PROCEEDINGS
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INVESTIGATING STUDENTS' DIFFICULTIES IN COMPLETING MATHEMATICAL LITERACY PROCESSES: A CASE OF INDONESIAN 15-YEAR-OLD STUDENTS ON PISA-*like* MATH PROBLEMS

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Abstract

Mathematical literacy, the ability which describes a person's capacity to formulate, employ, and interpret mathematics in a variety of contexts, has been becoming an important discussion in the international PISA (Programme for International Student Assessment) survey that compares the achievement of students in all country participants in using math in everyday life. In the period 2000-2012, however, Indonesian students have not shown a good performance when participating this survey. This fact give rise to this study which aims to investigate Indonesian student's difficulties in completing a set of mathematical processes mentioned in mathematical literacy components, i.e. formulate, employ, interpret/evaluate, when solving PISA-like tasks composed through a developmental study. A sample of 50 students aged 15 years worked the written examinations, and 8 of them were interviewed. Using 'source of errors in mathematical literacy examination' as a framework of analyzing student's difficulties, data analysis revealed that mathematical process:'formulate', i.e. the process of identifying opportunities to use mathematics and then provide mathematical structure to a problem presented in some contextualised form, constituted the most frequently observed errors in student's works. In term of Fundamental Mathematical Capabilities, a set of mathematical competencies mentioned in PISA framework 2012, the students found difficulties in all competencies, i.e. communication, reasoning and argumentation, mathematising, representation, problem solving, and the use of formal/symbolic language. The implications of this study motivate a further research on analyzing student's performance in similar tasks as well as using the results of this study as tools to improve mathematical literacy based learning in every mathematics teaching program.

Key words: mathematical literacy, student's difficulties, pisa-like math problems, fundamental mathematical capabilities, mathematical process

INTRODUCTION

Indonesia has a special case during participated PISA mathematics survey over the years 2000-2012. From the first participation, Indonesian student's performance have not shown satisfactory results. In the period 2003-2009 almost 80 % of students were only able to reach below level 2 out of 6 levels of questions examined (Widjaja, 2011). Moreover, on PISA survey 2009 almost all Indonesian students only reached level 3, whereas only 0.1 % of Indonesian students reaching level 5 and 6 (Kemdikbud 2013; Stacey, 2011). These results is reinforced by the results of the latest PISA survey in 2012 which puts Indonesia ranks 64 out of 65 countries with the level of attainment is relatively low where almost all Indonesian participating students, i.e. 98.5 % were only able to achieve level 3 (OECD 2013; National Center for Education Statistics 2013). These facts indicate that Indonesian students have not been able to succesfully activate fundamental mathematical capabilities, a set of mathematical competencies mentioned in PISA framework 2012, into each of mathematical process (formulate, employ, interpret) performed when solving PISA problems. In fact, these competencies are important to underly their ability to well execute those process (OECD, 2013).

This fact gives rise to the questions of why Indonesian students have such low mathematical literacy scores on the task like in PISA survey and why they seem to experience more difficulties in performing their mathematical literacy than students in other countries. Therefore, this present study aims to describe the Indonesian student's difficulties in solving mathematical literacy problems qualitatively which analyzes (1) level of student's errors in term of mathematical process proceeded and (2) difficulties in term of activating fundamental mathematical capabilities mentioned in PISA framework 2012, i.e. communication, reasoning and argumentation, mathematising, representation, problem solving, and the use of formal/symbolic language.

THEORETICAL BACKGROUND

Mathematical Literacy

In the Programme for International Student Assessment's (PISA) 2012 Mathematics Framework is defined as an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. (OECD, 2013). This definition can then be described into several points, i.e. what kind of problems needed to be solved (challenge in real world context), how mathematical process perform in the solution (mathematical thought and action), and how mathematical competencies are activated in each of the process. See the figure below.

