Error Analysis of Indonesian Junior High School Student in Solving Space and Shape Content PISA Problem Using Newman Procedure

U Sumule 1*, S M Amin 2, and Y Fuad 2

1Postgraduate in Mathematics Education, Universitas Negeri Surabaya, Ketintang, Surabaya, 60231, Indonesia
2Mathematics Department Universitas Negeri Surabaya, Ketintang, Surabaya, 60231, Indonesia

*Corresponding author: ulessumule@mhs.unesa.ac.id

Abstract. This study aims to determine the types and causes of errors, as well as efforts being attempted to overcome the mistakes made by junior high school students in completing PISA content space and shape. Two subjects were selected based on the mathematical ability test results with the most error, yet they are able to communicate orally and in writing. Two selected subjects then worked on the PISA ability test question and the subjects were interviewed to find out the type and cause of the error and then given a scaffolding based on the type of mistake made. The results of this study obtained the type of error that students do are comprehension and transformation error. The reasons are students was not able to identify the keywords in the question, write down what is known or given, specify formulas or device a plan. To overcome this error, students were given scaffolding. Scaffolding that given to overcome misunderstandings were reviewing and restructuring. While to overcome the transformation error, scaffolding given were reviewing, restructuring, explaining and developing representational tools. Teachers are advised to use scaffolding to resolve errors so that the students are able to avoid these errors.

1. Introduction

PISA problem items are aimed for measuring the ability of mathematical literacy. Mathematical literacy is the ability to use mathematical content (concepts, facts, procedures and tools) in real life situations [1]. Literacy refers to students’ capacity to apply knowledge and skills in key subjects to analyze, reason and communicate effectively as they identify, interpret and solve problems in a variety of situations [2]. There are four categories of mathematics content in PISA i.e. change and relationship, space and shape, quantity and uncertainty, and data [4]. The ability of Indonesian students is in low level in solving PISA problems related to geometric content, particularly in the understanding of space and shape. For example on solving PISA Problem 2000 as presented in figure 1.
Figure 1. The big cube in the left side is painted and then cut into three parts of three different directions. It becomes small cubes as shown. How many small cubes are produced?

Only 33.4% of students answered correctly and the rest 58.79% failed to solve [3]. This fact proves that the level of students' mathematical ability, especially geometry is still low. This low ability indicates that students have difficulty. The Difficulty is the cause of error [5]. The error is a mistake or negligence [6]. Math errors students need to get attention because if not addressed immediately, the error will impact in a row to the next math problem. To correct the error, students need to find the causes of their error [7]. Tracing the errors requires some analysis. Analysis can mean the procedure of solving the whole component into small parts to see how it effects [8].

Errors can occur at any time, therefore error analysis is a major step to be taken to avoid causing errors [9]. Newman proposed five activities to find the errors of the students in solving the given problem or called Newman's error categories, namely reading errors, comprehension errors, transformation errors, process skills errors and encoding errors [10]. In the problem solving process there are two types of obstacle that can prevent students from finding the right answer, namely: the first obstacle is the language problem and the conceptual understanding associated with the ability to read and understand the meaning of the given problem, and the second obstacle is the problem of mathematical processes consisting of transformation, process skills and accuracy of writing the final answer [11]. The Newman procedure presents a popular approach to teachers and offers a framework that is easy to understand and supported by study to find out the mistakes that students make in solving the problem [9]. The Newman procedure is a method of analyzing errors in the troubleshooting process [11]. Newman hierarchy provides a fundamental framework for sequencing important steps in the process of solving problems [12]. If errors and causes of errors are known then an attempt is needed to resolve the errors of the student in solving the problem. In education, scaffolding is defined as a help provided by a more competent friend or adult [13]. Scaffolding is a support strategy for children's convergent development areas [14]. Three levels of scaffolding which are support in mathematics learning are Level-1 called Environmental Provisions, Level-2 which consist of explaining, reviewing, and restructuring and Level-3 which are developing conceptual thinking [15].

