indicators then adapted to the mathematical context. This approach risks obscuring the contextual nature of CT in actual mathematics learning. For example, an algorithm in programming is defined as a sequence of steps, but in mathematics, it can be understood as a systematic, effective, and efficient approach to solving problems. Thus, the second novelty of this study lies in adopting the CT framework from Weintrop et al. (2016), which emphasizes practice and has been validated in mathematics and science education.

This framework by Weintrop et al. (2016) highlights how CT manifests in mathematical activities such as data practices, modeling and simulation practices, computational problem-solving, and systems thinking. Therefore, the use of the Weintrop et al. (2016) framework is considered more appropriate for analyzing the extent to which mathematics textbooks support the development of students' CT skills. Thus, this study not only addresses a thematic gap regarding CT in mathematics textbooks but also fills a methodological gap by applying a more contextual analytical framework. Consequently, based on these research gaps, this study aims to analyze the distribution of CT in mathematics textbooks and compare the proportions of its occurrence in Indonesian and Singaporean mathematics textbooks. Specifically, this study seeks to answer three research questions: how is CT distributed in Indonesian mathematics textbooks, how is CT distributed in Singaporean mathematics textbooks, and is there a significant difference in the proportion of CT between the two textbooks?

LITERATURE REVIEW

Textbooks are a key component of the education system because they serve as a bridge between the curriculum designed at the policy level and classroom teaching practices (Fan, 2013). In many education systems, textbooks are used not only as a source of learning materials for students but also as a guide for teachers in designing learning activities.

Therefore, textbooks play a strategic role in shaping the learning experiences students have during the learning process.

In the context of Indonesian education, the position of textbooks as learning resources is formally regulated in Law of the Republic of Indonesia No. 20 of 2003 on the National Education System, which affirms that the educational process is supported by various relevant learning resources to achieve learning objectives. This provision is further reinforced by Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 8 of 2016 on Books Used by Educational Institutions, which states that textbooks are the primary learning resource to help students achieve the competencies set forth in the curriculum (Ministry of Education and Culture, 2016).

In mathematics education studies, textbooks are often viewed as the most tangible representation of the curriculum in teaching practice. Fan (2013) explains that textbooks serve as an intermediary variable linking educational policies, curricula, values, and a nation's culture to teachers' instructional practices and students' learning experiences. Thus, an analysis of textbooks can provide insights into the learning experiences students undergo, their patterns of thinking, and the skills they acquire.

Furthermore, textbooks also reflect the pedagogical orientation adopted by an educational system. According to Pingel (2010), textbooks are educational artifacts that reflect cultural values, learning objectives, and pedagogical approaches considered important within a society. In the context of mathematics education, textbook design can influence how mathematical concepts are presented by teachers, how students interact with examples, activities, and problems, and the types of thinking processes developed during learning activities.

In the context of mathematics education, Fan (2013) notes that comparative research on mathematics textbooks is important for revealing how concepts and skills are represented across various educational systems. Thus, comparative analysis of problems serves as a tool for assessing how the characteristics of a textbook support the learning objectives to be achieved. Furthermore, Wijayanti et al. (2025) classify textbook analysis into three forms: content analysis, theoretical analysis, and problem analysis. Problem analysis is relevant in the context of this study because it focuses on mathematical problems or tasks, including their structure, cognitive level, context, and the type of response expected. Through comparative question analysis, researchers can identify how variations in question presentation influence the development of students' thinking skills, including higher-order thinking skills. This approach also helps evaluate the extent to which questions serve as a means of fostering the thinking skills expected by the curriculum and the demands of 21st-century education.

CT, as one of the 21st-century skills, is gaining increasing attention in the world of education because it is considered one of the essential skills needed to address technological and informational advancements. The concept of CT was first popularized by Wing (2006), who defined CT as a thinking process involving problem formulation and solution design that can be carried out effectively by both humans and computers. From this perspective, CT is not only related to programming but also to systematic thinking in problem-solving.

Wing's concept of CT was first developed into an operational framework in the field of education by Barr et al. (2011), members of ISTE (International Society for Technology in Education) and CSTA (Computer Science Teachers Association), with support from the National Science Foundation (NSF). They divided CT into two aspects: conceptual and practical. These findings were further developed by Brennan and Resnick (2012) by adding a third dimension: perspective. They argued that after understanding concepts and practices, people also need to be able to view themselves and the world as creators, not merely as users.

These various perspectives indicate that CT is a multidimensional concept that is not limited to the field of computer science but is also relevant in various other disciplines, including mathematics (Wing, 2011). In the context of mathematics education, CT has a strong connection with mathematical thinking practices. Activities such as recognizing patterns, performing abstraction, and designing problem-solving steps are integral parts of the mathematical thinking process. Therefore, the integration of CT into mathematics learning is viewed as a promising approach to support the development of students' higher-order thinking skills.

Weintrop et al. (2016) developed a CT framework specifically designed for the context of science and mathematics education. This framework categorizes CT practices into four main categories: data practices, modeling and simulation practices, computational problem-solving practices, and systems thinking practices. This framework provides a systematic analytical basis for identifying learning activities related to CT across various educational contexts.

Data Practices	Modeling & Simulation Practices	Computational Problem Solving Practices	Systems Thinking Practices
Collecting Data	Using Computational Models to Understand a Concept	Preparing Problems for Computational Solutions	Investigating a Complex System as a Whole
Creating Data	Using Computational Models to Find and Test Solutions	Programming	Understanding the Relationships within a System
Manipulating Data	Assessing Computational Models	Choosing Effective Computational Tools	Thinking in Levels
Analyzing Data	Designing Computational Models	Assessing Different Approaches/Solutions to a Problem	Communicating Information about a System
Visualizing Data	Constructing Computational Models	Developing Modular Computational Solutions	Defining Systems and Managing Complexity
		Creating Computational Abstractions	
		Troubleshooting and Debugging	

Picture 1. Dimensions of the CT by Weintrop et al. (2016)

The framework developed by Weintrop et al. (2016) addresses concerns that CT is perceived as biased toward metacognition. This is because, in practice, CT is still viewed as coding. This view is not surprising, as CT is integrated into learning using applications such as Scratch, Snap, GeoGebra, Logo, and Desmos, which are programming-based (Gadanidis et al., 2017). However, according to Weintrop et al. (2016), the integration of CT into classroom learning does not have to be a separate subject. CT can be integrated into practical activities such as identifying and visualizing data, connecting to phenomena in other fields, and providing students with the freedom to analyze and evaluate a process or system related to a phenomenon.