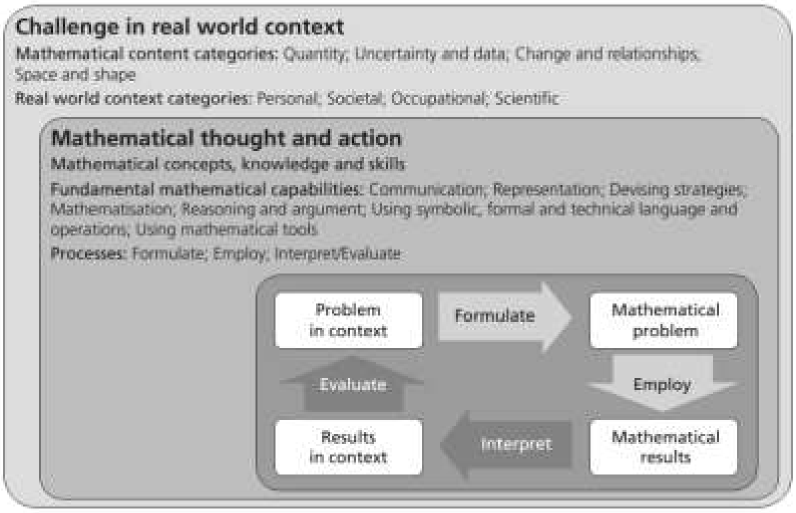

Fig. 1 A model of mathematical literacy in practice (OECD, 2013, Stacey, 2012)

Mathematical literacy starts from real world problems, which are categorized into category of contexts, i.e. personal, occupational, societal, and scientific, and contents, i.e. change and relationship, space and shape, quantity, and uncertainty and data (see OECD, 2013, Stacey, 2011). The process of mathematical literacy begins from identifying the real world problem and formulate the problem mathematically based on the concepts and relationship inherent in the problem. After getting an appropriate mathematical form of the problem, the next step is to employ certain mathematical procedures to obtain mathematical results, which then interpret those back into initial problem.

Mathematical Process

The three words, formulate, employ and interpret in the definition of mathematical literacy by PISA, provide a useful and meaningful structure for organizing the mathematical processes that describe what individuals do to connect the context of a problem with the mathematics and thus solve the problem. The word formulate in the mathematical literacy definition refers to one's ability to recognize and identify opportunities to use mathematics and then provide mathematical structure to a problem presented in some contextualized form. (OECD, 2013). Meanwhile, the process 'formulate' indicate the ability of performing certain mathematical procedures needed to derive results and find a mathematical solution (e.g. performing arithmetic computations, solving equations, making logical deductions from mathematical assumptions, performing symbolic manipulations, representing and manipulating shapes in space, and analysing data). The process 'interpret', on the other hand, shows the ability to translate the mathematical results into the context of a problem and determining whether the results are reasonable and make sense in the context of the problem (OECD, 2013).

In the process of 'formulate', 'employ', and 'interpret', fundamental mathematical capabilities (FMC) are activated successively and simultaneously in varying degrees depends on the related mathematics topics to obtain a solution. However, this three processes are sometimes not all involved in solving the problem. For example, in some cases forms of mathematical representations such as graphs and equations can be directly interpreted to obtain a solution. In addition, it is possible that a problem solver will perform repetitive actions in each process, such as re-consider the decision or initial assumptions taken before returning again to continue the next process.

PISA-*like* Problems

We call the problems used as instruments to investigate the student's difficulties as PISA-like problems since its characteristic which satisfies the framework of PISA mathematics problems released by OECD (see http://www.oecd.org/pisa/pisaproducts/). We tried to use framework of PISA mathematics 2012 as the primary source in developing the tasks. To obtain the validity of the problems, we submit the problems to some experts in PISA mathematics, i.e. 2 experts from MEG *(Mathematics Expert Group)* PISA team (Prof. Kaye Stacey and Dr. Ross Turner) and 4 PMRI (Pendidikan Matematika Realistik Indonesia) lecturers.

METHOD

To reach the aims of the study, we used an explorative study to investigate student's difficulties in solving PISA-*like* math problems. To investigate on what mathematical process the students had errors, we use framework 'source of error in mathematical literacy examination' adapted from Newman analysis (Clements, 1980), PISA governing Board (2013) and Vale, P., Murray, S., & Brown, B. (2012) as shown in the following diagram.