This study found that the kind of mistakes made by students is a mistake of comprehension and transformation error. Comprehension errors occur because students can not understand and interpret key words in the matter and students do not read the questions carefully so that there is unreadable information. Attempts to overcome the errors of comprehension is to provide the scaffolding that is reviewing and restructuring. The transformation error occurs because the student can not determine the formula or plan the solution to solve the problem. Efforts to overcome the misunderstanding is to provide scaffolding in the form of reviewing, restructuring, explaining, developing representation tools [15]. For that teachers are advised to use scaffolding to overcome errors so that later errors do not happen again.

2. Methods
This study used the qualitative method. This study aimed to identify the type of error and the cause of student error in solving the problem PISA content space and shape.
2.1 Subject of study
This study was conducted in Junior High School. Two students (EI and VA) were selected from 23 students of class VIII to be subjected to study. The selection of study subjects was conducted based on the results of the ability tests given to all students. The subjects of the study selected 2 low-ability students in completing the ability test.

2.2 Study instruments
The three instruments used in this study were ability test items, PISA test items, and interview guidelines. The instrument is described as follows.

2.2.1 Test of Ability. The ability test is used to select a study subject. The problem of the ability test is taken from the question of National Examination of geometry material [15]. Five problems were given to the students in the form of a description.

2.2.2 PISA Test Items. PISA test items that was used is taken from PISA 2012 of space and shape content. The test consist of four problems. The first problem is the personal context, the second issue is the general context, the third problem is in the scientific context, and the fourth problem is about the work context [15]. The type of the question are multiple choice and essay. From the student's answer to the problem is expected to be revealed the types of errors and causes of error.

2.2.2 Interviews Guidelines. Interviews were conducted on the subject after the students completed the PISA problem. The interview guidelines used were adapted from the five Newman questions [9]. The interview form in this study is an unstructured interview. Interviews were conducted to find out and dig deeper the types of mistakes and causes of student error in solving the Pisa problem, as well as to provide assistance in the form of scaffolding to solve the missed problem.

2.3 Collection and processing of data
2.3.1 Data collection. Data collection was done by giving the PISA test. After the results of the test obtained an unstructured interview was conducted to identify the types and causes of mistakes made by students in solving the problems of PISA. All interview activities were recorded for transcribed.

2.3.2 Provision of Scaffolding. The interview results and student answer sheets are then analyzed to determine the type of error and the cause of the error, as a basis for providing scaffolding. Scaffolding to students is based on the type of student error in completing the PISA test.

2.3.3 Data processing. The recording of the interview is transcribed to make the transcript, as well as to facilitate the categorization of the type of mistake made by the subject in solving the problem. Error analysis is done from the students’ result and the subject interview in answering the question.

3. Results and Discussion
Students’ errors make in solving the PISA problem of space and shape content are presented in Table 3.1 below.

| Subject names | Problem |
|---------------|---------|
|               | 1       | 2       | 3       | 4       |
| EI            | T       | T       | C       | C       |
| VA            | C       | C       | C       | C       |

Note: C = Comprehension; T = Transformation;

Based on Table 3.1 it can be seen that the type of mistakes made by students in solving the problem is comprehension and transformation error, the results of study in accordance with study Wijaya, A., van den Heuvel-Panhuizen.M, Doorman. M, & Robitzch.A [20], other than that Ismail Hj Raduan [19]. The following discussion of the types of mistakes made by students in this study and efforts to overcome these errors.
3.1 Comprehension Error
The comprehension error is done by the VA subject on all questions and EI subject done on item 3 and number 4.

3.1.1 Comprehension error done by VA on question number 1. For example, the VA subject's Comprehension Error can be seen in Figure 2

![Figure 2](image1)

Figure 2. VA error on problem number 1

Based on Figure 2, it can be seen that the VA error is caused by not carefully observing the image so it can not read the scale of 1cm representing 1m contained in the picture. To overcome the misunderstanding of comprehension is given scaffolding in the form of reviewing and restructuring. Reviewing is done by asking subjects to re-read the problem slowly and carefully observe the image to find the scale on the picture, and asking the students to write what is given and what is asked from the problem. Restructuring is done by doing question and answers method for compiling and rebuilding knowledge about a wide rectangle. Developing representational tools that ask students to re-draw the rectangle with the help of adding particular segment in order to understand that on the figure actually there are two different rectangles. Explaining how to determine the floor area of the house is to reduce the area of the two rectangles also be one of the scaffolding given to the student.

