Students' Difficulties in Solving Higher Order Thinking Skills Problems on Algebra Content

[1]*Fathiya Salsabila, [2]Rahmah Johar and [2]Bahrun

[1]Master Program in Mathematics Education, Faculty of Teacher Training and Education, Syiah Kuala University, Darussalam, Banda Aceh
[2]Faculty of Teacher Training and Education, Syiah Kuala University, Darussalam, Banda Aceh

*Corresponding author: fathiyasalsabila11@gmail.com

Abstract

Higher order thinking skills are one of the thinking skills needed in the 21st century. HOTS can make students more critical, creative and innovative in solving problems. Students with HOTS can distinguish clear ideas, clear opinions, solve problems, formulate explanations well and understand complicated things become clear. However, the actual ability of HOT students is still low seen from their difficulties in solving HOTS problems. Therefore, this study aimed to describe students' difficulties in solving HOTS problems in algebra. This type of research was qualitative with descriptive method. The subjects of this study consisted of three students in the eighth grade at one of the junior high school in Banda Aceh. The instruments used were tests and interviews. The results showed that difficulties in understanding the information and questions given, the difficulty of finding patterns and relationships, difficulty in manipulating algebraic forms, lack of prerequisite materials, difficulty in solving equations that had been made, difficulties in understanding images in the form of information, difficulties in presenting images in the form of symbols or equations and difficulties in distinguishing the two-variable linear equation material and the two-variable linear equation system. By knowing the difficulties of students, it is expected that teachers and schools can provide learning that can reduce difficulties and develop HOTS abilities to enter the 21st century.

Keywords: difficulty, higher order thinking skills, algebra.

Introduction

The rapid development of the era increase the demands of students. The 21st Century Partnership Learning Framework must possess a 21st Century Partnership Learning Framework, which is critical thinking and problem-solving skills (BSNP, 2010). According to Griffi, Care & McGaw (2012), Higher Order Thinking Skills (HOTS) and problem-solving are the two skills needed to work in the 21st century. In the 21st Century, students will experience problems that are not the same as those of previous centuries, in this century the problem that they are experiencing is HOTS so that in learning or assignment must be related to various problem solving, not only things related to memory, memorization, and repetition (Craig, 2011). The 21st century demands that students can think and act actively (Wijaya, Sudjimat & Nyoto, 2016).

Thinking is an activity to gain knowledge. A problem cannotbe solved without a thought process. According to Carson (2007), thinking is critical to solving the problem

rather than just science owned. A suitable learning process should encourage students to think.

One of ability to think is the ability of HOTS. Higher order thinking is more than pure memorization and understanding and involves various cognitive processes, such as generating ideas, exploring consequences, reviewing, monitoring progress, and so on (Perkins, Jay & Tishman, 1993; Wang & Wang, 2011). Krathwohl (2002) stated that there are three levels in higher order thinking that are C4 (analyze), C5 (evaluate), and C6 (create). A way that can be used to measure or assess HOTS is by assessing the ability to analyze, evaluate, and create (Brookhart, 2010).

According to Shadiq (2014), mathematics learning in the classroom focuses more on procedural capability, low order thinking skill, low-level questions, and more dominant routine questions. Itis reinforced by the results of Trends in International Mathematics and Science Study (TIMSS) in 2003, 2007, 2011, and 2015 showed Indonesia is still ranked lower. TIMSS results in 2015 stated that Indonesia is rated 45 out of 50 countries. The results of 2003, 2006, and 2009 survey of the Program for International Student Assessment (PISA) show that almost 80% of Indonesian students only manage to answer the problem at the low level (Widjaja, 2011). Candra, Zulkardi, and Yusuf (2017) said that in solving the PISA problems level 4, 5, and six students have difficulty in understanding problems, changing real problems into mathematical form, solving mathematical problems, interpreting mathematical solutions into real situations and in understanding question.

One of the most important mathematical material is algebra. NCTM (2000) suggests the first five standards that describe the objectives of mathematical content in number and operation, algebra, measurement, and analysis and probability. Algebra is considered the basis of mathematics learning. According to Blackie and Son (2008), Algebra is a branch of mathematics that studies about operations and relationships, including polynomials, equations, and algebraic structures.

