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Comparative Analysis of the Sine and Cosine Rules in Indonesian and Singaporean Mathematics Textbooks

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Abstract: Students continue to struggle with the sine and cosine rules because textbook content and questions do not fully support the development of mathematical abilities. This study aims to analyze and compare how Indonesian and Singaporean textbooks present content and question characteristics related to the sine and cosine rules. The study employed a qualitative descriptive-comparative method. The research objects were the Grade 11 Advanced Mathematics textbook based on the *Merdeka* Curriculum, the Grade 10 Mathematics textbook based on the 2013 Curriculum, and New Discovering Mathematics 3B from Singapore. Data were collected through document analysis and analyzed using qualitative content analysis, focusing on facts, concepts, principles, question cognitive levels based on Bloom's Taxonomy, the availability of problem-solving questions, and alignment with the PISA framework. The results showed significant differences among the three textbooks. The *Merdeka* Curriculum textbook demonstrates strengths in knowledge construction through a guided discovery approach, supports problem-to-prove problem-solving, and promotes mathematical literacy through PISA questions involving the formulating and interpreting processes. The 2013 Curriculum textbook places greater emphasis on procedural skills through an expository-deductive approach and a dominance of C3-level questions. Meanwhile, the Singaporean textbook demonstrates strengths in connecting concepts through an integrative approach, supports problem-to-find problem-solving and mathematical reasoning through a dominance of C4-level questions involving geometric analysis. These findings indicate the need for textbook development that balances content presentation through concept exploration and inter-conceptual connections while supporting conceptual understanding, mathematical reasoning, mathematical literacy, and problem-solving.

Keywords: comparative analysis, cosine rule, Indonesian textbook, sine rule, Singaporean textbook.

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INTRODUCTION

Mathematics education aims not only to equip students with procedural understanding but also to develop their problem-solving skills and the ability to apply mathematical concepts in various real-life contexts (Barumbun & Kharisma, 2022; Nilimaa, 2023; Stovner & Klette, 2022). These skills are essential to mathematical literacy, enabling students to use mathematical knowledge effectively to understand and solve contextual problems (Tarim & Tarku, 2022). Trigonometry is a key area of mathematics that students must master, as it underpins advanced mathematics (Obeng et al., 2024). Beyond its relevance t daily life, trigonometry is also applied across various fields of science and technology (Dhungana et al., 2023; Owusu et al., 2025). Therefore, students need to develop their trigonometric skills to solve a range of mathematical problems and understand more complex mathematical principles (Fuentes, 2024). Key trigonometry topics include the sine and cosine rules, which describe the relationships between sides and angles in any triangle (Hidayat et al., 2023). This material plays a crucial role in solving geometry and measurement problems and supports the mastery of mathematical competencies at higher levels.

The success of mathematics learning depends on the quality of the learning resources used, including textbooks (Jiang & Li, 2023; Pavešiæ & Cankar, 2022; Wijaya et al., 2022). Textbooks not only provide content but also reflect the curriculum's orientation, teaching approaches, and educational objectives within an educational system (Fan et al., 2025; Otieno & Povey, 2023; Patria et al., 2023). Therefore, textbook quality plays a vital role in shaping students' understanding and development of mathematical concepts during the learning process.

Nevertheless, Indonesian students still face various difficulties with the sine and cosine rules. Students often make mistakes in selecting the appropriate rule and struggle to represent problems accurately in diagrams, leading to inaccurate transformation into a mathematical model (Dewi et al., 2024; Hasanah et al., 2022). This limits students' ability to solve more complex problems, such as determining angles in three-dimensional figures (Fitri et al., 2022). Low proficiency in trigonometry is also influenced by students' failure to connect formal and visual representations, a tendency to memorize formulas, and difficulty linking prior knowledge to new problems and processing information effectively (Mickey et al., 2026; Mutia et al., 2023; Wardhani & Argaswari, 2022). These conditions indicate that textbook material and problems do not yet fully support the development of conceptual understanding, mathematical literacy, and problem-solving. The imbalance in problem distribution and the scarcity of problems oriented toward higher-order thinking skills result in students' understanding being limited to procedures and memorization (Siegler & Oppenzato, 2021; Tarim & Tarku, 2022).

In Indonesia, mathematics textbooks continue to change in line with curriculum developments, including the transition from the 2013 curriculum to the *Merdeka* curriculum (Wijayanti et al., 2025). These changes affect not only how content is presented, including facts, concepts, and principles, but also how questions are distributed and characterized by cognitive level, problem-solving focus, and alignment with the PISA framework. Singapore is also known for its excellent mathematics education system and consistently achieves high scores in international assessments such as PISA (OECD, 2023a). Therefore, comparing Indonesian and Singaporean mathematics textbooks helps clarify differences in how they support mathematical literacy and problem-solving.

Several previous studies have compared Indonesian and Singaporean mathematics textbooks on various topics, such as three-dimensional shapes, geometric similarity, sets, geometric transformations, and vectors (Fophin et al., 2024; Hendriyanto et al., 2023; Kuncoro et al., 2024; Nurhikmayati et al., 2025; Sanita et al., 2026; Zakiah et al., 2025). However, research specifically comparing high school mathematics textbooks on the sine and cosine rules across the *Merdeka* Curriculum, the 2013 Curriculum, and Singaporean textbooks remains limited. Therefore, a comparative analysis of textbooks on the sine and cosine rules is important to provide an overview of content presentation quality and problem characteristics in mathematics textbooks.

To address this gap, this study aims to analyze and compare three mathematics textbooks, namely the Merdeka Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook, regarding the sine and cosine rules. The analysis focuses on the presentation of facts, concepts, and principles; the cognitive level of questions based on Bloom's Taxonomy; the availability of problem-solving questions; and the alignment of questions with the PISA framework. The results of this study are expected to provide an overview of differences in how Indonesian and Singaporean mathematics textbooks present content and problems, and how they support the development of students' conceptual understanding, mathematical literacy, and problem-solving skills. Therefore, this study's research questions are as follows.

RQ1: How are the facts, concepts, and principles of the sine and cosine rules presented in the *Merdeka* Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook?

RQ2: How are the cognitive levels of questions on the sine and cosine rules distributed in the *Merdeka* Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook?

RQ3: How many problem-solving questions are available in the *Merdeka* Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook?

RQ4: How well do the sine and cosine rule questions align with the PISA framework in the *Merdeka* Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook?