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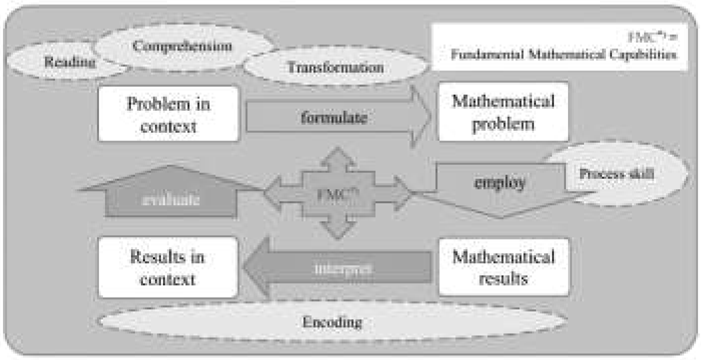

Fig 2. Source of error in mathematical literacy examination (adaptation from Vale *et al*, 2012 & PISA Governing Board OECD, 2013)

Using the diagram above, we then categorized the interview data from 8 out of 50 students aged 15 years old who worked written test into appropriate error codes based on the table 1. The students at this age were chosen since the recommendation from PISA framework which takes 15 years old students as the subjects of survey. Here, we examined 6 tasks to the students, i.e. 2 tasks in context category of 'faulty assembled phones', 1 task in context 'Body Mass Index' and the other 3 tasks in context 'biopori' (See appendix). Thus, we obtain 48 items (8 students x 6 problems) from student's works.

Table 1 Source of error in mathematical process

Mathematical process	**Error Code**	**Description**
Formulate	R-error (*reading error*)	Students do not understand what is known, i.e. fail in identifying or making sense with certain word/single term, or pictorial and textual information; do not read general information given preceding the item; or do not provide any written answers.
	C-error (*comprehension error*)	Students understand what is known but do not understand what is asked because they do not understand the meaning of overall relationship of the information given.
	T-error (*transformation error*)	Students can identify what is known, what is asked, the concept related to the item. However, they are unable to synthesize it into a corresponding mathematical models. This is because the students do not yet have an appropriate problem solving scheme of the solution.
Employ	P-error (*process skill error*)	Students are able to make an appropriate mathematical model, but fail in operating symbolic/algebraic/procedures working within formal mathematics itself. As a result, they get wrong mathematical results.
Interpret/ Evaluate	E-error (*encoding error*)	Students are able to determine the precise mathematical results, but fail in writing a final answer (e.g choose wrong answers on multiple choice questions). This is because it does not fit with the context of the given problem.

Adaptation from Newman error analysis and source of mathematical literacy examinations (Clements, 1980; Vale, *et al,* 2012)

We also describe the student's difficulties in activating FMC. To find those, we used FMC indicators described in table 2 as a scheme in analyzing 50 items of student's written work by analysing the extent to which students are able to bring up those indicators when solving the problems.

Table 2. Indicators of Fundamental Mathematical Capabilities

FMC	Indicators
Reasoning and argument	thinking logically that explore and link the elements of the problem so that can make inferences from these elements, examine the justification given, or provide justification to solutions or statements of the problems
Communication	reading, decoding and interpreting statements, questions, tasks or objects enables the individual to form a mental model of the situation (receptive component); presenting answers or justification of the statement provided
Representation	selecting, interpreting, translating between, and using a variety of representations (e.g. graphs, tables, diagrams, pictures, equations, formulae, and concrete materials) to capture a situation or interact with the problem.
Devising problem solving strategies	selecting or devising a plan or strategy to use mathematics to solve problems arising from a task or context, as well as guiding its implementation.
Mathematising	transforming a problem defined in the real world to a strictly mathematical form (which can include structuring, conceptualising, making assumptions, and/or formulating a model), or interpreting or evaluating a mathematical outcome or a mathematical model in relation to the original problem.
Using symbolic, formal and technical language and operations	understanding, manipulating, and making use of symbolic expressions within a mathematical context (including arithmetic expressions and operations), governed by mathematical conventions and rules; understanding and utilising constructs based on definitions, rules and formal systems.