As the fulfillment of National aspirations in education, the role of teachers in inculcating HOTS capabilities is an important aspect of effectively teaching HOTS skills (Yen & Halili, 2015). Student learning outcomes can increase if students and teachers know the difficulties and problems that occur. Therefore, based on the explanation above, the research question is: How is the student's difficulties in solving the Higher Order Thinking Skills problem in Algebra material?

Research Method
This research was conducted to describe students' difficulties in solving the problem of Higher Order Thinking Skills on algebracontent. This research was doneat one of the junior high school in Banda Aceh. The subjects obtained were three students with one subject has difficulties on the matter of analyzing, one subject had difficulties on the matter of evaluating, and one subject difficulties on the subject creation. The instruments used were test questions and interviews. The test question consisted of three questions. Questiona are adapted from Fryer Contest.

Results and Discussion
Students' difficulties measured in this study were their difficulty in solving problems on indicators of analyzing, evaluating and creating. Students' difficulties in solving number 1 problems with analyzing indicators (C4) could be known from the results of student answers in analyzing information and dividing or structuring information into smaller sections to recognize patterns or relationships. Student difficulties in solving problem 2 with evaluating indicator (C5) could be known from student answer result in making hypothesis, criticizing and doing testing. While to know the difficulties of

students in solving the problem number three with the indicator to create could be known from the results of student answers in designing a way to solve the problem.

Analyze Indicators
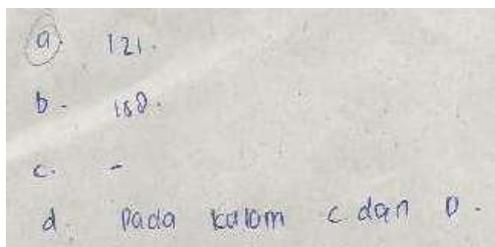
Figure 1. Difficulty in Solving Problem Analyzing Indicators (C4)

In Figure 1, the subject of difficulty in solving the problem of number 1. This subject only provided answers in the form of answers but no problem-solving steps and even problems that cannot be solved by this subject. In Figure 1, it appears that the subject was mistaken in solving the problem of number 1.a, which could be seen at the time of the interview the student replaced the answer for reasons of error. Problem 1.b this subject was wrong in answering, it turns out when the student interview was not able to solve it. The subject could not solve the problem 1.c, which was seen when the student interview was not able to solve it. In Figure 1 for answer 1.d, this subject could not understand the given question. Consequently, the student's answer was not a column but a line. When questioned during the interview, the subject had difficulty in solving the problem number 1 as the following interview quote:

P	:	Do you understand the information given about the problem?
S_1	:	Understand
P	:	Please try to explain
S_1	:	The columns 1, 3 and 5 are odd columns, so the numbers start from A to E. While columns 2 and 4 are even columns, numbers start from F to B
P	:	Okay, is the question you asked me to understand?
S_1	:	Understand
P	:	Try to explain
S_1	:	Problem 1.a asked is the largest number in column 23, question 1.b is asked the line number D column 32, the 1.c number in column 2018 continues to be added, whereas the question 1.d number of numbers in what column is more than 5000 but less than 9000

Based on the interview excerpt, the subject could understand the information on the problem and understand the questions given though by reading the question on the question sheet. The subject seemed to have difficulty in solving the problem because it focused on the question rather than the information provided. Here are the excerpts of student interviews in solving the HOTS problem.