3.1.2 Comprehension errors done by on second problem. Based on the results of VA work on second problem it can be seen that the VA does not write the height of the platform board contained in the picture. The error is caused because the VA is not careful observing the image. To solve the VA comprehension error in question number two is given scratching in the form of reviewing to ask students to re-read the problem slowly and carefully observe the image carefully in order to find the height of the platform board on the picture. Restructuring is done by doing question and answer to reorder knowledge about the radius of the circle, find the relation of radius, the height of platform board with the location of point M above river surface. Reviewing is done by asking student to re-read what the question asked then make a conclusion from the calculation.

3.1.3 Comprehension errors done by VA and EI on the third problem. Based on the results of the work EI and VA on the answer sheet it can be seen that the VA and EI made a mistake of comprehension caused by not writing on the answer sheet that the angle in one round is 360°. To overcome the errors EI and VA are given scaffolding. The scaffolding is reviewing that is asking students to re-read the problem slowly and carefully then emphasize important information that is circle. Restructuring is to remind the subject of the angle formed in one round, then connect it to the number of the doors, the question and answer to direct the students to determine the angle formed by the two wings of the door by dividing 360° by three. Reviewing is asking students to re-read what is asked and make conclusions related to the calculation results.

3.1.4 Error of comprehension done by EI and VA in question number 4. Based on the results of the work of EI and VA on the answer sheet it can be seen that VA and EI made a mistake of comprehension caused by not writing down the size of the sies contained in the question. To overcome the error, then given scanning in the form of reviewing to read slowly and observe images carefully and thoroughly to find important information used to solve the problem. Explaining is to explain the
relationship formed by the sides of a right triangle in order to determine the size of one side if there are two known sides. Developing representational tools is to ask students to draw the shape of the garage roof which is the same two rectangles, and the restructuring is the Q & A to rebuild the understanding that the area of the garage roof is the width of the rectangle multiplied by two.

3.2 Transformation error
Based on Table 3.1 it is known that transformation error is done the subject of EI in first and the second questions.

3.2.1 Error transformation done by EI in problem number 1. The result of EI's work on the first problem can be seen in figure 4.

![Figure 4. Results of EI work on question number 1](image1)

Based on the results of the work of EI in Figure 4 it is known that the EI misunderstood that caused the wrong method or formula to determine the floor area of the house. To overcome the transformation error, EI given scaffolding in the form of reviewing that is asking the subject to write what is known and asked again and observed the picture. Restructuring is a question and answers for compiling and rebuilding knowledge about a wide rectangle. Developing representational tools that ask students to draw back the plan with the help line in order to understand that on the plan there are two different rectangles. Explaining how to determine the floor area of the house to reduce the area of the two rectangles is also one of the scaffolding. Restructuring is a question and answer to guide students to do the calculation process. Reviewing is asking students to re-read what is being asked from the question. Restructuring is asking the subject to make a conclusion regarding the results obtained. The result of work after giving the scaffolding can be seen in figure 5.

![Figure 5. The results of scaffolding to EI on question number 1](image2)

3.2.2 Error transformation done by EI on second problem. Based on the result of the work of the EI subject it can be seen that the EI subject made a transformation error caused by the subject EI incorrectly determining the method for determining the location of point M with the surface of the stream. To overcome the error is given scaffolding in the form of Reviewing is asking the subject to write down what is known and asked from the problem. Restructuring is question and answer to reorder knowledge about the radius of the circle, find the relation of radius, the height of platform board with the location of point M above river surface. Reviewing is done by asking student to re-read what the question asked then find the meaning of the calculation results. Restructuring is done by asking student to make a conclusion from the calculation results.

