Statistical Literacy Process of Prospective Mathematics Teachers: A Case Study of Pisa Model Problems

Gunawan
Universitas Muhammadiyah Purwokerto

Nuhyal Ulia
Universitas Islam Sultan Agung Semarang

Lukmanul Akhsani
Universitas Muhammadiyah Purwokerto

Reni Untarti
Universitas Muhammadiyah Purwokerto

This study explained the use of the statistical literacy process for prospective mathematics teachers in solving PISA model problems. The applied approach was a qualitative descriptive approach The researchers grouped the subjects into low, moderate, and high ability categories based on the previous academic test results. Then, the researchers collected the data from statistical literacy skill tests and interviews. The researchers analyzed the data by reducing, presenting, and drawing conclusions. In this research, the statistical literacy processes consisted of data orientation, data process, data interpretation, and data evaluation. The results showed that moderate and high categories students could focus on math problems. The evidence was the students understood the given information. The middle and high-category students had excellent statistical literacy processes. However, the high-category students could explain the statistical literacy process systematically and carefully. The high-category students could demonstrate their writing, implementing, and interpreting strategies of the obtained answers.

Keywords: statistical literacy process, PISA model problems, mathematical literacy

INTRODUCTION

Mathematical literacy is the ability to formulate, apply, reason, and interpret mathematical concepts to solve problems in various contexts (Kusuma et al., 2022; Ojose, 2011; Stacey & Turner, 2015; Sudji et al., 2020; Umbara & Suryadi, 2019). This literacy has three processes, starting formulating, applying, and interpreting. Mathematical literacy characteristics are observable from the implementation of mathematics concepts in various real-life contexts (Umbara & Suryadi, 2019). In Indonesia, mathematical literacy is an essential concern in education. The compiled curriculum includes mathematical literacy as a domain of knowledge and skills in teaching mathematics (Peraturan Menteri Pendidikan Dan Kebudayaan Republik

Indonesia Nomor 22 Tahun 2016, 2016). The results of the PISA (Program for International Student Assessment) assessment showed that Indonesian students' have low mathematical literacy. In 2015 and 2018, the PISA scores of Indonesian students' mathematics literacy decreased from 386 to 397 (OECD, 2018). In 2018, the rank of Indonesian students' mathematics literacy was 72 out of 79 countries (Schleicher, 2019). These results showed the concern of mathematical literacy to solve.

The International Student Assessment Program (PISA) is an international education assessment system sponsored by the Organization for Economic Co-Operation and Development (OECD) that initially promoted the assessment in 2000 and carried out once in three years. The PISA assessment has three main focuses. They are reading (literacy), mathematical, and scientific (OECD, 2013; Schleicher, 2019). For mathematical literacy, specifically, the assessment description includes the components of reasoning abilities, such as using concepts, procedures, facts, and mathematical tools in describing, explaining, and predicting phenomena. The target includes students aged 15 years (OECD, 2013, 2018).

The characteristics of the PISA problem consist of three components: content, context, and competence (Ahyan et al., 2014; Arfiana & Wijaya, 2018; Jailani et al., 2020; OECD, 2018). The content relates to the topics of the given material at school. Context refers to a real-life related condition, covering mathematical problems and mathematical thinking skills of the students. The students receive the context to solve mathematically, starting from social, work, and personal contexts. Competence refers to the student's abilities to formulate, apply, and interpret mathematical ideas in solving problems. Two important contents of PISA problems in statistics are uncertainty and data (OECD, 2013, 2018). These contents require statistical theory, problem analysis, and an excellent understanding of uncertainty and data to solve the problems.

In most life contexts, statistics play an important role, including science (Jalajakshi & Myna, 2022) and educational (Takaria & Talakua, 2018). As a part of science, statistics discusses data collection, data process, data presentation, and data interpretation in the forms of graphs and tables (François et al., 2013; Hafiyusholeh et al., 2018). Statistical learning consists of building knowledge, direct and repeated practice, and providing evaluation (Garfield & Ben-Zvi, 2004). Therefore, statistics become the center of the curriculum starting from basic schools until the university level (Batanero et al., 2011; Budgett & Pfannkuch, 2010; Callingham & Watson, 2017; J. Watson, 2013).

At the basic school level, the main focus of statistics is computation instead of statistical literacy (Tarr et al., 2006). Unfortunately, students encountered difficulty in understanding statistical data and applying statistics in everyday life (Schield, 2004; Verhoeven, 2006). On the other hand, outside of schools, every individual must have statistical literacy. This literacy refers to the capabilities of understanding, interpreting, evaluating, and communicating statistical data and statistical data results (Gal, 2002, 2004, 2019). Therefore, statistical literacy is essential and fundamental for statistical information understanding (Callingham & Watson, 2017; Ziegler & Garfield, 2018).