Thus, given these similarities, the integration of CT in mathematics education actually offers broad benefits. Research indicates that CT significantly contributes to improved problem-solving skills and mathematical conceptual understanding (Isharyadi & Juandi, 2023; Ye et al., 2023; Gadanidis et al., 2017). Additionally, Fauzi et al. (2024) found that CT also has a positive impact on the affective domain, such as increased student self-confidence and creativity. Similar findings were reported by Gadanidis et al. (2017), who highlighted increased student engagement in the learning process. Its application across various topics, such as algebra, geometry, and arithmetic, has been shown to strengthen conceptual understanding (Kaup et al., 2023). Furthermore, CT serves as a crucial bridge connecting the abstract field of mathematics to the more concrete real world and supports higher-order thinking skills (Weintrop et al., 2016; Isharyadi & Juandi, 2023; Ye et al., 2023). For teachers, CT helps broaden perspectives on mathematical concepts, shifting the paradigm from static to exploratory, and fostering a growth mindset in pedagogical practice (Gadanidis et al., 2017).

However, despite the wide-ranging benefits of CT integration in mathematics education, challenges remain in its implementation, such as longer lesson durations due to its exploratory nature, resource readiness specifically regarding teachers, instructional materials, and assessment tools as well as varying levels of teachers' technological proficiency, and the need for complex pedagogical preparation (Isharyadi & Juandi, 2023; Gadanidis et al., 2017).

Regarding the comparison of Indonesian and Singaporean mathematics textbooks, several studies have examined the characteristics of mathematics textbooks, particularly within the context of this cross-national comparison. Manopo and Lisarani (2021) compared non-routine problems on the Pythagorean Theorem topic in Indonesian and Singaporean mathematics textbooks. The results indicate that Indonesian textbooks place greater emphasis on conceptual reasoning, whereas Singaporean textbooks are more focused on procedural fluency.

Another study by Ummah et al. (2024) analyzed the contexts of algebra practice problems in textbooks from several countries, including Indonesia and Singapore. The results indicate that most problems are still dominated by purely mathematical contexts, while the use of technology-based contexts remains relatively limited. However, Singaporean textbooks are beginning to demonstrate technology integration through the use of digital devices in learning. Additionally, Rahmawati (2024) investigated how elementary school mathematics textbooks develop students' spatial reasoning skills. The results indicate that Indonesian textbooks tend to be more diverse in cognitive demands, whereas Singaporean textbooks demonstrate a better balance in the development of spatial visualization.

When analyzed as a whole, comparative research examining how CT is represented in mathematics textbooks as students' primary learning resources remains limited. Furthermore, research on CT in the context of mathematics education remains limited to the use of general CT frameworks (Kurohman et al., 2025; Chan et al., 2020; Fitriyah et al., 2024), all of which examine CT through four main components: decomposition, pattern recognition, algorithmic thinking, and abstraction/generalization. These studies have not yet adapted a more discipline-specific framework for mathematics, such as the one developed by Weintrop et al. (2016). Thus, this study offers two novelties: first, an analysis of CT in Indonesian and Singaporean mathematics textbooks, which has not been conducted to date; and second, the application of the Weintrop et al. (2016) framework as a relevant analytical framework for CT in mathematics education.

Building on this research gap, this study aims to analyze the distribution of CT in mathematics textbooks and compare the proportions of their occurrence in Indonesian and Singaporean mathematics textbooks. Specifically, this study seeks to answer three research questions: how are CTs distributed in Indonesian mathematics textbooks, how are CTs distributed in Singaporean mathematics textbooks, and is there a significant difference in the proportion of CTs between the two textbooks?

METHODS

This study employs a sequential exploratory design using a mixed-methods approach with a descriptive-comparative methodology, as it aims to describe and compare the distribution of CT in Indonesian and Singaporean mathematics textbooks. The sequential exploratory design in the context of this study consists of three phases, beginning with an exploration of CT content in Indonesian and Singaporean textbooks using qualitative methods, followed by quantitative analysis, and concluding with a quantitative validation of the previous phase to determine the extent of differences in the proportion of CT-based questions in textbooks from both countries (Creswell & Clark, 2018). Furthermore, this design and method were chosen

because the combination of qualitative and quantitative methods in the sequential exploratory design allows researchers to gain both a deep understanding and measurable empirical evidence regarding the distribution patterns and differences in the application of CT in the problems in the mathematics textbooks under study.

The sources of this study are official mathematics textbooks or those recommended by the respective ministries of education. In Indonesia, textbooks from the Book Center are considered official because it is an extension of BSKAP, the Ministry of Education and Culture, while the Singaporean textbooks used are those published by Star Publishing and included in the Approved Textbook List (ATL) of the Ministry of Education Singapore (MOE). Furthermore, the selected books are those with comparable content in terms of learning outcomes, given the differences in educational systems and the spiral nature of the curriculum in Singapore. The research subjects are all questions found in the textbooks, including sample questions, activities, reflections, exercises, enrichment activities, and competency tests.

Tabel 1. Book Title and Publisher

Textbook Title	Publisher
Merdeka Curriculum Mathematics Textbook for Grade 10, Revised Edition 2023	Book Center
Merdeka Curriculum Mathematics Textbook for Grade 11	Book Center
Advanced Mathematics Textbook for Grade 11 under the Merdeka Curriculum, Revised Edition 2024	Book Center
Merdeka Curriculum Mathematics Textbook for Grade 12	Book Center
New Discovering Mathematics G3 Syllabus 2A (3th Edition)	Star Publishing
New Discovering Mathematics G3 Syllabus 2B (3th Edition)	Star Publishing
New Discovering Mathematics G3 Syllabus 3B (3th Edition)	Star Publishing
New Discovering Mathematics G3 Syllabus 4B (3th Edition)	Star Publishing

The primary instrument of this study is the researcher themselves, as is customary in qualitative research. The researcher plays a role in reading, coding, interpreting, and drawing conclusions from the data based on the theoretical framework employed. However, to maintain the consistency and quality of the analysis process, this study also uses an analysis sheet as an auxiliary instrument. Quantitatively, the instruments used consist of frequency and cumulative tabulation tables. The analysis sheet and tabulation tables are as follows. The CT dimension indicators that have been developed are as follows. These indicators have undergone construct and content validation by two experts: Roro Syarifati Sani, S.Si., M.Si., a high school mathematics teacher at Thursina International Islamic Boarding School, and Dyana Wijayanti, S.Pd., M.Pd., Ph.D., a lecturer in the Mathematics Education program at the Faculty of Teacher Training and Education (FKIP), Unissula.

