

Research Article

Ability of Olympiad Winning Student in Doing STEAM-based Test: Analysis of Literacy and Numeracy

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Abstract.

Literacy and numeracy abilities and critical thinking are very important challenges in the 21st century. It is important to develop stats from the level of elementary education. The results of literacy and numeracy shows that there is a significant problem. Based on the International Student Assessment Program (PISA) 2019 held by OECD, which evaluates the students' ability in various countries, about 1% of Indonesian students can solve the complex question model mathematically, even in the result of (PISA) released in 2023 about the ability of literacy and numeracy. Indonesia ranked 68 out of 81 countries and if compared with the result in 2018, it was significantly lower. This research aims to describe the ability of literacy and numeracy and also critical thinking of the Olympiad-winning student in solving the questions using STEAM-based test. The research uses qualitative approach, with the method of case study taken from the Junior High School student who wins the mathematics Olympiad. The research instrument was a test that consisted of 5 STEAM based questions. The data collection technique was giving test and it is continued with the interview based on the test result. The result of the research shows that the ability of literacy and numeracy in solving the test refers to the field of science, art, and mathematical subject to communicate, makes the students to be able to change the essay question to the mathematics form. The students can think logically, make valid statements, and construct strategy in solving the test using formal language and symbolic operation. While the test related with the technology, has an error in specifying the steps. In general, the subject's numeracy literacy skills are good.

Keywords: the ability of literacy and numeracy, STEAM, Olympiad winner

1. Introduction

Literacy and numeracy are the knowledge and the ability to apply various types of numbers, signs or symbols related to basic mathematics to solve practical problems in everyday life, presents the outcome of the analysis in the form of (graphs, tables, charts, and other forms) then interprets the outcome of the analysis to interpret and

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to make the right decisions[1], [2]. Literacy and numeracy can be defined as the ability to carry out mathematical reasoning, designing, applying, and interpreting relevant mathematical concept in various contexts of daily life problems effectively[3], [4]. Literacy and numeracy can develop logical and systematic thinking in understanding, analyzing, and solving problems by applying mathematical knowledge if it is integrated into the learning process well [5], [6]. The three main points required to support the literacy and numeracy process in learning at school include: the obligation to carry out literacy and numeracy, to provide platforms and opportunities for students, to acquire support and to provide solutions to problems related to literacy and numeracy [7], [8]. Each student's level of ability in mastering literacy and numeracy is different depends on the situation and requirement in the scope of their life but the knowledge in mathematics supports the two things as well.

Some indicators of literacy and numeracy include communication (reading, writing, describing, interpreting and formulating problems), mathematization (making changes from contextual to mathematical forms, interpreting mathematical models and results related to problems), representation (presenting problems in various forms such as tables, pictures, diagrams, and graphs), reasoning and building argument (logical thinking process to obtain conclusion, examine and provide justification for statements that have been created as an alternative solution to the problem), designing problem solving strategies (the ability to design strategic plans and process of implementation in applying mathematics as problem solving), applying formal language and symbolic operation, technique in involving between understanding and knowledge, interpretation, manipulation and symbolic expression related to the mathematical context, applying various mathematical device in solving mathematical problems[8], [9].

The ability in literacy and numeracy is extremely essential in mathematics because mathematics is not only always related to formula but also requires students' powerful reasoning or critical thinking pattern in answering each problem given. Literacy and numeracy can also assist students to understand the role of mathematics in solving problems related to everyday life. Based on the outcome of PISA 2018 released by the OECD (2019), it showed that the average mathematics score of Indonesian students stretched out 379 with an OECD average score of 487. This was revealed that the literacy and numeracy ability of Indonesian students were still low. Apart from that, the basis of the low literacy and numeracy ability can be influenced by several different factors. The facts in the field are that only a small number of people employ literacy and numeracy in everyday life. The ability to calculate as a basic mathematical concept

may have been mastered by students but the students' abilities are not deep enough in applying the concepts in real condition or when they solve unstructured problems but they ignore the problems instead. For instance, in everyday life, the lack of practice on literacy and numeracy falls out since there are still many teachers who are unable to assemble the questions of literacy and numeracy, especially for teachers at the elementary school level so that the students become more accustomed to solving the non-routine questions. Teachers tend to generate the closed questions which can be solved directly by using formula [10], [11].

