



www.ijemst.net

An Analysis of the Statistical Literacy of Middle School Students in Solving TIMSS Problems

Dwi Priyo Utomo 
Universitas Muhammadiyah Malang, Indonesia

To cite this article:

Utomo, D. P. (2021). An analysis of the statistical literacy of middle school students in solving TIMSS problems. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, 9(2), 181-197. <https://doi.org/10.46328/ijemst.1552>

The International Journal of Education in Mathematics, Science, and Technology (IJEMST) is a peer-reviewed scholarly online journal. This article may be used for research, teaching, and private study purposes. Authors alone are responsible for the contents of their articles. The journal owns the copyright of the articles. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of the research material. All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations regarding the submitted work.



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.



International Journal of Education in Mathematics, Science, and Technology (IJEMST) affiliated with
[International Society for Technology, Education, and Science \(ISTES\): www.istes.org](http://www.istes.org)

An Analysis of the Statistical Literacy of Middle School Students in Solving TIMSS Problems

Dwi Priyo Utomo

Article Info

Article History

Received:

11 May 2020

Accepted:

05 February 2021

Keywords

Literacy

Statistics

Details

TIMSS

Abstract

The aim of this research is to describe and explore the statistical literacy of middle school students in solving the Trends in International Mathematics and Science Study (TIMSS) problems. This research utilized the qualitative approach, with the research type being descriptive-explorative. The research subjects consisted of 6 Grade 8 students from Muhammadiyah Middle School 6 of Malang in Malang Regency, Indonesia. Two students had a high mathematical ability, two others had a moderate ability, and the last two had low ability. The data analysis technique applied in this research was the interactive technique, composed of data reduction, data presentation, and conclusion drawing. The data collection for this research involved testing and interviews. The utilized test consisted of an adaptation of TIMSS for the materials of data and opportunities. Interview guidelines were used to support the data collected from the test. The research results indicated that low-ability, moderate-ability, and high-ability students were similar in that they were able to understand the problems. The difference among students of across different categories lies in data processing and data communication. Students with high mathematical abilities could process data and communicate them in detail, while those with moderate abilities could process data and communicate them but not in detail, and students with low abilities could only explain the mathematical problems.

Introduction

Literacy comes from the Latin word *littera* (letter) and in English it refers to the mastery of writing systems (Mahdiansyah & Rahmawati, 2014; Budiharso, 2018; Turan & Matteson, 2021). Literacy can be understood as the ability of a person to read and write (Mainali, 2021; Suragangga, 2017; Permatasari, 2015). Literacy is a life skill and an important foundation for education, which covers the abilities to understand, read, write, and count (Mahdiansyah & Rahmawati, 2014). Research conducted by *The World's Most Literate Nations* that involved the analysis and examination of literacy levels in 61 countries found that the reading habit of Indonesian people ranked 60 (Miller, 2016). Indonesia only placed 1 rank above Botswana and 1 rank below Thailand, which was ranked 59. It can be concluded that the low level of literacy in Indonesia causes the

people to easily accept news whose accuracy has not been confirmed.

Students are expected to not only possess the abilities to read, understand, and count, but also to think critically and to reason logically (Bursal & Polat, 2020; Sari, 2015; Solikhah & Budiharso, 2020a). Mathematical abilities also involve the identification, understanding, and processing of information in order to be followed with making the right decision for solving a problem. This ability is known as the mathematical literacy (Astuti, 2018; Sari, 2015; Stacey, 2011; Syahlan, 2015; Wijaya, 2016; Turan & Matteson, 2021). Results of the 2011 the Trends in International Mathematics and Science Study (henceforth, TIMSS) showed that Indonesia was ranked 38 among 45 countries, with an average score of 386. Next, in 2015, the mathematical learning achievements of Indonesian students ranked 44 among 49 countries (Mulis, Martin, Foy, & Hooper, 2016; Widayanti & Kolbi, 2018; Sidauruk & Ratu, 2018). These results describe the considerably low level of mathematical literacy of Indonesian students. The results indicate that there are serious problems in the learning of mathematics.

The TIMSS mathematical problems mostly consist of multiple-choice problems (Rizta, Zulkardi & Hartono, 2013). In addition, TIMSS model of problems demands students not only to make use of formulas but also require them to use their reasoning abilities in problem-solving (Rizta *et al.*, 2013; Turan & Matteson, 2021). TIMSS for the subject of mathematics has an evaluation framework that is divided into two parts (Sidauruk & Ratu, 2018; Cahyatia & Kriswandani, 2017): the first part is related to mathematical knowledge, consisting of Numbers, Geometric Shapes and Measurement, Algebra, and Data Display, while the second part is related to the cognitive dimensions of Knowing, Applying, and Reasoning. The TIMSS contents have been covered in the core competencies and basic competencies for K-13 at the middle school level in Indonesia, and the contents also mention competencies to be achieved, namely, the spiritual competence, social attitudes, knowledge, and abilities (Nasir, 2020; Solikhah & Budiharso, 2019; Turan & Matteson, 2021). TIMSS problems at the middle school level measure the level of student ability from simply finding out facts and procedures and then using them in solving simple problems to dealing with problems that require a high level of reasoning (Adilah & Cahyono, 2016; Erbilgin, 2017; Rumiati & Wardhani, 2011).

Statistics plays an important role in all aspects of human activities. According to Kusmanto & Akbar (2017), statistics is one of the fields of knowledge that plays an important role in the development of science and technology. The importance of statistics in everyday life leads to increased attention on statistical literacy. In Indonesia, statistics is one of the topics studied in mathematics from elementary school to higher education (Hafiyusholeh, Budayasa, & Siswono, 2017; Rumahlatu & Takaria, 2016). At the K-13 level, statistics has been taught at the elementary level with the materials covering basic statistics, general statistics (simple collection and display of data), and statistics and probability (including simple statistical methods), as well as at the middle school level to the high school level. Based on the content of materials for learning statistics, it becomes unavoidable that statistics has been perceived by many students as a difficult and unpleasant subject.

In the field of mathematics instruction, there is currently a hot discussion on statistical literacy; however, this topic has not yet been researched further (Martadiputra, 2002; Bursal & Polat, 2020). Study results have illustrated that globally, the skills of statistics, reasoning, and thinking among junior high school students still

need to be considered more seriously for a more meaningful learning of statistics (Hafiyusholeh, 2015). Understanding of data is an important matter for all people in the society, particularly students from elementary to higher levels (Budiharso & Tarman, 2020; Turan & Matteson, 2021). Students must possess the ability to understand data in order to be able to act intelligently toward quantitative information around them, such as by reading, interpreting, and making conclusions from sets of data (Dasari, 2006; Hafiyusholeh, Budayasa & Siswono, 2017; Tadeu et al., 2019). Many problems in statistics do not have a single mathematical solution; they are initiated by a question that is the result of an opinion and that is then supported by findings and assumptions. This answer needs to be evaluated with reasoning abilities, appropriateness of the proposed method, and the natural quality and proof of the utilized data. People who are active, critical, and motivated by information can be considered to already possess statistical capacity and skills (Nikiforidou, Lekka, and Pange, 2010).