METHOD

Research Design and Procedures

This study employed a qualitative, descriptive-comparative approach to analyze and compare mathematics textbooks from Indonesia and Singapore. The comparative descriptive method was chosen because it can systematically describe the similarities and differences in the presentation of mathematical content and the characteristics of questions in textbooks derived from different curricula and educational systems (Sanita et al., 2026; Wulandari et al., 2025).

The research procedure began by selecting textbooks as the research objects, followed by determining the aspects of analysis. Next, data coding was conducted based on the predetermined aspects of analysis, followed by a Focus Group Discussion (FGD) to review the coding results. The analysis results were presented through grouped bar charts, comparison tables, and narrative descriptions, followed by conclusions regarding the similarities, differences, and characteristics of each textbook.

Research Objects

The research objects were two Indonesian textbooks and one Singaporean textbook. The textbooks were selected based on their relevance to the curricula used and their representation of different educational systems. Information regarding the research objects is presented in Table 1 below.

Table 1. Object of research

Country	Textbook	Curriculum
Indonesia	Kristanto et al. (2024), *Matematika tingkat lanjut (Edisi revisi, SMA/MA kelas XI)*	*Merdeka* Curriculum
Indonesia	Sinaga et al. (2017), *Matematika (Edisi revisi, SMA/MA/SMK/MAK Kelas X)*	2013 Curriculum
Singapore	Chow et al. (2022). *New discovering mathematics 3B*	Singapore Mathematics Curriculum (Cambridge GCE O-Level)

Based on the table above, these three textbooks target different grade levels and specialized tracks. These differences do not diminish the validity of the comparison and remain relevant from both a curricular and pedagogical perspective. From a curricular standpoint, the sine and cosine rules are taught at different grade levels because the structure, sequence, and organization of the material differ across curricula. Although taught at different grade levels, the substantive content remains equivalent. From a pedagogical perspective, this comparative analysis does not aim to equate the difficulty levels across grades but rather to examine how each

curriculum presents the same material. Furthermore, the selected textbooks are official textbooks used nationwide in each country, thus reflecting the educational policies and pedagogical approaches in effect within each country's education system.

Instrument

In this qualitative study, the researcher served as the primary instrument for collecting, coding, and interpreting the data. A document-analysis coding scheme was used as a supporting instrument to guide the systematic classification of the textbook content and questions based on the predetermined aspects of analysis. The analysis covered the presentation of material in three aspects: facts, concepts, and principles, and the presentation of questions in terms of cognitive level, the availability of problem-solving questions, and alignment with the PISA framework.

Data Analysis

Data were collected through document analysis of the textbooks' content. The analysis focused on material on the sine rule and the cosine rule. The data were then analyzed using qualitative content analysis techniques to identify each textbook's characteristics and compare them systematically.

To ensure the objectivity and reliability of the coding results, the coding results were discussed in a Focus Group Discussion (FGD) involving master's students in mathematics education and mathematics education lecturers, with each classification reviewed collectively to examine the accuracy and consistency of the data grouping and reduce subjectivity in the analysis.

■ RESULT AND DISCUSSION

A comparative analysis of three textbooks- the Merdeka Curriculum advanced mathematics textbook, the 2013 Curriculum mathematics textbook, and the New Discovering Mathematics textbook from Singapore- reveals significant differences in the order in which trigonometric material is presented and the placement of the sine and cosine rules. In the *Merdeka* Curriculum textbook, the sine and cosine rules appear in Grade 11 and are included in the chapter on trigonometric functions, with the order covering trigonometric functions, trigonometric identities, the sine rule, and the cosine rule. In the 2013 Curriculum textbook, the sine and cosine rules are introduced in Grade 10 in the trigonometry chapter, with the sequence covering angle measurement, trigonometric ratios, angle relationships, trigonometric identities, the sine and cosine rules, and graphs of trigonometric functions. Meanwhile, the Singapore textbook introduces the sine and cosine rules to Secondary 3 students, equivalent to Grade 9 in Indonesia. This material is included in the advanced trigonometry chapter, with the sequence of presentation covering the sine and cosine of obtuse angles, the triangle area formula, the sine rule, and the cosine rule.

Facts, Concepts, and Principles

This study examined the presentation of the sine and cosine rules in the Merdeka Curriculum textbook, the 2013 Curriculum textbook, and the Singapore textbook from three aspects: facts, concepts, and principles. A comparison of the three textbooks based on these three aspects is shown in Table 2 below.

Table 2. Comparison of facts, concepts, and principles in three textbooks

Aspect	*Merdeka* Curriculum Textbook	2013 Curriculum Textbook	Singapore Textbook
Facts	A diagram of a triangle with altitudes and a representation of the	A triangle diagram with three altitudes as visual aids. Notation for sides p,	Simple diagram; no auxiliary lines on the sine and one altitude on the

	triangle on a Cartesian coordinate plane. Notation for sides a, b, c, and angles A, B, C using the symbol ∠. Numerical data using units of inches, centimeters, meters, kilometers, hours, seconds, and degrees.	q, r, and angles P, Q, R. Using the symbols ∠ and Δ. Numerical data using units of kilometers and degrees.	cosine. Notation for sides a, b, c and angles A, B, C. Use of symbols ∠, Δ, and ∴. Includes technical abbreviations such as ext. ∠ of Δ and adj. ∠s on a st. line. Numerical data is presented in centimeters, meters, and degrees, accompanied by rounding rules such as "correct to 3 s.f." and "correct to 1 d.p."
Concepts	The concepts of altitude and acute angles appear in exploratory activities but are not defined. The concepts of trigonometric ratios in right triangles (sine and cosine) are used as a foundation.	Introduces the concepts of altitude and median as foundational ideas before deriving formulas. The concepts of trigonometric ratios in right triangles (sine and cosine) are used as a foundation.	The concept of triangle area is used to derive the sine rule, while trigonometric ratios in right triangles are used to derive the cosine rule.
Principles	Guided discovery approach: students are guided to discover the sine rule through altitudes and the cosine rule through coordinates.	Deductive expository approach: derivations are performed systematically using the altitudes of each angle, accompanied by detailed algebraic steps.	Integrative approach: the sine rule is derived from the area formula for a triangle, while the cosine rule is derived from the Pythagorean theorem.

