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A Comparative Analysis of Indonesian and Singaporean Mathematics Textbooks from the Perspective of Mathematical Creativity: A Case Statistics and Probability

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A Comparative Analysis of Indonesian and Singaporean Mathematics Textbooks from the Perspective of Mathematical Creativity: A Case Statistics and Probability

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Abstract. Mathematical creativity is very important in this 21st century competition. This skill can be taught and facilitated through a supported textbook. There is a relationship between textbooks used and mathematics achievement of the students. To what extent students' creative thinking can be seen in the tasks of the textbooks. This study compared the mathematical creativity for the topic of probability in Junior High School (JHS) Indonesian and Singaporean mathematics textbooks. Textbooks will be analyzed from the perspectives of originality, fluency, flexibility, and elaboration aspects. Indonesian mathematics textbooks and Singaporean mathematics textbooks both facilitate mathematical creativity. Indonesian textbooks can facilitate three of four aspect creativity and Singaporean mathematics textbooks two of four aspect creativity. There are many tasks that supported more than one aspect of mathematical creativity but all mathematics textbook were analyzed doesn't support fluency aspect. Singaporean textbook has 18% task that facilitated mathematical creativity and Indonesian mathematics textbook has 10%. The finding showed that Singaporean textbooks more facilitate thinking of students' mathematical creativity.

1. Introduction

Learning and innovation skills are important to prepare more complex life and work environments in the 21st century. These skill focus on critical thinking and problem solving, creativity and innovation, communication, and collaboration are important for students in the future [1]. The 21st century skills also require students to have a good Higher Order Thinking Skills (HOTS) [2]. HOTS includes the ability to think creatively [2]. Creative thinking is considered to be the essence of mathematics [3] and its one of the goals of Indonesian education [4]. Creativity is also very useful for themselves, education and social economic development [5, 6].

Creativity is an important skill that should be nurtured [7]. Torrance [8] was described creativity as the ability to be sensitive to a problem, identify problems, find solutions, make guesses or formulate hypotheses, test hypotheses that have been formulated, and finally be able to communicate the results. The ability to think creatively in mathematics is called mathematical creativity [9]. Mathematical creativity means an ability to produce many solutions for mathematics problems [10]. According to Guilford [11], creative thinking have several important characteristics, namely originality, fluency, flexibility, and elaboration. Originality refers to create ideas that are unique answers and different from other, fluency refers to create many solutions, flexibility refers to create many different methods or expressing solutions in one way later in another ways, and elaboration refers develop an idea and adding ideas in detail [10, 12, 13].

Mathematical creativity can be developed through a learning process in the classroom. There are many factors that affect students achievement i.e curriculum content, instructional strategies, and instructional resources [14]. One of the instructional resources is textbook. The textbook has been emphasized to be a tool in important mathematics teaching and learning processes [15]. Besides that, textbook is an important resources to give students the opportunity to learn [16, 17]. Different textbooks make students get different opportunity to learn and influence student achievement. One part of the textbook content is tasks. The tasks in the textbook or test can be used to measure the ability to think creatively [18]. The test given can be problem posing or problem-solving [19]. This indicates that mathematics textbooks need to be equipped with problems that can facilitate students' creative thinking [15].

According to the international tests such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA), attention to the textbooks is increasing. The International Association for the Evaluation of Educational Achievement (IEA) analyze textbooks from the TIMSS participating countries [20]. In addition to the IEA, there are several studies from Haggarty and Pepin [21], Charalombous et al. [22], and Silalahi and Chan [23] who also compared mathematics textbooks from several countries. The results of these studies show the similarities and differences in each textbook so that it can be used to develop future textbooks. This is important considering that textbooks are learning resources that support learning and affect student achievement. Considering the abovementioned that analyze textbook is important so this study aims to analyze mathematical textbooks from the perspective of mathematical creativity.

Recently, there are several studies that analyze textbooks from various perspectives. For example in TIMSS, initially analysis of textbook was focused on investigating the profiles of textbooks content [24]. Textbook was also examined based on five measures, one of which is physical characteristics of textbooks, such as the size of the book and the number of pages it has [20]. Charalambous et al [22] analyzed textbook from horizontal and vertical approaches. The horizontal approach means to examine background information and the overall structure of textbooks, while the vertical approach analyzes textbooks with topic-specific perspectives such as definitions, mathematical practices, and connections.