According to the explained background above, several studies have been conducted. A research conducted by Hafiyusholeh, Budayasa, and Siswono (2017) focused on high school students with high mathematical abilities with prior reading of statistical data and in paying attention to and understanding a provided chart or diagram. A research by Johannis & Dominggus (2016) focused on increasing student abilities to read statistical data with the application of a collaborative learning method, i.e. the Collaborative Problem Solving Model supported with the literacy media model (CPS-ALM). A research by Khaerunnisa & Pamungkas (2017) focused on examining the statistical literacy of mathematics-major students through the three indicators of statistical literacy abilities in formulating problems; using concepts, facts, procedures, and reasoning; and interpreting problems. A research by Kusmanto & Akbar (2017) led to the conclusion that the statistical literacy of high school-level students in the City of Cirebon is categorized as moderate, which is affected by knowledge, learning motivation, student's psychology, school facilities and infrastructure, influence of the subject teacher, and school environment.

Based on previous studies, the difference in focus for this research is on the ability to understand problems, process data, and interpret data regarding the ability of middle school students to solve TIMSS problems. According to this explanation, the problem that is examined in this research is "How is the statistical literacy ability of middle school students in solving TIMSS problems?"

Review of Literature

Literacy can be stated as the ability to read and write, and is often related to counting or arithmetic (Permatasari, 2015; Suragangga, 2017; Irianto & Febrianti, 2017; Bursal & Polat, 2020). Literacy is also stated as the ability of a person in understanding, utilizing, interpreting, and reflecting written text in order to achieve necessary objectives (Bernardo-Hinesley, 2020; Harsiati, 2018; Indah, Mania & Nursalam, 2016; Keefer & Haj-Broussard, 2020). Literacy can be understood as the conscience within a person to think critically and creatively, and is founded by the written tradition (Maryati & Priatna, 2018; Gibbs, 2020). Literacy supports the abilities of a person in utilizing information and developing knowledge intelligently in order to be beneficial for society (Irianto & Febrianti, 2017; Johnson, 2020; Solikhah & Budiharso, 2020b; Timberlake, 2020).

Statistics is the field of study that involves methods of data collection, management, display, and analysis in the form of charts or tables (Dasari, 2006; François, Monteiro, & Vanhoof, 2013; Hafiyusholeh *et al.*, 2017). Statistics plays an important role in the development of science, particularly in the field of mathematics (Akbar *et al.*, 2017). Statistical literacy is the ability to understand statistical words, symbols, and terms; the ability to interpret charts and tables; and the ability to read and understand statistics in the news, media, policies, and others (Callingham, Watson & Donne, 2008; Schield, 2011; Carmichael & Hay, 2010; Hidayah, 1998). Statistical literacy also includes the ability to understand concepts, terms, and symbols, and covers the understanding of probability as a measurement of uncertainty (Ben-zvi and Garfield, 2004). It has also been expressed that a person who possesses good statistical literacy will also be able to read and understand well about the various aspects of life (Hafiyusholeh, 2015). Statistical literacy may be defined as the ability to interpret and evaluate data (Carmichael and Hay, 2010). In this context, the emphasis on literacy is placed on the understanding of literacy as the basic ability of a person in reading, writing, and counting. A person can be said to be literate when the person is able to understand what has been read and then to communicate that through the words of the person, whether in writing or speech (Salinas-Vasquez, Varela, Martinez, et. al. 2020).

The process of statistical literacy in this research covers understanding the problem, processing the data, and interpreting the data. The indicators in this research were adapted from a study by Schield (2011). Table 1 displays the indicators of the statistical literacy process in this current research.

Table 1. Indicators of Statistical Literacy Ability

Aspect	Indicator
Problem Understanding	<ol style="list-style-type: none"> 1. Able to write down what is known from and what is being asked in the problem 2. Able to explain what is known from and being asked in the problem
Data Processing	<ol style="list-style-type: none"> 1. Able to execute data processing according to the strategy 2. Able to explain the strategy for solving the problem
Data Interpretation	<ol style="list-style-type: none"> 1. Able to write a conclusion based on the assigned problem 2. Able to communicate the interpretation results of the obtained data

Note: Adapted from Schield (2011)

Based on the indicators in Table 1, the categorization for the statistical literacy of students is given in Table 2. TIMSS is an international-scale comparison study that is focused on the evaluation of student achievement, and was first conducted in 1995 (Grønmo, Lindquist, Arora & Mullis, 2015; Provasnik *et al.*, 2012). TIMSS was designed to broadly harmonize mathematics and science curricula in participating countries. The evaluation basis of TIMSS is classified in two domains, which are the content domain and the cognitive domain, and are inescapably related to the curricula that apply in each country (Rumiati & Wardhani, 2011; Budiharso & Tarman, 2020; Bursal & Polat, 2020). The content domain is composed of the four categories of numbers, algebra, geometry, and data and probability, while the cognitive domain is composed of knowing, applying, and

reasoning (Sari, 2015; Waters & Hensley, 2020). This research utilized adaptations of TIMSS problems. The test problems used in this research were taken from materials related to data and probability with the cognitive domain category of application, but prior to being used, the problems were first adjusted to the curriculum applied in Indonesia.

Table 2. Criteria and Categories of Statistical Literacy Ability

Criteria of Statistical Literacy Skills	Category of Statistical Literacy Ability
Unable to write and explain what is known from and being asked in the problem, or only able to write and explain what is known and being asked.	Poor
Able to write and explain what is known and being asked, and able to write and explain the strategy for data processing, but unable to write and communicate the conclusion of the solution.	Fair
Able to write and explain what is known and being asked, able to write and explain the strategy for data processing, and able to write and communicate the conclusion of the solution, but not in detail.	Good
Able to write and explain what is known and being asked, able to write and explain the strategy for data processing, and able to write and communicate the conclusion of the solution in detail.	Very Good

Methods

This research used the qualitative approach designed as a descriptive-explorative, which is intended to uncover information to a greater depth and to describe a condition. This research collects written or spoken information from the subjects under study. This research applied qualitative approach where data of narrative texts were the focus of the analysis. The subjects of this research were 6 students of Grade 8 of Muhammadiyah Middle School 6 in Dau, Malang Regency, Indonesia. The 6 students were selected on the basis of their abilities as demonstrated in the evaluation results from the previous semester. Based on the evaluation, the students were categorized as high-ability, moderate-ability, and low-ability students. For each skill level category, two students were selected as subjects.