P	:	Okay, try to do the number one thing
S_1	:	Previously, I completed it manually.
P	:	What does the manual look like?
S_1	:	I take the number in row B. In row B there are numbers 2, 10, 12, 20 and 22. The number 2 to 10 is the difference of 8, the number 10 to 12 is the difference of 2 and so on
P	:	So how many answers?
S_1	:	112
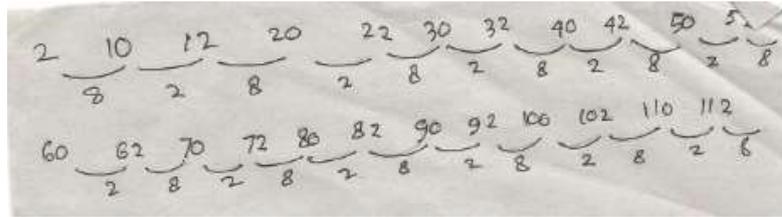
Figure 2. Answers on Interview Question Number 1

Subjects said that they could understand the information provided, but in fact, the subject was difficult in understanding the information provided. The subject worked in the same way as Fig. 2using the number pattern. The subject used line B to find the largest number in column 23. Using the number pattern as in Figure 2 was not wrong but subject S1 difficulties in understanding the information, if the student could understand the information, this subject surely added the number 112 with number three. Row B was not the largest number of plots for column 23 and the addition of the number three because column 23 was the odd column whose largest number was in column E. Here is a continuation of the question:

P	:	How to solve the 1.b?
S_1	:	Number 1.b I do not know
P	:	Why do not you know? Is this problem difficult?
S_1	:	Because usually I who know the difference between the same number all
P	:	So this question cannot be solved?
S_1	:	can, but I do not know
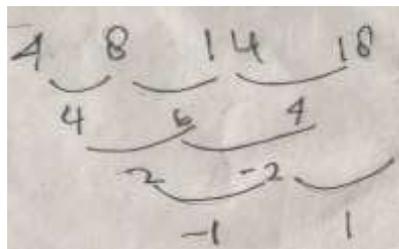
Figure 3. Answers on Interview Question Number 1

Based on the interview excerpt, the subject understands the question given, but they could not solve the problem 1.b. The subject assumed that this problem could only be solved by the number pattern. In Figure 3, the subject said that this problem could not be solved because the number obtained on the third line was not the same, but the students get the numbers 2 and -2. So, students could not solve the problem. If students could find patterns and relationships between columns, this problem could be solved easily.

Based on the answers and interviews, it was found that the students had difficulties in understanding the information given on the problem. Students also found difficulties in finding patterns and relationships from the information provided so that they could not solve the number 1 problem by analyzing the indicators.

The findings were in line with the results of Burhanzade and Aygor (2015) research which said that students' difficulties in solving mathematical problems were that they lack basic knowledge so that they do not solve many math problems. The results of Hadi, Munadi, and Retnawati (2017) showed that students' difficulties in working on HOTS problems were lack of understanding of students on the mathematical concepts being asked, less able to relate various concepts to grain that required many steps of completion, difficulty in understanding the context of questions, and difficulty

manipulating algebraic forms. Ruhyana (2016) stated that the students' difficulties in solving the problem are due to the lack of prerequisite materials, difficulty in using the right process, difficulty to apply relevant rules, and difficulty in understanding the purpose of the matter.