Thinking activities to solve mathematical problem requires high level thinking skill which consists of critical thinking, logical thinking, reflective thinking, metacognitive thinking, and creative thinking [12], [13]. These high-level thinking abilities are required for students to live in 21st century which are mentioned as ability of Critical Thinking, Creativity and Innovation, Communication Skills, and Collaboration Skills[13], [14]. Critical thinking ability is the ability to think systematically and acknowledge the relation between various ideas used in solving problems[15], [16]. The ability is very essential in solving mathematical problems [17], [18]. Critical thinking emphasizes thinking process which has six elements, named FRISCO, Focus, Reason, Inference, Situation, Clarity and Overview [16]. While carrying out the exercises, stepping up from the thinking about how to formulate the problem, planning solutions, reviewing the steps for solving, creating guess if the data presented is incomplete which requires critical thinking [19], [20].

The research findings manifest that the students with the low ability still cannot understand the meaning of the problem presented, resulting in not meeting the indicator achievement in literacy and numeracy ability while the students with medium ability still have several indicators of literacy and numeracy ability that are not fulfilled, such as ability to represent and apply symbols and language[11], [21]. The students with high ability are able to implement the mathematical understanding to solve problems so that they have met the indicators of literacy and numeracy abilities [16], [17].

Other researches show that the students with the highest literacy and numeracy test scores can meet two or three indicators while the students with low literacy and numeracy test scores only meet one of the indicators[22]–[24]. Non-fulfillment of indicators is caused by errors including not writing down known and asked data information, error in solving question, error in calculating and not writing conclusion on the answers obtained. Most of the students' errors in solving algebra story problems are that the students do not convey information from the questions and what is asked[25], [26]. When the interview is conducted, the students concerned can broach the information

in the questions. In the research, it is reported how the literacy and numeracy ability of junior high school students who won the Olympiads solve STEAM based questions.

2. Method

The research employs qualitative approach with a descriptive analysis method which aims to analyze and to set out the literacy and numeracy ability of Olympiad winning junior high school student in solving STEAM based problems. The research was conducted on class VIII student who won the Olympiads with a case study of a junior high school student. The data collection techniques applied were test and interview methods. The instruments applied are test and interview guidelines. The test includes 4 STEAM based questions, namely: science, technology, art and mathematics. The data analysis through stages of data reduction, data presentation, and drawing conclusion. The triangulation method applied test and interview.

3. Result and Discussion

3.1. The Result of the Research

The following is an excerpt from interview with the student related to science:

R: How did you do the question?

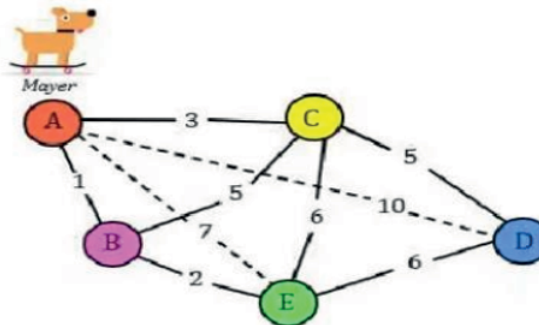
S: I looked at the picture and read the question, what was asked was the initial energy. So, I calculated the energy required by the dog from the point it passed and then added the remaining energy.

R: Where did you perceive the energy required from the point you passed through?

S: from the picture and question, there was already a number written that showed the energy required.

Based on the student's work and interview with the student on scientific question, the student could read and interpreted the problem. The student knew how much energy was required to walk from one point to another and understood what the question asked. The student could carry out a mathematization process by recording the energy required from the point the dog passed and then carried out the process of adding up the energy according to the point the dog passed. The student could determine a problem solving planned by adding up all the energy required for each point traversed and by

Suatu hari anjingnya Rudi sedang berjalan – jalan mengelilingi beberapa titik. Rute perjalanan anjing tersebut seperti pada gambar berikut :



Ada 5 titik lokasi anjing tersebut singgah, yaitu A, B, C, D dan E. Untuk mencapai titik tersebut, anjing menghabiskan energi setara dengan angka yang terdapat pada gambar. Sebagai ilustrasi : anjing tersebut ingin mencapai titik B dari titik A. Rute ke B membutuhkan 1 energi. Dari titik B ke titik E membutuhkan 2 energi. Jadi, jika anjing tersebut berjalan dari A ke B lalu ke E, maka ia membutuhkan total 3 energi. Rute ini bisa ditulis sebagai A-B-E. Saat ini, anjing tersebut berada di titik A dengan bekal x energy. Jika kemudian anjing tersebut menempuh rute A-B-C-A-D-E, dan tersisa 7 energi, berapa total energi anjing tersebut mula-mulai (energy awal) ?