The data collection process in this research involved two methods. The first of these was testing. The test utilized in this research consisted of adapted TIMSS problems in the subject of data and probability that had been adjusted to core and basic competence as well as indicators for the subject of statistics for Grade 8 in middle school, and these problems were composed to find out the information about the statistical literacy skills of students. Before the test problems were utilized, the test problems were first validated by a certified expert team. The second method is interviews. Interviews were conducted to obtain information about the work performed by students from the written test. An interview guideline was created as a reference in conducting the interview process in order to not miss any information and to make the interview process more focused.

The data was analyzed using the interactive technique, which is composed of the three stages of data reduction,

data presentation, and drawing conclusions. Data reduction was performed by the researcher, which was directed to the processes of selecting, summarizing, and focusing on important data. Data presentation was conducted by displaying the results of student work on the statistical literacy skill test and the interview results that had been analyzed, then composing a narrative text to include them. The final stage of drawing conclusions was performed by comparing the results of student answers and interviews in order to be able to make an inference to describe and explore the statistical literacy skill of students.

Results

Group of Low-Ability Students

The group of students with low mathematical ability consisted of 2 subjects, and they are identified as Student 1 and Student 2. In accordance with the research process, the subjects were assigned test problems for statistical literacy ability, and their results appear in Figure 1.

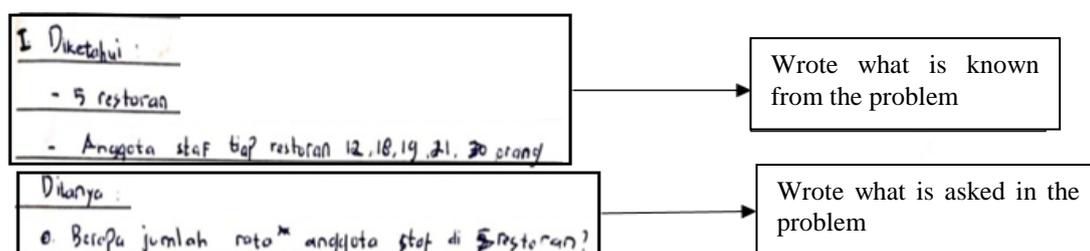


Figure 1. Response of Student 1 in Understanding the Problem

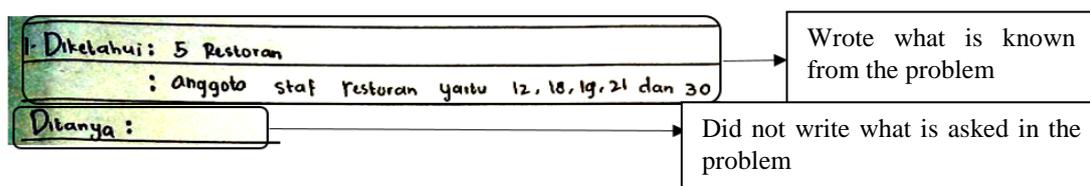


Figure 2. Response of Student 2 in Understanding the Problem

Figures 1 and 2 show that the students performed the process of understanding the problem by writing down what is known from the problem assigned, and the results indicated that the subjects could understand the point of the problem. Based on the interviews, it could be seen that one of the subjects could already understand the point by explaining the information that could be taken, i.e. the five restaurants and the staff members in each of the five restaurants. Understanding the point of the problem allows the subjects to solve the problem more easily. The following is an excerpt from an interview:

- T : "Why did you write this?"
 S : "Well, this is what is known from the problem."
 T : "What information did you use to be able to solve the problem?"
 S : "There are 5 restaurants and the staff members are 12, 18, 19, 21, and

30 people.”

T : “What can you understand from the problem?”

S : “So, what the problem asks is the average number of staff members.”

Below is the statistical literacy process of Students 1 and 2 in processing the data.

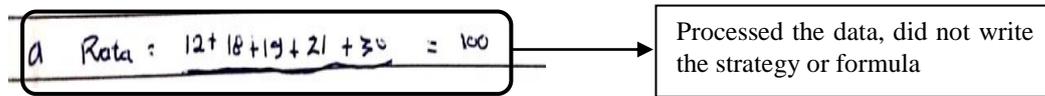


Figure 3. Response of Student 1 in Processing the Data

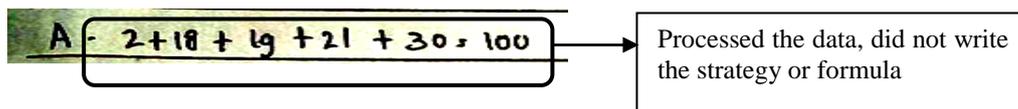


Figure 4. Response of Student 2 in Processing the Data

According to the answer sheets of the subjects with low ability, the subjects were not yet able to complete the problem-solving strategy and to perform the correct processing strategy according to what is asked in the problem. This could be seen in the answers, in that the subjects only wrote down the total number of staff members in the five restaurants and did not continue the problem-solving process. As such, the subjects are not yet able to solve the problem and explain the appropriate strategy for solving the assigned problem. According to the results of an interview, the student forgot the formula that had to be used in order to solve the problem.

Below is the statistical literacy process carried out by Students 1 and 2 in interpreting the data.

Figure 5. Response of Student 1 in Interpreting the Data

Figure 6. Response of Student 2 in Interpreting the Data

Based on the answers from the low-ability students subjects with low ability, the subjects did not write down conclusions based on the process of solving the assigned problem. The subjects were not yet able to write and narrate the obtained data; in other words, the subjects are not yet able to interpret the data. This could be seen in that according to an interview, one of the subjects appeared to be confused in explaining the conclusion obtained from solving the problem and could not narrate the problem-solving results. The following is an excerpt from an interview:

T : “Why did you not write the conclusion of the problem?”

S : “I’m sorry, I forgot.”

P : “What information did you get from solving the problem?”

S : “The number of restaurant staff members is 100.”

Based on the descriptions above and the criteria in Table 2, it is apparent that the low-ability students have a poor literacy ability. The students could only write about and explain what is known from and asked in the problem. In other words, the students of low ability could only understand the problem but could not process the data and interpret the data.

