**THE ANALYSIS OF PROPORTIONAL REASONING PROBLEMS IN THE JUNIOR HIGH SCHOOL MATHEMATICS TEXTBOOK BASED ON THE 2013 CURRICULUM**

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***Abstract***

The lack of Indonesian students achievement in the international assessment is doe to several factors. Students are not familiar with the problems requiring reasoning, in particular the proportional reasoning. This research aims to identify the distribution and the Level of Cognitive Demands (LCD) of the proportional reasoning problems found in the Year 7 and Year 8 mathematics textbooks of the 2013 curriculum (revised edition 2014). The data collection is conducted by identifying the proportional reasoning problems found in the whole chapters of the textbooks which are then analysed and classified using the Smiths and Stein’s criteria of LCD (1998). The results reveal that the distribution of the proportional reasoning problems is not equal in the Year 7 and Year 8 textbooks. The proportional reasoning problems are only found in the four chapters namely: Ratio, Rectangle and Triangle, Linear Equation and Comparison, which represent different LCD including Lower-LCD (Low-M and Low-P) and Higher-LCD (High-P and High-DM). A total of 33 proportional reasoning problems are found in the Year 7 textbook including 19 Higher-LCD problems and 14 Lower-LCD problems. While, there are 30 proportional reasoning problems in the Year 8 textbooks consisting of 21 Higher-LCD problems and 9 Lower-LCD problems. There is no proportional reasoning problem found in the topics of percentage and probability. It is recommended that each chapter should have at least one proportional reasoning problem.

**Keywords:** Text Book, Proportional Reasoning Problems, The 2013 Curriculum, Level of Cognitive Demands

***Abstrak***

Rendahnya prestasi siswa Indonesia pada assesmen internasional dipengaruhi oleh beberapa faktor. Siswa Indonesia tidak terbiasa dengan bentuk soal-soal yang menuntut penalaran, khususnya penalaran proporsional. Penelitian ini bertujuan untuk mengidentifikasi distribusi dan Level of Cognitive Demands (LCD) dari soal-soal penalaran proporsional yang terdapat pada buku teks Kurikulum 2013 kelas VII dan VIII (edisi revisi 2014). Pengumpulan data dilakukan dengan cara mengidentifikasi soal-soal penalaran proporsional yang terdapat pada keseluruhan bab pada buku teks tersebut yang selanjutnya dianalisis dan diklasifikasikan menggunakan kriteria LCD yang dikemukkan oleh Smith dan Stein (1998). Hasil penelitian menunjukkan bahwa distribusi soal-soal penalaran proporsional tidak merata pada buku teks kelas VII dan VIII. Soal penalaran proporsional hanya terdapat pada empat pokok bahasan, yaitu Perbandingan, Segiempat dan Segitiga, Persamaan Garis Lurus dan Perbandingan, yang mewakili tingkatan LCD yang berbeda, yaitu Lower-LCD (Low-M dan Low-P) dan Higher-LCD (High-P dan High-DM). Secara keseluruhan dari 33 soal penalaran proporsional pada buku kelas VII terdapat 19 soal Higher-LCD dan 14 soal Lower-LCD, sedangkan pada buku kelas VIII dari 30 soal penalaran proporsional terdapat 21 soal Higher-LCD dan 9 soal Lower-LCD. Tidak ditemukan soal penalaran proporsional pada topik persen dan peluang. Sebaiknya jika pada setiap pokok bahasan tersebut memiliki satu soal penalaran proporsional

