Students’ Mathematical Literacy in Solving PISA Problems Based on Keirsey Personality Theory

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Abstract. This research is descriptive-qualitative research. The purpose is to describe students’ mathematical literacy in solving PISA on space and shape content based on Keirsey personality theory. The subjects are four junior high school students grade eight with guardian, artisan, rational or idealist personality. Data collecting methods used test and interview. Data of Keirsey Personality test, PISA test, and interview were analysed. Profile of mathematical literacy of each subject are described as follows. In formulating, guardian subject identified mathematical aspects are formula of rectangle area and sides length; significant variables are terms/conditions in problem and formula of ever encountered question; translated into mathematical language those are measurement and arithmetic operations. In employing, he devised and implemented strategies using ease of calculation on area-subtraction principle; declared truth of result but the reason was less correct; didn’t use and switch between different representations. In interpreting, he declared result as area of house floor; declared reasonableness according measurement estimation.

In formulating, artisan subject identified mathematical aspects are plane and sides length; significant variables are solution procedure on both of daily problem and ever encountered question; translated into mathematical language those are measurement, variables, and arithmetic operations as well as symbol representation. In employing, he devised and implemented strategies using two design comparison; declared truth of result without reason; used symbol representation only. In interpreting, he expressed result as floor area of house; declared reasonableness according measurement estimation.

In formulating, rational subject identified mathematical aspects are scale and sides length; significant variables are solution strategy on ever encountered question; translated into mathematical language those are measurement, variable, arithmetic operation as well as symbol and graphic representation. In employing, he devised and implemented strategies using additional plane forming on area-subtraction principle; declared truth of result according calculation process; used and switched between symbol and graphic representation. In interpreting, he declared result as house area within terrace and wall; declared reasonableness according measurement estimation.

In formulating, idealist subject identified mathematical aspects are sides length; significant variables are terms/condition in problem; translated into mathematical language those are measurement, variables, arithmetic operations as well as symbol and graphic representation. In employing, he devised and implemented strategies using trial and error and two design in process of finding solutions; declared truth of result according the use of two design of solution; used and switched between symbol and graphic representation. In interpreting, he declared result as floor area of house; declared reasonableness according measurement estimation.
1. Introduction

Every human activity does not escape activities that use mathematical concepts. People need math as a practical need and help them in solving their daily life problems. This is because mathematics is one of the basic sciences needed in calculation and studying science and other technologies. So, everyone needs to learn math well. Mathematics need to be taught to all students from elementary school to equip students with the ability to think logically, analytically, systematically, critically, creatively and the ability to work together (Permendiknas [1]). Puspitasari [2] stated that in understanding the role or usefulness of mathematics in everyday life, the ability of mathematical literacy needs to be mastered by the students.

Literacy is individual ability to read, write, speak, calculate, and solve problems at the required level of proficiency, in individuals, families and communities (National Institute for literacy in Remund [3]). Mathematical literacy is the ability of individuals to formulate, apply, and interpret mathematics in a variety of contexts. By mastering mathematical literacy, each individual will be able to reflect mathematical logic to contribute to his life, community, and society (Mahdiansyah and Rahmawati [4]).

PISA (Program for International Students Assessment) as an international study, assessed students' mathematical literacy in the world including Indonesia, and the mathematical literacy of Indonesian students is still low compared to other countries. It can be seen in the results of Indonesian students score on PISA. From 2006 to 2012, Indonesia's rating on PISA has declined and Indonesia's ranking is still relatively low compared to the average score of OECD participating countries (OECD [5]; OECD [6]; OECD [7]). One of the mathematical content tested in PISA is the space and shape.

Some research suggested the ability of students in solving the problem of PISA in the space and shape material is still low. Johar and Zainabar's research [8] showed only 15% of students successfully solved the problem of PISA in the space and shape material (Score 4). Mahdiansyah and Rahmawati's research [4] showed the average score of students on space content and form was 25.8 of 50.

Minister of Education and Culture of Indonesia stated that the ability of Indonesian students is very low in: (1) understanding complex information; (2) theory, analysis, and problem solving; (3) using tools, procedures and problem solving; and (4) conducting an investigation (Kemendikbud [9]).