OECD (2013);Turner (2012;2013)

As a guideline to interview, we used the following list of questions: (1) *formulate*: Please read the question to me. If you don't know certain word, say it *(reading)*, tell me what the question is asking you to do *(comprehension)*, tell me how you are going to find the answer *(transformation)*; (2) *employ:* show me what to do to get the answer *(process skill)*; (3) *interpret*: write down your answer to the question *(encoding)*. These questions are possible to be also used to get how students perform FMC in their work. For example, when investigating about *process skill*, we asked what the mathematical procedures or method used to find certain mathematical results to know how they perform competency of *using symbolic/formal/technical language*, while we also asked what they understand about certain information to know how they perform *communication.*

RESULT AND DISCUSSION

Student's Error in Performing Mathematical Process

Table 3 shows the levels at which the students' errors occurred in each question.

Table 3. Level of student's error in completing mathematical processes

Problem	Formulate			Employ	Interpret	Full score
	I	II	III	IV	V	VI
1	0	0	0	0	2	6
2	2	1	0	1	2	2
3	0	0	3	0	1	4
4	2	3	2	0	0	1
5	0	0	3	0	4	1
6	2	0	3	1	0	2
Percentage	12,50%	8,33%	22,92%	4,17%	18,75%	33,33%

Note:
N= the number of students, I= reading error, II= comprehension error, III=transformation error, IV= process skill error, V=encoding error

$$\text{Percentage} = \frac{\text{the number of error items based on the analysis}}{\text{the total number of analyzed items (48)}} \times 100\%$$

From the table 3 above, we can see that the biggest percentage showing level of student's error come to transformation error, which means most students failed in synthesizing the problem which has been understood into a corresponding mathematical models. Regarding the mathematical processes, process of *formulating* the problem into appropriate mathematical structure constitute the biggest percentage (43,75%) accumulated from reading error, comprehension error, and transformation error which respectively is 12,5%;8,33%, and 22,92%. Here, there are only 33,3% or 16 out of 48 items which are coded as correct answer.

Now, we will show how we coded student's errors using the two examples of problems tested to the students. Here, we also describe what problems should be solved as well as what mathematical process should be performed by students.

<u>Problem 2</u>

This problem is designed to test students' understanding of the concept of percentage by comparing two percentages resulting from some calculations. The need of processing of 'formulate' is more dominant than other two process: 'employ' and 'interpret', due to the students need to understand the contextual information that is presented such as the data entry table, the percentage of failures per day, average of the number of phones which are assembled, and the phrase of 'the higher overall percentage of faulty assembled phones', and then translate the problem into the form of formal mathematics. To work in the world of formal mathematics, students need to link the results of the calculation about the number of failed assembled phones for each brand and its comparison to the total of assembled phones. The result of calculation are the interpreted by checking whether the steps done has completely finished until come to the percentage or ratio showing the overall percentage of faulty assembled phones or only come to the calculation showing the number of faulty assembled phones.

Based on the analysis of all students' work, there were only 10% students who successfully got full score, and 36% got partial score, and the remaining got no score. This analysis also shows there are two main types of errors in the completion of this problem, namely (1) make a conclusion from the sum of the percentage for each type of brand: Nito 11%, Vexian: 12% (done by 24% of

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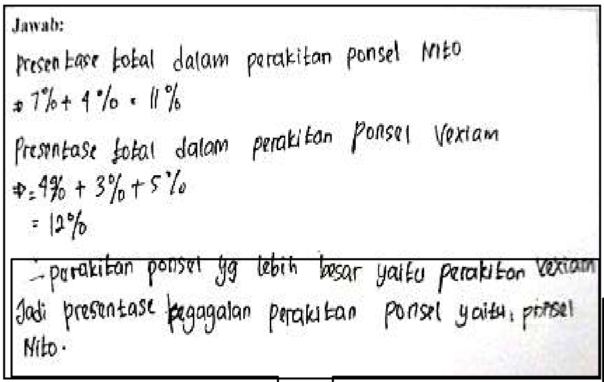
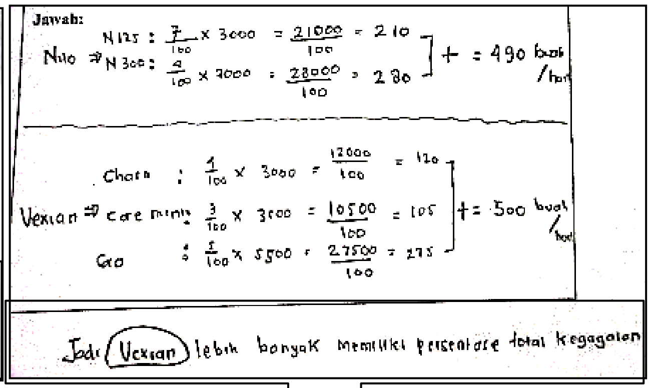
students), and (2) make an interpretation from total of faulty assembled phones on each type of brand (done by 24% of students). As an illustration, the following figure presents the two types of errors