Figure 1: Questions for Science.

$$\begin{array}{l}
 A \rightarrow B = 1 \\
 B \rightarrow C = 5 \\
 C \rightarrow A = 3 \\
 A \rightarrow D = 10 \\
 D \rightarrow E = 6 \\
 \hline
 25 + \text{sisanya} \rightarrow 25 + 7 = 32
 \end{array}$$

Figure 2: Student's Work for Scientific Questions.

adding the remaining energy. The student applied symbols and addition operation. The following is a diagram of solving scientific question by the student.

The following is an excerpt from interview with the student related to mathematics:

R: What came to your mind when you saw the picture in the question?

S: em,...the numbers in the box are related

R: What did you mean by connection?

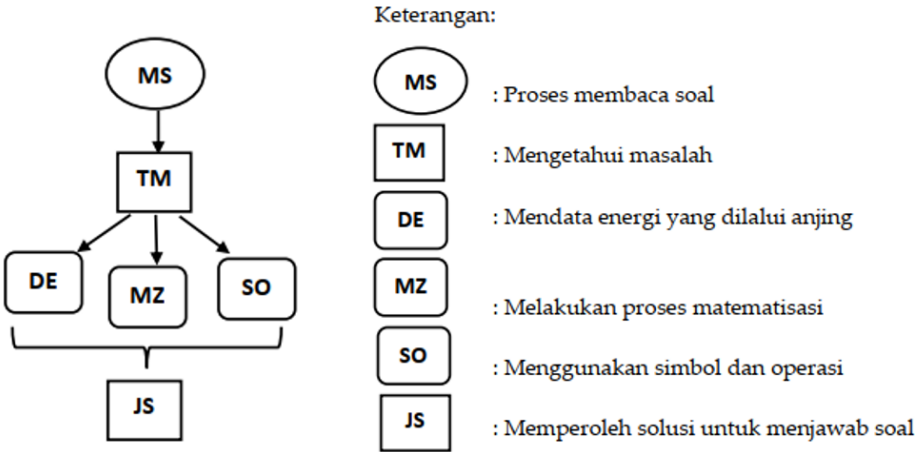
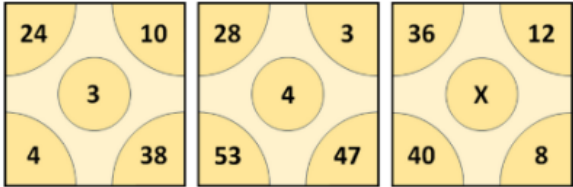


Figure 3: Diagram of Process in Solving Scientific Question.

Perhatikan gambar di bawah ini!



Nilai X yang tepat untuk mengisi gambar tersebut adalah

Figure 4: Question for Mathematics.

$$(4+38) : (24-10) = 3$$
$$42 : 14 = 3$$

Gambar 1

$$(53+47) : (28-3) = 4$$
$$100 : 25 = 4$$

Gambar 2

$$(40+8) : (36-12) = X$$
$$48 : 24 = X$$
$$2 = X$$

Figure 5: Student's Work for Mathematics Problem.

S: Yes, in the third box there was a number that you didn't know yet, you could find it by connecting the numbers that already existed

R: How did you find the number you were looking for (x value)?

S: I attempted to combine the numbers, until I found one that could apply to all the numbers in the middle of the box. So, the bottom number in one box was added and then divided by the difference in the number above in one box.

Based on the student’s outcome of the work and interview with the student on mathematics problem, the student could read and interpreted the problem. The student recognized that the numbers in the boxes were related. The student carried out mathematics by attempting to operate the numbers. The student could determine problem solving plan by finding a formula to find the number in the middle of the box. The student applied symbol and operation for addition, subtraction, and division. The following is a diagram of solving mathematics problem by the student.

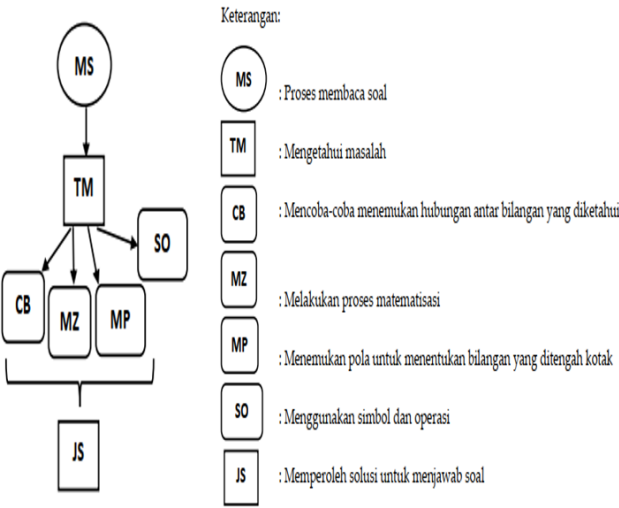


Figure 6: Diagram of Mathematics Problem Solving Process.