The other perception of statistical literacy sees this literacy as transnumerative thinking. Chick and Pierce (2012) explain that statistical literacy, as transnumerative thinking, deals with understanding and unique data representation capabilities in daily life. Students not only increase their mathematical knowledge but must understand the context of the information to understand statistical information (J. M. Watson et al., 2007). Students with good statistical literacy skills can read, understand, and communicate information to others both in writing manner and verbally (Salinas-Vasquez, Varela, Martinez, et al., 2020). In Gould (2017) states that one part of statistical literacy is data literacy. According to Oceans of Data Institute (2015), a person with excellent data literacy can identify, collect, interpret, display, correct, and communicate data.

In previous research, Utomo (2021) explained that the statistical literacy thinking process consisted of understanding the problem, processing data, and interpreting the data. Research by Callingham and Watson (2017) analyzed students' statistical literacy understanding abilities in schools based on the statistical literacy level developed by Watson's model. The results showed the statistical understanding literacy skills were at level 4 (consistently not critical). In Weiland (2017) defined critical statistical literacy as a combination of statistical and critical literacy. Sharma (2017) applied four stages to develop statistical literacy skills: informal, consistent non-critical, early critical, and advanced critical.

This research had a novelty in terms of the research focus, the statistical literacy process, which required data orientation, data processing, data interpretation, and evaluation. From the research background, the researchers formulated the problem into "What is the statistical literacy process for prospective mathematics teachers in solving PISA model problems?"

RESEARCH METHOD

Research Design

This descriptive qualitative research design described the stages of statistical literacy processes in solving PISA problems. This study analyzed the characteristics of each stage of the statistical literacy process in solving PISA problems.

Participants and Data Collection

The researchers collected the data from the first semester students of mathematics education, 32 students. Then, the researchers took the sample with purposive sampling. The results were six students as the sample. After that, the researchers grouped the students into three two-member groups: low, moderate, and high ability. This procedure was useful to facilitate the research progress (Sukestiyarno, 2020). The researchers labeled the high-category subjects with S1 and S2, the moderate-category subjects with S3 and S4, and the low-category subjects with S5 and S6. In this research, the researchers did not implement specific treatment for students, before and after the study.

The researchers collected the data with the PISA test for statistical material and interviews. The PISA statistical literacy test had three main aspects: content, context, and competence. The applied design for the test was to determine the statistical literacy process of students. Before implementing the test instrument, the researchers involved validators to examine and review the question items. After that, the researchers promoted a restricted test to ensure the validity and reliability of the test items. The second applied technique was an interview to collect related information about students' statistical literacy stages. The researchers used an interview guide while the object of the interview was the written test text.

Analyzing of Data

The researchers analyzed the data by reducing, presenting, and concluding the data (Sukestiyarno, 2020). In the data reduction process, the researchers selected, summarized, and focused on important information. In the data presentation, the researchers presented the student works of a statistical literacy test and the interview results. This step required the researchers to present the analyzed data and connected the data analysis with other research results. The last stage was – to conclude by comparing the data analysis results of the student literacy test results and interview results. After analyzing all data, the researchers ensured the data validity by applying technique triangulation, among the PISA statistical literacy ability test results, interviews, observations, and documentation (Bekhet & Zauszniewski, 2012; Renz et al., 2018).

RESULT

At the beginning of the research, the researchers provided the pretest of PISA statistical literacy skills. The test consisted of 10 multiple-choice question items. From the test results, the researchers grouped the students into high, moderate, and low categories. Then, the researchers formed three two-member groups. Table 1 describes the results of the initial PISA statistical literacy skill test for every respondent.

The documents of the written test and the results of the in-depth interview described the thinking process of PISA's statistical literacy skills. In this research, the statistical literacy thinking process consisted of four stages with a focus on problem orientation, data process, data interpretation, and data evaluation. Table 2 describes the characteristics of each stage of statistical literacy.