The results of PISA [25] indicated that the mathematical achievements of Singapore and Indonesia had significant differences. The achievements of students in Singapore are in the top rankings while the achievement of Indonesian students are always in the bottom. This may be influenced by the quality of the textbooks. Singapore mathematics textbooks are widely used in some schools both Indonesia and other countries, because of teachers and mathematicians like the mathematics textbook because of the simple approach to solving problems [26]. Even in some international schools in Indonesia use mathematics textbooks from Singapore. This condition triggers the importance of research on the analysis of textbook content, especially in perspective mathematical creativity. Furthermore, the topic statistics and probability was analyzed because is an inseparable part of mathematics curriculum in junior high school and one of material that measured in PISA [25]. Probability represents mathematics in real life and also connects many section of mathematics, specifically counting and geometry [27]. The experience of studying probability can contribute to students' conceptual knowledge about working with data and chance [28]. Overall, this study reports the analysis of probability presentation in Indonesian and Singaporean textbooks from the perspective mathematical creativity.

2. Method

2.1 Mathematics textbooks analyzed

This study was a qualitative research using content analysis method. In order to investigate to what extend the Indonesian and Singaporean mathematics textbooks could facilitate students' mathematical creativity. For this purpose, a textbook analysis was carried out for which the focus of analysis was on mathematics tasks in grade 8. The mathematics textbooks that will be analyzed are shown in Table 1. In Indonesia, the applicable curriculum is the 2013 curriculum where textbooks that must be used in schools are published from the ministry of education and culture, namely the revised textbook 2017.

Schools usually use additional mathematics textbooks from other publishers. Based on the pre-study, it indicated that the most widely used mathematics textbook in Indonesia was a publication from Erlangga. In Singapore, all textbooks need to be approved by Singapore's Ministry of Education before they can be adopted. Since 2008 and 2014, respectively, mathematics teaching materials from Singapore have been used in California and France, showing that mathematics textbooks from Singapore are well regarded [29]. As a representative of mathematic textbooks and workbooks in Singapore, the New Syllabus series and Math in Focus were chosen. These books were included in the top search and often used in similar research [30]. From the fourth textbooks to be analyzed there were the same material, namely probability. So this study just focused on the material and only analyzed exercises in the end chapter.

Table 1. Analyzed textbooks

Country	Textbook Series	Abbreviation	Publisher
Indonesia	Matematika SMP/MTs Kelas VIII Semester 2 Revisi 2017	MSK	Indonesian Ministry of National Education
	Matematika untuk SMP/MTs Kelas VIII Semester 2: 2B	MSE	Erlangga
Singapore	New Syllabus Mathematics 7th Edition	NSM	Shinglee
	Math in Focus	MF	Marshall Cavendish Education

2.2 Procedures of textbook analysis

The procedures developed by Charalambous et al. [22] was used to analyze the textbooks. The textbook analysis was done from two perspectives, i.e. horizontal and vertical approaches. The horizontal approach included the physical characteristics and instructional components of the textbooks, whereas the vertical approach included the characteristics of the tasks. The aim of investigating physical characteristics and instructional components of the textbooks was to know the amount of exposure to the content of mathematics textbook. The data about the page size, the number of pages, and the page surface area of the textbooks were collected. Furthermore, the number of worked example sections and the end task of section was also identified.

Table 2. Coding scheme for mathematical creativity in mathematics textbook

Aspect	Indicators	Explanation
Originality	The textbooks present new or different types of task with examples problem that given and facilitates different types of task.	a. There are at least two different types of task about the task with the example problem. b. The task must vary at least two different types of task and must represent the material presented in the textbook.
Fluency	The tasks in mathematics textbooks have many solutions.	a. The task has at least two different answers or solutions. b. The instructions of the task can motivate students to find more than one solution.
Flexibility	The tasks in mathematics textbooks have many ways to solving them.	a. Problems can be solved at least with two ways b. Instructions of the task do not limit the method of settlement used.
Elaboration	The tasks in mathematics textbook can motivate students to issue, develop, generalize ideas and products, and add or elaborate in detail situation.	a. The task in mathematics textbook can motivate students to add or detailing of an object, idea or situation b. Instructional of the task can motivate students to elaborate their solutions.

The vertical analysis aims to investigate the contents of mathematical textbooks in the perspective of mathematical creativity. The analytical framework (see Table 2) was developed based on mathematical creativity aspect: originality, fluency, flexibility, and elaboration. The total of each task according to the aspect of mathematical creativity was counted.