Translation: The total number of assembled phones belong to Vexian. So, the higher percentage of faulty assembled is Nito

(a)



Translation: So, Vexian has the higher percentage of failures

(b)

Fig 3. Errors of student's work on problem 2

According to the table 2, out of 8 interviewed subjects consecutively failed during the process of reading (2 students), comprehension (1 student), process skill (1 student), and encoding (2 students), and 2 other students answered correctly. To show how the students made error in performing reading in the process of 'formulate', we present an interview with a student producing this error below. See fig 3 (a).

I :Please read the question, then reveal whether there are words / phrases you do not understand.
S :clear ..
I :What do you know about the meaning of the overall percentage of faulty assembled phones?
I : Surely, the sum of percentage
S : What do you think about the difference between the 'overall percentage of failures' and 'the total percentage of failures?
I : .... (long answer). I think the 'overall percentage of failure' is this. (pointing to the percentage values presented in the table), but if the percentage of the total ...... ehmm, (silence, could not continue the answer) ***(R-error)***

From the dialogue above, it appears that the student failed understanding the meaning of the phrase 'overall percentage of failures', so that she assumed that th esum of percentage on each brand (Nito and Vexian) given in the table represent the meaning of this phrase. Hence, we code this mistake as reading error.

Now, we will see how encoding error appeared in student's work. The following dialog shows an interview with a student who failed during the process of encoding/interpreting the mathematical result as shown in fig 3 (b).

I : Please read the question, then reveal whether there are words / phrases you do not understand .
S : (reading about) .. no , obviously ..
I : What do you know about the meaning of overall percentage of faulty assembled phones?
S : The percentage showing the comparison between the number of phones which are failed in assembling with the total number of assembled phones per day.
I : Okay, now reveal what the question ask you about ?
S : Finding the percentage of total failure, whichever is higher between the 2 companies: Nito or Vexian .
I : What do you plan to address this matter ?
S : I calculated the total of each phone that failed to be assembled, and then I compare the percentage.
I : So, you wrote this 490 pieces for the Nito and 500 pieces for Vexian, and your conclusion is...
S : Vexian has higher percentage of total failure ..
I : Why?
S : Because I see from the comparison between the failed phones and the total number of assembled phones. (pointing calculations performed, i.e. 490 broken for Nito and 500 broken for Vexian). When I compared this number with its total number of assembled phones, I would see the percentage of Vexian is larger than Nito. ***(E -error)***

From the dialogue above, we can conclude that the student had a problem during the process of interpreting the mathematical result. At the stage of transformation, he understood that he had to compare the percentage of failures of each brand after finding the number of failed phones which are assembled from calculation, but at the time he wrote the final answer, he did not continue the process of calculation in finding the value of comparison as the percentage of faulty assembled phones so that this error led to the failure process of 'interpret'. In other words, he stop performing process of employing mathematical procedure and then used that unfinished mathematical result as tool to make conclusion about the higher percentage of faulty assembled phones. Thus, we code this error as E-error.

Problem 6

This problem is categorized in context of 'Biopori'. It examines students' ability to determines the maximum number of biopori holes for given area of a field where both size of the area and design of laying out biopori holes are given. It is categorized in the process of 'formulate' since the need to make a mathematical model which can be used to find the number of holes in accordance with the design and the size of the field requires more attention. When applying certain mathematical procedures, students also need to perform a quite strict arithmetical calculations by considering the relationship between field size and the maximum holes that can be made in one side of the square-shaped field. Meanwhile, the process of interpreting the results of these calculations is needed to check whether it makes sense with the size of the field or not.