TABLE 1
RECAPITULATION OF TEST RESULTS OF EACH RESPONDENT

No	Respondents	Score	Score Criteria	Categories
1	S1	90	80 ≤ Score ≤ 100	High
	S2	90		
2	S3	60	50 ≤ Score < 80	Moderate
	S4	60		
3	S5	40	0 ≤ Score < 50	Low
	S6	30		

TABLE 2
STAGE OF STATISTICAL LITERACY PROCESS

Stage	Description
Data Orientation	a. Write down the known information in detail b. Explain the core of the problem
Data Processing	a. Write down the strategies used b. Use strategies to solve problems c. Write down detailed steps for solving problems
Data Interpretation	a. Writing conclusions b. Explaining the results of the analysis
Evaluation	Re-examine the results of their work and correct errors

The following are the results of each respondent's analysis of the PISA statistical literacy process.

High Ability Student Group

FIGURE 1
S1 ANSWERS RESULTS

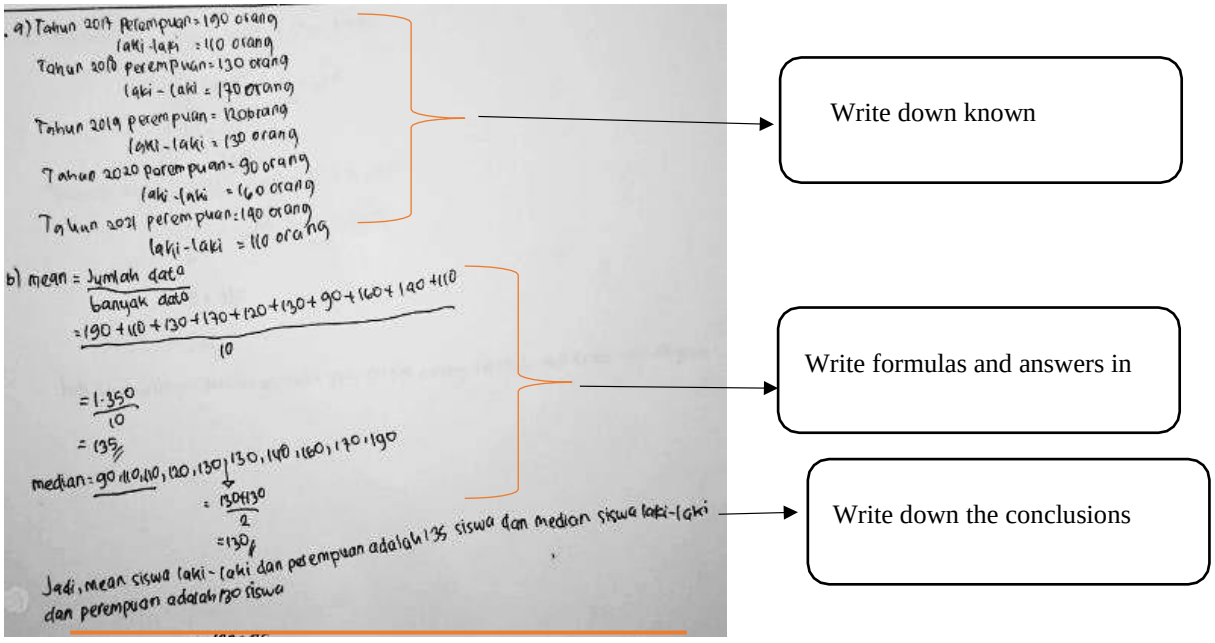


Figure 1 shows the solving process of the given questions, about mean and median. In the beginning, S1 wrote the information about the female and male students' numbers from 2017 to 2021. In the interview, S1 also explained the given problem.