All three textbooks present the sine and cosine rules as fundamental concepts that students must master, but their approaches to introducing and deriving these rules differ significantly. The *Merdeka* Curriculum textbook uses a guided discovery approach, in which formulas are not provided directly but are constructed through explorator activities. For the sine rule, students are presented with an arbitrary triangle and guided, through step-by-step instructions, to draw the altitude and discover the sine rule. For the cosine rule, students are presented with a representation of an arbitrary triangle in the Cartesian coordinate system and guided through leading questions to discover the cosine rule. In contrast, the 2013 Curriculum textbook uses an expository-deductive approach, presenting the derivation of the sine and cosine rules systematically through problems involving arbitrary triangles, along with detailed solutions. The derivation is carried out by constructing the altitude from each angle of the triangle, with each algebraic step explained explicitly, from applying the definitions of sine and cosine, to substituting into the Pythagorean Theorem, to algebraic manipulation leading to the final form. The procedure is repeated for the altitudes from the other angles; the three derivations are then equated to obtain the sine rule, and the resulting relationship between the squares of the sides is formulated into the cosine rule. Meanwhile, the Singapore textbook adopts an integrative approach by deriving the sine and cosine rules through connections to previously learned

concepts. The sine rule is derived from the area of a triangle by equating three sine-based area formulas to obtain a relationship between the sides and sines. The cosine rule is derived by constructing altitudes and applying the Pythagorean Theorem to the two right triangles formed, using concise, structured algebraic steps.

The differences in the presentation and derivation processes of the sine and cosine rules in these three textbooks can be seen in the following concept map.

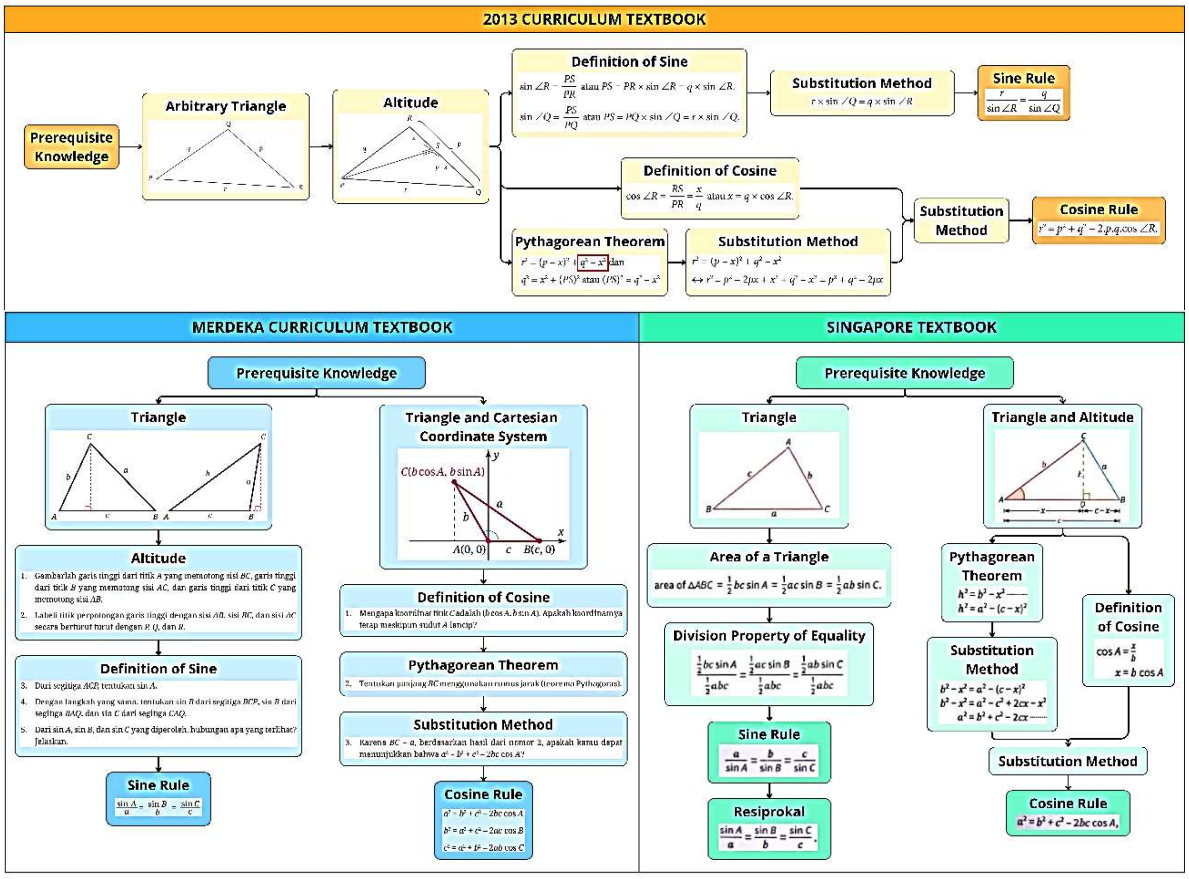


Figure 1. Concept map of sine and cosine rule presentation in three textbooks

In the 2013 Curriculum textbook, an error in the presentation of facts appears in the section on applying the Pythagorean Theorem, as indicated by the red section in the concept map above. Based on the representation of the triangle provided, the relationship written in the application stage of the Pythagorean Theorem should be expressed as $(PS)^2$, not $q^2 - x^2$. The form $q^2 - x^2$ should be derived in the next stage through the substitution method. Presenting $q^2 - x^2$ during the application of the Pythagorean Theorem and then deriving it again during the substitution step risks confusing students about how the equation $r^2 = (p - x)^2 + q^2 - x^2$ can be derived from the triangle representation and why the process of deriving that equation is repeated in the subsequent step. Thus, this error obscures the connection between the geometric representation, the application of the Pythagorean Theorem, and the substitution process in deriving the cosine rule.

Cognitive Level of Questions

The analysis of the cognitive level of questions in the three textbooks was conducted

based on the Revised Bloom's Taxonomy, covering C1 (Remembering), C2 (Understanding), C3 (Applying), C4 (Analyzing), C5 (Evaluating), and C6 (Creating). The distribution of cognitive levels in the three analyzed textbooks is shown in Figure 2 below.