The results showed only 8% or 4 out of 50 students who obtained a full score for this question.. From the analysis of student's work, it is known that some students' error patterns are: (1) used an unppropriate mathematical models such as the concept area that does not match the

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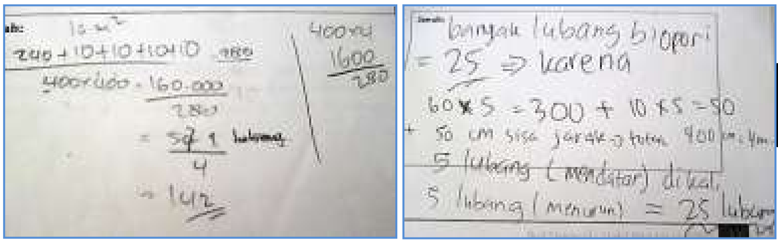
completion of this problem and (2) perform incorrect mathematical procedures using an established mathematical model. The results are then confirmed by interviews showing that 2 students answered correctly with logical reasons, 2 failed in reading, evidenced by no answers for this question, 3 failed in transformation, and 1 failed in performing mathematical procedures (process). The following figure presents an example of two patterns of errors at the time of transformation and process.



Translation: The number of holes=25 since 60 x5 =300+10x5=50 the remaining 50 cm→total 400 cm=4 m

Fig 4. Errors of students' work on problem 6

The student who worked shown by fig 4(a) did not show understanding of the proper use of the concept in solving this problem. Here is transcript of an interview showing this error. See fig 4(a).

I : Please read the problem. Then reveal what it means.

S :(reading) We have a field measuring 4 x 4 m. Some biopori holes will be made into the ground. The diameter is 10 cm . The distance between 1 biopori and anther one is 60 cm (pointing the the line with length of 60 com on the figure). So we have to look for how many biopori holes can be made in the ground.

I :Okay , what did you plan for this problem?

S :The first, I tried to find the area of the field.

I :Ok. Now explain the meaning of this writing, 240 means what? ?

S :60 times 4 (pointing to distance between two holes on the design of a square pattern in the picture)

I : How about 10 ?

S : That is.. (pointing to the diameter of the hole). The area of field is 400x400 = 160000 cm. Then, this value is divided by 280.

I :Why did you make a division operation on this calculation?

S :It was to find the maximum number of holes that can be made. ***(T-error)***

I : Ghiant , Are you sure with your answer?

S : I doubt... (while smiling)

I : Why are you not sure ? Which steps make you doubt ?

S : Confused...actually, I'm confused about the way..

From the dialogue above, the student seemed not fluent when deciding an appropriate scheme to determine the maximum number of holes which could be made at the time of transformation. This means that he was difficult in reasoning to associate images representing the design of laying out the holes as a form of representation of information that needs to be interpreted in a mathematical structure. The use of the completion strategy by dividing the field area (160.000 cm^2) by the circumference of a design for a square pattern (280 cm) becomes the primary key error in determining the mathematical model that expressed the relationship between the number of biopori holes and size of the field. Thus, we coded this difficultie as transfromation error.

Student's Difficulties in Activating Fundamental Mathematical Capabilities

The following are the student's difficulties to activate FMC.