Student learning process may or may not depend on the individual itself. Personal students determine whether or not learning activities occur. Perceptions that exist in the individual will affect how the individual behavior. Students as individuals have a characteristic behavioral pattern, which determines one's self-adjustment to the environment especially the learning environment; Or so-called personality (Atkinson et al in Sugiyanto [10]). Friedman and Schustack [11] stated that every child has a different response when entering a certain environment or what is called a difference in personality. When students are given a specific problem, then each student has a different response to the problem.

Personality is a characteristic feature of a person who is innate which causes the emergence of certain feelings, thoughts, and behaviors. One classification of personality based on one's behavioral outlook is Keirsey's Personality theory (Keirsey [12]). Keirsey classified personalities into four types: The Guardians, The Artisans, The Rationales, and The Idealists or otherwise known as The Keirsey Temperament Sorter (Keirsey, [12]).

Mathematical literacy has a relationship with problem solving. The concept of mathematical literacy is very close to some concepts within the scope of mathematics education discussion. One of the important concepts is the mathematical modeling (de Lange in Stacey [13]) and the processes of those components (Stacey [13]). Such processes include formulating real-world problems with terms that can be solved as a mathematical problem, and then the mathematical solution was interpreted as an answer to the real-world problem. (Stacey [13]). Furthermore, Fitriana's research ([14]) showed the difference of any Keirsey personality type in solving problems. Based on these statements, student’s mathematical literacy may be different on any Keirsey personality type. The problem of students' ability in solving PISA problem especially in space and shape content in relation to differences in student personality encourages researchers to conduct research entitled “Students’ Mathematical Literacy in Solving PISA Problems Based on Keirsey Personality Theory”
The purpose of this study is to describe the profile of mathematical literacy of guardian, artisan, rational, and idealist students in solving the problem of PISA in the space and shape contents.

2. Method
This is descriptive-qualitative research. The subjects were four eight grade students of junior high school 4 Kediri, East Java that have guardian, artisan, rational or idealist personality types. Research Data was collecting by using instruments: (1) Keirsey Personality Type Tests. It contains 70 questions about how students respond to a particular event according to their habits or thoughts. It was used to classify their personality as: guardian, artisan, rational, or idealist subjects. It was taken from Kiersey's book "Please Understand Me II"; (2) PISA Test. It was used to know students' mathematical literacy profile in solving the PISA problems. It was taken from the PISA math problem of 2012 on space and shape contents with Apartment Purchase topic at level 4. It required students to show their designs that require the length side of floor as minimum as possible to determine the area; (3) Interview. It was used to obtain deeper information that was not obtained from student answers sheets. It was task based interview and conducted after PISA test.

Data analysis was conducted as follow: The data obtained from the Keirsey Personality Type Tests were grouped based on Keirsey's personality type ie guardian, artisan, rational, or idealist. Then, it was selected one student of each group of Keirsey personality types who met these criteria: (a) The learning outcomes of mathematics were relatively same, and (b) They can express their opinions orally or in writing. The data obtained from the PISA test were analyzed based on mathematical literacy indicators. The indicators are shown in the Table 1 below.

| Mathematics Process | Indicators |
|---------------------|------------|
| Formulate           | 1. Identify the mathematical aspects of the problems contained in the real context situation and the important variables.  
                      2. Translates the problem into mathematical language or representation |
| Employ              | 1. Design and implement strategies to find mathematical solutions.  
                      2. Use and switch between different representations in the process of finding solutions. |
| Interpret           | 1. Interpret the results of mathematical answers to the initial problem.  
                      2. Evaluate the reasonableness of mathematical solutions in the context of real-world problems. |

(Adapted from PISA 2015 Mathematics Framework, 2013)

The data of interview result was analyzed using four stages i.e. data reduction, data presentation and drawing conclusion.

3. Result and Discussion
The results of the personality tests of the students of eighth grade of Junior High School 4 Kediri, East Java showed that there were: 72 students had guardian, 9 students had artisan, 3 students had rational, 4 students had idealist personality types, and 9 students had no tendency of personality type. Based on the subject selection criteria, it was selected one student from each personality type to be the subject of research. They were guardian, artisan, rational and idealist personality types.

