COMPARATIVE ANALYSIS OF PYTHAGOREAN PROBLEMS IN INDONESIAN AND SINGAPOREAN MATHEMATICS TEXTBOOKS: AN OVERVIEW OF COGNITIVE LEVEL, REPRESENTATION FORM, CONTEXTUAL FEATURE, AND RESPONSE TYPE

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Abstract:

Several studies revealed that mathematics problems in textbooks, which were expected to encourage students' reasoning and problem-solving skills, were still lacking. This study aimed to compare Pythagorean problems in Indonesian and Singaporean mathematics textbooks based on the cognitive level of Bloom's taxonomy, representation form, contextual feature, and response type. The data were collected through documentation and observation. The research results indicated that on the cognitive level, the C3-C4 level dominated the Pythagorean problems in Indonesian and Singaporean textbooks. Regarding representation form, Pythagorean problems in Indonesian textbooks used visual and combined forms, while Singaporean textbooks applied mostly combined forms. In contextual feature and response type, Pythagorean problems in Indonesian and Singaporean textbooks used non-application and closed-ended problems. Therefore, the result of this study is expected to contribute to the improvement of high-quality mathematics textbooks, which can compete internationally to support students' learning.

Abstract:

Beberapa penelitian menunjukkan soal-soal matematika dalam buku ajar Indonesia yang diharapkan dapat mendorong kemampuan penalaran dan pemecahan masalah siswa masih kurang. Penelitian ini bertujuan untuk membandingkan soal-soal Teorema Pythagoras dalam buku matematika Indonesia dan Singapura berdasarkan tingkat kognitif Bloom, bentuk representasi, fitur kontekstual, dan tipe respon. Pengumpulan data dilakukan melalui dokumentasi dan observasi. Hasil penelitian menunjukkan bahwa pada tingkat kognitif, soal Pythagoras dalam buku teks Indonesia dan Singapura sebagian besar berada pada kategori C3-C4. Terkait bentuk representasi, soal-soal Pythagoras dalam buku Indonesia lebih banyak menggunakan bentuk visual dan gabungan, sedangkan buku Singapura lebih banyak menggunakan bentuk gabungan. Pada aspek fitur kontekstual dan tipe respon, soal-soal Pythagoras baik dalam buku Indonesia dan buku Singapura menggunakan soal non-aplikasi dan soal tertutup. Oleh kare itu, hasil penelitian ini diharapkan dapat berkontribusi pada peningkatan kualitas buku teks matematika yang dapat bersaing secara internasional, untuk mendukung pembelajaran siswa.

Keywords:

Pythagorean Problems, Mathematics Textbooks, Cognitive Level, Representation Form, Contextual Feature, Response Type

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INTRODUCTION

In recent years, many countries have paid special attention to the quality of mathematics education in their countries. The increasing number of countries participating in the TIMSS (Trends In International Mathematics and Science Study) competition is evidence of the world's interest in the importance of mathematics education. Based on TIMSS results in 2015, Indonesian students were ranked 45th out of 50 countries with an average score of 397. The Indonesian average score was still far below that of other ASEAN countries, such as Singapore, which ranked first in the 2015 TIMSS with a score of 621.

The curriculum is created as a guide or reference in the educational process. Besides the 2013 curriculum, some curriculums are applied in particular schools in Indonesia. International School, known as SPK, adapted curriculum from abroad, including the Cambridge curriculum. The curriculum has five main components, namely: (1) Objectives; (2) Material; (3) Learning Strategy; (4) Curriculum Organization; and (5) Evaluation (Ibrahim, 2012). These components are closely related and cannot be separated. Textbooks are included as one of the main sources of school curriculum application. The regulation stipulated by the Minister of National Education Number 11 of 2005 states that textbooks are used as mandatory references by teachers and students in the learning process.

Mathematics textbook in each country has different characteristics related to the curriculum applied in those countries. The study of comparing mathematics textbooks over countries has been carried out by many researchers, such as Cady, Hodges, & Collins, (2015), Charalambous, Delaney, & Hsu (2010), Erbas, Alacaci, & Bulut (2012), Hong & Choi (2014), Kul, Sevimli, & Aksu (2018), Yang, Tseng, & Wang (2017). The aim of comparing mathematics textbooks over countries is to provide insight into essential features of mathematics textbooks that can affect students' learning and achievement (Hong & Choi, 2014).