The following is an excerpt of interview with the student:

R: How did you answer this question?

S: I read the text first and then I found out the right answer in the text.

R: Where did you find the answer?

S: in the first paragraph, it was explicated that it was Palace Batik, then it was explicated that Batik was developed in the palace environment.

Based on the student’s work and interview with the student on questions related to art, the student could read and interpreted the problem, the student recognized where the answer for the question was. The student could provide arguments about the answer obtained. The following is diagram of solving question related to art by the student.

Vorstenlanden adalah sebutan untuk tanah kerajaan di Jawa Tengah bagian selatan. Kini Vorstenlanden menjadi tengara untuk bekas teritori Kasunanan Surakarta dan Kasultanan Yogyakarta. Batik Vorstenlanden sering disebut dengan batik keraton atau batik larangan. Batik Vorstenlanden berkembang di lingkungan Keraton, baik Yogyakarta maupun Surakarta yang keduanya merupakan penerus kekuasaan Kerajaan Mataram. Meskipun sama-sama merupakan batik keraton, motif batik Vorstenlanden tidaklah sama. Desain, warna, hiasan emas (prada), dan motif parangnya mempunyai perbedaan. Motif batik Yogyakarta lebih besar dan hampir semua dilapisi warna emas. Sementara itu, batik Surakarta motif cenderung kecil, desain luwes, terkesan kalem, dan hiasan emas hanya di bagian luar corak atau sebagian saja. Selain proses pembuatannya yang rumit dengan serangkaian ritual khusus, batik mengandung filosofi hidup dari warna dan motifnya. Warna cokelat menyimbolkan kerendahan hati, kesederhaan, dan membumi. Warna biru tua (wuhung) menyimbolkan ketenangan, kepercayaan, kelembutan, dan rasa kesetiaan. Warna putih melambangkan arah timur menunjukkan kesucian, ketenteraman hati, dan keberanian, serta sifat pemaaf. Sementara itu, warna hitam menyimbolkan kekuatan, kemewahan, sensualitas, misteri, dan kenggunaan.



Gambar 1



Batik parang Surakarta (ini) Batik parang Yogyakarta (jurnal)

Gambar 2

Batik-batik tersebut dibuat oleh para putri keraton dan pembatik ahli yang hidup di lingkungan keraton. Motif batiknya terlarang, tidak boleh digunakan oleh orang 'biasa.' Contohnya, motif batik parang barong, batik parang rusak, batik semen, batik lar, batik cemukiran berbentuk ujung lung, dan beberapa motif lainnya. Pakubuwono III menciptakan batik motif parang untuk perkawinan keluarga raja. Sementara itu, kerajaan Yogyakarta, motif larangannya adalah motif parang, huk, kawung, dan motif semen. Namun, dalam perkembangannya saat ini, batik sudah mengalami perubahan baik dari motif, desain, dan warna. Selain itu, pemakainya pun sudah tidak dibatasi

lagi. Namun, bagaimanapun perkembangannya, batik adalah doa dan harapan yang diembuskan pembatik sehingga kain-kain itu memiliki jiwa. Dan manusia membutuhkan doa untuk mengisi jiwa dan menapaki setiap langkah hidupnya. Mengapa batik Vorstenlanden disebut dengan batik keraton?

Figure 7: Questions about Art.

Karena batik Vorstenlanden berkembang dilingkungan keraton

Figure 8: Student's Work for Art Questions.

The following is an excerpt from an interview with the student:

R: How did you answer the question?

S: em.. I read the steps in the question again and again, then I settled the steps in the right order, namely 1,2,3,5,7, 4 and 6