Q1: *Explain what is the given problem in the question!*

S1: *The given question is to determine the mean and median values.*

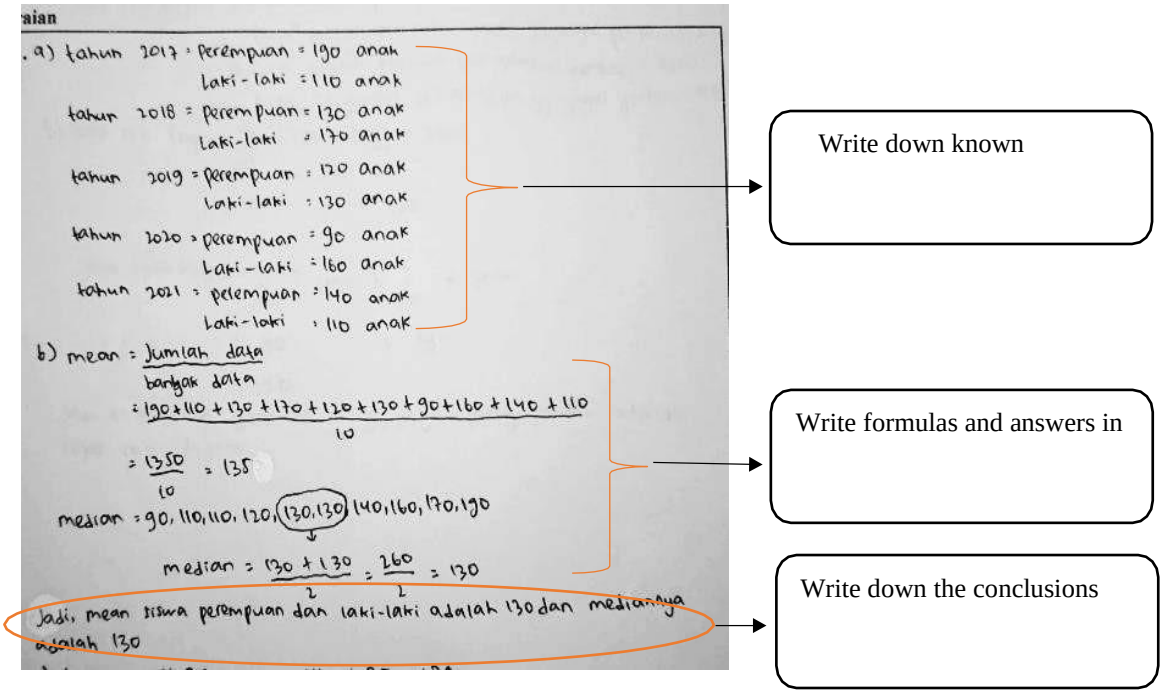
The respondent wrote the formula, dividing the total by the number of the data, to determine the average. The respondent also did the same thing in determining the median value. The respondent sorted the data from the smallest to the largest and put an arrow in the middle to show the median value. In the end, the respondent concluded the mean and median values for men and women, respectively.

This interview result showed that the respondent re-examined the written answers. Here is the excerpt from the conversation.

Q2: *Did you double-check the written answer?*

S1: *Yes, I corrected and found no mistakes.*

FIGURE 2
S2 ANSWERS RESULTS



S2 wrote the information about the male and female students' numbers from 2017 to 2021 in detail. The interview results of S2 show the explanation of the given problem.

Q1: *In your opinion, what is the meaning of this question?*

S2: *The point is to determine the mean and median, then investigate whether the values are the same or not between men and women.*

Based on Figure 2, the applied formula to find the average value is – divided by the amount of data. The respondent sorted the data from smallest to largest to determine the media. Then, the respondent circled the value of the median, 130. After that, the respondent concluded that the average and median values between men and women were not the same.

In the evaluation process, S2 re-examined the obtained answers and found miscalculations. The results of the interview with S2 explained this.

Q1: *Did you double-check the answer?*

S2: *Yes, I corrected and found an error. When looking for the average, the total score of the data has not been divided by 10.*