Several studies proposed different frameworks to analyze or compare textbooks. Some previous studies showed that representation form, contextual feature, and response type are three significant components in analyzing mathematical problems (Yang, Tseng, & Wang, 2017). According to Yang, Tseng, & Wang (2017), representation form reflects whether mathematical problems includes mathematics expressions, pictures, graphs, tables, or diagrams; contextual feature show if the problems are presented in the context of a real-world situation or not; and response type refers to the form of open-ended or close-ended problems. Those studies also revealed that the three aspects probably affect students' problem-solving skills. In addition, Krathwohl (2002) mentioned that Bloom's cognitive level functions as a means for justifying the similarities and comparing learning assessments in a course or curriculum. Bloom's taxonomy of cognitive level is also used to indicate the content and the quality of problems (Kul, Sevimli, & Aksu, 2018).

Mathematics textbooks are essential in teaching and learning (Hong & Choi, 2014; Vicente, Sanchez, & Verschaffel, 2020). Some studies reveal that students' mathematical

achievements correlate significantly with the quality of mathematics textbooks (Fan, Zhu, & Miao, 2013; Kul, Sevimli, & Aksu, 2018). Students will be proficient in mathematics if they obtain a lot of practice working on math problems with various levels of difficulty and complexity. However, mathematics problems in the textbook, which are expected to encourage students' reasoning and problem-solving skills, are still poor. This is shown by the study of Giani, Zulkardi, & Hiltrimartin (2015), who analyzed the problems in the seventh-grade mathematics textbook chapter on Linear Equations. The results of this study indicated that C3 and C4 levels dominated the problems. The results showed that the problems in the textbook did not meet the suggested proportion to support the achievement of students' basic competencies: 30% for C1 and C2, 40% for C3 and C4, and 30% for C5 and C6.

In the contextual feature, students must understand the relationship between learning experiences at school and real-life experiences (Selvianiresa & Prabawanto, 2017). The contextual feature is very important for developing students' memory as the material embed deeply in students' memory. The representation form refers to students' expressions of mathematical ideas in their efforts to solve mathematics problems (Ferrini-Mundy, 2000).

Some schools adopted the Cambridge curriculum, such as Global Inbyra School Tegal, using the Singapore-Cambridge approach. To contribute to improving education, this study aimed to compare the mathematics problems in Indonesian and Singaporean textbooks. The Indonesian textbook selected was the 8th-grade Mathematics textbook with a revised curriculum 2017 Published by PT. Sarana Pancakarya Nusa. At the same time, the Singaporean textbook used in this study was the 2nd edition of Discovering Mathematics 2b, published by Star Publishing Pte Ltd Singapore. The two books are used in several schools in Indonesia, such as SMPN 1 Jamblang, which uses an 8th-grade Mathematics book with a revised curriculum 2017, and Global Inbyra School, which uses the 2nd edition of Discovering Mathematics 2b. The government or relevant agencies have approved the books used in this study following the standards for textbooks in Indonesia and Singapore. Hadi (2012) showed that many teachers in Indonesia still teach using mathematics textbooks issued by the Indonesian government. To maintain the equality of the analyzed sources, the topic of the Pythagorean Theorem was selected as it is in the same grade and contains the same concepts in both Indonesian and Singaporean textbooks.

The result of this study is expected to contribute to improving mathematics problems in Indonesian textbooks to support students' reasoning and problem-solving skills. Improvements to the quality of mathematics textbooks for students and teachers are carried out on an ongoing basis to compile high-quality mathematics textbooks, which can be used nationally following the applicable curriculum and compete internationally. Based on the explanation, the formulation of the research question is drawn as follows: how is the comparison of Pythagorean problems in the selected Indonesian and Singaporean mathematics textbooks on the dimension of Bloom's taxonomy of cognitive level, representation form, contextual feature, and response type?