Tabel 2. CT subdimension indicators

CT Subdimensions	Code	CT Indicator
Data Collection	DP1	1) The item requires students to identify or select the necessary data. 2) The question requires students to extract data from tables, graphs, or measurements.
Creating Data	DP2	1) The question asks students to generate new data through calculations or iterations.

CT Subdimensions	Code	CT Indicator
		2) 2) The question asks students to determine values/data that are not directly provided in the question.
Manipulating Data	DP3	1) The problem asks students to sort, clean, or group data. 2) The question asks students to transform data (eg, from a table to a graph).
Analyzing Data	DP4	1) Questions ask students to identify patterns, trends, or relationships between variables. 2) Questions that ask students to draw conclusions based on data analysis.
Visualizing Data	DP5	1) The question asks students to create a graph or diagram from the data. 2) Questions ask students to interpret graphs or data visualizations.
Using Models to Understand Concepts	MS1	1) The question presents a model (function/graph) for students to understand or predict its behavior. 2) Questions ask students to analyze the relationship between variables based on the provided model.
Using Models to Test Solutions	MS2	1) The question asks students to try different values/parameters and compare the results. 2) The question asks students to evaluate several scenarios based on the model.
Evaluating the Model	MS3	1) The question asks students to determine whether the model or formula is appropriate and reasonable. 2) The question asks students to identify the model's limitations or assumptions.
Designing Models	MS4	1) The question asks students to determine the variables and parameters for modeling a phenomenon. 2) The question asks students to outline the steps for the mathematical representation of a process.
Building Models	MS5	1) The question asks students to construct equations/functions to represent real phenomena. 2) The question asks students to modify the model for new conditions.
Preparing Problems for Computational Solutions	CPS1	1) The question asks students to break down a complex problem into sub-problems. 2) The question asks students to simplify information into mathematical form.
Programming / Algorithmic	CPS2	1) The question asks students to write down systematic steps such as an algorithm or iterative table.

CT Subdimensions	Code	CT Indicator
		2) Questions use a sequence/logic pattern that students must follow.
Choosing Effective Computing Tools	CPS3	1) The questions require students to choose the most efficient method (graph, table, or equation). 2) The question asks students to compare two solution methods.
Assessing Solution Approaches	CPS4	1) The question asks students to compare two mathematical strategies. 2) The question asks students to evaluate the advantages and disadvantages of a solution method.
Developing Modular Solutions	CPS5	1) The question asks students to create a stepwise procedure. 2) The question asks students to create a general solution that can be reused.
Creating Computational Abstractions	CPS6	1) The question asks students to find general patterns from several cases. 2) The question asks students to create a simplification or general rule of the phenomenon.
Troubleshooting & Debugging	CPS7	1) The question asks students to find errors in the solution steps. 2) The question asks students to correct inaccurate models/formulas.
Investigating Complex Systems	ST1	1) The question asks students to observe the overall pattern of a dynamic system. 2) The question asks students to explain the behavior of the system based on the output/graph.
Understanding Relationships in Systems	ST2	1) The question asks students to explain the relationship between variables in the model. 2) The question asks students to analyze how changes in one variable affect another.
Thinking in Levels	ST3	1) The question asks students to analyze micro-macro relationships in a context. 2) The question asks students to interpret how local changes affect global outcomes.
Communicating System Information	ST4	1) The question asks students to present the results of the system analysis in visual form (diagram/graph). 2) Questions ask students to explain the system process through narrative or flowcharts.

CT Subdimensions	Code	CT Indicator
Defining Systems & Managing Complexity	ST5	1) The question asks students to determine the system boundaries and relevant components. 2) The question asks students to simplify a complex system into an efficient mathematical model.

Developed from Weintrop et al. (2016)

Tabel 3. Example of a data collection technique using a coding sheet

Merdeka Curriculum Mathematics Textbook for Grade 11																								
Circle			DP					MS					CPS							ST				
No	Question Rubric	Page	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5
1	Exercise 2.1	13	E	N	I	N	N	I	N	E	E	I	N	N	N	E	I	N	E	E	E	E	I	N
2	Critical Thinking 1	15	E	E	E	E	N	N	N	I	I	E	E	N	N	I	N	E	E	N	E	E	E	I

Description:

CT Dimensions

- DP = Data Practice
- MS = Modeling & Simulation
- CPS = Computational Problem Solving
- ST = Systems Thinking

Entry (Assessment Category)

- E = Explicit
- I = Implicit
- N = None

Tabel 4. Example of a frequency table of the coding results for the CT dimension

Dimensions	IND (f)	%	SGP (f)	%	Total
Data Practice	42	28	58	29	100
Modeling & Simulation	25	12	40	20	65
Computational Problem Solving	60	41	72	36	132
Systems Thinking	18	19	30	15	48
Total	145	100	200	100	345

Data collection was conducted using the documentation technique, which relies on documents as the primary data source. This technique was chosen because the research subject was a textbook, meaning that data collection did not require the involvement of respondents, interviews, or observation. Documentation allows researchers to collect stable and unchanging data, as documents are static data sources that can be reviewed repeatedly

without distortion. Furthermore, the steps involved include identifying the questions, reading thoroughly, marking or coding based on specific indicators, and recording them on an analysis sheet.

Furthermore, coding is performed to track the presence of CT indicators that are explicit, implicit, or absent. This approach aligns with Wijayanti's (2019) perspective, which emphasizes that the connection between concepts or skills in textbooks can appear explicitly, implicitly, or not at all, depending on the form of the task and the provided explanations. In the context of this study, explicit instances are denoted by the letter "E," implicit by "I," and absent by "N." Quantitatively, the researcher calculated the total number of items and the percentage of coding results.

Before conducting data analysis, the next step is to ensure data validity. Validity in qualitative research determines the extent to which research results can be trusted and justified. Validity in this study is established through two main aspects: credibility and reliability.

Data credibility is maintained through an extended observation period and the researcher's diligence in examining each item and aligning it with the CT indicators. The research period, which ran from December to February, provided the researcher with the opportunity to re-read the data, revalidate analytical decisions, and correct categorization inconsistencies. According to Moleong (2017, as cited in Rahmawati 2024), extending the observation period makes the research process more meticulous and careful, thereby yielding more systematic and accurate research results.