Q2: *Has the error been fixed?*

S2: *Yes, I have.*

Moderate Ability Student Group

FIGURE 3
S3 ANSWERS RESULTS

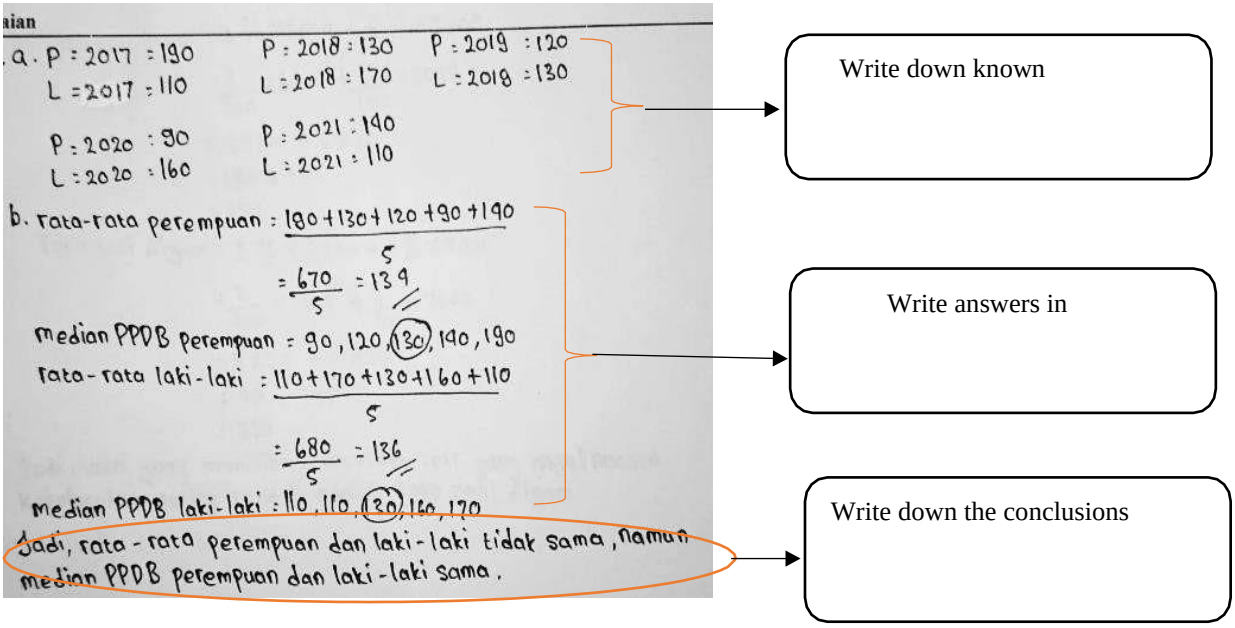


Figure 3 shows the respondent writing the given information, the women and the men. In this case, the respondent labeled the women with P while the men with L. The respondent also wrote the numbers of males and females carefully from 2017 to 2021. The following interview results explain the given problem.

Q1: *Explain the meaning of the question!*

S3: *Finding the mean and median*

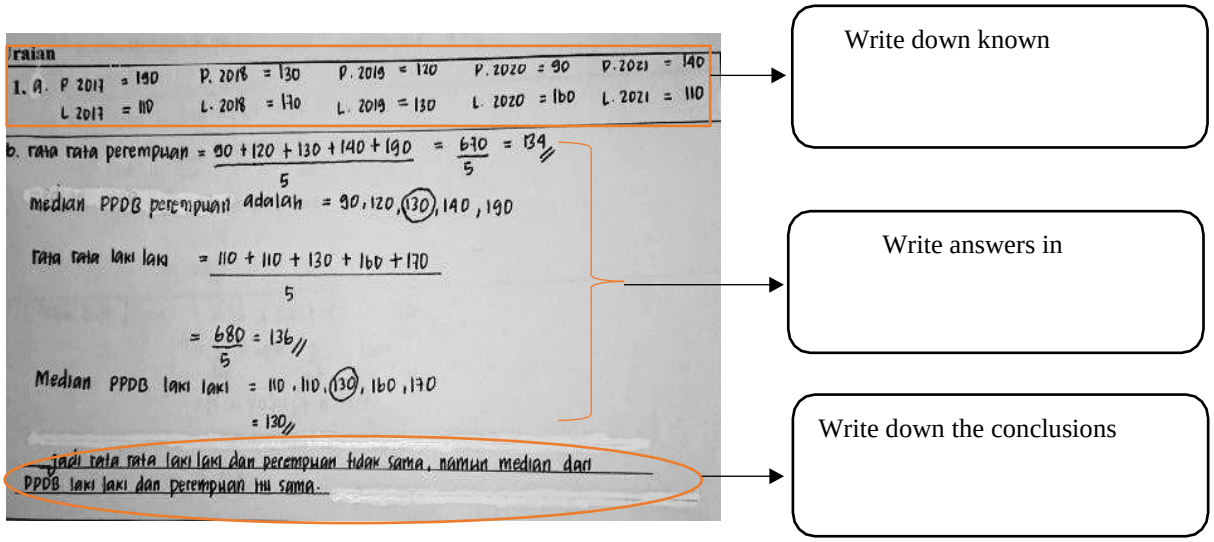
The respondent wrote the answers for men and women separately. Then, the respondent used the formula to find the average by summing up all the data. Then, the respondent divided the sum-up total with

the numbers of the data. In this case, the researchers found something different with the calculation of the median value. The respondent sorted the values from the lowest to the highest. Then, the respondent circled the smallest value. After that, the student concluded that the averages between male and female data were not the same, but the median was the same. The following interview results show how the respondent rechecked the answers.

Q1: *Did you double-check the answer?*

S3: *Yes, I double-checked.*

FIGURE 4
S4 ANSWERS RESULTS



The fourth respondent labeled the men with L and the women with P based on the given information about PPDB, from 2017 to 2021. The following interview results illustrate how the respondent provides the given information.

Q1: *What do you think is being asked in the question?*

S4: *Finding the mean and median for each boy and girl*

The respondent answered the question systematically. Figure 4 shows the respondent starts with labeling the women and then labeling the men. However, the respondent did not write the formula but directly calculate the average. Then, the respondent sorted the data from the smallest to the largest to find the median. The respondent concluded that the averages of men's and women's PPDB were different but the median values were the same. In the final stage, the respondent rechecked the answers. Here are the results of the interview.