2.3 Coding procedure

All tasks in Indonesian and Singaporean textbooks were analyzed by the first author using an analysis framework as shown in Table 2. Afterward, to determine the level of agreement between the rater in analyzing teksbooks, inter rater reliability was required by an external rater who analyzed all the task in the teksbooks. In this study using Cohen's kappa with results .772 for the aspect originality, 1.00 for fluency, .799 for flexibility and 1.00 for elaboration. These results indicate level of inter rater reliability are almost perfect so the coding was reliable [31].

3. Result

3.1 Physical characteristics and instructional components of the mathematics textbooks

Table 3. Physical characteristics and instructional components of Indonesian and Singaporean textbooks

	Textbook			
	MSK	MSE	NSM	MF
Physical characteristic				
Page size (in mm)	176 × 250	176 × 250	215 × 275	215 × 275
Number of page[a]	40	41	24	52
Page surface area[b] (in cm^2)	176	180,4	141,9	307,45
Instructional components				
Number of worked examples	2	41	24	20
Total number of tasks	126	123	157	137
Number of tasks in worked example section	31	14	29	28
Number of tasks in section	63	76	91	80
Number of the end task	32	34	37	29

[a]Only the total page of material was analyzed.
[b]Multiplication of the page number and the area of a page [16, 20].

Regarding instructional components (see Table 3), MSE has the largest number of worked example but MSK has the smallest. For the number of task in worked example section, MSK has the largest and MSE has the smallest. For two textbooks from Singapore don't differ much about number of tasks in worked example. The result of the present study reveals a small difference between the textbook for the number of tasks. NSM has a total of 157 tasks, which is the largest than others. In addition to MSE has the smallest total number of tasks. NSM has the largest of the number of task in section and the end tasks large. For Indonesian textbook, MSE has the total number of task that small than MSK but MSE have number of task in section and number of the end tasks large than MSK. For Singaporean textbook, not only the number of tasks in section but also the number of the end task have the large than MF or Indonesian textbook.

3.2 The amount of mathematical creativity tasks in the mathematics textbooks

As shown in Table 4 NSM has the largest percentage that facilitates originality and flexibility. Tasks that supported the fluency aspect was not found in the analyzed textbooks. Furthermore, MF has the largest

percentage for elaboration aspect and NSM hasn't elaboration task. Relatively, Singaporean mathematics textbooks have the largest percentage for facilitating students creative thinking than Indonesian mathematics textbook.

Table 4. Frequency of mathematical creativity in the textbooks

Aspects of Mathematical Creativity	Textbook							
	MSK		MSE		NSM		MF	
	N	%	n	%	n	%	n	%
Originality (O)	5	16	2	6	17	46	4	14
Fluency (C)	0	0	0	0	0	0	0	0
Flexibility (F)	8	25	9	26	13	35	0	0
Elaboration (E)	1	3	1	3	0	0	15	52
Average (%)	11		9		20		16	
Average (2 Countries)	10%				18%			

There are many tasks in each book that have same criteria for mathematical creativity (see Figure 1, Figure 2, Figure 3 and Figure 4). NSM facilitated the greatest for originality and flexibility tasks than others. MF facilitated the greatest for elaboration but it hasn't flexibility task. Although Singaporean mathematics textbook facilitates the greatest, it just facilitated 2 out of 4 aspects mathematical creativity. Uniquely, mathematics textbooks of Indonesia have 3 out of 4 aspects of thinking mathematical creativity.

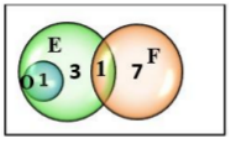

Figure 1. Frequency of mathematical creativity for MSK

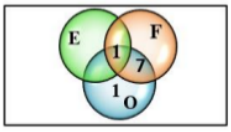

Figure 2. Frequency of mathematical creativity for MSE

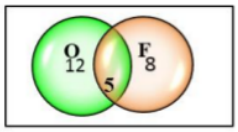

Figure 3. Frequency of mathematical creativity for NSM

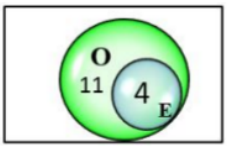

Figure 4. Frequency of mathematical creativity for MF

Example of each type of mathematical creativity aspect is given in Figure 5, Figure 6, Figure 7. These pictures were taken by the books that it has the largest to support each aspect of mathematical creativity. Figure 5 and Figure 6 is the task in NSM then task in MSK for Figure 7. The tasks are all about probability with a different context. For example, the task that hasn't aspect of mathematical creativity taken from MSE.