Data dependability is maintained by systematically documenting the entire research process through an audit trail. This audit trail contains records of changes to indicators, results of instrument revisions, categorization decisions for each item, and interpretive changes that occurred during the analysis process. The audit trail includes the final validated coding framework, analysis worksheets containing item excerpts, CT categories, and coding justifications, as well as the researcher's reflective notes reflecting the evolution of thought during the analysis process.

Reliability was also assessed using the intra-rater stability technique. This technique was used to ensure that the instrument could be administered consistently (Neuendorf, 2017). This method was chosen because the study involved a large dataset, consisting of 1,503 questions. A 20% sample of questions from each chapter was randomly selected and analyzed over a 14-day period. The level of agreement in coding results was calculated using the percentage of agreement. An agreement rate of 80% or higher indicates that the instrument is stable and the coding is reliable. The stability test results for 300 items showed a value of 80.03%, indicating satisfactory stability in item coding (Krippendorff, 2019).

After the data were deemed valid and reliable, the analysis process was conducted based on the interactive analysis model by Miles and Huberman (1994, as cited in Yusuf, 2017). The analysis began with data reduction, which is the process of selecting, abstracting, and simplifying raw data to create more structured information. At this stage, the researcher identified relevant CT indicators for each item and discarded data unrelated to the research focus. The next stage was data presentation, which involved organizing the data into narratives, tables, or matrices illustrating relationships among indicators. The final stage was drawing conclusions. At this stage, the researcher formulates findings based on the patterns of the analyzed data. In the quantitative domain, a chi-square test is conducted to determine significant differences in the distribution of CT, where it is first ensured that the expected value is above 5, and if the p-value is below 0.05, then H_0 is rejected and H_1 is accepted. An example of question analysis can be performed as follows.

“An airplane is at an altitude of 200 meters. From point A, the angle of elevation of the airplane is 38° . What is the horizontal distance between the airplane and point A?”

In this problem, students must first identify the required data namely, the angle of elevation and the altitude of the aircraft so this problem meets the “Collecting Data” indicator (DP1). Next, students need to translate the story’s information into a right-angled triangle diagram illustrating the relationship between the front side, the side, and the angle of elevation. This step falls under the Preparing Problems for Computational Solutions (CPSP1) indicator, as students must transform the narrative text into a computable mathematical model. Next, students systematically calculate the horizontal distance using trigonometric formulas, which aligns with Developing Algorithmic Solutions (CPSP5). Thus, based on the framework by Weintrop et al. (2016), this problem involves two main CT dimensions: Data Practices through the extraction of relevant data (DP1) and Computational Problem Solving Practices through modeling and algorithmic steps (CPSP1 and CPSP5).

RESULT

This section presents the results of a comparison of Indonesian and Singaporean mathematics textbooks regarding their potential to develop students’ critical thinking skills. The research data were sourced from eight textbooks, consisting of four Singaporean textbooks for grades 2–4 and four Indonesian textbooks for grades 10–12. In total, 1,503 items were analyzed, with 1,006 items from Singaporean textbooks and 497 from Indonesian textbooks.

The questions analyzed are part of subject chapters deemed equivalent in both countries based on learning outcomes. The compared subject chapters are as follows: 1) Trigonometry vs. Trigonometric Ratios, 2) Quadratic Equations & Functions vs. Quadratic Functions, Graphs & Equations, 3) Representation & Descriptive Statistics vs. Statistical Diagrams & Measures of Central Tendency, 4) Basic Probability vs. Probability, 5) Circles vs. Properties of Circles, 6) Trigonometric Functions with Further Trigonometry, 7) Vectors with Vectors in Two Dimensions, and 8) Arcs and Sectors of Circles with Arc Lengths, Sector Areas & Radian Measure.

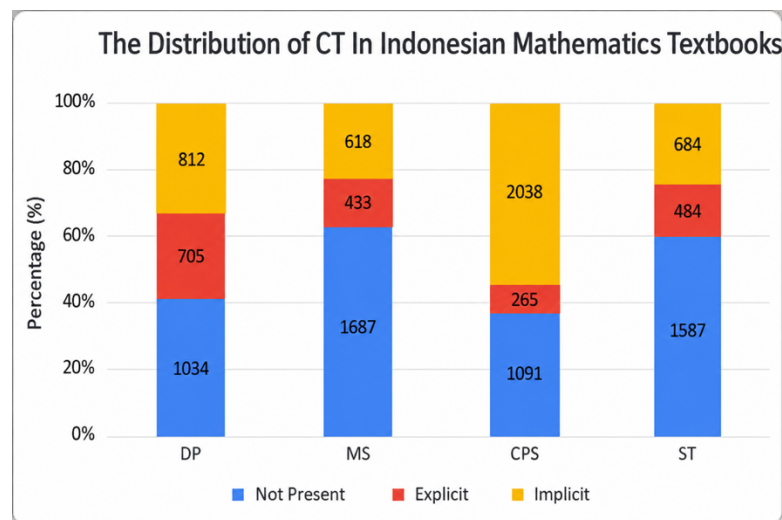
Items from corresponding chapters were coded based on the presence of computational thinking indicators whether explicit, implicit, or absent. Coding results were accumulated for each subdimension and then aggregated to the main dimension level. Subsequently, a chi-square test was conducted to determine the significance of differences in the proportions of computational thinking indicator presence between Indonesian and Singaporean textbooks.

The cumulative distribution of CT competencies in Indonesian mathematics textbooks tends to be absent or implicit. Based on the data, the “absent” category has the highest frequency in almost all dimensions, except in the computational problem-solving dimension, followed by the “implicit” category, while the “explicit” category appears the least.