Q1: *Did you double-check the answer?*

S4: *Yes, definitely*

Q2: *Is something wrong or not?*

S4: *I believe it is correct.*

Low Ability Student Group

FIGURE 5
S5 ANSWERS RESULTS

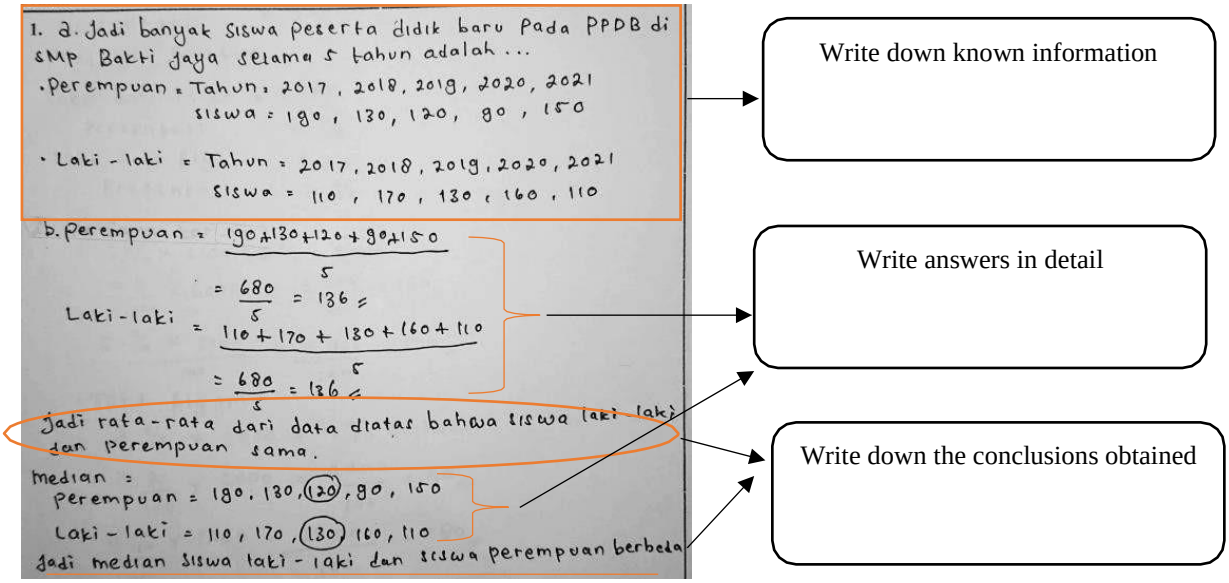


Figure 5 shows the respondent wrote the given information, the numbers of male and female PPDB, separately, from 2017 to 2021. These interview results show how the respondent explains the given problem.

Q1: *What does this question mean?*

S5: *Look for the mean and median, then see if the values are the same or not*

The respondent did not write the formula but directly calculate the average. Unfortunately, the respondent committed a mistake while calculating the number of female students in 2021. Thus, the obtained answers were incorrect. The respondent did not sort the data from the smallest to the largest to find the median but the respondent sorted the data based on the years, from 2017 to 201. This procedure also led to incorrect answers. Then, the respondent concluded the mean and median of the mean and women incorrectly. The respondent's conclusion showed that the mean or average values of the men and women were the same while the median values for both parties were different. In the last stage, the respondent did not recheck the answer due to limited time. Here are the results of the interview.