Group of Moderate-Ability Students

The group of students with moderate mathematical ability consisted of 2 subjects, and they are identified as Student 3 and Student 4. In accordance with the research process, the subjects were assigned test problems for statistical literacy ability, and their results can be seen below:

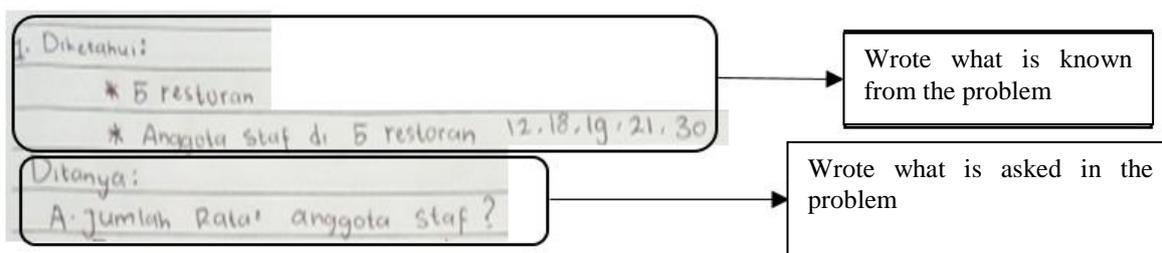


Figure 7. Response of Student 3 in Understanding the Problem

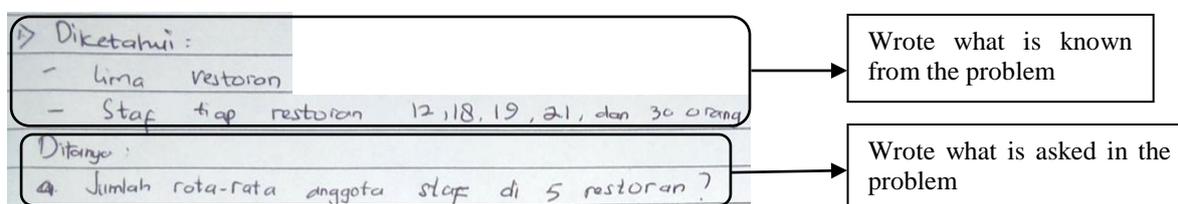


Figure 8. Response of Student 4 in Understanding the Problem

Based on the results of student work as in Figures 7 and 8, the students performed the process of understanding the problem by writing down what is known from the assigned problem. This could be seen as the subjects wrote down the information that there are five restaurants along with the number of staff members in each. The subjects correctly wrote down the assigned information from the problem, and during the interviews, the subjects could explain, know about, and understand what they wrote. The following is an excerpt from an interview:

- T : "Why did you write this?"
- S : "Well, I wrote what is known from and asked in the problem."
- T : "What information did you use to be able to solve the problem?"
- S : "What is known is that there are 5 restaurants and the staff members in the 5 restaurants are 12, 18, 19, 21, and 30 people."
- T : "What can you understand from the problem?"
- S : "From the problem, what is asked is the average number of staff members in the 5 restaurants."

Below is the statistical literacy process of Students 3 and 4 in processing the data.

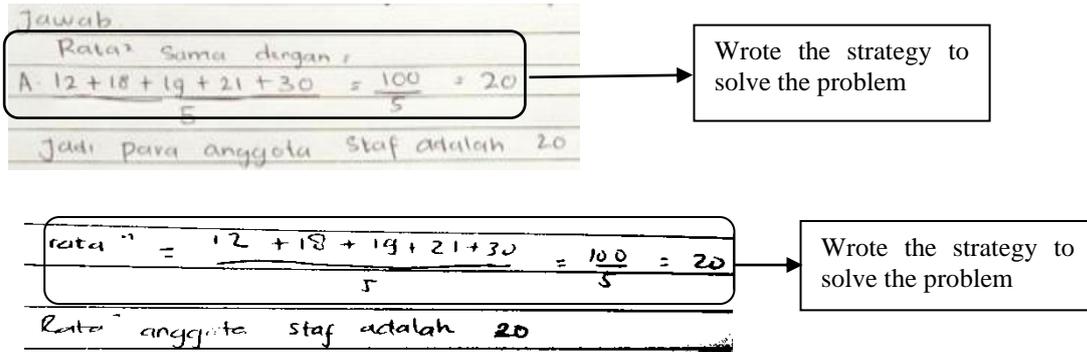


Figure 10. Response of Student 4 in Processing the Data

According to the answers from the subjects with moderate ability, the problem-solving strategy carried out by the subjects succeeded in solving the problem correctly and the subjects had carried out the appropriate processing strategy according to what was asked in the problem. This could be seen in the answers, where the subjects wrote down the formula as the strategy to solve the problem and could also solve the problem correctly. This was also in line with the results of the interviews, in that the subjects could accomplish and explain the appropriate strategy in order to solve the assigned problem.

Below is the statistical literacy process carried out by Students 3 and 4 in interpreting the data:

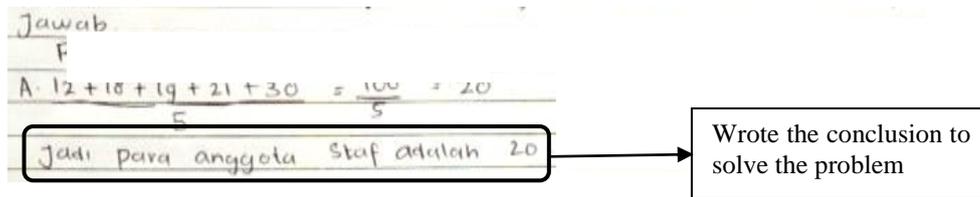


Figure 11. Response of Student 3 in Interpreting the Data

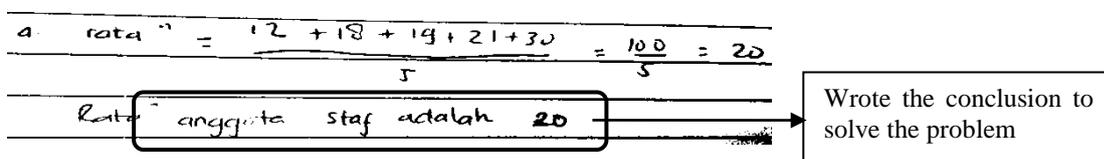


Figure 12. Response of Student 4 in Interpreting the Data

Based on the answers from the moderate-ability subjects, the subjects wrote down the conclusion correctly based on the problem-solving process and the information taken from the assigned problem. According to the interview results, the subjects appeared to be able to narrate the conclusion from solving the assigned problem, which is that the average number of staff members from the five restaurants is 20. The following is an excerpt from the interview with one of the subjects:

- T : "Why did you write this down?"
- S : "I wrote this because this is the conclusion of the solution."
- T : "What information did you get from solving the problem?"
- S : "The average number of members of the 5 restaurants is 20."