1) *Reasoning and argument*. Providing incorrect justification to statements of the problems. For instance, some students failed in giving correct conclusion about a statement revealed by the quality tester on task 1. This is caused by their lack understanding about the relationship between the percentages given in the table and the number of phones which should be repaired on each type of phone, so that they only made a justification based on the value of percentages. Thus, they made conclusion that the statement is correct.
2) *Communication.* Giving unappropriate meaning to the certain words/phrases. For example, on task 2, some students failed in interpreting the meaning of 'the higher overall percentage of of faulty assembled phones' which led them compare the total value of percentages given on the table between the two brands instead of calculating percentage based on the comparison between the number of faulty assembled phones and the total number of assembled phones on each brand.
3) *Mathematising*. Using a mathematical formula in unappropriate situation. For instance, on the task 4, many students were actually know which part of a biolpori hole representing the area of infiltration, but they were more confident using a formula of surface area of cylinder that they typically use when solving similar task, i.e. 2πr(r+t) rather than rebuilding a formula to find the area of biopori infiltration which only calculate the area of circular base and the area of the tube, i.e. πr2 + 2πrt.
4) *Representation*. Difficult to determine the precise scheme to process information related to graph. On task 5, students were unable to make a mathematical relationship between diameter of circular base of a biopori hole and the maximum volume of waste that can be loaded by the hole. This difficultiy can be seen as they did not catch with the idea of textual representation written in the body of the task and unfamiliar with the graph represented without any numerical data within the axis.
5) *Devising problem solving strategies*. Incomplete in performing steps of problem solving. On task 2, some students conclude the company which has the larger faulty assembled phones, i.e. Vexian, as the company with the higher percentage of overall faulty assembled phone. In term of what step they failed to perform, they did not make sense with the mathematical result they obtained. In fact, they should have come to the calculation of the requested percentage and used it as the tool to make a precise interpretation. In other words, they did not perform repetitive action to confirm what the completion should be within the process of 'employ' well.
6) *Using symbolic/formal language.* Not precise in handling with standard unit of measurement in calculation. On task 3, many students calculated a BMI for the weight of 60 kilos and the height of 160 cm and got 23.4, then substracted the result by the desired BMI of 20. Finally, they interpreted that Amalia, the person in the task, must reduce her weight as much as 3.4 kilos (23.4-20). From this result, it is known that they did not consider that BMI and weight has different unit of measurement (kilos/m2 for BMI; kilos for weight).

Using source of errors in mathematical literacy examination by Vale, P. et al (2012) we obtain data about profile of students in performing their mathematical literacy ability in solving PISA-like mathematics tasks. These data reveal that the biggest contributors for students in making errors is in the 'transformation' stage, i.e. when students translate problems into appropriate formal mathematics. This finding supports studies conducted Jupri, et al (2014) which states Indonesian students have

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difficulty in making the form of mathematical equations of the problem are expressed in terms of the sentence (word problems) and Edo, et al (2013) in his study stating PISA students have difficulty in formulating everyday problems into mathematical structures. On the other hand, the students also made errors in interpreting the mathematical result like shown by their incomplete steps used to get the final result. Here, this finding also found in Lutfianto's study that they missinterpreted the mathematical solution resulted from the process of 'employ' which eventually doesn't answer the requested context. Concerning with FMC, we also found students' difficulties in activating all FMC. This finding has similar result with the study conducted by Sáenz, et al (2009) with Spanish students as subjects that also found some student's difficulties in activating mathematical competencies: communication and argumentation, reasoning and representation, and the use of formal/simbolic language/operation by linking each of those competency indicators with the type of knowledge needed.

CONCLUSION AND REMARK

Finally, we would argue that the framework of 'source of errors in mathematical literacy examination' can be used as a useful tool to investigate students' difficulties in solving PISA-like problems, the tasks which are developed based on PISA mathematics framework. From the result of analysis of students' written work and interview, we found most students failed when come to the end of 'formulate' process, i.e. transformation. This finding is supported by the fact that they found difficulties in activating all Fundamental Mathematical Capabilities (FMC) as the mathematical competencies underpinning each of mathematical processes.

Appendix

MOBILE PHONE ASSEMBLY

The *Nito* brand mobile phone company assembles two types of latest mobile phones: N125 and N300. Every day these two types of mobile phones are manufactured and tested their quality. The phones that fail to satisfy the standards will be sent for repair before being released to the market.

The following table shows the average number of mobile phones assembled and the percentage of instances of faulty assembling per day.

Type of phones	Average number of assembled phones per day	Average percentage of faulty assembled phones per day
N125	3000	7%
N300	7000	4%

Problem 1

A quality tester gives a statement about the mobile phones assembled,
"On average, there are more N125 that must be repaired than N300 that must be repaired per day"
Decide whether or not the statement is correct? Explain your reason mathematically.

Problem 2

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Another mobile phone company, *The Vexian*, assembles three types of the latest phones: *Vexian Charm, Vexian Core Mini* and *Vexian Gio.*
The following table shows the comparison between the number of mobile phones assembled and the percentage of faulty assembled phones for both the two companies.

