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A Comparative Analysis of Non-Routine Problems in Mathematics Textbooks of Indonesia and Singapore

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Abstract. Textbooks used in schools affect the quality of mathematics learning in the country. Indonesian Ministry of Education (Kemendikbud) already launched students' and teachers' textbooks that are distributed nationally in 2013; however, improvements are needed to revise the textbooks since there are concerns such as the difficulty level of problems contained in the textbooks. The main objective of this study is to compare non-routine problems contained in mathematics textbooks used in Indonesia and Singapore. This is qualitative research with a content analysis design. Researchers compare Singaporean and Indonesian mathematics textbooks since Singapore got a higher rank in mathematics based on PISA results in 2018. The topic in this study is limited to the Pythagorean Theorem. The result of the research shows that Indonesia and Singapore has consecutively 22,1% and 11,3% non-routine problem. Another finding of this study was Singaporean mathematics textbooks focused more on developing students' fluency in solving problems, meanwhile Indonesian mathematics textbooks focused more on students' reasoning ability. The results and findings in this paper are expected to provide input in developing future mathematics textbooks.

Keywords: Mathematics Textbook, Indonesian Mathematics Textbook, Non-Routine Problems, Singaporean Mathematics Textbook

Abstrak. Buku teks yang digunakan di sekolah mempengaruhi kualitas pembelajaran matematika di suatu negara. Kemendikbud Indonesia telah meluncurkan buku guru dan buku siswa yang didistribusikan secara nasional pada tahun 2013; namun banyak perbaikan bisa diajukan untuk merevisi buku tersebut karena muncul kekhawatiran mengenai tingkat kesulitan masalah yang terdapat dalam buku teks. Tujuan utama penelitian ini adalah membandingkan masalah nonrutin yang disajikan dalam buku teks matematika Indonesia dan Singapura. Penelitian ini merupakan penelitian kualitatif dengan analisis ini. Peneliti membandingkan soal nonrutin dalam buku teks matematika Indonesia dan Singapura yang memperoleh ranking tinggi dalam bidang matematika berdasarkan hasil PISA 2018. Penelitian ini terbatas pada materi teorema Pythagoras. Hasil penelitian menunjukkan bahwa Indonesia dan Singapura secara berurutan memiliki 22,1% dan 11,3% soal nonrutin. Temuan lain dalam penelitian ini adalah buku teks matematika Singapura berfokus pada pengembangan kelancaran siswa dalam menyelesaikan masalah, sedangkan buku teks matematika Indonesia lebih berfokus pada kemampuan penalaran siswa. Hasil dan temuan dalam artikel ini diharapkan dapat memberikan masukan dalam mengembangkan buku teks matematika di masa depan.

Kata kunci: Buku Teks Matematika, Buku Teks Matematika Indonesia, Buku Teks Matematika Singapura, Soal Nonrutin

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INTRODUCTION

Due to the change of the national curriculum of Indonesia in 2013, the Indonesian education and Culture or Kementerian Pendidikan dan Kebudayaan (Kemendikbud) of Indonesia launched students' and teachers' textbooks that are distributed nationally in the form of both physic and electronic. The textbooks are designed following the nature of the new curriculum; hence they are based on a scientific approach and authentic assessment (Muklis & Setyaningsih, 2015; Widyaharti et al., 2015). However few revisions need to be done since there are several studies such as Retnawati (2015) which explained that teachers reckon that materials are not well-sequenced composed in the textbook. Meanwhile, Fajriatin (2015) explained that few typos were found in the textbook and the difficulty level of the problems is too high. A similar thing also became research findings of Muklis & Setyaningsih (2015) where they found that teachers show concern related to the difficulty level of the problem presented in the textbook which will affect the time allocation needed to finish all materials in the academic year.

How mathematics is structured and presented in the textbooks used will affect how students construct mathematical ideas. Almost every country develops books that are adjusted to the views and habits of the country's mathematical education culture (Sutherland, 2007). This means analyzing textbooks used in a country might reveal learning opportunities provided, the effectiveness of the teaching and learning process in schools, and how well the curriculum has been implemented in the country (özer & Sezer, 2014). This importance of textbook hence encourages researchers to design researches related to it, including researches that compare textbooks from various countries (Lisarani et al., 2019).