RESEARCH METHOD

Research Design and Approach of the Study

This research was a descriptive qualitative study with document analysis or content analysis. This study was carried out systematically on documents as a data source to compare Pythagorean problems in Indonesian and Singaporean textbooks. The design of this study is described below:

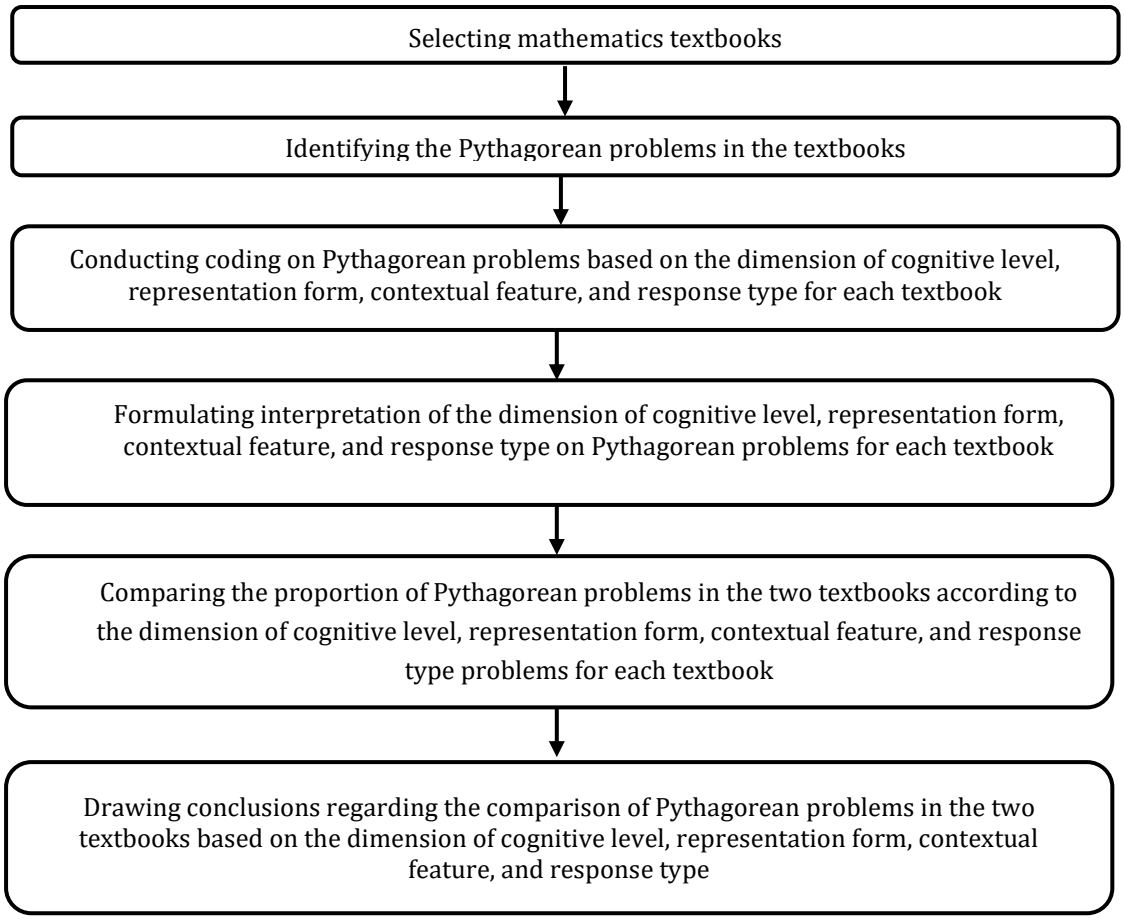


Figure 1. Flowchart of the study

Research Subject and Object

The subject of this study was the researchers themselves. In the process of analyzing, the researchers performed as raters to maintain the consistency of the analysis. The object of this study was the 8th-grade Mathematics textbook with revised curriculum 2017, published by PT Sarana Pancakarya Nusa Indonesia, and the 2nd edition of *Discovering Mathematics* 2b, published by *Star Publishing Pte Ltd Singapore*.

Data Collection and Analysis

The data were collected through documentation. It is used for a study whose source comes from writing, pictures, or monumental works of someone (Sugiyono,

2013). Documentation was used to obtain the percentage of each dimension studied by assigning a score to each category for Pythagorean problems. Three raters collected the data. Before collecting the data, the three raters were informed and coached about the four aspects to analyze the problems: cognitive level, representation form, contextual feature, and response type. Thus, the three raters have the same perception of those four aspects.