T : "20 what?"
 S : "Well... 20 staff members."

Based on the descriptions above and the criteria in Table 2, it is apparent that the moderate-ability students have a good literacy ability. The students, in addition are able to write down and explain what is known from and asked in the problem, could also write down and explain the data processing. In addition, the students could write down the conclusion and communicate the results from interpreting the data. However, the students were not able to write and communicate in detail. In other words, the moderate-ability students could understand the problem, process the data, and interpret the data, but could not communicate the results of data interpretation with particular details.

Group of High-Ability Students

The group of high-ability students consisted of 2 subjects, identified as Students 5 and 6. Below are the answer sheets of the subjects:

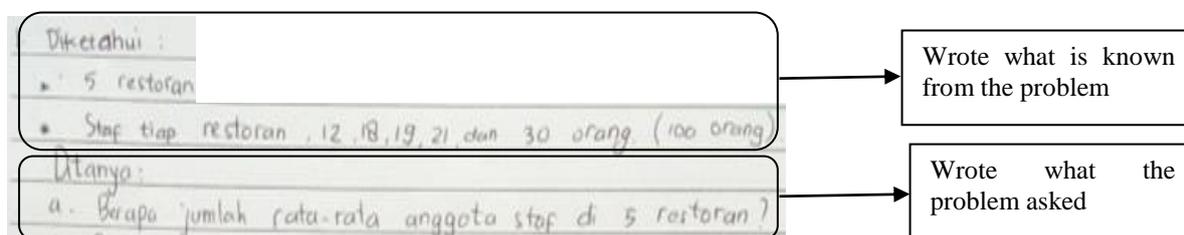


Figure 13. Response of Student 5 in Understanding the Problem

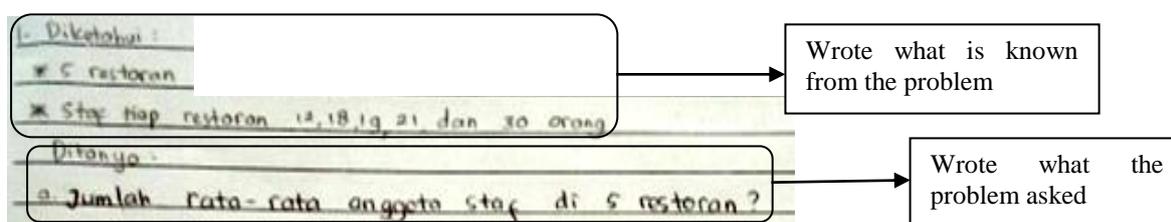


Figure 14. Response of Student 6 in Understanding the Problem

Based on the results of student work as in Figures 13 and 14, the students performed the process of understanding the problem by writing down information from the assigned problem, which is that there are five restaurants with the number of staff members in each, and writing down what is asked in the problem. The results from the interview showed that the subjects could explain the information that can be taken to solve the problem. The following is an excerpt from the interview with a subject:

T : "Why did you write this?"
 S : "I wrote this because this is what is known from and what is asked in the problem."
 T : "What information did you use to be able to solve the problem?"

- S : “The information that I got from the problem is that there are five restaurants, with the number of staff members in each restaurant being 12, 18, 19, 21, and 30 people.”
- T : “What can you understand from the problem?”
- S : “What the problem asked me was what was the average of the total number of staff members in the 5 restaurants.”

Below is the statistical literacy process of Students 5 and 6 in processing the data.

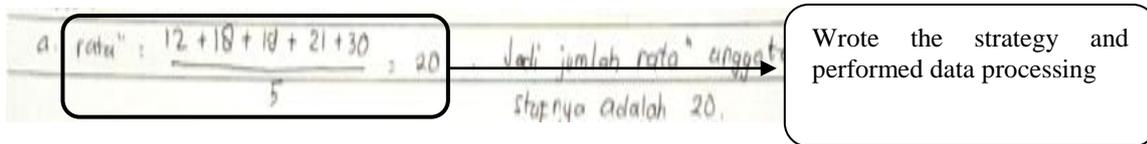


Figure 15. Response of Student 5 in Processing the Data

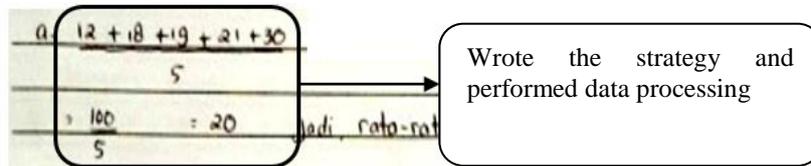


Figure 16. Response of Student 6 in Processing the Data

According to the above answers, the high-ability subjects could write down the problem-solving strategy as the formula for the average or mean, and the subjects also appeared to be able to perform data processing according to the written strategy, and the resulting answer from the problem-solving process is correct. This was in line with the results of the interviews, in that the subjects discovered the formula that had to be used to find the average as was asked in the assigned problem: “I used the formula for an average, so I added all the members of the 5 restaurants and then I divided it by 5.”

Below is the statistical literacy process carried out by Students 5 and 6 in interpreting the data.

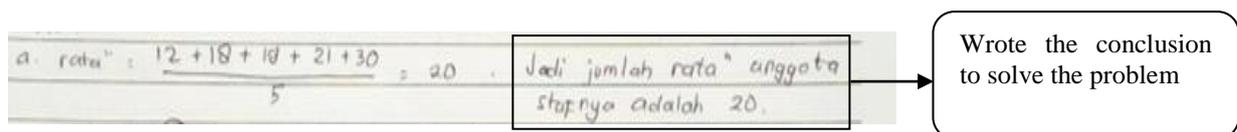


Figure 17. Response of Student 5 in Interpreting the Data

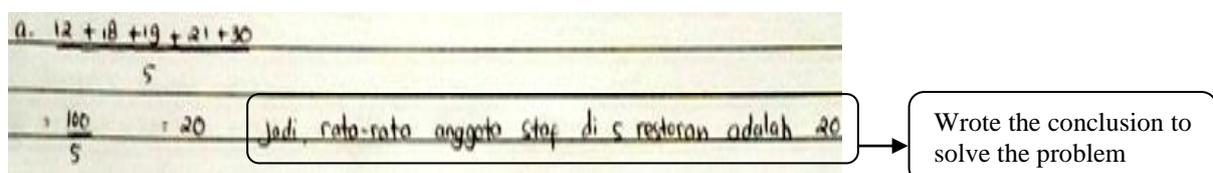


Figure 18. Response of Student 6 in Interpreting the Data

Based on the answers above, it could be seen that the high-ability subjects could write down the conclusive results from solving the assigned problem, and according to the interview results, the subjects could narrate well and clearly the resulting conclusion from the problem. The following is an excerpt from the interview with one of the subjects:

- T* : “What information did you get from solving the problem?”
- S* : “Here, there are five restaurants with the number of staff members being 100, so to look for the average, I divided the 100 members by 5, and so the average number of staff members in the 5 restaurants is 20 people.”