The quality of textbooks can be determined by evaluating the various aspects of content, pedagogical approaches, language, and illustrations (Seguin, 1989). One of the contents that certainly exist in mathematics textbooks is the problems. Generally, problems can be divided into two: routine and non-routine problems. Routine problems are given if the goal is to help students understand the meaning of a particular operation or mathematical idea which usually require only basic operations and calculations (Arslan & Altun, 2007), whereas non-routine problems require students to think out of the box to solve them because the solution and the approach to the solution are not easy to predict, not explicitly suggested in the problems, problems' instructions, or worked examples (Woodward et al., 2012).

Non-routine problems will encourage students to be able to think strategically (Goldin, 2010). Unfortunately, students' non-routine problem-solving skills are still low (Putri, 2018). In this paper, non-routine problems from Indonesia's and Singapore's textbooks will be compared. Such comparison is important since it will give us information about what to deepen and what to delete for our future textbook development.

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Singapore is chosen to be compared against Indonesia due to its geographical adjacency and also by considering its high ranking of mathematics in PISA. Problems to be compared are limited to the Pythagorean Theorem since out of released mathematics items of PISA 2012, 4 problems explicitly used Pythagorean Theorem in its solving process (OECD, 2013), which shows that the test takers are assumed to have studied the unit in their respective country. PISA test takers are 15-year-old students in general (OECD, 2016), the average age of 9th-grade students in both Indonesia and Singapore. In both mathematics textbooks of Indonesia and Singapore, Pythagorean Theorem was taught in 8th grade, hence the unit is chosen to be analyzed in this research. So, the main objective of this study is to compare non-routine problems contained in mathematics textbooks used in Singapore and Indonesia, limited to the Pythagorean Theorem topic.

METHOD

This is qualitative research with a content analysis design. Content analysis is a research method that provides a systematic and objective way to conclude by analyzing one form of communication (Bengtsson, 2016; Fraenkel et al., 2011). The form of communication referred to in this study is *written communication* in the form of textbooks.

The role of researchers in this study is both an instrument and a data collector. The researcher both chooses and collects data. The data in this study are non-routine problems on the Pythagorean Theorem topic contained in Indonesian and Singapore textbooks. Purposive sampling is used to select the two countries, the textbook, the topic, and also the problems to be analyzed. Indonesia is the country of origin of researchers; hence the country becomes one of the countries that are the subject of research. Singapore was chosen to be a comparison for Indonesia because the country ranked first in mathematics performance in PISA 2015 and ranked second in PISA 2018, also has geographical proximity to Indonesia (OECD, 2019). In addition, both Singapore and Indonesia implement a national curriculum. The selection of Singapore textbooks is also based on the ability of researchers to understand the language used and also the ease of access to textbooks in the country.

The Indonesian mathematics textbook studied was the Mathematics Student Book or Buku Siswa Matematika (BSM) written by As'ari et al., (2017) because this book was distributed nationally by the Indonesian government, whereas in Singapore, there are no books distributed nationally by the government. The selection of books is returned to the school to suit the needs of students because the effectiveness of the learning process is very dependent on the selection of appropriate learning materials. However, Singapore's Ministry of Education (MoE) issued a list of books that can be accessed in the form of spreadsheets on the page https://www.moe.gov.sg/education-in-sg/approved-textbook-list as a benchmark for schools to

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choose textbooks that have been approved by the MoE. The Singapore mathematics textbook chosen to be studied in this research is New Syllabus Mathematics (NSM) written by Yeo et al., (2015) for the following reasons: (1) NSM is included in the book list approved by the MoE, and (2) NSM has the largest market share in Singapore (Yang, 2014).

After determining the countries, textbooks, and topic that is limited to Pythagorean Theorem, the researcher then determined what kind of problems to be studied. After carefully reading the NSM and BSM, the researcher decided to analyze 62 problems spread under the subtitles *Exercise, Practice Now*, and *Challenge Yourself* in the Singapore textbooks and 77 problems spread under *Ayo Kita Berlatih*, *Uji Kompetensi*, and *Ayo Kita Menalar* subtitles in Indonesian textbooks. Problems under those subtitles are not followed by solutions.