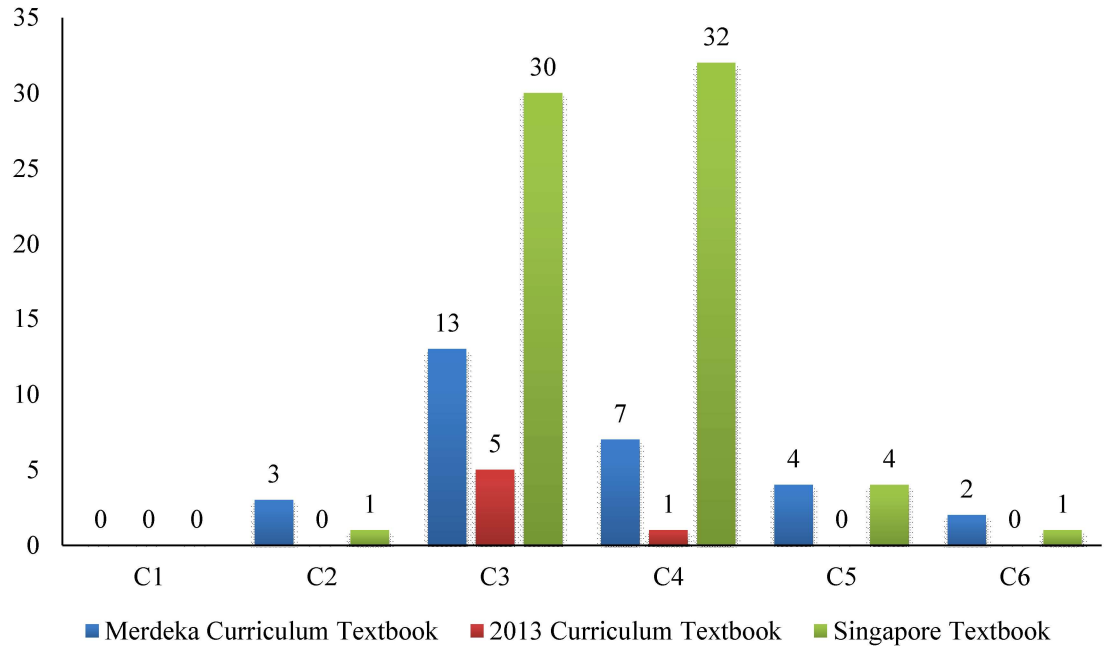


Figure 2. Distribution of cognitive levels of questions across the three textbooks

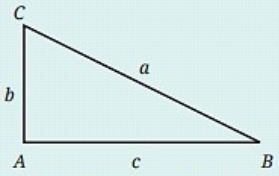
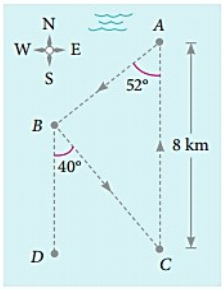
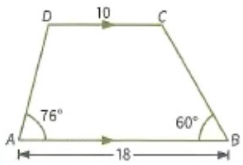
Based on the figure above, the three textbooks contain different numbers of problems on the sine and cosine rules. The *Merdeka* Curriculum textbook contains 29 problems, the 2013 Curriculum textbook contains 6 problems, while the Singapore textbook contains 68 problems. These differences indicate that the three textbooks place varying emphasis on mastery of the sine and cosine rules: relatively limited in the 2013 Curriculum textbook, stronger in the *Merdeka* Curriculum textbook, and strongest in the Singapore textbook.

From a cognitive-level perspective, none of the three textbooks includes C1-level questions, indicating that the questions do not focus on simple recall. Meanwhile, the distribution of questions across cognitive levels C2 through C6 differs across textbooks. The 2013 Curriculum textbook is dominated by C3 questions and contains only one C4 question. This suggests the book emphasizes procedural skills and does not yet provide significant support for higher-order thinking skills. Meanwhile, the *Merdeka* Curriculum textbook and the Singapore textbook cover a wider range of cognitive levels, from C2 to C6, indicating that both support the development of higher-order thinking skills. Nevertheless, the *Merdeka* Curriculum textbook is dominated by C3 questions, so procedural skills remain the primary focus. The Singapore textbook, on the other hand, is dominated by C3 and C4 questions; thus, in addition to emphasizing procedural skills, it also requires the ability to analyze more complex problem structures, such as breaking down composite geometric shapes, interpreting situations with more than one possible solution, and integrating multiple concepts. Overall, the Singapore textbook places the strongest emphasis on reasoning skills, the 2013

Curriculum textbook focuses more on procedural skills, while the *Merdeka* Curriculum textbook falls between the two with a more balanced distribution of cognitive levels.

One C4-level question from each of the *Merdeka* Curriculum, the 2013 Curriculum, and the Singapore textbook is presented in Table 3 below.

Table 3. C4-level questions (analyzing) in three textbooks

Textbook	Sample Question	Solution Structure
Merdeka Curriculum Textbook	Untuk segitiga siku-siku seperti pada gambar di bawah, kamu mengetahui bahwa $a^2 = b^2 + c^2$ (teorema Pythagoras).  **Gambar 3.49** Segitiga Siku-Siku *ABC* Dapatkah kamu menemukan hubungan antara *a*, *b*, dan *c* dengan memanfaatkan Aturan Kosinus untuk $\angle A < 90°$ dan $\angle A > 90°$?	$a^2 = b^2 + c^2 - 2bc\cos A$. For $A < 90°$: $a^2 < b^2 + c^2$; $A = 90°$: $a^2 = b^2 + c^2$; $A > 90°$: $a^2 > b^2 + c^2$.
2013 Curriculum Textbook	Pada latihan mengendarai suatu kapal cepat di perairan, lintasan latihan didesaian seperti yang diberikan pada Gambar 4.52. Pengemudi harus mulai dari titik *A*, dan bergerak ke arah barat daya dengan membentuk sudut 52° ke titik *B*, kemudian bergerak ke arah tenggara dengan membentuk sudut 40° ke titik *C*, dilanjutkan kembali ke titik *A*. Jarak titik *A* ke *C* sejauh 8 km. Hitung panjang lintasan si pengemudi kapal cepat tersebut.  	$\angle B = 180° - (52° + 40°) = 88°$. By the Sine Rule: $AB = \frac{8\sin 40°}{\sin 88°} \approx 5.15$ km; $BC = \frac{8\sin 52°}{\sin 88°} \approx 6.31$ km; $AC = 8$ km; total $= 19.45$ km.
Singapore Textbook	In the diagram, *ABCD* is a trapezium in which *AB* // *DC*, *AB* = 18 cm, *DC* = 10 cm, $\angle DAB = 76°$ and $\angle ABC = 60°$.  Find (a) the length of *BC*, (b) $\angle ACD$, (c) the length of *AD*, (d) the area of *ABCD*.	Since $AB \parallel DC$, $\angle ACD = \angle CAB = x$, $\angle BCD = 120°$, and $\angle ADC = 104°$. Using the Sine Rule in $\triangle ABC$ and $\triangle ADC$ gives $x = \angle ACD \approx 37.94°$, $BC \approx 11.17$ cm, and $AD \approx 9.97$ cm. The height is $AD\sin 76° \approx 9.68$ cm; hence $L = \frac{1}{2}(18 + 10)(9.68) \approx 135.48$ cm^2.