Tabel 5. Cumulative distribution of the CT indicator in Indonesian mathematics textbooks

Aspect	E (f)	E (%)	I (f)	I (%)	N (f)	N (%)	Total
DP	705	27.64	812	31.83	1,034	40.53	2,551
MS	433	15.81	618	22.57	1,687	61.62	2,738
CPS	265	7.81	2,038	60.05	1,091	32.14	3,394
ST	484	17.57	684	24.83	1,587	57.60	2,755

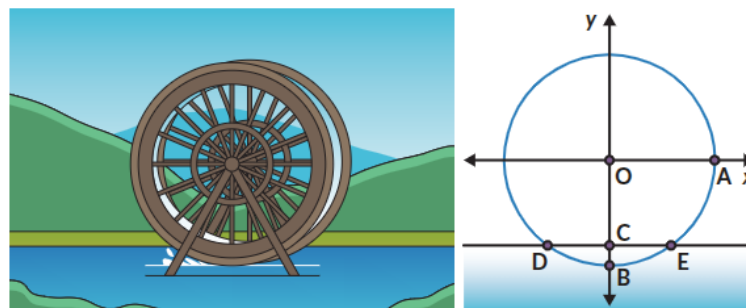
This graph shows the number of occurrences of the CT indicator across each dimension in Indonesian mathematics textbooks. The “none” category has the highest count across all dimensions, followed by ‘implicit’ and “explicit.” The highest value was recorded in Computational Problem Solving Practices, with 2,038 data points in the “implicit” category.



Picture 2. Dimension distribution of Indonesian textbooks

This distribution is illustrated by the following example.

Kincir air berikut digunakan untuk pembangkit energi dan irigasi. Pada diagram sebelah kanan, roda dengan diameter 10 m diletakkan pada sungai sehingga titik terendah roda terletak pada kedalaman 1 m.



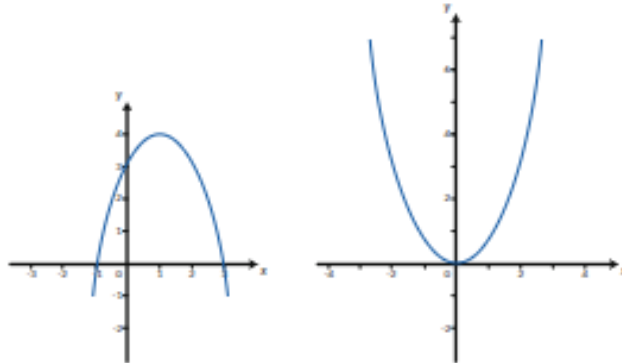
- Tentukan ketinggian titik A dari permukaan air.
- Permukaan air ditunjukkan oleh tali busur $\overline{DE}$. Tentukan besar $\angle DAE$.
- Tentukan jarak dua titik pada roda yang terletak di permukaan air.

Picture 3. Questions on the proof of the circumference formula (In Indonesian)

The question above highlights several CT indicators that align with those in the cumulative distribution table. In the data practice dimension, the subdimension of collecting and creating data appears explicitly, as the question explicitly requires students to request the high value of point A, which is not provided in the question. Meanwhile, in the subdimension of analyzing and visualizing data, the indicators appear implicitly; students indirectly interpret images and graphs and draw conclusions. Moving on to the modeling and simulation dimension, only MS1 is explicit because it presents a model of a problem, and MS4 indirectly designs a systematic solution model, while the others do not appear. In the computational problem-solving dimension, CPS 1, 2, 5, and 6 appear implicitly, as there are no action verbs explicitly requiring students to perform them, but they are carried out unconsciously—such as breaking down problems, taking systematic steps, developing reusable solutions, and

identifying general patterns while CPS 3, 4, and 7 do not appear. In the dimension of systems thinking, these skills are implicit in ST 1, 2, and 4 because students indirectly observe graph patterns and redraw circles, but they are absent in the others.

Tentukan koordinat titik puncak, sumbu simetri, koordinat titik potong dengan sumbu y, dan banyak titik potong dari grafik fungsi-fungsi kuadrat di bawah ini.



Apakah hubungan antara titik puncak dengan grafik terbuka ke atas atau ke bawah?

Picture 4. Practice Problems on the Justification of the Quadratic Equation (In Indonesian)

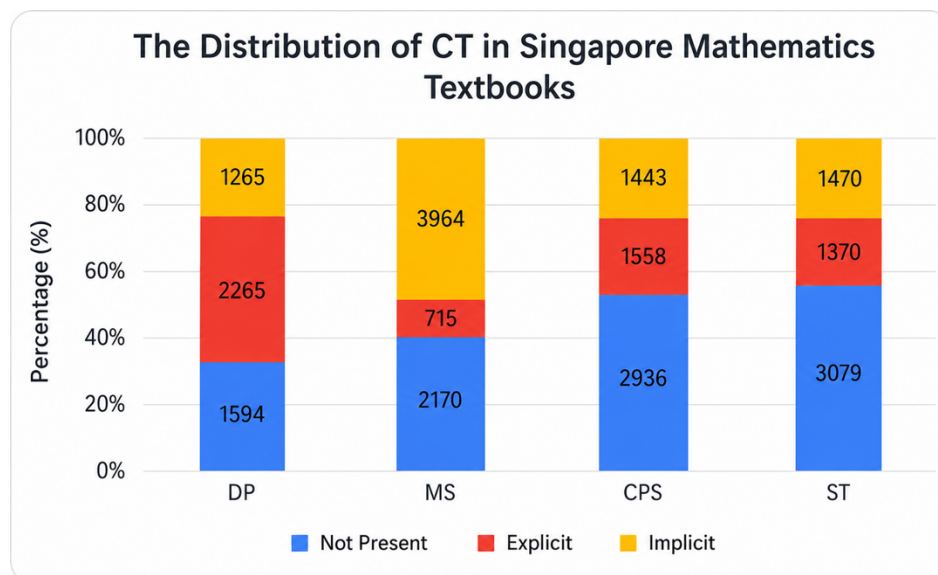
In the Data Practices dimension, the subdimensions of data collection, creation, and visualization appear implicitly because they indirectly involve extracting, generating, and interpreting graphs. Meanwhile, DP3 is absent and DP4 is explicit because they involve asking about relationships. In the modeling and simulation dimension, it is explicit in MS1 because a model is presented, implicit in DP4 because it indirectly designs solutions, and absent in the others. In the Computational Problem-Solving dimension, CPS1, 2, 3, 5, and 6 are implicit because they indirectly involve decomposition, systematic steps, selecting relevant relationships, developing solutions, and abstraction; the others are absent. Finally, in Systems Thinking, ST1 and ST2 are explicit because they involve observing and identifying relationships, while the others are absent.

The data patterns show that the “explicit” category appears dominant in most dimensions, particularly in Data Practices followed by Modeling and Simulation Practices. Meanwhile, the “absent” category appears across all dimensions with varying proportions.