The dimension of problems analysis used in this study was modified from Charalambous, Delaney, & Hsu (2010) and Yang, Tseng, & Wang (2017), namely (1) cognitive level; (2) representation form; (3) contextual feature; and (4) response type. The analysis of mathematics textbooks was carried out with textbook evaluation sheets which contain several aspects, as shown in Table 1.

Table 1. Aspects of problems in mathematics textbooks

Aspect	Category	Explanation
Cognitive level	a. Remembering (C1) b. Understanding (C2 c. Applying (C3) d. Analyzing (C4) e. Evaluating (C5) f. Creating (C6)	a. C1/remembering is an attempt to regain knowledge from memories that have just been obtained or have been acquired for a long time. b. C2/understanding is related to the ability to build an interpretation from various sources. c. C3/applying refers to a cognitive process of applying knowledge to solve problems. d. C4/analyzing is the ability to solve a task by separating the task into smaller parts and looking for the relationships between these parts. e. C5/evaluation is related to a cognitive assessment process based on predetermined criteria and standards. f. C6/creating emphasizes the cognitive process of combining elements to form a coherent whole.
Representation form	a. Purely Mathematical form b. Verbal form c. Visual form d. Combined form	a. Purely mathematical form means that the problems only include mathematical expressions. b. Verbal problems refer to problems that are only presented in the written form. c. Visual problems mean that the problem only includes pictures, graphs, tables, or diagrams. d. Combined form problems are problems that contain two or three of the previously

		mentioned forms.
Contextual feature	a. Application form b. Non-application form	a. Application form problems are problems that are presented in the context of a real-world situation. b. Non-application form problems are presented without any context.
Response type	a. Closed Task b. Open Task	a. An open problem means that a problem has several correct answers. b. A closed problem means the problem has only one correct answer.

There were three steps in analyzing qualitative data in this study: data reduction, data presentation, and conclusion and verification (Sugiyono, 2013). Data reduction meant the data obtained in the field were presented in detailed written form. Before being presented, the data were checked for consistency among three raters using the inter-rater reliability (kappa) test. Data presentation related to data presented in the form of brief descriptions, charts, relationships between categories, flowcharts, and the like. Then, conclusions and verification must be drawn based on valid and consistent evidence.

RESULTS AND DISCUSSION

The topic discussed was Pythagorean Theorem. To maintain the equality of the analyzed sources, Pythagorean Theorem was selected as it was in the same grade and contained the same concepts in both Indonesian and Singaporean textbooks. Table 2 shows the scope of Pythagorean Theorem material presented in Indonesian and Singaporean textbooks.

Table 2. Composition and sub-chapters of Pythagorean Theorem materials in the selected Indonesian and Singaporean textbooks

Materials	**Mathematics Textbooks**	
	Indonesia	**Singapore**
Pythagorean Theorem	a. Statement of the Pythagorean theorem. b. Determine the length of the sides of a right triangle if the lengths of two sides are known. c. Determine the type of triangle based on the length of the sides. d. Pythagorean triples. e. Application of the Pythagorean Theorem in a real-life context.	a. Statement of the Pythagorean Theorem. b. Applying the Pythagorean Theorem to solve problems involving right triangles. c. Applying the Pythagorean Theorem to determine whether a triangle has right angles.

Interrater Reliability

Discussions between three raters were conducted to reduce biased classification results and improve the results' reliability. It can be seen in Table 3 that in Indonesian textbooks, the average of the Kappa coefficient on the cognitive level was 0.807, while in Singaporean textbooks, the average of the Kappa coefficient was 0.945. Regarding representation form, the average Kappa coefficient of Indonesian textbooks was 0.925, while that of Singaporean textbooks was 0.950.

Regarding representation form, the Kappa coefficient average of Indonesian and Singaporean textbooks was 0.902 and 0.873, respectively. On the aspect of response type, the average of the Kappa coefficient was 0.689 and 1.000 for Indonesia and Singapore, consecutively.

As shown in Table 3, the Kappa coefficient average value indicated that the interrater reliability level was classified as high. Thus, there was agreement on the raters' perception of the proportion of Pythagorean problems on the four aspects in the two textbooks.