For the C4-level question from the *Merdeka* Curriculum textbook, students are not required to perform numerical calculations using the law of cosines directly (C3), but rather to break down and connect two distinct concepts: the Pythagorean Theorem for right triangles and the general law of cosines applicable to any triangle. Students need to analyze the general form of the law of cosines under two angle conditions, when "A is acute and when "A is obtuse, and compare them with the special case of a right triangle. This activity, which decomposes the formula's structure based on these angle variations, demonstrates analytical ability.

The C4-level question from the 2013 Curriculum textbook presents a situation that cannot be solved by direct substitution into a single formula. The information is presented as verbal and visual descriptions of the ship's path forming a triangle. Nevertheless, the question demands logical precision because the angles shown in the figure are not the triangle's interior angles and cannot be used directly. The key analysis is determining the interior angle at point B: students must identify the relationship between the opposite interior angles at point A and the segment at point B, then add them to the 40° angle. The process of identifying relationships between parallel lines to determine the exact angle components before applying the law of sines represents a characteristic of analytical ability.

For the C4-level question from the Singapore textbook, students are presented with a trapezoid with two parallel sides and two known base angles, but no explicit information about the height, diagonal, or sloping side. The solution requires decomposing the shape into several simple triangles, identifying indirect elements such as auxiliary lines or the height, and developing a step-by-step strategy involving the law of sines, the properties of opposite angles, and the area formula. Transforming the trapezoid's structure into analyzable triangular models and integrating information across these parts reflects analytical reasoning skills.

All three analyzed textbooks include C4 (Analyzing) problems, but they differ in the type of analysis students are required to perform. The *Merdeka* Curriculum textbook emphasizes conceptual analysis of mathematical formula structures without involving external contexts or additional geometric constructions. The 2013 Curriculum textbook presents contextual problems supported by visual representations and focuses on geometric analysis to determine interior angles through relationships between opposite angles. Meanwhile, the Singapore textbook requires more complex geometric analysis, where students must decompose a plane figure into several triangles using auxiliary lines and properties of parallelism. This difference reflects variations in pedagogical approaches: the *Merdeka* Curriculum textbook focuses on understanding mathematical structures, the 2013 Curriculum textbook on applying geometric concepts in simple contexts, and the Singapore textbook on developing mathematical reasoning skills through geometric analysis.

Problem Solving Questions

Classifying questions based on problem-solving types distinguishes routine problems, which can be solved through standard procedures, from non-routine problems, which lack clear solution procedures (Pólya, 2004). In this context, a question is categorized as a problem if it requires thinking processes, discovery, and the formulation of solution strategies. Problem-solving questions can be classified into two main forms: problems-to-find and problems-to-prove (Pólya, 2004). Problems-to-find aim to identify a specific unknown object within the problem. Meanwhile, a problem-to-prove aims to demonstrate that a statement is true or false. These two forms represent differences in the level of cognitive

engagement in the mathematical problem-solving process.

The distribution of problem-solving questions across the three analyzed textbooks is shown in Figure 3.

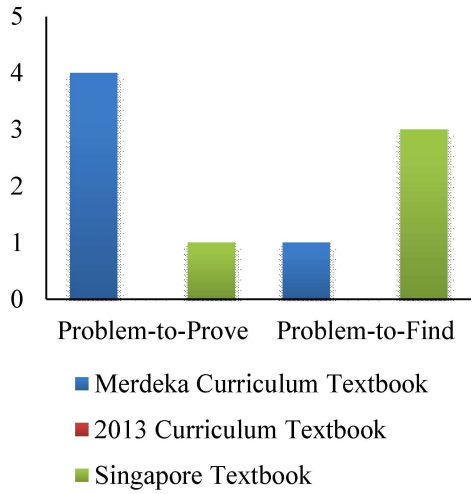


Figure 3. Distribution of problem-solving questions across the three textbooks

Based on the figure above, the number of problem-solving questions in the three textbooks remains very limited compared to the total number of questions. The *Merdeka* Curriculum textbook contains 5 problem-solving questions out of 29, while the 2013 Curriculum textbook contains none out of 6. Meanwhile, the Singapore textbook contains only 4 problem-solving questions out of 68. This indicates that the three textbooks have not placed strong emphasis on, or given sufficient attention to, developing problem-solving skills in the sine and cosine rules. In terms of question types, the *Merdeka* Curriculum textbook contains more problem-to-prove questions. In comparison, the Singapore textbook includes more problem-to-find questions, reflecting different cognitive orientations in problem-solving.

One problem-solving question from each of the *Merdeka* Curriculum and Singapore textbooks is presented in Table 4 below.

For the problem-solving question from the *Merdeka* Curriculum textbook, students are asked to find an alternative proof of the law of sines after being given a specific method. This task places students in a non-routine situation because no standard procedure can be followed directly. Students need to use their conceptual understanding of triangles and trigonometric relationships and integrate it with other concepts, such as triangle area, the circumcircle, and vectors, to independently design a valid proof

Table 4. Problem-solving questions from the *merdeka* curriculum textbook and the singapore textbook

Textbook	Sample Question	Solution Structure
Merdeka Curriculum Textbook	Kamu telah mengetahui cara mendapatkan Aturan Sinus. Dapatkah kamu menemukan cara berbeda dalam mendapatkan Aturan Sinus?	Construct a different proof of the Sine Rule using triangle area/circumcircle/vector relationships, leading to $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$.
Singapore Textbook	Ali wants to draw a triangle ABC with $BC = 4$ cm, $CA = 3$ cm, $\angle BAC = 70°$ and $\angle ACB = 68°$. Explain whether it is possible to draw the triangle.	$\angle B = 180° - 70° - 68° = 42°$. By the Sine Rule, $\frac{4}{\sin 70°} \approx 4.26$, whereas $\frac{3}{\sin 42°} \approx 4.48$. Since the ratios are inconsistent, the triangle cannot be drawn.

path. Therefore, this problem is classified as a problem-to-prove, as it focuses on constructing a logical argument to demonstrate the truth of the sine rule, rather than on finding a specific mathematical solution. This process demands intellectual creativity and the selection of non-procedural strategies.