Tabel 6. Cumulative distribution of the CT indicator in Singaporean textbooks

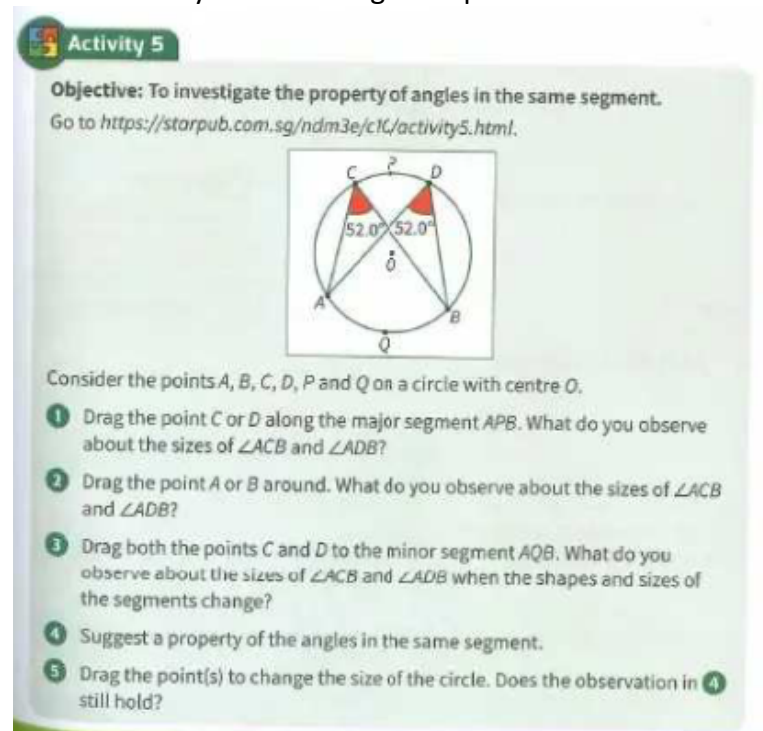
Aspect	E (f)	E (%)	I (f)	I (%)	N (f)	N (%)	Total
DP	2265	44.20	1265	24.69	1594	31.11	5124
MS	1558	26.24	1443	24.31	2936	49.45	5937
CPS	715	10.44	3964	57.88	2170	31.68	6849
ST	1370	23.15	1470	24.84	3079	52.02	5919

This graph shows the number of occurrences of the CT indicator in Singaporean mathematics textbooks across the four dimensions. The explicit category has the highest number of occurrences in nearly all dimensions, while the “none” category has the lowest. The highest value was recorded in Computational Problem Solving Practices, with 3,964 instances in the implicit category.



Picture 5. The Distribution of CT in Singapore Mathematics Textbooks

This distribution is illustrated by the following example



Picture 6. Practice problems on the properties of a circle

Data practices are clearly evident in the explicit data collection (DP1), as students are instructed to select several angles that determine the measure of an angle, and then explicitly record the data (DP2). Data manipulation (DP3) does not appear, but data analysis (DP4) is performed explicitly when students draw conclusions from their observations, and data visualization (DP5) is also explicit, as seen in the images that must be interpreted and the drawing activities on the website.

In Modeling and Simulation Practices (MS), MS1 is explicit because the model is clearly provided; MS2 is explicit because there are solutions to compare and models to evaluate; however, model design (MS4) appears implicit through the instruction to create equations. Meanwhile, in Computational Problem Solving Practices, CPS1 appears implicitly because

students break down the problem, while the systematic formulation of solutions (CPS2) also appears implicitly. The selection of computational tools (CPS3) and CPS4 are absent, but the development of modular solutions (CPS5) is implicit and abstraction (CPS6) is explicit because students are asked to draw conclusions, while troubleshooting and debugging (CPS7) emerge implicitly from observations of shifts or changes, without direct instruction. Regarding Systems Thinking Practices, ST1, ST2, and ST4 appear explicitly because students explore changes and consequences among system components and communicate the results, whereas ST3 and ST5 do not appear.

7 The variables x and y are connected by the equation $y = (2x + 3)(2x - 9)$. Some corresponding values of x and y are given in the table below.

x	-3	-2	-1	0	1	2	3	4	5	6
y	45	13	-11	-27	-35	p	-27	-11	13	45

(a) Find the value of p .

(b) Draw the graph of $y = (2x + 3)(2x - 9)$ for $-3 \leq x \leq 6$ using a scale of 1 cm to represent 1 unit on the x -axis and 1 cm to represent 10 units on the y -axis.

(c) Use your graph to find

- the value of the y -intercept,
- the coordinates of the points where the graph intersects the x -axis,
- the minimum value of y and the value of x at which this occurs.

(d) (i) On the same axes, draw the line $y = 8x - 16$ for $-3 \leq x \leq 6$.

(ii) Write down the x -coordinates of the points where this line intersects the curve.

Picture 7. Questions on the justification of CT for quadratic material, graphs, and functions

In this problem, Data Practices appear quite explicitly: DP1 is evident in the collection of data from the table; DP2 is explicit in the search for the value of p , which is not given in the problem; DP3 is explicit through the graph; DP4 is explicit through the analysis of the relationship between variables x and y ; and DP5 is also explicit when students draw a graph for visualization. Regarding Modeling and Simulation Practices, MS1 is explicit because a model is provided; MS2–3 do not appear; MS4 is explicit through problem design and graphing; and MS5 is explicit because students write down coordinates to solve an additional problem. In Computational Problem Solving Practices, CPS1 appears implicitly when students break down the problem, CPS2 is explicit through graphing and data recording, CPS3 does not appear, CPS4–CPS6 are implicit, and CPS7 is absent. In Systems Thinking Practices, ST1 and ST2 are explicit because they relate changes and relationships among components; ST3 does not appear; ST4 explicitly describes the system; and ST5 is explicit when students create graphs and write down coordinates.

The following table shows the results of a comparison of the distribution of CT abilities between Indonesian and Singaporean mathematics textbooks. The data pattern shows clear differences in proportions across each dimension, where the chi-square (χ^2) value indicates significant results with a p -value < 0.001 across all four dimensions. Thus, H_0 is rejected and H_1 is accepted.