Evaluate Indicators

(a)   (b)
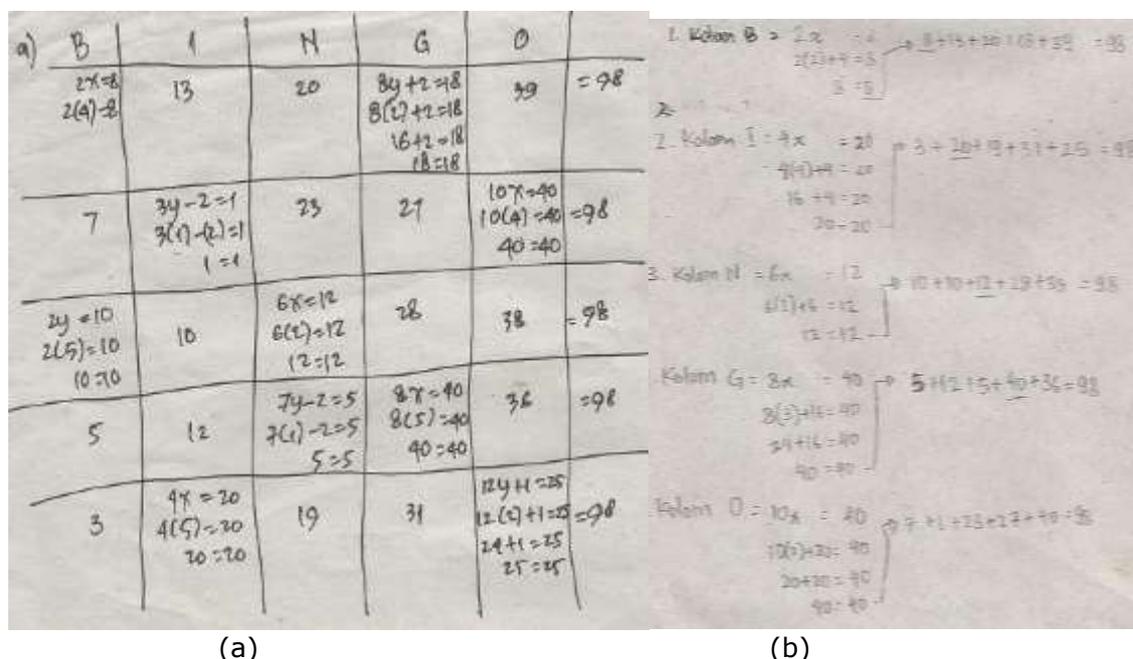
Figure 4. Subject Difficulties Resolving Problems Evaluating Indicators (C5)

In Figure 4 (a) it could be seen that the student solved the problem by changing the x and y values so that the number of the numbers on each line becomes the same number. The subject was determined the value of x and y by guessing a different number for each x and y. The answer to this subject showed that the values of x and y in each box might vary. The x and y values presented in each box be the same. In Figure 4 (b) it could be seen that the student has understood the information about the number that was replaced on the box according to the predetermined criteria. The completion of this subject showed that the replaced value was not a value on the specified criteria but the number in the box corresponding to the criteria.

Based on these answers the subject had difficulties in understanding and analyzing the information provided so it rose the perception that the x and y values given on the BINGO card might differ on each box. This subject also assumed that the information about the number being replacedwas not the value of a box by the criteria but its number. The subject had difficulties in understanding and analyzing the information provided. When questioning during the interview, the subject had difficulty in solving the problem of analyzing indicators such as the following interview excerpts:

   P : Do you understand the information given about the problem?
   S_2 : Understand
   P : Please try to explain
   S_2 : On the BINGO card there are columns B, I, N, G and O. In column B
        the numbers should only be from 1 to 8, the column I should only be
        from 9 to 16, the N column should just be from 17 to 24, column G
        the number should just be from 25 to 32 and the O column is only
        allowed from 33 to 40u

P	:	Okay, is the question you asked me to understand?
S_2	:	Understand
P	:	Try to explain
S_2	:	The 2.a finds the x and y, and the number of rows must be equal to the number of other rows. Number 2.b is required to make a BINGO card

The subject at the interview said that he could understand the information on the problem and understand the questions given even by reading the information and questions on the questionnaire. But when working on the problem, the subject had difficulty in understanding the information provided. Here are the excerpts of student interviews in solving the HOTS problem:

P	:	Okay, try to explain how to solve it
S_2	:	Equate, x and y in this first line are exemplified by a number, suppose the number is for x = 4 and y = 2. Then all the numbers earned on the first line are summed. For columns two, three four and five are also like that, let's say x and y so that the sum of the other rows is equal to the number in the first row.
P	:	Why do you know the numbers for the first row are 4 and 2?
S_2	:	Try it out
P	:	Besides the way of trial, is there no other way?
S_2	:	Maybe there is, but I only know this way

Based on the excerpt of the above interview, this subject has difficulty in solving the problem because it assumed that the variables x and y had different values. This subject also understands that the sum of all the numbers of each row was self-determined with different values of x and y, whereas the number of each row was determined by the same x and y values.