The results of the problem analysis were presented in four aspects: Bloom's taxonomy cognitive level, representation form, contextual feature, and response type as below.

Table 3. Interrater reliability of the Kappa statistic

Aspects	Textbook	Kappa coefficient				Category
		Rater 3 and 1	Rater 3 and 2	Rater 1 and 2	Average	
Cognitive Level	Indonesia	0.752	0.862	0.814	0.809	High
	Singapore	0.942	0.949	0.902	0.931	Very high
Representation form	Indonesia	0.893	0.957	0.896	0.915	Very high
	Singapore	0.933	0.967	0.944	0.948	Very high
Contextual Feature	Indonesia	0.899	0.905	0.900	0.901	Very high
	Singapore	0.854	0.892	0.870	0.872	High
Response Form	Indonesia	0.644	0.735	0.721	0.700	Moderate
	Singapore	1.000	1.000	1.000	1.000	Very high

Cognitive Level

The results of the problem comparison analysis of Indonesian and Singapore textbooks are presented in Table 4 below. There were 69 and 60 Pythagorean problems in Indonesian and Singapore textbooks, respectively. It can be seen from Table 4 that the majority of the problems were in C3 and C4 levels. Meanwhile, the composition C1 and C6 problems were the two lowest percentages.

Table 4. Pythagorean problems comparison on the cognitive level

Aspects	Category	Pythagorean Problems in Textbooks			
		Indonesia		Singapore	
		n	%	n	%
Cognitive Level	Remembering (C1)	0	0	0	0
	Understanding (C2)	8	11.6	7	11.7
	Applying (C3)	31	44.9	18	30
	Analyzing (C4)	25	36.2	28	46.6
	Evaluating (C5)	3	4.3	7	11.7
	Creating (C6)	2	2.9	0	0
Total		69	100	60	100

Classification of Pythagorean problems based on the cognitive level showed that the Indonesian textbooks facilitated C2 to C6 level, while the Singapore textbooks facilitated C2 to C5 level. In contrast, the highest cognitive level C6 problems were spotted merely in Indonesian textbooks. The proportion of each cognitive level in each textbook was similar. The difference was that Indonesian textbooks added a small number of problems which facilitated the “creating” level. The two textbooks did not have problems with the "remembering" level. In other words, the problems in the two textbooks did not facilitate the C1 category. For the “understanding” level, the two textbooks contain a similar percentage of C2-level problems. The “applying” and “analyzing” categories dominated the Pythagorean problems in the two textbooks. In Indonesian textbooks, C3 problems had the highest percentage, while in Singapore textbooks, C4 problems were the greatest. This result followed the study of Baqiyatussolihat (2019), which revealed that problems in Indonesian and Singapore mathematics textbooks were mostly at the C3-C4 level. For the “evaluating” level, more C5 problems were found in Singapore textbooks than in Indonesian textbooks.

Figure 2 shows a sample of Pythagorean problems in Indonesian and Singapore textbooks. The questions in Indonesian textbooks ask students to apply Pythagorean Theorem and connect it to the concept of a pyramid net and the surface area of the pyramid. Thus, this problem was categorized as an “analyzing” problem.

The problems in Singapore textbooks ask students to determine the length of three sides of a triangle inscribed inside a rectangle, whether the triangle is right-angled, and the shortest distance from a point to a line. This problem is included in the C4 level as connecting the Pythagorean Theorem to the distance concept is required to solve problem (c).