The problems on the Pythagorean Theorem topic contained in Indonesian and Singapore textbooks are categorized into non-routine or routine problems using the indicator of non-routine problems based on Goldin (2010) and Woodward (2012), namely: (i) students have never encountered any problem and/or sample problem or worked on a similar problem in the mathematics textbook understudy, (ii) the problem has a unique solution, which means that the solving procedure is different from that of problems presented in the mathematics textbook under study, and (iii) the problem does not contain instructions/suggestions on how to solve it. Problems satisfying all three indicators simultaneously were coded and will be analyzed further.

RESULTS AND DISCUSSION

The NSM textbook which has 62 problems in the Pythagorean Theorem topic, contains 19 problems (30,6%) satisfying indicator (i), 9 problems (14,5%) of indicator (ii), and 60 problems (96,8%) of indicator (iii). These data show that the NSM textbook having nearly 70% similar problems that have been encountered by students, a few problems having a unique solution, and the majority of problems have neither instructions nor hint to solve it.

Meanwhile, the Indonesian textbook, BSM, has more Pythagorean Theorem problems than NSM. From 77 problems contained, it has 37 (48,1%) problems related to indicator (i), 20 (26%) problems at indicator (ii), and 70 (90,9%) problems at indicator (iii). The proportion of each indicator is similar to the NSM textbook. The summary of this information can be found in Table 1.

Table 1. Comparing Non-Routine Problem in NSM And BSM Textbook

Issues	**NSM (Singapore)**	**BSM (Indonesia)**
Indicator (i)	30,6%	48,1%
Indicator (ii)	14,5%	26%
Indicator (iii)	96,8%	90,9%
Non-routine problem	7 of 62	17 of 77

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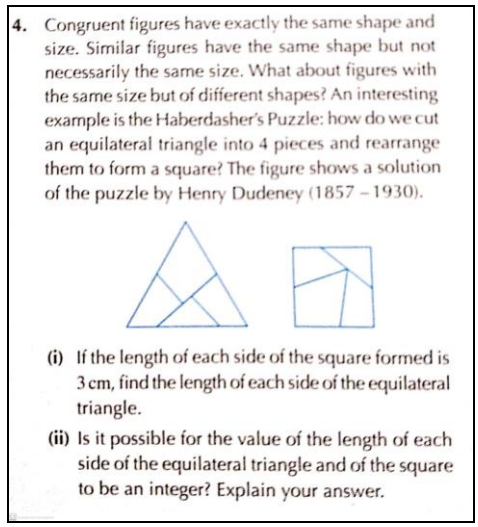
Non-routine problems are problems that satisfy all three indicators. As shown in Tabel 1, BSM has more non-routine problems since it has 17 problems (22,1%), meanwhile, NSM has 7 (11,3%) non-routine problems. Examples of non-routine problems in NSM and BSM respectively can be seen in Figure 1 and Figure 2.



4. Congruent figures have exactly the same shape and size. Similar figures have the same shape but not necessarily the same size. What about figures with the same size but of different shapes? An interesting example is the Haberdasher's Puzzle: how do we cut an equilateral triangle into 4 pieces and rearrange them to form a square? The figure shows a solution of the puzzle by Henry Dudeney (1857 – 1930).

(i) If the length of each side of the square formed is 3 cm, find the length of each side of the equilateral triangle.

(ii) Is it possible for the value of the length of each side of the equilateral triangle and of the square to be an integer? Explain your answer.

Figure 1. Non-routine Problem in NSM

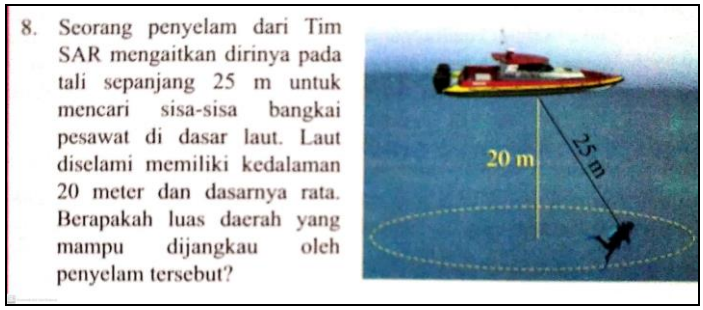


Figure 2. Non-routine Problem in BSM

Besides analyzing the non-routine problem, researchers also found some similarities and differences between the two textbooks as shown in Table 2. Both NSM and BSM have discovery activities in their textbook for students to discover the concepts by themselves, promoting student-centered exploration, and containing mostly contextual problems.