All the 26 red cards from a standard pack of playing cards are mixed thoroughly. A card is then drawn at random. Find the probability of drawing
(i) the queen of hearts,
(ii) the jack of clubs,
(iii) either the six of hearts or the seven of diamonds,
(iv) a card which is not a nine.

Figure 5. Example of an originality task (NSM, p. 328)

A bed of flowers consists of 100 stalks of flowers, of which 20 are lilies, h are roses and the rest are tulips.

(i) Given that the probability of picking a stalk of tulip at random is $\frac{1}{4}$, find the value of h.

(ii) 10 stalks of lilies are removed from the bed. A stalk of flower is picked at random from the remaining stalks of flowers. Find the probability that a stalk of rose is picked.

Figure 6. Example of a flexibility task (NSM, p. 329)

When Rudi walked around the mall, he got good luck as a chosen visitor mall on that day. Rudi had the opportunity to choose 1 prize from 3 boxes provided by the mall committee. Each box contains a red ball that representing the car, yellow representing the motorcycle, and green representing the TV with the following composition.

Box	Red	Yellow	Green
A	8	9	10
B	10	11	14
C	12	14	19

Rudi was only given the opportunity to take 1 prize from one of the boxes. Find which box has the greatest probability of getting a car, explain it!

Figure 7. Example of an elaboration task (MSK, p. 310) (translated version)

Three coins were tossing together. These events are the sample space at least 2 tail, except...

A. (H, T, T) C. (T, T, T)
B. (T, H, T) D. (H, T, H)

Figure 8. Example of non-mathematical creativity task (MSE, p. 221) (translated version)

4. Discussion

In this study, mathematical creativity presented in textbooks from Indonesia and Singapore were compared. In order to describe mathematical creativity in the textbooks, an analytical framework was developed to investigate how the textbooks supported students' mathematical creativity that comprised four aspects: originality, fluency, flexibility, and elaboration [11].

4.1 Mathematical creativity in mathematics textbook

The analyzed textbooks present mathematics textbooks of Indonesia and Singapore both facilitate mathematical creativity. In the four mathematics textbooks were analyzed, the whole facilitates aspects of originality. It means that the textbooks provide opportunity-to-learn for students to develop new ideas in solving problems so the students are not fixed only on the method of example problems. In the aspect of flexibility, the two Indonesian mathematics textbooks and only one book of Singapore (NSM) facilitate students to be able to find many ways to solving problems. Furthermore, the two Indonesian mathematics textbooks and only one book of Singapore (MF) facilitate thinking of mathematical creativity in the aspect of elaboration. It means that the textbooks facilitate students to develop ideas and give opinions. Although the four mathematics textbooks facilitate thinking of mathematical

creativity, it does not facilitate the fluency aspect. It means that the mathematics textbooks do not facilitate students thinking to find many solutions to the problem. In fact, the material of probability has the potential to develop fluency type tasks. Both Indonesian and Singaporean mathematics textbooks, the type of task presented by most questions determine the probability value, but the context tasks in Singaporean mathematics textbooks are more varied. The textbooks can facilitate mathematical creativity thinking of students then they get good opportunity to learn. This is in line with the opinion of Brewer & Stasz [14] that opportunity to learn of students influence learning outcomes.

In summary, the total percentage of mathematical creativity in mathematics textbooks of Indonesia had 10% and Singaporean mathematics textbook had 18%. It shows that Singaporean mathematics textbooks have a greater percentage than Indonesian mathematics textbook. This is in line with Haggarty and Pepin [21] and Wijaya [16, 32] that textbooks affect student achievement. Because Singapore has good textbooks so it has better achievement than Indonesia based on TIMSS [33] and PISA [25].

4.2 Educational implications

Based on our finding, the present study recommends that mathematics textbook should include more mathematical creativity task. For the publisher, it's very possible to develop probability tasks that can facilitate fluency aspects. Especially for Indonesian books, the problem should be presented in a variety of contexts, similar to the Singaporean textbooks that present one task with variation context. Teachers need to write creativity task if such tasks are insufficient in the textbooks. Although this study only analyzed textbooks from Indonesia and Singapore, the results of this study may also benefit for developing mathematics textbook in others countries. For analysis of other textbooks that focus on mathematical creativity, other researchers can use the framework from this research.

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