**Kata kunci:** Buku Teks, Soal Penalaran Proporsional, Kurikulum 2013, *Level of Cognitive Demands*

It is hoped that the implementation of education in Indonesia can develop students’ personality as the generation of the nation who are expected to improve the nation and country. Curriculum is one of the factors that contribute to the development of students. The development of current curriculum in Indonesia is based on the challenges of both internal and external educational advancement. The internal challenges are related to the current situation of education with eight standard of education and the growth of Indonesian population. The external challenges are the quality of education, infestation and transformation at the educational sector and international assessment such PISA and TIMSS (Depdikbud, 2013). The results of PISA 2011 show that nearly 95 percent of Indonesian students are at the intermediate level of the four levels of Advanced, High, Intermediate and Low. On the other hand, 40 percent of Taiwanese students are able to achieve at the high and advanced level. The problems used to measure students’ cognitive ability in the international assessment are divided into four categories including: (i) low, measuring the ability up to the level of knowing, (ii) intermediate, measuring the ability up to the level of applying, (iii) high, measuring the ability up to the level of reasoning and (iv) advance, measuring the ability up to the level of reasoning with incomplete information. The problems used in the international assessment are not only from the low cognitive level such as remembering, understanding and applying but also from the high cognitive level such as reasoning including the ability to analyze, generalize, synthesize, assess, and solve non-routine problems (OECD,2015). These are considered by the government in the evaluation of the educational system which results in the change of curriculum.

The change of curriculum in Indonesia leads to the change of textbooks as the content of the textbook should be in line with the standard content of the curriculum. A good book should follow the development of knowledge and technology. Textbooks are one of the main resources used at schools which results in teachers’ teaching strategies are often based on the content of the textbooks used (Freeman & Porter, 1989; Reys, Reys, & Chavez, 2004). Therefore, a textbook plays an important role in determining students’ involvement and opportunities. In addition, mathematics textbooks have a significant role in assisting teachers in planning the lesson (Alajmi, 2012). Textbooks are strongly related to students’ performance (Tornroos, 2005; Xin, 2007). In conclusion, textbooks are expected to help students in learning in order to improve the education.

Wijaya (2015) conducted research about context based problems in the junior high school textbook in Indonesia and found that there was only 10 percent of context based problems that give students freedom to solve while the other 85 percent give students the required information to solve the problem without giving students opportunities to choose their own relevant information. This is in line with Xin (2007) who revealed that Chinese students solve mathematics problems based on the algorithm available in their textbooks. Kolovou et al (2009) mentioned that the problems provided in textbooks in the Netherlands mainly consist of procedural problems. In addition, Bergvist (in Boesen, Lithner dan Palm, 2010) showed that most of the learning environment such as teaching, textbooks and the test created by teachers were focused on the procedural algorithm without giving students enough opportunities for students to learn various reasoning. These shows that students are having difficulties in solving problems with different level of difficulties, in particular high level problems or problems requiring analysis as students are used to solve problems provided by teachers based on the problems available in the textbooks. Most problems in the textbooks have similar steps of solution between the examples and the exercises problems. In fact, problems requiring advanced analysis are needed to solve students’ reasoning.

Marie (2016) mentioned that textbooks in Sweden provided less opportunity for students in problems related to ratio problems using both additive and multiplicative strategies, identifying the structure of multiplication and proportional thinking, and using meaning from representation symbol.

Vincent and Stacey (2008) found that some best seller books in Australia emphasized more on memorization and procedures without connection. Shield and Dole (2002) analyzed Australian junior high school textbook and found the limitation definition of the topic of ratio and comparison. Furthermore, Shield and Dole (2013) also found that the limitation of the textbook in introducing the understanding related to the proportional reasoning including the understanding in connecting the relation of mathematics structure to solve problems of various situations related to the context of proportional reasoning.

The problems in the textbooks are expected to develop students’ mathematical ability such as the reasoning ability mentioned before, especially the proportional reasoning. Allain (2000) mentioned that in the Piaget cognitive development steps, the proportional reasoning is considered to lead students to the early formal operation. Therefore, it is important to learn the proportional reasoning. The proportional reasoning problems are also one of the reasoning problems in the international assessment. The proportional reasoning problems are categorized into the high level. The problem distribution of cognitive domain in the TIMSS problems from 2007 to 2011 consists of three dimensions including knowing (35%), applying (40%) and reasoning (25%) (Jones, Wheeler & Centurino, 2011). In the TIMSS 2015, the composition of the problems changes to 35 percent of knowing, 35 per cent of applying and 30 percent of reasoning (Jones, Wheeler & Centurino, 2015). Students are expected to be able to solve reasoning problems. The proportional reasoning is the reasoning related to similarity of the structure of two numbers in proportional problem. Van de Walle (2008) argued that the proportional problems in some mathematics topics namely: fraction, algebra, symmetry, graph, probability, etc. The proportional reasoning is not only in mathematics but also in other subject such as physics related to speed, momentum, etc.