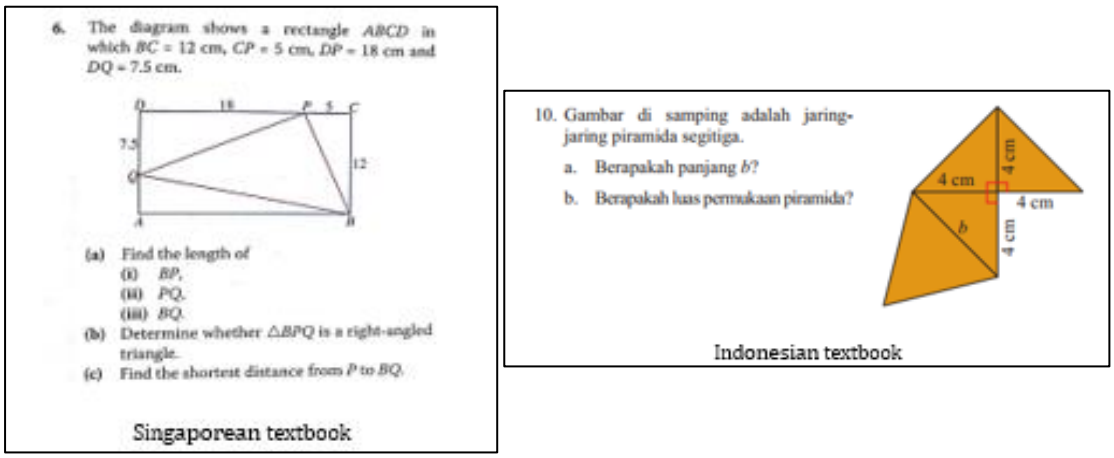


Figure 2. Sample of problems in Indonesian and Singaporean textbooks regarding the aspect of cognitive level

Representation Form

Table 5 shows the coding results of Pythagorean problems from the representation form aspect in Indonesian and Singaporean textbooks. As presented in Table 5, the majority of Pythagorean problems in Indonesian textbooks were in verbal, visual, and combined forms. Merely two out of 69 problems were in purely mathematical form. Meanwhile, Singaporean textbooks mostly contained combined form problems with a percentage of 68.3%.

Table 5. Pythagorean problems comparison on representation form

Aspects	Category	Pythagorean Problems in Textbooks			
		Indonesia		Singapore	
		n	%	N	%
Representation Form	Purely Mathematical Form	2	2.9	7	11.7
	Verbal Form	18	26.1	6	10
	Visual Form	25	36.2	6	10
	Combined Form	24	34.8	41	68.3
	Total	69	100	60	100

Regarding representation form, Pythagorean problems in Indonesian and Singaporean textbooks facilitated each category of representation form. However, the proportion of each representation form in the two textbooks differed. In Indonesian textbooks, visual and combined problems shared a similar percentage, followed by verbal problems. On the contrary, there were merely two pure mathematics problems in Indonesian textbooks. Unlike Indonesian textbooks, Pythagorean problems in Singaporean textbooks were presented mostly in combined form. Each purely mathematical, verbal, and visual form consisted of 6-7 questions.

This result differed from the study of Lisarani (2018), which concluded that Indonesian mathematics textbooks focused more on combined form, while Singaporean mathematics textbooks focused more on verbal category. The difference might arise because the analyzed textbooks were different. Thus, it led to different results. This result implied that students who learn from these books might be engaged more in combined-form problems. According to the National Council for Mathematics Teachers (Ferrini-Mundy, 2000), using combined forms in mathematics problems was highly recommended because it encouraged students to get used to various forms of representation.

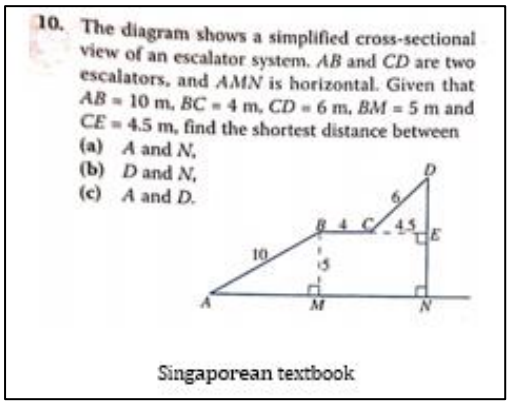


Figure 3. Sample of problems in Indonesian and Singaporean textbooks regarding the aspect of representation form

Figure 3 illustrates the sample problems in Indonesian and Singaporean textbooks. In Indonesian textbooks, the problem asks students to determine the area of a circular area whose radius is one side in the right triangle. Meanwhile, the problem in Singaporean textbooks is determining the distance between two points in a simplified escalator system cross-section. The two problems are presented in a description form. Moreover, the illustration of the problems is also presented beside the problem. Thus, the problems are included in "combined form" since the problem is presented in both verbal and visual form.