3.1. Guardian Subject
In the formulating process, guardian subject identified the mathematical aspects of the problems contained in the real context situation, namely the formula of the area of the rectangle and the size of its sides. This was in accordance with the theory presented by Arif et. al. [15] that a type of judging person who likes regularity of something or something that is planned well. The use of the rectangular area
formula was the result of understanding the problem and connecting with the known problem. The application of the rectangular area formula required the size of the sides to obtain how was the area. He identified the important variables of the terms or conditions in the problems and formulas of other problems ever encountered. This is in accordance with the theory presented by Arif et. al. [15] that a person of type sensing believes in his experience that is linked to the use of formulas on problems that have been encountered. He translated the problem into math only i.e the use of measurements and operations. It corresponds to a person of type sensing who believes in the truth he held. It was shown that he did not use a variable, but he directly operated numbers to get the solution.

In the employing process, he designed and implemented a strategy that is ease of calculation on the principle of widespread reduction to find solutions.

In the interpreting process, he referred the results of mathematical answers obtained to the initial problem of area of the house floor. He stated that the results obtained are reasonable by giving reasons of measurement estimation.

3.2. Artisan Subject

In the formulating process artisan subject identified that the mathematical aspects of the problems contained in situations of real context was the plane shape and size of the sides. The identified mathematical aspects were derived from understanding the problem, connecting the problem, the known information and the necessary information; But he only mentioned the plane shape and size of its sides. This is in accordance with the theory of Russo and Kaynama [16] that someone of a type of perceiving is less well-planned and prefers to allow possibilities or open options in expressing mathematical aspects that are identified. He also identified that the important variables were the solution procedures in everyday problems and questions that have been encountered. This is in accordance with the theory described by Arif et. al. [15] that the sensing criterion believes in his experience. It was shown when he connects the procedure of problem solution with problems that he had encountered. He translated the problem into the mathematical language by using measurements, variables, operations and symbol representation. But he was not consistent in using variables (He did not use variables in operating the floor area of the house with the area of unused space. It is in accordance with someone whose type of perceiving i.e less planned in using variables consistently. In the employing process, he designed and implemented a strategy of comparison between two designs to find a solution. He had used different designs. He used a second design because the first design is less efficient. This also suits someone whose type of perceiving is still open the choices of the possibility that exists. He stated that the results obtained were correct but did not explain the reason. He used a single representation of symbol, and did not switch between different representations in the process of finding solutions. It also corresponds to someone with a sensing type who believes in the truth they hold that there is no need for image representation. Besides, it also corresponds to someone whose perceiving type is poorly planned in using representation. In the interpreting process, he interprets the mathematical answers obtained to the initial problem i.e. the overall of area of house floor. He believed that the results obtained were reasonable by giving reasons of measurement estimation.
3.3. Rational Subject

In the formulating process, rational subject identified that the mathematical aspects in the problems that were encountered in the real context situation were the scale and size of the sides. He also identified that the important variable was the problem solving strategy ever encountered. He translated the problem into the mathematical language i.e. the use of measurements, variables, and operations; as well as symbol and image representation. This is in accordance with the theory presented by Arif et. Al. [15] that a person with intuitive criteria focuses more on the creativity of the insights and considers new events which are shown in the representation of symbols and images used further in the design of solution and use of solution strategies from other questions, although the procedure is different, it also indicate those criteria; The process of connecting the solution strategy to the new procedure suggests that he includes a person of thinking type that is using analytical reasoning in making decisions.

In the employing process, he planned and implemented the strategy of forming an additional plane on the reduction principle of area to find solutions. He used and switched to image representations and symbols in the process of finding solutions. It showed that a person of thinking type that is using analytical reasoning in making decisions which analytically design strategies based on thinking idea that begins by making the image representation continued to symbol representation, to make it easier to do. He can also give explanation of different design that are more efficient than the design used. It showed that he was an intuitive person who considered a new event. He stated that the results obtained were correct and explained the reasons based on the calculation process. It also showed that he includes a person of thinking type that was analytically the calculation process was explained as the reason for the truth of the results.

In the interpreting process, he interpreted the results of mathematical answers that he acquired to the initial problem of as area of house along with the terrace and the wall. He stated the reasonableness of the results by giving reasons for measurement estimation, calculation estimation, and estimation in the context of the problem.

3.4. Idealist Subject

In the formulating process, SI identified that aspects of mathematics in the problems contained in the real context situation was the size of the sides. He identified that the important variables are the terms or conditions in the problem. He translated the problem into the mathematical language i.e. the use of measurements, variables, and operations; as well as representations of images and symbols. This is in accordance with the theories conveyed by Russo and Kaynama [16] that someone who includes intuitive criteria will obtain information based on creativity and insight that is the use of image representations and symbols used further in the solution plan.