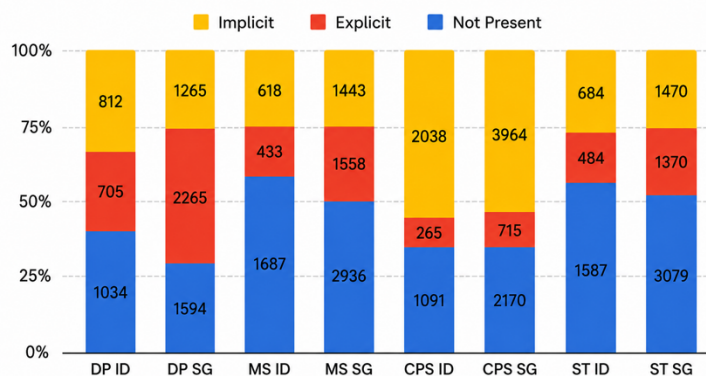
Tabel 7. Cumulative joint distribution of CT indicator occurrences

Dimensions	E (ID)	E (SG)	I (ID)	I (SG)	N (ID)	N (SG)	χ^2	P	Synthesis
DP	705	2265	812	1265	1034	1594	197.092	0.000	Sig.

Dimensions	E (ID)	E (SG)	I (ID)	I (SG)	N (ID)	N (SG)	χ^2	P	Synthesis
%	27,64	44,20	31,83	24,69	40,53	31,11	143.158	0.000	Sig.
MS	433	1558	618	1443	1687	2936			
%	15,81	26,24	22,58	24,31	61,61	49,45	18.402	0.000	Sig.
CPS	265	715	2038	3964	1091	2170			
%	7,81	10,44	60,05	57,88	32,14	31,68	38.267	0.000	Sig.
ST	484	1370	684	1470	1587	3079			
%	17,57	23,14	24,83	24,84	57,60	52,02			

The combined graph shows a comparison of CT distributions between the two textbooks across each dimension. Each dimension pair displays the number of explicit, implicit, and none categories based on the aggregated data. The total proportion is shown as a percentage on the vertical axis to facilitate cross-country comparisons.

Distribution of CT in Indonesian and Singaporean Mathematics Textbooks



Picture 8. Combined CT Dimensional Distribution

DISCUSSION

The distribution of questions in Indonesian mathematics textbooks shows a dominant trend toward the lack of explicit representation of CT. This pattern is evident across all four dimensions; the questions in the textbooks are predominantly in the form of procedural activities and concept application, where CT indicators emerge as an implication of solving the problems rather than through exploratory activities that require students to collect, manipulate, model, and analyze systemic relationships.

The dominance of such a pattern reflects the function of textbooks as a means of connecting the curriculum in classroom learning, rather than as a medium for the formation of knowledge and CT reflection. This position aligns with Fan's (2013) view that textbooks in education serve as an intermediary variable between a country's policies, curriculum, culture, and values and learning practices. In the Indonesian context, textbooks are strictly regulated by the 2022 Decision of the Head of the National Agency for Standards, Curriculum, and Educational Assessment (BSKAP) and Ministry of Education and Culture Regulation No. 8 of 2016, which designate textbooks as the primary source of learning (Kemendikbud, 2016).

Furthermore, textbooks compiled by the National Textbook Center are the primary textbooks that must include all learning outcomes outlined in the curriculum. Consequently, their content is inherently general and standardized to be used throughout Indonesia. Thus,

it is not surprising that Indonesian textbooks lack explicit CT indicators in their activities and questions. Moreover, there is currently no explicit legal framework for mathematics as a subject that serves as a foundation. Indonesian textbooks also function more as content guidelines that must be consistent to meet minimum learning outcomes, rather than as tools for critical thinking. Consequently, this results in a linear textbook structure, beginning with introduction, examples, exercises, knowledge reflection, and competency tests, yet exploratory activities remain limited.

The distribution of CT in the Data Practices dimension, its activities, and questions is limited to reading and using data. Data plays a static role as a tool for mathematical calculations. In this context, students are rarely asked directly to create, manipulate, and analyze data to solve problems. Data collection and visualization are concentrated only on subjects such as geometry and statistics, not across the entire curriculum. However, according to Weintrop et al. (2016), the practices of collecting, creating, manipulating, analyzing, and visualizing data serve as the gateway or primary entry point to CT. This is based on the requirement for students to demonstrate analytical and representational skills.

A similar situation is observed in the Modeling and Simulation Practices dimension. Most approaches treat mathematical models as pre-existing entities rather than processes that must be constructed. Students are directed to use provided formulas or graphs, rather than designing or evaluating models that represent a phenomenon. According to Weintrop et al. (2016), the absence of modeling processes severs the connection between mathematics and the real world. Yet in this context, CT demands the ability to simplify or represent real-world problems or phenomena in models that can be logically solved.

Unlike other dimensions, Computational Problem Solving Practices exhibit a significant implicit scope. Problems analyzed under this dimension indirectly require specific algorithmic steps, yet these are not explicitly stated and lack the underlying understanding. Consequently, students merely follow solution patterns without analyzing the problem structure, evaluating answers or models, or developing alternative strategies that could be employed. Within the framework of Brennan and Resnick (2012), this condition reflects a level of practice lacking perspective; students can perform CT procedures but have not yet grasped their role as creators of ways of thinking.

The Systems Thinking Practices dimension shows the weakest emergence of indicators. Activities and problems in the textbook almost entirely focus on isolated variables without relating them to a broader system. For example, in the material on arcs and sectors—which should be part of the larger system of a circle—understanding of hierarchical thinking, solutions to a system, or cause-and-effect relationships from micro to macro or vice versa is rarely found. Yet, according to Weintrop et al. (2016), systems thinking requires recognizing cross-level interconnections and understanding the system's behavior as a whole.

The prevailing patterns of activities and problems in Indonesian mathematics textbooks confirm that textbooks function as curriculum-driven tools rather than thinking tools. According to Fan (2013), Indonesian textbooks represent pedagogical conformity. The consequences for the education system will affect both teachers and students. Teachers must act as the primary mediators to interpret and bring out the implicit aspects or the absence of CT so that it emerges in classroom practice. As for students, they lack the stimulus to systematically develop their CT skills when using the textbooks. Consequently, CT skills generally remain only potential.

The distribution of problems in Singaporean mathematics textbooks shows a significant contrast with Indonesian mathematics textbooks. Explicit patterns dominate across all dimensions when compared, particularly in the Data Practices dimension, suggesting a deliberate integration of CT practices into the activities and problems provided. This trend

does not stand alone. According to Auliya' and Widjajanti (2023), Singaporean textbooks are structured progressively beginning with conceptual introductions, exploratory activities, contextual examples, graded exercises, and reflections. Each stage provides stimuli for student interaction with data, indirectly applying the principle of "learning by doing."