Contextual Feature

The coding results of Pythagorean problems according to contextual feature aspects in Indonesian and Singaporean textbooks is described in Table 6. According to contextual features, the majority of Pythagorean problems both in Indonesian and Singaporean textbooks were presented as non-application problems with 81.2% and 61.7%, consecutively. Meanwhile, merely 18.8% and 38.3% of the problems in Indonesian and Singaporean textbooks were written in real-life contexts.

Table 6. Pythagorean problems comparison on contextual feature

Aspects	Category	Pythagorean Problems in Textbooks			
		Indonesia		Singapore	
		n	%	N	%
Contextuality Features	Application Form	13	18.8	23	38.3
	Non-Application Form	56	81.2	37	61.7
	Total	69	100	60	100

In the analyzed textbooks, both books facilitated problems for each category of contextual features with different percentages. However, most of the problems in the two textbooks were non-application problems, even though the Singaporean textbooks provided a smaller percentage of non-application forms. Merely 18.8% and 38.3% of the problems were presented in the application form in Indonesian and Singaporean textbooks, respectively. This result aligned with previous studies, which revealed Indonesian (Lisarani, 2018) and Singaporean mathematics textbooks (Ozer & Sezer, 2014) focused more on non-application tasks. Students with insufficient experience in real-world problems likely had difficulties solving this kind of problem (Wijaya, Van den Heuvel-Panhuizen, & Doorman, 2015).

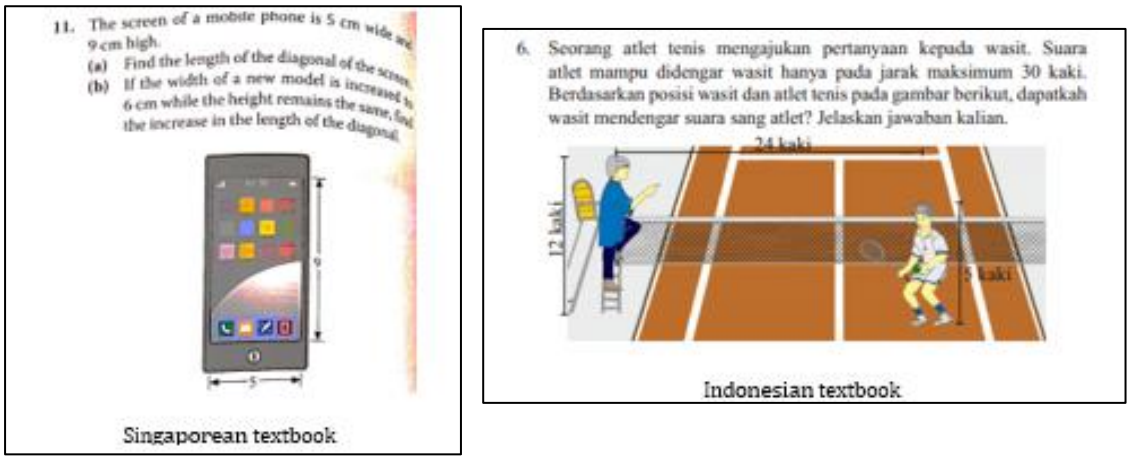


Figure 4. Sample of problems in Indonesian and Singaporean textbooks regarding the aspect of the contextual feature

Figure 4 shows an example of the Pythagorean problem in Indonesian and Singaporean textbooks. The problem in Indonesian textbooks asked students to determine and explain whether or not someone's voice is heard from two predetermined points. Meanwhile, the problem in Singaporean textbooks asked students to determine the diagonal length of the mobile phone and the increase in diagonal length if the screen width of the new model increases. The two problems were included as application problems because the problem was presented in a real-life context.