Imron (2014) found that “the thinking process of junior high school students in solving ratio problem and scale had not meet the requirement, more than 75 percent of students were not capable of differentiating the problem that are related to proportion or not. This is due to the lack of exercises and introduction for students related to problems involving ratio and proportion”. In conclusion, one of the factors contributing to students’ difficulties in solving proportional reasoning problems is the fact that students are not used to the problems. This indicates that the exercise problems related to proportional reasoning affect students’ understanding to know both proportional reasoning and non proportional reasoning problems. Therefore, it is expected that the textbooks include at least one proportional reasoning problem in each related topic. Bayazit (2013) conclude that in Turkish mathematics textbook had included different level of proportional reasoning problems, even 75 percent of the proportional reasoning problems are classified as the higher-LCD problems to meet the requirement of the curriculum and educational development in general.

Based the review of the previous research, there is no research explore the distribution of the proportional reasoning problems in the textbook. Research problems of this research are: 1) how is the distribution of the proportional reasoning problems in the textbook of the 2013 curriculum?, and 2) how is the cognitive level of proportional reasoning problems in the mathematics textbooks of Year 7 and Year 8 of the 2013 curriculum?.

## METHOD

This research employs descriptive method using qualitative approach. This method is used as the researchers aim to identify the proportional problems included in each chapter in the Year 7 and Year 8 mathematics textbook of the 2013 curriculum (2014 revised edition) and to identify the cognitive level the proportional reasoning problems found. The research stages are conducted based on the analysis of Miles and Huberman (2014), namely reducing data, presenting data, and drawing conclusion. The first stage, reducing data, is conducted by identifying the proportional reasoning problems in each chapters in the Year 7 and Year 8 textbooks. The problems are then classified based on the criteria of Level of Cognitive Demands (LCD) Smith and Stein (1998).

According to Smith and Stein (1998), LCD was divided into two categories including Lower-LCD and Higher-LCD. The category of lower-LCD is divided into two categories. First, Lower-level demand (memorization), the characteristics include: (i) remembering the fact, rules, formula or definition learned before, (ii) not being able to solved using procedures because the procedures have not learned yet or because of the limited time provided to use the procedures, (iii) clear, the tasks given are clear and can be solved directly, not implying double meaning, and (iv) there is no connection between concept and definition including facts, rules, formulas and definition that are currently learned and the ones that will be learned. Second, Lower-level demand (procedures without connection), the characteristics include: (i) the algorithm used is the simple algorithm that has been found daily, (ii) Cognitive ability is required to solve problems with double meaning which acts as distractor, (iii) no connection between concept and meaning which are the base of the procedures used, (iv) focusing on the correct answer in developing mathematical understanding and (v) other explanations focused on the description of the procedures used are not required.

Higher-LCD is divided into two categories including Higher-level demands (Procedures with connections) and Higher-level demands (Doings Mathematics). The characteristics of Higher-level demands (Procedures with connections) are: (i) students’ attention is focused on the use of procedures to be developed to the higher level of understanding mathematical concepts and ideas; (ii) it is suggested to use procedures that are in general connected to the based conceptual ideas in order to narrow the unclear algorithm of the basic concepts, (iii) it is usually described in various ways, such as visual diagram, manipulative symbol and problem situation to assist the representation in solving problems and (iv) certain cognitive level is required and students need to use the conceptual ideas that base the procedures or rules to solve tasks in order to be successful in developing the understanding. The characteristics of Higher-level demands (doings mathematics) are: (i) more thinking is needed in analyzing, well-trained, complex approach and non algorithm or the solution which is not immediately given in the task, task guidance or the example of work, (iii) students are required to explore and understand the characteristics and rules of the concepts or mathematics process, (iii) demanding self-monitoring or self regulation of one’s cognitive process, (iv) students are required to connect the knowledge and relevant experience, and use them to solve the task, (v) students are required to analyze the task and actively search the obstacles that hinder the problem solving, and (vi) major cognitive efforts are needed and may involve some level of students’ anxiety because of unexpected characteristics of the required solution.