P	:	What about the number 2.b?
S_2	:	Number 2.b this is the value of x and y already known in question 2.a, on this question the value of x and y it asks to be replaced again but not ignore the original provisions
P	:	Which initial provisions?
S_2	:	The initial provision is that although the values of x and y are replaced the number of each row remains the same as the settlement 2.a
P	:	So how do you solve number 2.b?
S_2	:	In the first row replace the x and y values so that the sum of all row values is equal to the sum of all the first row values in completion 2.a
P	:	Can means be made a new BINGO card huh?
S_2	:	Yes
P	:	Try to write down the new BINGO card
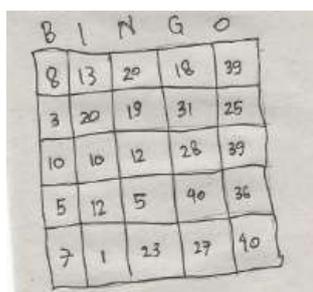
Figure 5. Answers on Interview Question Number 2

Based on interview excerpts, this subject difficulties in understanding the information on the problem and the question, so that in solving this problem students did not make the order of information about the matter that states students must have made first BINGO card found earlier. The subject also difficulties in understanding the provisions that applied to resolve question number 2.b. Based on the answers and interviews, it was found that the subject of difficulty in understanding the information and questions given on the problem. This subject also had difficulties in determining the value of x and y so that the student was using try and error so that it could not solve the problem 2 with evaluating indicator. These findings were in line with Hadi, Munadi, and Retnawati (2017) research showed that students 'difficulties in doing HOTS problem were students' lack of understanding of math concepts being asked, not connecting concepts to grains that required many steps to solve and difficulty understanding the context of the problem.

Created Indicators
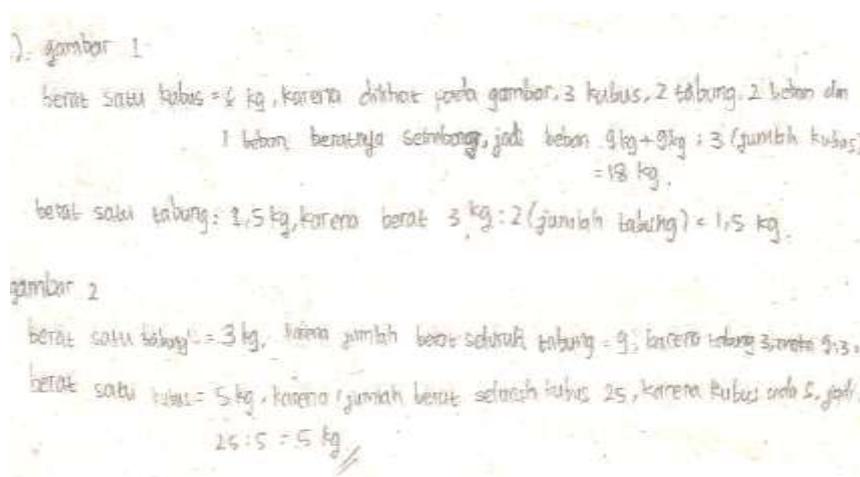
Figure 6. Difficulties in Solving Problems of Created Indicators (C6)

In Figure 6 it can be seen that the subject solved this problem by first finishing the first drawing. In picture one there are two tubes, three cubes, one load 3 kg and two loads 9 kg. The subject solved the problem in this one by equating the weight of two tubes with 3 kg and three cubic loads with two 9 kg loads. So, this subject split 3 kg with two tubes, got a tube worth 1.5 kg. Likewise, with the cube, students complete by dividing 18 kg with three cubes, so obtained a cube worth 6 kg. In figure two, the subject also completed with the same settlement. The three tubes were equalized with 9 kg, and five connections were equalized by 25 kg, so the subject completed it by dividing 9 kg with three tubes and 25 kg with five cubes.

Based on the answer, the subject difficulties in representing images in the form of symbols. This subject could not find any connection between picture one and picture two so that students assumed that the weight of cubes and tubes in figures one and two were different. This subject also made a mistake when performing integer operations.