In the employing process, he designed and implemented a strategy of “trial and error” and using of two solution plans to find solutions. This is in accordance with the theory presented by Russo and Kaynama [16] that the criterion feeling has a subjective decision-making tendency which is seen when he declares that the result obtained is correct. The reason is because he used two solution designs. It also showed the criteria of feeling that is decision-making based on the assessment of how the decision will affect the others shown in how he is using two solution plans to convince the truth of the answer even if only explicitly observed and intuitive criteria that is in terms of creativity to get two different solution plans.

In the interpreting process, he interpreted the results of mathematical answers obtained to the initial problem of area of house floor. He believed that the results obtained are reasonable by giving reason of measurement estimation.

4. Conclusions

Based on the research results, it was concluded about students’ literacy profile in Solving Pisa Problems based On Keirsey Personality Theory as follows

a. In the process of formulating, guardian Subject identified that the mathematical aspects in the problems that were encountered in real situation context were the formula of rectangular area and
size of its sides. He also identified the important variables were the terms or conditions in the problem and the formula on other problems ever encountered. He translated the problem into the mathematical language i.e. the use of measurement and operations. In the process of employing, he designed and implemented strategies of easy calculation on the principle of area reduction to find solutions. He stated that the results obtained were correct but the reasons of the truth were not accurate. He did not use and switch between different representations in the process of finding solutions. In the process of interpreting, he interpreted the results of mathematical answers obtained to the initial problem of house floor area. He stated the reasonableness of the results by giving reasons for measurement estimation.

b. In the process of formulating, artisan subject identified the mathematical aspects of the problems contained in the real context situation i.e. the plane shape and the size of the sides. He also identified that the important variables were the solution procedure on daily problems and questions that had been encountered. He translated the problem into the mathematical language i.e. the use of measurements, variables, and counting operations, and symbol representation. In the process of employing, he designed and implemented a strategy of comparison between the two designs to find a solution. He stated that the results obtained were correct but he did not explain the reason. He used only symbol representation, did not exchange between different representations in the process of finding a solution. In the process of interpreting, he interpreted the results of mathematical answers obtained to the initial problem of all area of the house floor. He expressed the reasonableness of the result by giving a mathematical reason that was measurement estimation.

c. In the process of formulating, rational subject identified that the mathematical aspects in the problems contained in the real context situation were the scale and size of the sides. He identified that the important variable was problem solving strategy ever encountered. He translated problems into the mathematical language i.e. the use of measurements, variables, and counting operations, as well as symbol and image representation. In the process of employing, he designed and implemented strategies of the formation of additional planes on the principle of area reduction to find solutions. He stated that the results obtained were correct and explained the reasons based on the calculation process. He used and exchanged to image representations and symbols in the process of finding solutions. In the process of interpreting, he interpreted the results of mathematical answers that were processed to the initial problem that i.e. area of the house with the terrace and the wall. He stated the reasonableness of the results by giving reasons for measurement estimation, calculation estimation, and estimation in the context of the problem.

d. In the process of formulating, idealistic subject identified that the aspects of mathematics in the problems contained in the real context situation was the size of the sides. He identified that the important variables were the terms or conditions in the problem. He translated problems into the mathematical language i.e. the use of measurements, variables, and counting operations, as well as representations of images and symbols. In the process of employing, he designed and implemented strategies of trial and error and the use of two plans to find a solution. He stated that the results obtained were correct by giving a reason. He used two solution designs. He used and exchanged to image representations and symbols in the process of finding solutions. In the process of interpreting, he interpreted the results of mathematical answers obtained to the initial problem of floor house area. He stated the reasonableness of the results by giving reasons for measurement estimation.

5. Recommendations

Based on the research results and conclusions, it was suggested to Mathematics Teachers that they should provide questions have context or content similar to the PISA problems, as many students do not understand the PISA questions tested, and accept the diversity of student procedures in solving mathematics problems, as long as the process can be considered correct. It was also recommended to other researchers: it needs to test the legibility of test questions to students’ equivalent to the subjects of the research so that more known lack of test questions used in the study.
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