The second stage is presenting data that is conducted by tabulation. Tabulation can be conducted towards the results of identification of proportional reasoning problems found in order to assist the researchers in drawing conclusion and identifying the number of proportional reasoning problems in each chapter and in each category of LCD. The next stage is conducting triangulation after the researchers obtain the results of the analysis in order to evaluate the validity of the findings. This process can be done using FGD (Focus Group Discussion). The FGD are the experts in the field of mathematics education. The criteria of FGD members involved in the research are: 1) knowing and understanding the mathematics materials in junior high school, 2) the mathematics teachers with at least 3 years of experience, 3) the lecturer at the mathematics education department who are at least having master degree, 4) being active as the national instructor and keynote speaker in the field of mathematics education. The FGD members include tqo lecturers, two teachers and one instructor from the institution of educational quality guarantor (LPMP) of Aceh.

The third stage is drawing conclusion based on the results validated. The results obtained is the distribution data of proportional reasoning problems in the Year 7and Year 8 textbooks of the 2013 curriculum and the cognitive level or LCD from the proportional reasoning problems.

## RESULT AND DISCUSSION

**The distribution of proportional reasoning problems**

The results shows that there are four chapters in the Year 7 textbook of semester 1 and only one chapter has the proportional reasoning problems namely the chapter of Ratio. Similarly, the Year 7 textbook of semester 2 also has four chapters and the proportional reasoning problems are only found in one chapter namely, the chapter of rectangle and triangle. In the Year 8 textbook of semester 1, one out of six chapters has the proportional reasoning problems, namely the chapter of linear equation. The proportional reasoning problems are also found in only one chapter out of five chapter of the Year 8 textbook of semester 2, namely the chapter of ratio. The proportional reasoning problems are located in different chapters and therefore the connection between the concepts of proportional reasoning problems and different materials. This is in line with Van de Walle (2008) who mentioned “the proportional reasoning problems can be seen in the material of ratio of the similar value and opposite value, the proportional reasoning problems can also be seen in the material involving materials such as fraction, algebra, symmetry, etc.

NCTM (2000) stated that a good mathematics curriculum integrates different topics in order to assist students to enrich their knowledge and skills. Furthermore, Allain (2000) argued that in the level of Piaget cognitive development, the proportional reasoning problem is considered to be able to lead student to the formal operation stage. Therefore, the proportional reasoning problems should be provided in each chapter related to the proportional reasoning. According to NCTM (2000) proportional reasoning is related to the ratio and comparison, percentage, symmetry, scale, linear equation, gradient, relative frequency histogram and probability problem. The distribution of proportional reasoning in the junior high school mathematics textbook of Year 7 and Year 8 is not equal in each chapter related to proportional reasoning as suggested in NCTM. One of the chapters is probability which does not consist of proportional reasoning. In general, there are only four out of 20 chapters taught in Year 7 and Year 8 and are included in the Indonesian mathematics textbook consisting of proportional reasoning namely, triangle and rectangle, ratio, linear equation and comparison.

**The classification of the problems based on *Level of Cognitive Demands (LCD)***

The proportional reasoning problems in each chapter in Year 7 and Year 8 textbooks is then further analyzed using the criteria of LCD developed by Smith and Stein. The Low-M (memorization) level problems as presented in Figure 1 are the problems with characteristics of remembering facts, rules, formula or definition learned before. The problems are clear and can be solved without any double meaning.