Table 2. Findings In NSM And BSM Textbook

Issues	NSM (Singapore)	BSM (Indonesia)
Integrated to Website	√	–
Discovery Concept	√	√
Student-Centered Exploration	√	√
Contextual Problem	√	√
More Repetition Problem	√	–
More Non-Routine Problem	–	√
Having Multiple Choice Problem	–	√

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NSM is integrated into website links that contain software to help the student to understand the concept and also contains more similar problems. On the contrary, BSM does not have such integration, but it has varying problems and also multiple choices problems, therefore it has fewer repetition problems than NSM.

The problem and examples in the NSM textbook are arranged systematically in order-making students familiar with and understand the concept of the presented topic. Many problems are similar to examples and other practice problems. Only 9 out of 62 problems in the NSM textbook have unique solution problems showing that the presented problems mostly are repeated problems. Compared to Indonesia's textbook, the problems in NSM are relatively easier. One characteristic of the NSM textbook is allowing students to improve their fluency in solving problems by repetition of problems. Furthermore, the textbook contains discovery concept activities and provides mostly contextual problems to help students relating the Pythagorean Theorem in the real world.

The activity of the discovery concept is more enormous on BSM than NSM. BSM presents many activities and variety on proving concepts, which are designed to be discovered by students. Meanwhile, in NSM, concepts without any proof are given, hence concept discoveries by students. Despite that issue, the arrangement of the discovery concept in NSM is structured well. It started with easier activities to harder activities such as "Trial and Error" to discover three lengths of a given right triangle. The role of the teacher in guiding the student at the beginning of the topic is critical to prevent misconceptions. Therefore, NSM is easier to be understood on comprehending concepts because it is presented slowly and systematically.

Both NSM and BSM have contextual problems. The difference is that NSM presents a series of problems titled *"Exercise"* having all contextual problems to be solved. On BSM, the contextual problem is mixed at each practice part. BSM has a varying problem than NSM since NSM has many similar problems for the student to repeatedly solve it and BSM has many types of problems to improve the students' ability of reasoning. The consequence is BSM has *"Ayo Kita Menalar"* as a reasoning practice for the student.

BSM has a more non-routine problem than NSM. Based on the explanation above, the result can be influenced by the objective of each textbook. In NSM, repetition of similar problems is established for the student to have fluency in solving the problems, meanwhile, in BSM the activity to reasoning is established by various problems and tasks given, especially in the intention of improving the student's reasoning ability.

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CONCLUSION

Based on the result, there are some conclusions given as follow: (1) NSM has 11,3 % non-routine problems and BSM has 22,1 % non-routine problems, (2) NSM has more similar problems (repetition problems) and BSM has a more varying problem, (3) NSM focused more on developing students' fluency of solving problems, meanwhile BSM focused more on students' reasoning ability. Each NSM and BSM has its objectives in developing the textbook. The expectation of what students get after studying the textbook influencing how the textbook is arranged including the types of problems that should be presented to the student.

Based on the similarity and difference in both countries' textbooks, some suggestions can be proposed for both Indonesia and Singapore textbook developers to complement the existing textbooks. For Indonesian textbook developers, the beginning of the textbooks shall be designed to promote students' discovery by giving easier problems first then slowly building up to harder problems. The quantity of easier problems can also be added as an exercise for students in solving similar problems. This will ensure that the subtopics are fully grasped before students continue to learn the next subtopic and/or harder problems such as non-routine problems. In addition, websites or software can be integrated into Indonesian textbooks. Meanwhile, for Singaporean textbook developers, more non-routine problems can be added to improve students' reasoning ability. The types of problems can be added to extend the knowledge of students about many varieties of problems.

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