The subject had difficulties in representing images in symbol form. When the subject was being questioned during the interview, the subject had difficulty in solving the problem as the following interview quote:

P : Do you understand the meaning of the picture given on the problem?
S_3 : Understand
P : Please try to explain

S₃	:	The first picture there are two tubes, and three cubes equal the weight of 21 kg, weight balanced but because in line
P	:	Okay, is the question you asked me to understand?
S₃	:	Understand
P	:	Try to explain
S₃	:	The question is what he is asking is the weight of the cube with the tube

Based on the excerpt of the interview, the subject could understand the image in the form of information and could understand the questions given. Subjects could understand that the image was a scale which means that the weight of the left and right loads was the same. Here are the excerpts of student interviews when solving question number 3.

P	:	Okay, try to explain how to solve it
S₃	:	The question is how many pounds weighed each cube and its tube, so I calculate that if the first picture has three tubes and the load is 9 + 9 = 18, then I divide 18 by 3 can 6 kg each one cube. So also with the tube, 3 divided by 2 can weigh 1.5 kg each tube.
P	:	What about the second picture?
S₃	:	there are 5 cubes and 3 tubes, 25 divided by 5 cubes and 9 divided by 3 tubes
P	:	Where are the numbers 25 and 9 mentioned?
S₃	:	It is the burden that 24, if 24 divided by 5 will be difficult to borrow the above one hence 25, stay above that 9.

Based on the results of the interview, the subject had difficulty in representing images in the form of symbols so that students finish by equalizing the right load with a tube or cube.

Figure 7. Difficulties in Solving Problems of Creative Indicators (C6)

In Figure 7 it can be seen that the subject made an equation unrelated to the previous settlement. The value of the cube and tube that the subject used to solve this problem was the value determined by the subject. In making this equation the subject first determined the equation. After the equation was specified, this subject defined its x and y values. This subject determined the amount of x and y where the values of x and y, when operated with the equation, were not less than 100 and not more than 150. Student responses showed that this subject did not understand the difference between equations and systems of equations. This subject only made four equations whereas the requisite was four system of linear equations of two variables.

Based on the answer, the subject had difficulty in linking a settlement that had been obtained to solve a problem. This subject was also difficult in designing a way of making an equation. Students also did not understand the questions asked about the problem, and they had difficulties in distinguishing the two-variable linear equation material and the two-variable linear equation system. When the subject wasquestioned during the interview, the subject had difficulty in solving the problem as the following interview quote:

P : Is the question you asked to understand?
S_3 : Understand
P : Try to explain
S_3 : This question is asked to create 4 kinds of equations
P : Try to read again, what is asked
S_3 : Oh, four kinds of system equations
P : Can you make it?
S_3 : Like this.
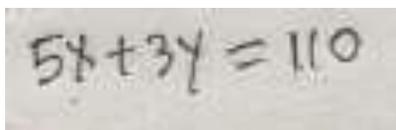
$$5x + 3y = 110$$

Figure 8. Answers to Interview Question Number 3

Based on interview excerpts, a subject could understand the information on the problem and understand the questions given. A subject could understand that the question command was to create four kinds of system of linear equations two variables if the number of cubes and tubes weigh were more than 100 and less than 150. Here are excerpts of student interviews when solving problem number 3.

P : Nice. Where did you get the 5 for x and 3 for y?
S_3 : The values 5 and 3were taken from the previous settlement. It weighs more than 100 kg and less than 150 kg, continue for this one (after the sign =) up to it, 110 I made
P : Why 110? 225 is it okay?
S_3 : Because it's asked for more than 110 and less than 150 if it's not okay
P : You know the difference between equations and inequality systems?
S_3 : Forget
P : Or maybe not the same?
S_3 : I do not know

Based on the results of student answers during the interview, the subject had difficulty in making the system of linear equations of two variables with the provisions on the matter. This subject made the system of linear equations based on the value of cubes and beams obtained from the previous settlement. The subject assumed that 110 was derived from the question, whereas 110 was the result of the two linear equations. Based on the answers and interviews, the subject had difficulties in understanding representing images in the form of symbols and difficulty in making system of two linear equations. Difficulties that students faced were due to lack of prerequisite materials that they have, so they could not solve the problem number 3 with the created indicators.