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| 3 . Multiple choice. Choose the fastest pedestrian.  Rosi walk 4.8 km in an hour  Endang walk 9.8 km in 2 hours  Rosuli walk 9.6 km in 1.5 hours  Rina walk 14.4 km in 2 hours |

*Source: Year 7 textbook, exercise 3.2, page 183*

Figure 1. The example of low-M level proportional reasoning problem

The Low-P level problems (procedures without connection) are the problems which have the characteristics of demanding cognitive ability to be solved. The algorithm used is the simple and common algorithm learned. Focusing on the correct answer in developing mathematical understanding and there is no reasoning for using the procedures. Low-P level problems are the simple problems and slightly confusing, so that good understanding of the problems is needed for solving them. The example of Low-P level problem is presented in Figure 2.

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| --- |
| Ulus is a cook in a hotel. He is modifying the recipe to serve the guests that are increasing during holiday. The previous recipe is 2 measurement glasses of flour makes 3 dozen of *‘kue pukis’*. If he changes the recipe to be 12 measurement glasses of flour, how many dozens of *‘kue pukis’* can be made? |

*Source: Year 7 textbook, exercise 3.3, page 191*

Figure 2. The example of Low-P level proportional reasoning problem

The High-P level problems (procedures with connection) are presented in Figure 3. The characteristics of the High-P level problems are including using rules aiming to develop to the next level of mathematics concepts and ideas in solving the problem. Student can develop and present what they have learned before, for example, using comparison concept to solve a problem. The High-P level problems are usually described in various ways such as visual diagram, manipulative symbol and problem situation as well as being interconnected with some representation which assist the problem solving.

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| 8. a field is a rectangle with the length is 64 m and the width is 48 m. The owner of the field will make a path that is 1.5 m in length. Find the area of path made by the owner? |

*Source: Year 7 textbook, competency test problem of semester 2, page 174*

Figure 3. The example of High-P level proportional reasoning problem

High-DM level proportional reasoning problems (doings mathematics) are the problems with the characteristics of demanding better thinking in analysis, well trained, complex and non algorithm approach or solution that is not clearly explained in the problem or the sample problem. Students should explore and understand the characteristics and rules of concepts or mathematical process needed in the solution and connect with the relevant knowledge. The example of High-DM problem is presented in Figure 4.

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| --- |
| 9. Pulley  The relation between the size of pulley and the rotation speed is the opposite    **BELT**  The diameter of the pulley A is twice the diameter of the pulley B. So, if the pulley A rotates once, the pulley B will rotates twice.  If the diameter of the pulley is triple the diameter of the pulley B, so if A rotates once, the pulley B will rotates three times. The diameter of the pulley B is smaller than the diameter of the pulley A. The rotation speed of the pulley is the opposite of the diameter. We can express it in the equation below:  R=k/d, where R is the speed of the pulley in rpm (revolution per minute) and d is the diameter of the pulley.   1. The pulley A is rotated toward the pulley B. The diameter of the pulley B is 40 cm and rotates 240 rpm. Find the speed of the pulley A, give the diameter is 50 cm. 2. The pulley B is rotated toward the pulley A. The diameter of the pulley A is 30, 48 cm and the spee d is 30 rpm. The diameter of pulley B is 38.1 cm. What is the speed of the pulley B? 3. The diameter of the pulley in a machine is 9 inch and rotates1260 rpm. The pulley is tied with rubber to the smaller puller in the electric machine. The diameter of the smaller pulley is 5 inch. What is the speed of the smaller pulley? 4. Is the perimeter of the circle (pulley) is in line with its diameter? Explain? 5. How the perimeter of the circle is affected if the diameter is multiplied? |

*Source: Year 8 textbook, competency test 5, page 151-152*

Figure 4. The example of High-DM level proportional reasoning problem

Based on the analysis of the 64 problems, there are 29 proportional reasoning problems in Year 7 semester 1. Five of the proportional reasoning problems are found in the Year 7 textbook of semester 2, 12 problems are found in the Year 8 textbook of semester 1 and 18 problems are found in the Year 8 textbook of semester 2. Based on the result of FGD, it is identified that one of the problem as presented in Figure 4 is not a proportional reasoning problem. The problem is a comparison problem.