Based on the descriptions above and the criteria in Table 2, it is apparent that the high-ability students have a very good literacy ability. The students, in addition are being able to write down and explain what is known from and asked in the problem, could also write down and explain the data processing results. The high-ability students could write down the conclusion and communicate the results. Further, the high-ability students could write and communicate in a detailed manner. In other words, the high-ability students could understand the problem, process the data, and interpret the data. Moreover, the high-ability students could communicate the results of data interpretation with particular details.

Discussion

Based on the results of the research, the subjects categorized as low-ability students had been able to understand the assigned problem, but the subjects had not been able to write down and explain the strategy for processing the data and had not been able to interpret the data obtained from solving the assigned problem. According to these results, the obtained information is that the low-ability subjects are still at the stage of understanding the assigned problem. This is in line with the research by Hanafi, Wulandari & Ni'mah (2019), who indicated that students with low initial mathematical ability possess a low evaluation ability level. Yet this is in contrast with the research by Ratnaningtyas (2016), wherein low-ability subjects were able to fulfill the indicators of critical thinking, which are the ability to differentiate useful or useless information as well as the ability to analyze characteristics of a certain problem. In teaching mathematics, representation is of prominent to present as for the major topic, the mobilized knowledge in multiple representation, symbolization, to grasp abstract subjects, and one of the standard curriculum. The evidence shows that the low level students can benefit from the use of representation, symbols, such as graphs and lines in the area of TIMMS (Mainali, 2021; Turan & Matteson, 2021; Bursal & Polat, 2020; Grønmo, Lindquist, Arora & Mullis, 2015; Provasnik *et al.*, 2012).

Meanwhile, students categorized as moderate-ability subjects, were able to understand the problem as well as to perform the strategy for processing the data and to explain correctly, and ultimately to interpret the results of solving the assigned problem. Based on the results of the research, the students categorized high-ability subjects had fulfilled the indicators of statistical literacy, which is being able to understand the problem well, to process data from the assigned problem, and ultimately to interpret the data of the resulting solution. This is in line with the research by Ratnaningtyas (2016), which shows that fair-ability subjects were able to fulfill the indicators of

critical thinking, which are the ability to differentiate useful or useless information, the ability to analyze the problem, the ability to make decisions or conclusions, the ability to think openly, and the ability to evaluate. This finding confirms the previous study results that emphasize that in TIMSS contexts, representations are useful for fairly competence students to handle problems on the abstract into concrete objects with the helps of symbols, graphs and lines (Mainali, 2021; Turan & Matteson, 2021; Rizta, Zulkardi & Hartono, 2013). The problems in TIMSS strongly indicate that problems on mathematic teaching that relate to the representation has been faced by most of the students with fair competence in mathematic achievement (Bursal & Polat, 2020; Mulis, Martin, Foy & Hooper, 2016; Widayanti & Kolbi, 2018; Sidauruk & Ratu, 2018).

The high competence students indicated in this study are characterized by the flow of identifying complex objects to solve. In agreement, the high ability students have the self-confidence, perseverance, and self-autonomous learning. The attitude motivates to make any effort to overcome the obstacles and practices when complex cases in mathematical issues are encountered (Mulis, Martin, Foy & Hooper, 2016; Widayanti & Kolbi, 2018; Sidauruk & Ratu, 2018; Wijaya, 2016; Turan & Matteson, 2021). The high competence students can easily proceed and adapt the new cases that are deemed complicated through the multiple representation (Astuti, 2018; Sari, 2015; Stacey, 2011; Syahlan, 2015; Mainali, 2021; Bursal & Polat, 2020).

The differences between the low-ability, moderate-ability, and high-ability subjects lie in processing data and narrating data; high-ability subjects were able to explain in complete detail, while moderate-ability subjects were able to explain briefly about the obtained information but not in full detail, and low-ability subjects could only explain about the assigned problem. A research by Karimah (2017) showed that students according to the abilities they possess will differ in their understanding of the assigned data. In brief, the evidence shows that the ability of low level students limits their mastery to understand the assignment only with restricted efforts, middle competence students use their cognitive representation to solve their problems and high level students use their abstract representation to link with the problems being identified for alternate solutions ((Mainali, 2021; Turan & Matteson, 2021; Bursal & Polat, 2020; Grønmo, Lindquist, Arora & Mullis, 2015; Provasnik *et al.*, 2012).

In summary, the low-ability, moderate-ability, and high-ability subjects share a similarity in that they were able to understand the assigned problem. The difference in statistical literacy abilities could also be seen directly through the interviews when the researcher posed the questions (Delmas, Garfield, Ooms & Chance, 2007). The characteristics of TIMSS problems are that they are often linked with the context of everyday life, and the contextual content demands understanding, argumentation, and creativity in the problem-solving process. The administration of TIMSS problems has the objective to increase the literacy level of students in Indonesia and to start preparing students with international-standard problems (Rumiati & Wardhani, 2011; Mainali, 2021; Turan & Matteson, 2021; Bursal & Polat, 2020; Grønmo, Lindquist, Arora & Mullis, 2015; Provasnik *et al.*, 2012).

Conclusion

Based on the results of the research on testing the statistical literacy abilities of middle school students, it can be

concluded that low-ability, moderate-ability, and high-ability students are similar in that they are able to understand the assigned problem, but students with low ability are not yet able to fulfill the indicator criteria for processing data and interpreting results. Thus, low-ability students are categorized to have poor literacy ability. Moderate-ability students are categorized as having good literacy ability because they are able to understand the assigned problem, process the data, and interpret the results. Meanwhile, high-ability students are categorized as having very good literacy ability. This is because students with high mathematical ability, in addition to being able to understand the assigned problem, to process the data, and to interpret the results, are also able to write conclusions and communicate those conclusions in a detailed manner.