For the problem-solving question from the Singapore textbook, students are asked to determine whether a triangle with specific specifications can be drawn. This situation is non-routine because no direct procedure exists to verify the consistency of the given data. Students need to identify potential inconsistencies and then design a verification strategy using the sum of the angles in a triangle or the sine rule. This problem falls under the problem-to-prove category, as it requires establishing a proposition's truth through logical argumentation rather than quantitative calculation. The solution process emphasizes evaluating data consistency and applying the appropriate concepts.

Both the *Merdeka* Curriculum textbook and the Singapore textbook include problem-to-prove questions, but they place different cognitive demands. Problems in the *Merdeka* Curriculum textbook are exploratory and open-ended, asking students to construct alternative proofs for a formula whose truth is already known. Students are encouraged to design strategies independently by flexibly applying trigonometric concepts. Conversely, problems in the Singapore textbook are verifiable and closed-ended. These problems present numerical data that appears complete but contains mathematical inconsistencies. The main challenge is to critically examine the data's validity and construct logical arguments to accept or reject a proposition. Thus, *Merdeka* Curriculum questions foster creativity and flexible thinking in constructing proofs, while Singaporean questions train analytical acuity and critical evaluation of mathematical data consistency.

PISA Questions

Analysis based on the PISA (Programme for International Student Assessment) framework encompasses four main aspects: (1) mathematical content, which includes space and shape, quantity, change and relationships, and uncertainty and data; (2) problem contexts, which are personal, occupational, societal, and scientific; (3) mathematical processes, consisting of formulating situations mathematically; employing mathematical concepts, facts, procedures, and reasoning; and interpreting, applying, and evaluating mathematical results; and (4) PISA levels 1–6 (OECD, 2023b). The alignment of the questions with the PISA framework in the three analyzed textbooks is shown in Figure 4 below.

Based on the figure above, the proportion of questions aligned with the PISA framework differs across the three textbooks. The *Merdeka* Curriculum textbook contains 8 PISA questions out of 29 total questions; the 2013 Curriculum textbook contains 2 out of 6 questions; while the Singapore textbook contains 4 out of 68 questions. The Singapore textbook has the lowest proportion of PISA questions, suggesting its questions focus more on mathematical contexts than on connecting mathematics to real-life contexts. The 2013 Curriculum textbook has the highest proportion of PISA questions, but the small number of questions is not sufficient to support the development of mathematical literacy. The *Merdeka* Curriculum textbook has a fairly good proportion of PISA questions and more questions overall, providing more scope to develop mathematical literacy.

Alignment with the PISA framework also varies across the three textbooks. In terms of content, all three focus on space and shape. All questions in the *Merdeka* Curriculum textbook and the 2013 Curriculum textbook fall under this content area, while the Singapore textbook varies, covering change and relationships and space and

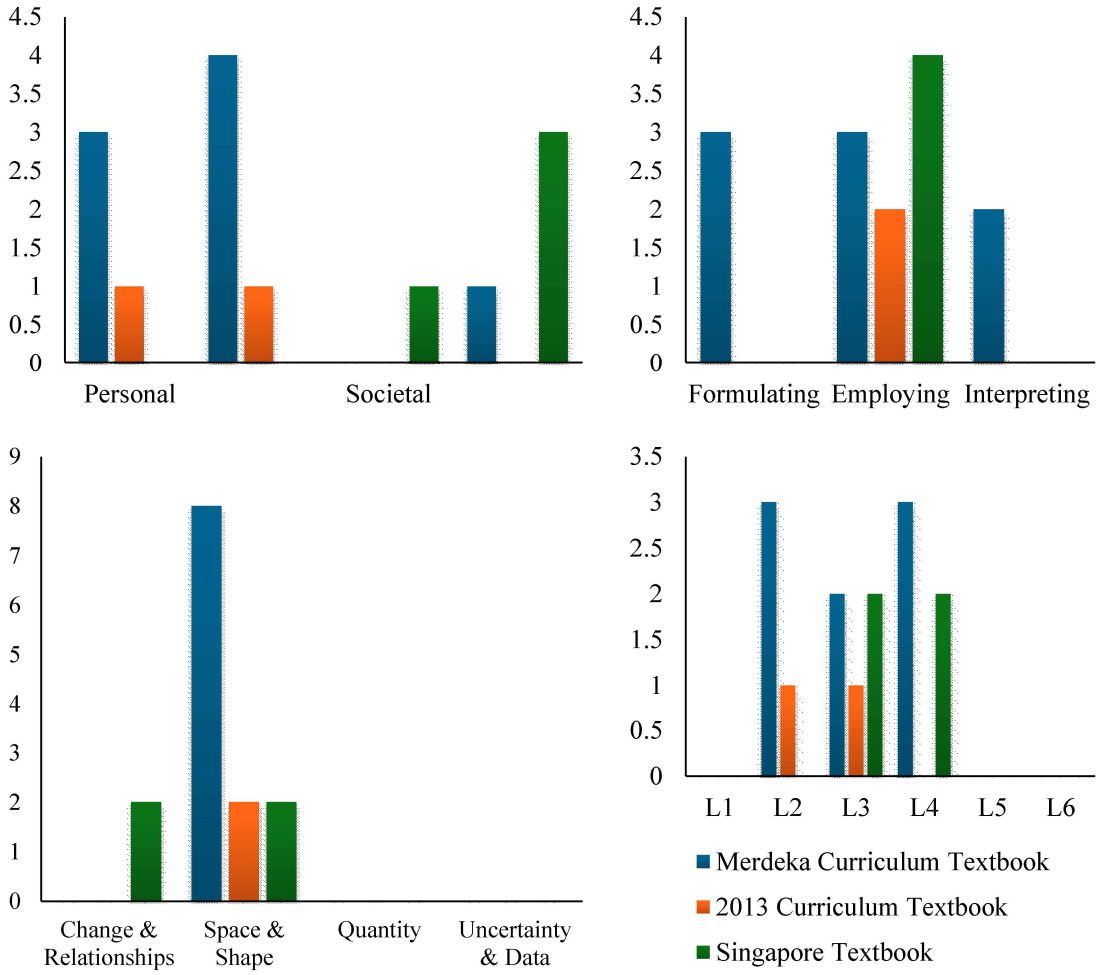


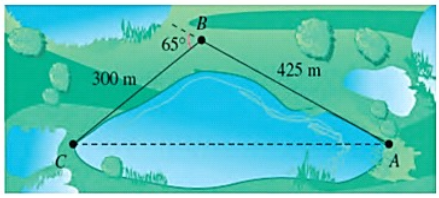
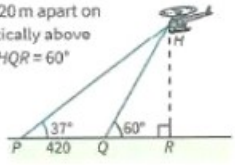
Figure 4. Alignment of questions with the PISA framework