In the Modeling and Simulation Practices dimension, Singaporean mathematics textbooks are more systematic. The problems not only use mathematical models but also modify them, evaluate their appropriateness, assess their boundaries, and even design entirely new models. As a result, models do not become static objects but thinking tools. This aligns with Weintrop et al. (2016), who argue that in order to bridge mathematics and the real world, students' ability to model phenomena or problems and then evaluate them through simulation is paramount. However, even though they are more developed than Indonesian textbooks, few problems lead toward simulation for testing purposes.

The Computational Problem Solving Practices dimension presents an ambivalent pattern. On one hand, there is higher explicitation compared to Indonesia; on the other, most of the CT indicators that appear are still implicit. Even in the subdimensions of evaluating solution approaches and debugging, occurrence rates remain low. This indicates that the provided activities and problems more often require students to apply logical, systematic steps and compare several strategies, yet still provide limited space for reflection on whether the solutions and processes obtained are appropriate. This pattern aligns with Gadanidis, Cendros, and Namukasa (2017), who found that mathematics learning in Singapore emphasizes procedural accuracy and clarity of steps, but does not always allow room for students' improvement and creativity in problem-solving.

The distribution in the Systems Thinking Practices dimension shows a relatively low occurrence of indicators compared to the other dimensions. Although some activities and problems demonstrate inter-variable relationships, the layered relationships and their cascading effects are not yet well represented. These findings resemble the argument of Li and Li (2018) regarding Chinese textbooks which also represent an Asian country that tend toward logical and reflective thinking while still avoiding systemic complexity in order to preserve clarity in students' thinking flow.

This situation has important implications for mathematics education, particularly in how Singaporean textbooks demonstrate successful CT integration. This may be relevant for textbook developers in other contexts, including Indonesia. The Singaporean approach can serve as a model for building progressive thinking bridges, but must be adapted to avoid becoming trapped in procedural activities and problem-solving. Pedagogically, this phenomenon reveals that CT explicitation in Singaporean textbooks is partial: strong at the illustrative layer (data and models), but weak at the reflective and systemic layer (problem solving and systems thinking). Consistent with Fan (2013), Singaporean textbooks succeed as a pedagogical medium, yet have not fully become a cognitive medium guiding students to think logically and systematically, but not yet pushing them to evaluate their own ways of thinking.

The comparison between Indonesian and Singaporean mathematics textbooks shows that the difference in CT distribution is not merely numerical, but reflects how each educational system conceptualizes knowledge and ways of thinking. Indonesia is oriented toward content uniformity and curricular compliance by incorporating all learning outcomes, while Singapore is oriented toward cognitive structure and directed thinking. Nevertheless, neither has yet demonstrated a fully integrated CT approach the reflective and systemic dimensions remain a shared weak point. The significance of these findings lies in a paradigm shift in mathematics education: from the ability to solve problems procedurally to the cultivation of thinking awareness.

From a policy standpoint, these findings underscore the need for cognitively oriented textbook design guidelines and a regulatory framework supporting CT integration not only in the Informatics subject, but extending beyond the curriculum and its learning outcomes. BSKAP regulations should incorporate CT integration principles into content structure, activities, and assessment across all subjects, with particular emphasis on mathematics. At the grassroots level, teachers need to be trained to recognize the CT potential embedded in implicitly formulated problems, while textbook authors need to build a bridge between exploratory thinking structures (as seen in Singapore) and open reflective-systemic spaces (which remain underdeveloped in both countries).

Furthermore, for book authors and developers, these findings also indicate that CT indicator occurrences are more frequently found in activities involving digital technology, such as the use of mathematics software or data-based simulations. Nonetheless, as Weintrop et al. (2016) argue, CT is not limited to programming activities or digital technology use. CT is fundamentally a way of thinking that can be integrated even in non-digital activities, as long as students are invited to formulate problems, structure solutions, and systematically reflect on outcomes. Therefore, strengthening CT in textbooks and mathematics learning does not depend solely on the use of technology, but also on the design of activities that demand students' conceptual exploration and reflection. These findings thus provide a strategic direction for contextualizing 21st-century mathematics learning transforming textbooks from mere learning resources into architects that develop students' CT potential.

CONCLUSION

This study provides a comprehensive overview of the CT integration profile in Indonesian and Singaporean mathematics textbooks. Based on an in-depth analysis of CT dimensions, it was found that there is a significant difference in how the two countries integrate CT skills into their instructional materials. Indonesian mathematics textbooks show a dominant pattern of implicit integration across all CT dimensions. Learning activities and practice problems tend to be oriented toward basic concept application and procedural problem-solving. As a result, the deeper aspects of CT such as exploratory, reflective, and systematic thinking are still found only within a limited scope. This characteristic arises from the curriculum-driven nature of textbooks in Indonesia, where the primary focus is on broadly encompassing all national learning outcomes so that they can be generally adapted across the entire country.

In contrast, Singaporean mathematics textbooks demonstrate consistent explicitation, particularly in the Data Practices and Modeling and Simulation Practices dimensions. This indicates the presence of a strong instructional design policy direction in shaping students' structured thinking. However, this study also identifies a gap in Singaporean textbooks, where the Computational Problem Solving Practices and Systems Thinking Practices dimensions remain weak in reflective and systematic aspects.

Quantitatively, the Chi-Square statistical test confirms that there is a statistically significant difference in the distribution of CT indicators between Indonesian and Singaporean mathematics textbooks. The significance of this difference affirms that the disparity found is not coincidental, but rather the result of fundamental differences in curriculum philosophy and instructional design in the two countries. Despite being statistically different, the two textbooks are complementary. Singapore excels in explicitness of structure, while Indonesia excels in interpretive flexibility for teachers.

The significant contribution of this research to the field of mathematics education is the repositioning of the textbook's role not merely as a curriculum intermediate variable, but as a thinking tool. Effective CT integration does not depend solely on the number of explicitly available problems, but on the book's ability to position students from a perspective-based viewpoint in problem-solving. While providing new insights, this study is limited to content analysis of the primary textbooks. Future researchers are recommended to examine the direct impact of using these textbooks in the classroom, conduct analyses on partially equivalent materials, and explore supplementary textbooks from private publishers that may offer different levels of content depth. Finally, for curriculum developers and textbook authors, this study recommends developing a hybrid textbook design capable of presenting CT structures explicitly without eliminating the space for teachers' discussion and creativity as mediators of students' thinking processes.

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