References

- Adilah, N., & Cahyono, B. (2016). Analisis Soal Dalam Buku Siswa Matematika Kurikulum 2013 Kelas VIII Semester I Berdasarkan Dimensi Kognitif Dari TIMSS. *Jurnal Review Pembelajaran Matematika*, 1(1), 86–98.
- Akbar, R. O., MZ, N. N., & Kusmanto, H. (2017). Analisis Tingkat Kemampuan Literasi Statistik Siswa SMA Sederajat Berdasarkan Mutu Sekolah. *PROCEDIAMATH*, 1, 33–47.
- Astuti, P. (2018). Kemampuan Literasi Matematika dan Kemampuan Berpikir *Tingkat Tinggi*, 1, 263–268.
- Bernardo-Hinesley, S. (2020). Linguistic Landscape in Educational Spaces. *Journal of Culture and Values in Education*, 3(2), 13-23. <https://doi.org/10.46303/jcve.2020.10>
- Ben-zvi, D., & Garfield, J. (2004). The Challenge of Developing Statistical Literacy, *Reasoning and Thinking*, (June 2014). <https://doi.org/10.1007/1-4020-2278-6>
- Budiharso, T. & Tarman, B. (2020). Improving Quality Education through Better Working Conditions of Academic Institutes, *Journal of Ethnic and Cultural Studies*, 7(1), 99-115. <http://dx.doi.org/10.29333/ejecs/306>
- Budiharso, T. (2018). Pembelajaran Menulis Esai dalam Disertasi: Kajian Metakognitif. *CENDEKIA: Jurnal Pendidikan dan Pembelajaran*, 12(1), 141-152. <https://doi.org/10.30957/cendekia.v12i2.535>.
- Bursal, M. & Polat, F. (2020). Middle school students' line graph skills and affective states about common graph types used in science courses. *International Journal of Education in Mathematics, Science and Technology (IJEMST)*, 8(4), 290-303.
- Cahyatia, A. M. D., & Kriswandani. (2017). Lapisan pemahaman konsep matematika dalam menyelesaikan soal timss bagi siswa smp kelas viii. *Jurnal Inovasi Pendidikan dan Pembelajaran Matematika*, 3(2), 83–97.
- Callingham, R., Watson, J. M., & Donne, J. (2008). Influencing Statistical Literacy In The Middle Years Of Schooling: The First Year Of The Statsmart Project. International Congress on Mathematical Education.
- Carmichael, C., & Hay, I. (2010). Developmental Changes In Australian School Students' Interest For Statistical Literacy. *International Association of Statistical Education*, 8(11), 8–11.
- Dasari, D. (2006). Kemampuan Literasi Statistis dan Implikasinya dalam Pembelajaran. Seminar Nasional Matematika dan Pendidikan Matematika, 1–9.
- Delmas, R. C., Garfield, J. B., Ooms, A., & Chance, B. L. (2007). Assessing Students' Conceptual Understanding After A First Course *In Statistics*. *Statistics Education Research Journal*, 6(2), 28–58.
- Erbilgin, E. (2017). A Comparison of The Mathematical Processes Embedded in The Content Standards of

- Turkey and Singapore. *Research in Social Sciences and Technology*, 2(1).
<https://doi.org/10.46303/ressat.02.01.3>
- François, K., Monteiro, C., & Vanhoof, S. (2013). Mathematical And Statistical Literacy : an analysis based on PISA results. *Revista de Educação Matemática e Tecnológica Iberoamericana*, 4(1), 1–16.
- Gibbs, B. (2020). Critical teaching in classrooms of healing: Struggles and testimonios. *Journal of Curriculum Studies Research*, 2(1), 95-111. <https://doi.org/10.46303/jcsr.02.01.6>
- Grønmo, L. S., Lindquist, M., Arora, A., & Mullis, I. V. S. (2015). TIMSS 2015 Mathematics Framework. In Chapter 1 (pp. 11–27).
- Hafiyusholeh, M. (2015). Literasi Statistik dan Urgensinya Bagi Siswa. *Wahana*, 64(1), 1–8.
- Hafiyusholeh, M., Budayasa, K., & Siswono, T. Y. E. (2017). Literasi Statistik: Siswa SMA dalam Membaca, Menafsirkan, dan Menyimpulkan Data. *Prosiding SI MaNIs (Seminar Nasional Integrasi Matematika Dan Nilai Islami)*, 1(1), 79–85.
- Hanafi, M., Wulandari, K. N., & Ni'mah. (2019). Analisis Kemampuan Siswa Dalam Menyelesaikan Soal High Order Thinking Ditinjau Dari Kemampuan Awal Matematis Siswa. *Seminar Nasional Penelitian Pendidikan Matematika (SNP2M) 2019*, 46–55.
- Harsiati, T. (2018). Programme for International Student Assessment. *LITERA*, 17(1), 90–106.
- Hidayah, N. (1998). The Sport Students' Ability of Literacy and Statistical Reasoning. *Brazilian Dental Journal*, 9(1), 3–10. <https://doi.org/10.1088/1742-6596/755/1/011001>
- Indah, N., Mania, S., & Nursalam. (2016). Peningkatan Kemampuan Literasi Matematika Siswa Melalui Penerapan Model Pembelajaran Problem Based Learning di Kelas VII SMP Negeri 5 Pallangga Kabupaten Gowa. *Jurnal Matematika dan Pembelajaran*, 4(2), 200–210. <https://doi.org/https://doi.org/10.24252/mapan.2016v4n2a4>
- Irianto, P. O., & Febrianti, L. Y. (2017). Pentingnya Penguasaan Literasi bagi Generasi Muda dalam Menghadapi MEA. *The 1st Education and Language International Conference Proceedings*, 640–647.
- Johnson, M. (2020). Serious with the Wordplay: Battle Rap as a Critical Literacy Site and Model. *Journal of Culture and Values in Education*, 3(2), 24-41. <https://doi.org/10.46303/jcve.2020.11>
- Karimah, N. (2017). Profil Literasi Statistik Siswa Sma Ditinjau Dari Gaya Kognitif. UIN Sunan Ampel Surabaya.
- Keefer, N., & Haj-Broussard, M. (2020). Language in Educational Contexts. *Journal of Culture and Values in Education*, 3(2), 1-12. <https://doi.org/10.46303/jcve.2020.9>
- Khaerunnisa, E., & Pamungkas, A. S. (2017). Profil Kemampuan Literasi Statistis Mahasiswa Jurusan Pendidikan Matematika Universitas Sultan Ageng Tirtayasa. *Aksioma*, 6(2), 246–255.
- Mahdiansyah, & Rahmawati. (2014). Literasi Matematika Siswa Pendidikan Menengah: Analisis Menggunakan Desain Tes Internasional dengan Konteks Indonesia. *Jurnal Pendidikan dan Kebudayaan*, 20(4), 452–469. <https://doi.org/10.24832/JPNK.V20I4.158>
- Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, 9(1), 1-21. <https://doi.org/10.46328/ijemst.1111>
- Martadiputra, B. A. P. (2002). Kajian Tentang Kemampuan Melek Statistis (Statistical Literacy), Penalaran Statistical (Statistical Reasoning), dan Berpikir Statistis (Statistical Thinking) Guru SMP/SMA. Kemampuan Melek Statistik, Penalaran Statistik, dan Berpikir Statistik, 1–7.