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| 11. Look at the figures below. Which plane is the widest? Explain. |

*Source: Year 7 textbook, competency test 1, page 56*

Figure 5. Not a proportional reasoning problem

The classification of the proportional reasoning problems of the researchers and the participants of FGD is different. Therefore, discussion is conducted between the researchers and the participants of FGD to re examine the problems based on the criteria of LCD. One of the problem discussed and the level changed is presented in Figure 6. The researchers consider the problem as Low-P (Procedures without connection) based on the criteria of LCD. However, after the discussion, the problem is categorized as High-P problem (Procedures with connection) because the problem demands explanation of the answer and the procedures used.

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| --- |
| 3. Salma wants to make a cup of coffee for her father. She knows that to make a cup of coffee she need 2 spoons of coffee. Salma said ‘I am sure that the amount of coffee is always one more from the number of cups I need to serve’. Do you agree with Selma? Explain your answer. |

*Source: Year 7 textbook, exercise 3.3, page 191*

Figure 5. The problem which level is changing

Based on the analysis of 63 proportional reasoning problems in the Year 7 and 8 textbooks, the summary of the results and the classification of the problems are presented in Table 1.

**Tabel 1** The number of problems in each Level of Cognitive Demand (LCD) in each year of schooling

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Level of cognitive demands*** | | **Year VII** | | **Year VIII** | | **Total** | |
| **f** | **%** | **f** | **%** | **f** | **%** |
| Lower LCD | Low-M | 4 | 12.12 | 1 | 3.33 | 5 | 7.94 |
| Low-P | 15 | 45.45 | 8 | 26.67 | 23 | 36.51 |
| **Total of Lower-LCD** | | **19** | **57.57** | **9** | **30.00** | **28** | **44.45** |
| Higher LCD | High-P | 13 | 39.40 | 15 | 50.00 | 28 | 44.44 |
| High-DM | 1 | 3.03 | 6 | 20.00 | 7 | 11.11 |
| **Total of Higher-LCD** | | **14** | **42.43** | **21** | **70.00** | **35** | **55.55** |
| **Total (n)** | | 33 | 100 | 30 | 100 | 63 | 100 |

Table 1 shows that there is 33 proportional reasoning problems in Year 7 textbook consisting of 19 higher-LCD and 14 lower-LCD problems. In the Year 8 textbook, there are 30 proportional reasoning problems consisting of 21 higher-LCD and 9 lower-LCD problems. Based on the level, the number of higher-LCD problem in Year 8 textbook is greater than in Year 7 and therefore it can be concluded that there are more problems at the level of higher-LCD than at the lower-LCD. There are 35 out of 63 (55.55 %) of the higher LCD and 28 out of 63 (45.45 %) of the lower-LCD. The findings of the level of cognitive demand related to the proportional problem in the Indonesian textbook is different from the findings of the research conducted on Turkish mathematics textbook by Bayazit (2011). Bayazit (2010) found that nearly all cognitive level is available in the textbook. 75 per cent of the problems in the mathematics textbook are the higher-LCD problems and the rest are the lower-LCD problems. This indicates that the textbook used in Turkey support the students’ higher order thinking. It is expected that the higher level problems can help students to be used to the problems of the international assessment given that Turkish students achievement is still lacking, similarly the Indonesian students.

**CONCLUSION**

Based on the results, it can be concluded that the distribution of the proportional reasoning problems in the Year 7 and Year 8 textbooks of the 2013 curriculum is not equal. There are only four chapters out of 20 chapters in the four textbooks (Year 7 semester 1, Year 7 semester 2, Year 8 semester 1 and Year 8 semester 2) consisting of the proportional reasoning problems, namely ratio, rectangle and triangle, linear equation and comparison.

Based on the cognitive demand of proportional reasoning problems, the Year 8 textbook generally has more problems of the higher level of cognitive demands (higher-LCD) such as High-P (procedures with connections) and High-DM (doings mathematics) problems compared to Year 7 textbook. The Year 7 textbook consists of problems of the lower cognitive demands (lower-LCD) such as Low-M (memorizations) and Low-P (procedures without connections) problems. It is expected that the problems of various cognitive levels can help students in developing their reasoning skill. Teachers should provide more problems requiring reasoning skill by creating their own or adopting problems from different resources.

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