shape. None of the three textbooks include the content areas of quantity and uncertainty and data. In terms of context, the *Merdeka* Curriculum textbook shows the highest diversity, covering personal, occupational, and scientific contexts. The 2013 Curriculum textbook covers only personal and occupational contexts, while the Singapore textbook focuses on scientific contexts and includes only a small portion on societal contexts. In terms of mathematical processes, the *Merdeka* Curriculum textbook is the only one that covers formulating, employing, and interpreting, while the 2013 Curriculum and Singapore textbooks involve only employing. In terms of difficulty levels, no questions reached levels 5 or 6. The *Merdeka* Curriculum textbook has questions distributed across levels 2 through 4, the 2013 Curriculum textbook across levels 2 and 3, and the Singapore textbook across levels 3 and 4. Overall, the number of questions and the coverage of PISA aspects in all three textbooks remain limited.

One PISA-type question from the Merdeka Curriculum, 2013 Curriculum, and Singapore Curriculum textbooks is presented in Table 5 below.

For the PISA-type question from the *Merdeka* Curriculum textbook, PISA characteristics are reflected through the presentation of a real-world context closely

Table 5. PISA-type questions in three textbooks

Textbook	Sample Question	Solution Structure
Merdeka Curriculum Textbook	Akmal, Aira, dan Ariz bermain petak umpet. Akmal dan Aira berlari untuk bersembunyi meninggalkan Ariz pada waktu yang sama. Akmal berlari ke arah 150° dengan kecepatan 2 m/s dan Aira berlari ke arah 225° dengan kecepatan 1 m/s. Setelah 10 detik, mereka berhasil menemukan tempat persembunyian masing-masing. Berapakah jarak tempat persembunyian Akmal dengan Aira?	$d_1 = 2(10) = 20$ m, $d_2 = 1(10) = 10$ m; $\theta = 225° - 150° = 75°$. By the Cosine Rule, $d \approx 19.91$ m.
2013 Curriculum Textbook	Pada saat mensurvei sebidang rawa-rawa, seorang pensurvei berjalan sejauh 425 meter dari titik *A* ke titik *B*, kemudian berputar 65° dan berjalan sejauh 300 meter ke titik *C* (lihat Gambar 4.53). Hitungl panjang *AC*. 	The interior angle at B is $180° - 65° = 115°$. By the Cosine Rule, $AC \approx 615.14$ m.
Singapore Textbook	In the diagram, *P* and *Q* are two points that are 420 m apart on the horizontal ground. A helicopter *H* hovers vertically above a point *R* on the ground such that $\angle HPR = 37°$, $\angle HQR = 60°$ and $\angle HRP = 90°$. Find **(a)** the distance *HQ*, **(b)** the height of the helicopter above the ground. 	$\angle PQH = 180° - 60° = 120°$; $\angle PHQ = 180° - 37° - 120° = 23°$. By the Sine Rule, $HQ = \frac{420 \sin 37°}{\sin 23°} \approx 646.90$ m; hence $HR = HQ \sin 60° \approx 560.23$ m.

related to students' lives, namely a game activity with peers. The question does not merely require formula mastery; it involves mathematical literacy processes, such as translating information about direction and speed into a triangle model, identifying two sides and the included angle, and selecting the law of cosines as a solution strategy. The result obtained is then interpreted as the distance between two points within the context of the game. From a PISA perspective, this question falls under the personal context because it relates to students' daily activities within their social environment, specifically playing with peers. The content involves space and shape, as it requires understanding position, direction, and spatial relationships represented as triangles on a flat plane. The dominant mathematical process is interpreting, as students must translate contextual information into a mathematical model and then translate the results back into contextual meaning. This question is classified as Level 4 because it requires applying models in a fairly complex situation, integrating various representations, and selecting and integrating different representations, all tied to the given context.

For the PISA-type question from the 2013 Curriculum textbook, PISA characteristics are reflected in the presentation of a real-world work context: a swamp survey activity. This situation illustrates how mathematics can determine the distance between two points that cannot be measured directly, only through a path and changes in direction. The question asks students to use a triangular representation based on the given distance and turning-angle information, reflecting how mathematics is used in practical situations. From a PISA perspective, this question falls under the occupational context because it relates to measurement and mapping activities in the workplace. The content involves space and

shape, as it requires understanding the relationships among angles, sides, and orientation in a triangular representation. The dominant mathematical process is applying the law of cosines, as students use a provided model and determine the interior angle from the given turning angle. This question is classified as Level 2 because students interpret a clear situation, extract information from a single representation (a diagram), use routine procedures, and interpret the result directly as the length of AC.

For the PISA-type question from the Singapore textbook, the PISA characteristics are reflected in the presentation of a scientific context involving the indirect measurement of an object's height in the air using elevation angles from two observation points. Solving the problem requires structured application of trigonometric concepts to both general triangles and right triangles, reflecting mathematics in a real-world context. From a PISA perspective, this question falls under the scientific context because it applies mathematics to measurements and observations based on elevation angles. The content involves space and shape, as it relates to the positional relationships and distances between the observation points and the object in the air, represented as a triangle. The dominant mathematical process is using the triangle model already presented, and students must select and apply relevant concepts and procedures. This question is classified as Level 3, as students follow clear procedures with sequential decisions, interpret representations of various provided information, and choose simple solution strategies based on an understanding of the relationships among elements in the model.

The three PISA questions described above share similarities in the space and shape content area but differ in their presentation. The 2013 Curriculum textbook and the Singapore textbook include images that directly depict the triangular model, whereas the *Merdeka* Curriculum textbook provides only a narrative description. This difference affects the cognitive demands placed on students. The presence of images helps students recognize the model quickly, allowing the process to focus more on employing it, as seen at Level 2 (2013 Curriculum textbook) and Level 3 (Singapore textbook). Conversely, the Merdeka Curriculum textbook's lack of images requires students to construct their own model from textual information, thereby fostering interpreting skills and reaching Level 4. Additionally, the three problems present different contexts: personal in the *Merdeka* Curriculum textbook, occupational in the 2013 Curriculum textbook, and scientific in the Singapore textbook. These differences in representation, cognitive demands, and context indicate that each textbook adopts a distinct approach to developing PISA-based mathematical literacy.