- Maryati, I., & Priatna, N. (2018). Analisis Kemampuan Literasi Statistis Siswa Madrasah Tsanawiyah dalam Materi Statistika. *Journal of Mathematics Education IKIP Veteran Semarang*, 2(2), 205–212.
- Miller, J. W. (2016). World's Most Literate Nations Ranked.
- Mulis, V. S. I., Martin, O. M., Foy, P., & Hooper, M. (2016). Timss 2015 International Results in Mathematics. Amerika: IEA TIMSS & PIRLS. Retrieved from <http://timss2015.org/timss-2015/science/student-achievement/distribution-of-science-achievement/>
- Nasir, M. (2020). Curriculum Development and Accreditation Standards in the Traditional Islamic Schools in Indonesia. *Journal of Curriculum Studies Research*. <https://doi.org/10.46303/jcsr.2020.3>
- Nikiforidou, Z., Lekka, A., & Pange, J. (2010). Statistical literacy at University level: The current trends. *Procedia - Social and Behavioral Sciences*, 9, 795–799. <https://doi.org/10.1016/j.sbspro.2010.12.236>
- Permatasari, A. (2015). Membangun Kualitas Bangsa dengan Budaya Literasi. Seminar Nasional Bulan Bahasa UNIB, 146–156.
- Provasnik, S., Kastberg, D., Ferraro, D., Lemanski, N., Roey, S., & Jenkins, F. (2012). Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context (NCES 2013-009). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.
- Ratnaningtyas, Y. (2016). Kemampuan Berpikir Kritis Siswa SMP Kelas VIII dalam Menyelesaikan Soal Higher Order Thinking Ditinjau dari Kemampuan Matematika. *Jurnal Ilmiah Pendidikan Matematika*, 1(5), 86–94.
- Rizta, A., Zulkardi, & Hartono, Y. (2013). Pengembangan Soal Penalaran Model TIMSS Matematika SMP. *Jurnal Penelitian dan Evaluasi Pendidikan*, 17(2), 230–240. Retrieved from <https://journal.uny.ac.id/index.php/jpep/article/view/1697>
- Rumahlatu, D., & Takaria, J. (2016). The Effectiveness of CPS-ALM Model in Enhancing Statistical Literacy Ability and Self Concept of Elementary School Student Teacher. *Journal of Education and Practice*, 7(25), 44–49.
- Rumiati, & Wardhani, S. (2011). Instrumen Penilaian Hasil Belajar Matematika SMP : Belajar dari PISA dan TIMSS. Yogyakarta.
- Salinas-Vasquez, L., Varela, D. G., Martinez, M.E. & Jones, D. (2020). A comparative study of the 21st Century Afterschool Center on Education in elementary schools in south Texas. *Research in Educational Policy and Management (REPAM)*, 2(2), 19-37. <https://doi.org/10.46303/repam.2020.2>
- Sari, D. C. (2015). Karakteristik Soal TIMSS. Seminar Nasional Matematika Dan Pendidikan Matematika UNY, 303–308.
- Sari, R. H. N. (2015). Literasi Matematika : Apa , Mengapa dan Bagaimana ? Seminar Nasional Matematika dan Pendidikan Matematika UNY 2015.
- Schild, M. (2011). Statistical literacy: A New Mission for Data Producers. *Statistical Journal of the IAOS*, 27(3–4), 173–183. <https://doi.org/10.3233/SJI-2011-0732>
- Sidauruk, E. E. V., & Ratu, N. (2018). Deskripsi Pemecahan Masalah Siswa SMP dalam Menyelesaikan Soal Timss Konten Aljabar. *Jurnal Karya Pendidikan Matematika*, 5(2), 28–37.
- Solikhah, I. & Budiharso, T. (2020a). Exploring Cultural Inclusion in the Curriculum and Practices for Teaching Bahasa Indonesia to Speakers of Other Languages. *Journal of Social Studies Education Research*, 11(3),

177-197.

- Solikhah, I. & Budiharso, T. (2020b). Standardizing BIPA as an International Program of a Language Policy. *Asian ESP Journal*, 16(5.2), 181-205. <https://www.elejournals.com/asian-esp-journal/volume-16-issue-5-2-october-2020/>
- Solikhah, I. & Budiharso, T. (2019). Investigating the Learning Outcomes of an INQF Based English Language Teaching Curriculum in Indonesia. *Journal of Social Sciences Education Research*, 10(4), 153-175.
- Stacey, K. (2011). The PISA View Of Mathematical Literacy In Indonesia. *Indonesian Mathematical Society Journal on Mathematics Education*, 2(2), 95–126.
- Suragangga, I. M. N. (2017). Mendidik Lewat Literasi Untuk Pendidikan Berkualitas. *Jurnal Penjaminan Mutu*, 3(2), 154–163.
- Syahlan. (2015). Literasi Matematika Dalam Kurikulum 2013. *Penelitian, Pemikiran Dan Pengabdian*, 3(1), 36–43.
- Tadeu, P., Fernandez Batanero, J., & Tarman, B. (2019). ICT in a Global World. *Research in Social Sciences and Technology (RESSAT)*, 4(2), i-ii. <https://doi.org/10.46303/ressat.04.02.ed>
- Timberlake, M. (2020). Recognizing Ableism in Educational Initiatives: Reading between the Lines. *Research in Educational Policy and Management (REPAM)*, 2(1), 84-100. <https://doi.org/10.46303/repam.02.01.5>
- Turan, S., & Matteson, S. M. (2021). Middle school mathematics classrooms practice based on 5E instructional model. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, 9(1), 22-39. <https://doi.org/10.46328/ijemst.1041>
- Waters, S. & Hensley, M. (2020). Measuring Rural P-12 Teachers' Attitudes, Perceptions, and Utilizations of Social Media. *Research in Social Sciences and Technology (RESSAT)*, 5(3), 25-54. <https://doi.org/10.46303/ressat.05.03.2>.
- Wijaya, A. (2016). Students' Information Literacy: A Perspective from Mathematical Literacy. *Journal on Mathematics Education*, 7(2), 73–82. <https://doi.org/10.22342/jme.7.2.3532.73-82>

Author Information

Dwi Priyo Utomo

 <https://orcid.org/0000-0002-9925-7222>

Universitas Muhammadiyah Malang

Malang City, East Java

Indonesia

Contact e-mail: dwipuumm@yahoo.com