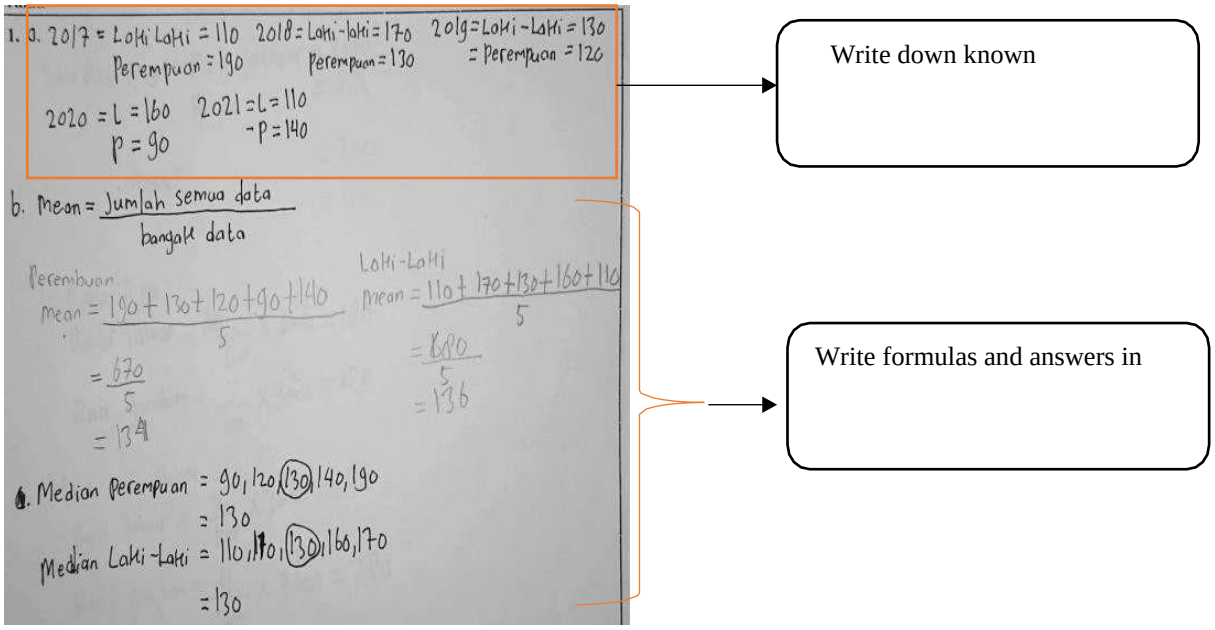
Q1: *Did you correct the answer again?*

S5: *No*

Q2: *Why is it not correct?*

S5: *Because the processing time has run out, there is no time to correct it.*

FIGURE 6
S6 ANSWERS RESULTS



The respondent wrote the PPDB data of men from 2017 to 202 clearly and carefully. Here are the interview results with the respondent.

Q1: *Explain what is being asked in the question.*

S6: *The problem asked is mean and median.*

Figure 6 shows the respondent writing the formula of calculating the mean before promoting the calculation by summing up all data and dividing the results with the numbers. The respondent also sorted the data from the smallest to the highest so that the respondent could determine the median value. After that, the respondent circled the median value. Figure 6 shows that the respondent does not provide any conclusion. However, from the interview result, the respondent seemed to be capable of explaining the obtained conclusion. Here are the results of the interview.

Q1: *Is the average PPDB between men and women the same?*

S6: *Different, but the median value is the same*

In the final stage, the respondent did not recheck the answers. The following are the results of interviews that show this.

Q1: *Before your answer is submitted, is it corrected again?*

S6: *No, because the time is up.*

Table 3 explains the characteristics of statistical literacy thinking processes in solving PISA model questions.

TABLE 3
CHARACTERISTICS OF STATISTICAL LITERACY PROCESS IN SOLVING PISA MODEL PROBLEMS

Category	Stage			
	Data Orientation	Data Processing	Data Interpretations	Evaluation
Low	➢ Write down the known information in detail. ➢ Explain the problem being asked.	➢ Apply the formula to the problem. ➢ Write in detail the steps to solve the problem.	➢ Write down the conclusion. ➢ Explain the results of the analysis.	➢ Didn't double-check the answer.
Moderate	➢ Write down the known information in detail. ➢ Explain the problem being asked.	➢ Apply the formula to the problem. ➢ Write in detail the steps to solve the problem.	➢ Write down the conclusion. ➢ Explain the results of the analysis.	➢ Recheck answers. ➢ Correcting errors.
High	➢ Write down the known information in detail. ➢ Explain the problem being asked.	➢ Write a problem-solving strategy. ➢ Implementing strategies. ➢ Write down the detailed steps for solving the problem.	➢ Write down the conclusion. ➢ Explain the results of the analysis.	➢ Recheck answers. ➢ Correcting errors.

DISCUSSION

This study provides findings on students' statistical literacy thinking processes in solving PISA model questions based on low, moderate, and high ability categories. The low-category students could understand the problem excellently and identify the given information. However, they did not write the applied strategy. Hee et al. (2019) found the importance of orientation activities to obtain detailed information in finding solutions. Individuals with excellent literacy skills could use information effectively and efficiently to find solutions (Serap Kurbanoglu et al., 2006). The low-category students could explain the interpretation of the obtained results. Unfortunately, they could not provide an evaluation of the written answers. Aoyama and Stephens (2003) also found that eighth graders had no experience in evaluating data.