Company	**Type of mobile phones**	**Average number of assembled phones per day**	**Average percentage of faulty assembled phones per day**
The Nito	*N125*	3000	7%
	N300	7000	4%
The Vexian	*Charm*	3000	4%
	Core Mini	3500	3%
	Gio	5500	5%

Which of the two companies, *The Nito* or *The Vexian*, has the higher overall percentage of faulty assembled phones? Show your work using data in the table above.

BODY MASS INDEX *(BMI)*

Sumber: www.nydailynews.com

Body Mass Index (BMI) is a number calculated from an adult's weight and height. BMI provides a reliable indicator of body fatness for most people and is used to screen for weight categories that may lead to health problems.

BMI score is given as follows

$$BMI = \frac{w}{h^2}$$

w = weight (kilograms)
h = height (metres)

Problem 3
Amalia has a height of 160 cm. Her current weight is 60 kg. In order to achieve an ideal weight, she wants to reduce her BMI to 20. By how many kilos would she have to reduce her weight?

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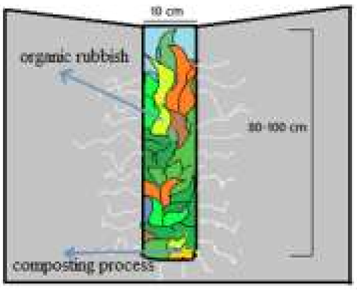
BIOPORI

Biopori is one of the flagship programs of Governor of Jakarta, Jokowi, in addressing flooding problems. The work of biopori is to include organic waste into a tubular hole on the ground so that trigger organisms such as worms to create cavities in the ground called biopori. These cavities become a channel for the water to seep into the soil so that water does not stagnate on the surface and cause flooding. (see picture)



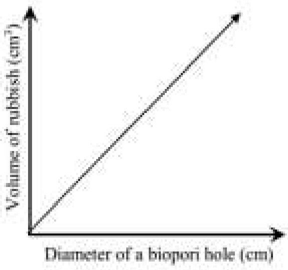
Problem 4

The construction biopori hole will expand the field of surface area of water infiltration as large as the surface area of the hole that formed after the ground is excavated. By making a hole with a diameter of the hole is 10 cm and a depth of 100 cm, what is the surface area of the infiltration area of the biopori? (in cm^2). Write down your calculation.

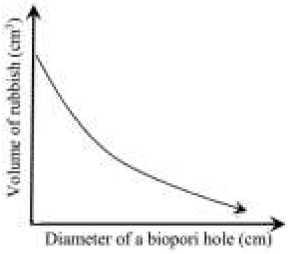
Problem 5

If the diameter of a biopori hole is widened and the depth of the hole is fixed, which one of the following graphs represents the relationship between the diameter of the hole and the maximum volume of rubbish that can be loaded by a biopori hole?

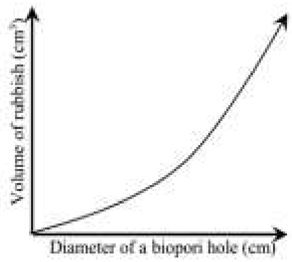
A.



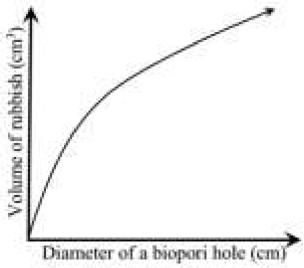
B.



C.

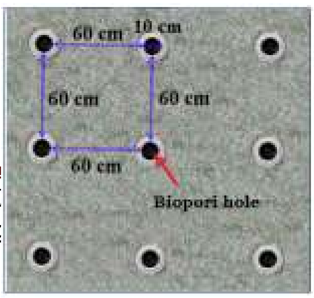


D.



Problem 6

Zaki wants to make a number of biopori holes having a hole diameter of 10 cm in the lawn behind his house. He plans to make the arrangement of the biopori hole with a square pattern as shown in the following figure.



Using this design, what is the maximum number of holes that can be made by Zaki if the size of the field is 4 x 4 m? Explain your strategy.

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