4. Conclusion
This study found that the kind of errors made by students are comprehension and transformation error. Comprehension errors occur because students can not understand and interpret key words in the problem and students do not read the questions carefully so that there is unreadable information. Attempts to overcome the errors of comprehension is to provide the scaffolding that are reviewing and
restructuring. The transformation error occurs because the student cannot determine the formula or plan to solve the problem. Efforts to overcome the transformation errors is to provide scaffolding in the form of reviewing, restructuring, explaining, developing representation tools. The implication for teachers is teachers are suggested to use scaffolding to overcome errors so that later errors do not happen again.

5. References
[1] Stacy K & Turner R 2014 Assessing Mathematical Literacy. *ThePISAXperience* (New York: Springer Cham Heidelberg Dordrecht)
[2] OECD 2014 *Education at a Glance 2014: OECD Indicators* (OECD:OECD Publishing)
[3] Wardhani S & Rumiyati 2011 *Instrumen Hasil Belajar Matematika SMP: Belajar Dari PISA dan TIMSS* (Yogyakarta: Pusat Pengembangan dan Pemberdayaan Pendidikan dan Tenaga Kependidikan (PPPPTK) Matematika)
[4] OECD 2016 *PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematics, and Financial Literacy* (Paris: OECD Publishing)
[5] Soedjadi R 1996 *Diagnosis Kesulitan Siswa Sekolah Dasar Dalam Belajar Matematika* (Team Basic Science LPTK Dikti)
[6] Rajasah S 2003 *Kamus Lengkap Bahasa Indonesia* (Surabaya: Mitra Cendekia)
[7] Subanji 2015 *Teori Kesalahan Konstruksi Konsep dan Pemecahan Masalah Matematika* (Malang:Universitas Negeri Malang)
[8] Ritechy T 1996 *Analysis and Synthesis on Scientific Method-Based on a Study by Bernhard Riemann* (Online) https://www.swemorph.com/pdf/anaeng-r.pdf diakses Sabtu, 21 Januari 2017, pkl 19.00
[9] White A L 2005 Active Mathematics in Classrooms: Finding Out Why Children Make Mistakes *Square One* 15 (4) pp 15-19
[10] Newman M A 1977 An Analysis of Sixth-grade Pupils’ Error on Written Mathematical Task *Victorian Institute for Educational Study Bulletin* 39 pp 31-43
[11] Praktipong N & Nakamura S 2006 Analysis of performance of grade five students in Thailand Using Newman Procedure CICE Hiroshima University *Journal of International Cooperation in Education* 9 (1) pp 111-112
[12] Clements M A Ken & Ellerton N F 1996 *The Newman Procedure for Analysing Errors on Written Mathematical Tasks* (The University of Newcastle: Faculty of Education)
[13] Slavin R E 2000 *Educational Psychology Theoryand Practice* (United States: A Person Education Company)
[14] Chang K, Chen I, & Sung Y 2002 The effect of concept mapping to enhance textcomprehension and summarization *The Journal of Experimental Education* 71(1) pp 5-23
[15] Anghileri J 2015 *Scaffolding Practices that Enhance Mathematics Learning* (Cambridge: University of Cambridge)
[16] PISA released items-mathematics-OECDwww.oecd.org/pisa/38709418.pdf Terjemahkan lamanini (diakses Jumat, 20 Januari 2017, pk 20.00).
[17] Kementerian Pendidikan dan Kebudayaan Republik Indonesia 2015 *UjianNasionalTahunPelajaran 2014/2015* (Jakarta: BNSP)
[18] Singh P, Rahman A A, Hoon T S 2010 *The Newman Procedure for Analyzing Primary Four Pupils Errors on Written Mathematical Tasks: A Malaysian Perspective. University Technology MARA, Shah Alam, Malaysia*
[19] Raduana I 2009 Error analysis and the corresponding cognitive activities committed by year five primary students in solving mathematical word problems *Mathematics Department, Institute of Teacher Training Dato’ Razali Ismail Campus 21030 Kuala Terengganu Malaysia*
[20] Wijaya A, an den Heuvel-Panhuizen M, Doorman M, & Robitza A 2014 *Difficulties in solving context-based PISA mathematics task: An analysis of students’ error* (Montana: The Mathematics Enthusiast)