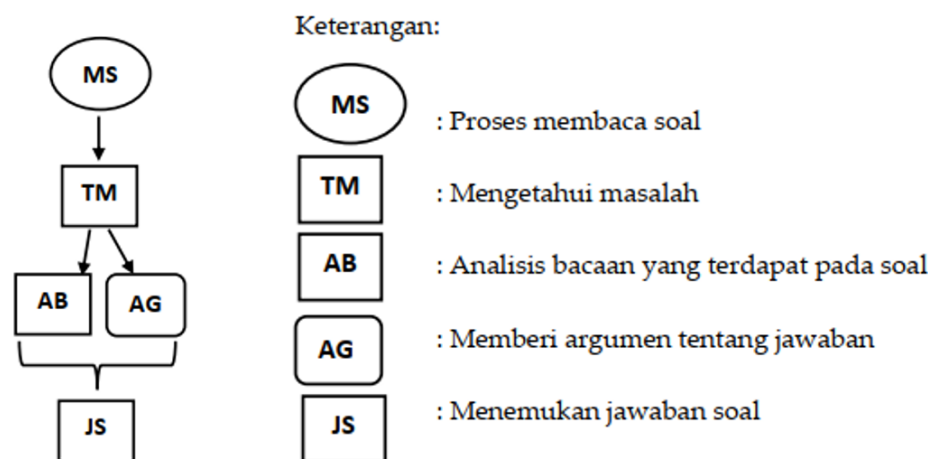


Figure 9: Diagram of Solving Process for Questions Related to Art.

Perhatikan pernyataan di bawah ini!

- 1) Buka Pengaturan (Settings) dan pilih Jaringan Internet (Network & Internet) di ponsel.
- 2) Nyalakan area bersinyal (hotspot) WiFi ponsel.
- 3) Kemudian pilih menu Hotspot & Tethering di ponsel kamu.
- 4) Kemudian, pilih jaringan WiFi.
- 5) Pastikan kamu sudah mengatur/mengetahui kata sandi untuk area bersinyal WiFi di ponsel kamu.
- 6) Jika terdapat nama area bersinyal ponsel milikmu, masukkan kata sandi untuk bisa mengaksesnya.
- 7) Setelah itu, kamu dapat membuka Pengaturan (Settings) dan memilih Jaringan Internet (Network & Internet) di laptop.

Urutan yang tepat pada pernyataan di atas tentang Thetering dari HP ke Laptop tanpa menggunakan kabel yaitu

Figure 10: Questions about Technology.

1 - 2 - 3 - 5 - 7 - 4 - 6

Figure 11: Student's Work for Technology Question.

R: had you ever switched from your phone to your laptop?

S: Yes, I had done that

Based on the outcome of the student's work and the interview with the student on question related to technology, the student was able to read and interpret the problem. The student answered the question based on experience with switching from smartphone to laptop without cable. The student could provide argument about the answer obtained. There were students who were reversed in determining the order the switching steps. The following is diagram of solving scientific question by the student.

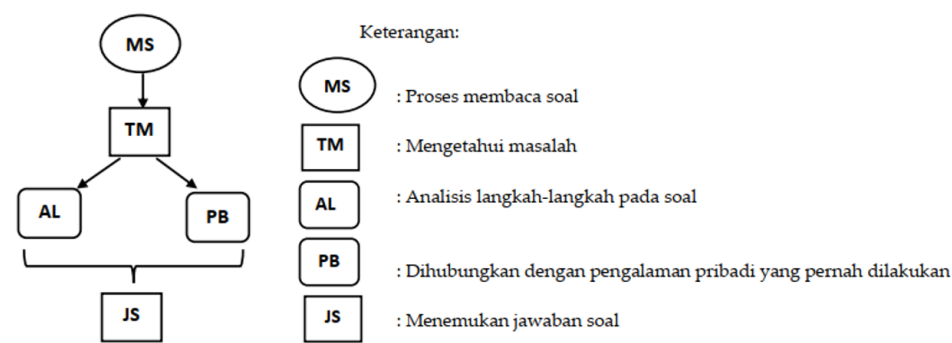


Figure 12: Diagram for Solving Problem Process Related to Technology.

3.2. Discussion

Based on the outcome of the student’s work and interview about science, not all indicators of literacy and numeracy ability were achieved. Indicators which were not achieved were representation and applying mathematical devices[10], [27]. For mathematics question, the indicators for representation and applying mathematical devices were also not achieved. Meanwhile, for questions related to art and technology, several indicators, including representation, mathematization, and applying mathematical device, were not acgieved. This was not in accordance with the research outcome which showed the student with high ability was able to implement the mathematical understanding to solve problem so that she had achieved the indicators of literacy and numeracy ability. Several literacy and numeracy indicators were not achieved due to the form of questions. The process of solving STEAM based questions by the student with various strategies according to the type of question[28], [29]. The student did not write down the information on the question and what was asked but when the interview was conducted, the student was able to mention the information on the question, this was in accordance with the previous research [21], [22].

4. Conclusion

Based on the outcome of data analysis, it can be concluded that the student is able to communicate, mathematize, think logically, and provide arguments. The student can also design problem solving plan, can use symbol and operation. The student created error in working on question related to technology. There were second and third step that were reversed. Several literacy and numeracy indicators were not achieved due to

the form of questions. The process of solving STEAM based questions by the student with various strategies according to the type of question.

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