Response Type

Table 7 describes the coding results of Pythagorean problems following the response type aspect in Indonesian and Singaporean textbooks. Based on Table 7, most of

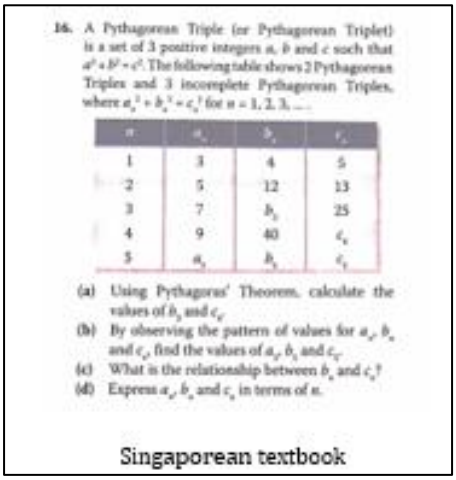
the Pythagorean problems in Indonesian and Singaporean textbooks were categorized as closed tasks with 94.2% and 95%, respectively. The problems mostly did not enable students to provide various correct answers or strategies.

Table 7. Pythagorean problems comparison on the response type

Aspects	Category	Pythagorean Problems in Textbooks			
		Indonesia		Singapore	
		n	%	n	%
Response Form	Closed Task	65	94.2	57	95
	Open Assignment	4	5,8	3	5
Total		69	100	60	100

Pythagorean problems in the two textbooks were mostly closed tasks, with more than 90% for each textbook. On the contrary, less than 10% of the problems were presented as open-ended problems. This result agreed what Hidayah and Forgasz (2020) revealed that Indonesian mathematics textbooks focused more on the "closed task" category.

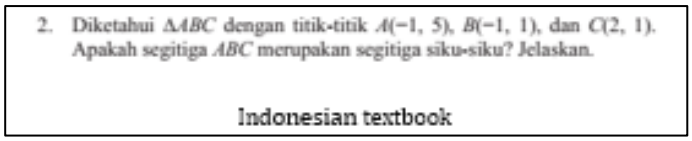
Figure 5 illustrates a sample of closed tasks in Indonesian and Singaporean textbooks. The problem in Indonesian textbooks asked students to determine whether a triangle was a right triangle if the triangle's three points were given. This problem could be solved by using the concept of Pythagorean Triplet. Similarly, the problem in Singaporean textbooks was related to a Pythagorean triple. Those two problems had only one correct answer, and most students would likely apply the Pythagorean rule. Thus, this problem was categorized as a closed task.


16. A Pythagorean Triple (or Pythagorean Triplet) is a set of 3 positive integers a, b and c such that $a^2 + b^2 = c^2$. The following table shows 2 Pythagorean Triples and 3 incomplete Pythagorean Triples, where $a_n^2 + b_n^2 = c_n^2$ for $n = 1, 2, 3, \ldots$.

n	a_n	b_n	c_n
1	3	4	5
2	5	12	13
3	7	b_3	25
4	9	40	c_4
5	a_5	b_5	c_5

(a) Using Pythagoras' Theorem, calculate the values of b_3 and c_4.
(b) By observing the pattern of values for a_n, b_n and c_n, find the values of a_5, b_5 and c_5.
(c) What is the relationship between b_n and c_n?
(d) Express a_n, b_n and c_n in terms of n.

Singaporean textbook


2. Diketahui ΔABC dengan titik-titik $A(-1, 5)$, $B(-1, 1)$, dan $C(2, 1)$. Apakah segitiga ABC merupakan segitiga siku-siku? Jelaskan.

Indonesian textbook

Figure 5. Sample of problems in Indonesian and Singaporean textbooks regarding the aspect of response type

CONCLUSION

Pythagorean problems in Indonesian and Singaporean textbooks presented slightly different tendencies in each aspect. On the cognitive level aspect, the “applying” and “analyzing” categories dominated the Pythagorean problems in the two textbooks. In

Indonesian textbooks, C3 problems had the highest percentage, while in Singaporean textbooks, C4 problems were the greatest. Regarding representation form, the problems in Indonesian textbooks facilitated more visual and combined forms, while Singaporean textbooks facilitated mostly combined forms. Indonesian and Singaporean textbooks showed the same contextual feature and response types trend. Most of the problems in the two books were presented in non-application forms and closed tasks.

This mathematics textbook research only focused on the cognitive level aspects of Bloom's taxonomy, representation form, contextual feature, and response type. In addition to analyzing these four aspects, it is expected that further researchers can add other aspects that are not explained in this study, such as analysis of tasks based on the cognitive dimensions of TIMSS, horizontal and vertical aspects, or criteria from Higher Order Thinking Skills (HOTS).

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