The guided discovery approach in the *Merdeka* Curriculum textbook aligns with constructivist theory (Bruner, 2009), which positions students as active learners who construct knowledge through exploration and investigation. This approach is evident in the discovery of the sine rule by constructing a triangle's altitude and the cosine rule by representing a triangle on the Cartesian coordinate plane. This process reflects Bruner's three modes of representation: enactive, through drawing and observing triangles; iconic, through visual representations; and symbolic, through algebraic formulation that leads to general formulas. Guiding questions also scaffold learning, helping students build understanding gradually until they can formulate concepts independently. The inclusion of C5- and C6-level questions, problem-to-prove questions, and PISA processes such as formulating and interpreting demonstrates the textbook's support for developing students' mathematical abilities. These findings support previous research stating that mathematics instruction needs to provide space for the development of conceptual

understanding, mathematical literacy, and problem-solving (Nilimaa, 2023; Stovner & Klette, 2022; Tarim & Tarku, 2022). However, the still-limited number of problem-to-find questions and the suboptimal development of analytical geometry skills indicate that problem-solving and mathematical reasoning skills still need improvement.

The deductive-expository approach in the 2013 Curriculum textbook can be understood through the theory of didactic transposition (Chevallard, 1985), which explains the process of transforming scientific knowledge (savoir savant) into knowledge ready for teaching (savoir enseigné) through the selection, simplification, and organization of knowledge. In this book, this is evident in the direct and structured presentation of formulas, definitions, and procedures, making them ready for students to understand and apply. This approach leaves little room for independent exploration and conceptual reconstruction, so the textbook emphasizes mastering organized, procedural knowledge. This orientation also shows in the questions: they are few in number, dominated by C3-level questions, exclude problem-solving questions, and cover a very narrow PISA scope. This may limit students' opportunities to develop higher-order mathematical thinking skills. These findings support previous research indicating that an unbalanced distribution of questions and the dominance of procedural questions in textbooks can affect the development of mathematical abilities and hinder the development of students' mathematical literacy (Siegler & Oppenzato, 2021; Tarim & Tarku, 2022).

The integrative approach in the Singaporean textbook can be understood through the theory of didactic anthropology (Chevallard, 1999), particularly the concept of praxeology, which views mathematical knowledge as an interconnection between task types, techniques, technologies, and theories. This is evident in how the textbook derives the sine rule from the triangle area formula and the cosine rule from altitude constructions and the Pythagorean Theorem. Deriving rules to determine the sides or angles of an arbitrary triangle is the task type, while the area formula, algebraic manipulation, and the Pythagorean Theorem are techniques. Mathematical explanations linking techniques to the derived rules serve as technology, while the underlying concepts and principles of geometry and trigonometry form the theoretical foundation. In terms of question count, this textbook has the most questions and is dominated by C4-level questions, indicating an emphasis on reasoning skills. The inclusion of C5- and C6-level questions, as well as problem-to-find questions, reinforces this and encourages the development of higher-order mathematical thinking skills. These findings align with Patria et al. (2023), who state that textbook structure and organization reflect the curriculum's orientation and strategies for developing student competencies. However, problem-to-prove questions remain limited. The predominance of visually aided questions and a stronger focus on the application process also indicate that students still have limited opportunities to engage in independent mathematical modeling through formulation and interpretation. This suggests that visual representations can help students apply procedures but may also reduce the cognitive demands of independently constructing mathematical models.

The findings indicate that the three textbooks present the sine and cosine rules with different pedagogical orientations. The *Merdeka* Curriculum textbook emphasizes knowledge construction through guided discovery. It supports problem-solving skills of the problem-to-prove type, as well as mathematical literacy through PISA questions that involve formulating and interpreting. The 2013 Curriculum textbook places greater emphasis on procedural skills through an expository-deductive approach and

a predominance of C3-level questions. Meanwhile, the Singapore textbook emphasizes interconnections between concepts through an integrative approach. It supports problem-solving skills of the problem-to-find type and mathematical reasoning by emphasizing C4-level questions. These differences indicate that textbook design influences students' opportunities to develop problem-solving skills, mathematical reasoning, and mathematical literacy. Overall, the findings of this study reinforce previous research confirming that textbook characteristics influence student learning and the development of mathematical skills (Jiang & Li, 2023; Pavešiæ & Cankar, 2022; Tarim & Tarku, 2022; Wijaya et al., 2022).

■ CONCLUSION

The research results show significant differences among the three textbooks. The *Merdeka* Curriculum textbook excels in knowledge construction through a guided discovery approach, supporting problem-to-prove problem-solving skills and mathematical literacy through PISA questions that involve formulating and interpreting. However, the questions are still dominated by procedural C3 questions and still offer limited support for problem-to-find problem-solving skills. The 2013 Curriculum textbook places greater emphasis on procedural skills through an expository-deductive approach and a predominance of C3 questions. This textbook does not include problem-solving questions and has limited PISA coverage. Meanwhile, the Singapore textbook excels at linking concepts through an integrative approach, supporting problem-to-find problem-solving and mathematical reasoning skills through a predominance of C4 questions involving geometric analysis. However, this textbook still limits support for problem-to-prove problem solving and remains focused on the PISA-employing process.

This study contributes to mathematics education by comprehensively comparing Indonesian and Singaporean textbooks. In practical terms, the findings indicate that mathematics textbooks need to balance presenting material through conceptual exploration and interconnections between concepts while supporting conceptual understanding, mathematical reasoning, mathematical literacy, and problem-solving. However, this study has several limitations. First, it is limited to textbook content and does not examine classroom implementation or student responses. Second, coding was based on collective discussion and consensus rather than independent coding; therefore, inter-coder reliability coefficients were not calculated. Third, as a qualitative descriptive-comparative study, it did not employ inferential statistical tests to determine the statistical significance of differences among the textbooks. Thus, the findings should be interpreted as descriptive comparisons of the selected textbooks rather than statistical generalizations. Future research may involve independent coders and appropriate quantitative or mixed-method approaches, while also examining how textbook characteristics influence students' mathematical abilities and how these characteristics are enacted in classroom learning.

■ DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the drafting of this manuscript, the author utilized DeepL for translation assistance and language refinement. The translated and refined content was carefully reviewed and revised by the author to ensure accuracy, consistency, and alignment with the research findings. The author assumes full responsibility for the final content, accuracy, and integrity of this article.

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