These findings are in line with Burhanzade and Aygor (2015) research suggesting that students' difficulties in solving mathematical problems are caused by the lack of basic knowledge so that they did not solve math problems quite a lot. Ruhyana (2016) said that students' difficulties in solving problems are due to low verbal skills, lack of

prerequisite materials, difficulty in applying relevant rules and difficulties in understanding the images.

Conclusions

The difficulties of students in solving the HOTS problem are caused by 1) difficulty in understanding the information and questions given, 2) difficulty in finding patterns and relationships, 3) difficulty in manipulating algebraic forms, 4) lack of prerequisite materials, 5) difficulty in solving equations that have been made, 6) difficulties in understanding images in the form of information 7) difficulties in presenting images in the form of symbols or equations, and 8) difficulties in distinguishing two linear equations of linear equations and two linear equations. From the indicators of analyzing, evaluating and creating, students were very difficult in solving problems that require the ability to evaluate due to their difficulties in understanding the questions and questions and when the researcher gives a little help the student cannot make a hypothesis. Students who could make hypotheses were also difficult in criticizing and drawing conclusions about a problem. By knowing the difficulties of students, it is expected that teachers and schools can provide learning that can reduce difficulties and develop HOTS abilities to enter the 21st century.

References

Blackie & Son. (2008). *Blackie's Dictionary of Mathematics*. New Delhi: Rajendra Ravindra.

Brookhart, S. M. (2010). *How to Assess Higher Order Thinking Skill in Your Classroom*. Virginia: ASCD.

Candra, A. I., Zulkardi, Z., & Yusuf, M. (2017). Difficulties of students in solving problems PISA 2012 level 4, 5, and 6 in SMPN 1 Indralaya. *Journal of Mathematics Education, 11*(2), 1-15.

Carson, J. Y., Tesluk, P. E., & Marrone, J. A. (2007). Shared leadership in teams: An investigation of antecedent conditional and performance. *Academy of Management Journal, 50*(5), 1217-1234.

Craig, R. (2011). Developing Cognition And Language Proficiency Through the Acquisition and Articulation of Knowledge: Real World Communication.

Gais, Z. & Afriansyah, E. A. (2017). Analisis kemampuan siswa dalam menyelesaikan soal *high order thinking* ditinjau dari kemampuan awal matematis siswa. *Mosharafa, 6*(2): 255-266.

Griffi, P., Care, E., & McGaw, B. (2012). *Assessment and Teaching of 21st Century Skills*). (Patrick Griffi, Barry McGaw, & Esther Care). Springer. New York, 1 – 345.

Hadi, S., Munardi, S., &Retnawati, H. (2017). Difficulties of high school students in working on questions that measure HOTS. *Institutional Research Articles 2017*. Yogyakarta State University.

Krathwohl, D. R. (2002). A revision of Bloom's Taxonomy: An overview. *Theory into practice*, *41(4),* 212-218.

NCTM. (2000). *Principles and Standards for School Mathematics*. United States of America: The National Council of Teachers of Mathematics, Inc.

Perkins, D., Jay, E. & Tishman, S. (1993). Introduction: New conceptions of thinking, *Educational Psychologist, 28*(1), 1-5.

Ruhyana, R. (2016). Analysis of students' difficulties in solving mathematical problems. *Journal of Computech & Bisnis*, *10*(2), 106-118.

Shadiq, Fadjar. 2014. *Mathematics Learning: How to Improve Student Thinking Ability.* Yogyakarta: Graha Ilmu.

Widjaja, W. (2011). Towards Mathematical Literacy in the 21st Century: Perspectives from Indonesia. *Southeast Asian Mathematics Education Journal*, 1, 70-79.

Wijaya, E. Y., Sudjimat, D. A., & Nyoto, A. (2016). The transformation of 21st-century education as the demand for human resource development in the global era. *In*

Proceeding of National Seminar on Mathematics Education (Vol. 1, No. 26, pp. 263-278).

Yen, T. S. & Halili, S. H. (2015). Effective teaching of higher-order thinking in education. *Distance Education and e-Learning, 3*(2), 41-47.