The moderate-category students had excellent statistical literacy thinking processes, observable from the written answers starting from understanding information and problems, processing data, providing interpretations, and re-examining answers. They also carried out the thinking process correctly in each statistical literacy stage. The students carried out some activities in the problem orientation stage, including writing down general information and problems. In the data processing stage, the students did not write strategies but directly applied strategies in solving problems. Mulya et al. (2018) found the students'

difficulties in processing data occurred due to a lack of conceptual knowledge about statistics. One of the influential factors was literacy skills as a part of mathematical science (Sproesser et al., 2014). In this category, the students could provide a clear conclusion based on the data interpretation stage. The students could also re-examine the obtained results. They also double-checked the writing errors and the applied concepts. The result showed that the students could evaluate their answers. The results also asserted that statistical literacy skills also required the understanding abilities on the problem context, problem interpretation, and data evaluation along with computational ability (Jurečková & Lucia Csachová, 2020).

For high-category students, they could understand the problem well. The findings were observable from their actions while writing the given information carefully and explaining the problems fluently. Understanding problems and interpreting data are crucial for statistical literacy (Aoyama & Stephens, 2003). In the data processing stage, the students could solve problems systematically by writing a strategy and applying the solution to the problem. In this process, the students completed the stages carefully. Dasaprawira et al. (2019) found the importance of a problem-solving formulation strategy in solving PISA model problems.

From the obtained answers, the students could provide several related conclusions. In addition, they could explain the interpretation of the results verbally. In the end, the student re-examined the completion steps along with the final answer to ensure the answer's correctness. The high-category students had excellent habituation both in tests and daily learning. They had an excellent critical evaluation of the research data to develop statistical literacy skills (Budgett & Pfannkuch, 2010). The research results also indicated the importance of problems with various daily life contexts to develop statistical literacy skills, starting from collecting information and interpreting the data (Go et al., 2017).

In solving PISA model problems, the students had difficulties in representing problems in mathematics and evaluating the solutions to problems (Edo et al., 2013). This is in line with research Nikiforidou et al. (2010) that statistical literacy at the college level cannot be separated from data evaluation, data interpretation, and data communication. The moderate category students could solve the problems. On the other hand, students with low categories could not determine the relevant formula for the problems (Edo et al., 2013). Problems developed with the PISA model could improve students' mathematical literacy skills, including, in this case, related statistics topics (Rosana et al., 2020; Sutama et al., 2020).

CONCLUSION

The research results conclude that students with low, moderate, and high abilities could understand the problem excellently. The evidence was observable from the students' actions to writing the given information and the essence of the problem. The moderate and high-ability students also had excellent statistical literacy processes. The evidence was observable from their understanding of the problem (data orientation), using statistical formulas to solve problems (data processing), providing conclusions (data interpretation), and providing evaluations. High-ability category students could write the statistical literacy processes systematically, starting from the information and the given problems, the strategy, implementing the strategy, providing the results of the analysis of the answers, and finally re-checking the written answers.

ACKNOWLEDGMENTS

The author would like to thank the Universitas Muhammadiyah Purwokerto and Universitas Islam Sultan Agung Semarang for providing motivation and funding for this research.

REFERENCES

Ahyan, S., Zulkardi, Z., & Darmawijoyo, D. (2014). Developing mathematics problems based on Pisa level of change and relationships content. *Journal on Mathematics Education*, *5*(1). https://doi.org/10.22342/jme.5.1.1448.47-56

Aoyama, K., & Stephens, M. (2003). Graph interpretation aspects of statistical literacy: A Japanese perspective. *Mathematics Education Research Journal*, *15*(3), 207–225. https://doi.org/10.1007/BF03217380

Arfiana, A., & Wijaya, A. (2018). Problem solving skill of students of senior high schools and Islamic high schools in Tegal Regency in solving the problem of PISA based on Polya's stage. *Jurnal Riset Pendidikan Matematika*, *5*(2), 211–222. https://doi.org/10.21831/jrpm.v5i2.15783

Batanero, C., Burrill, G., & Reading, C. (2011). *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education*. Springer Netherlands. https://doi.org/10.1007/978-94-007-1131-0

Bekhet, A.K., & Zauszniewski, J.A. (2012). Methodological triangulation: An approach to understanding data. *Nurse Researcher, 20*(2), 40–43. https://doi.org/10.7748/nr2012.11.20.2.40.c9442

Budgett, S., & Pfannkuch, M. (2010). Assessing Students' Statistical Literacy. In *Assessment Methods in Statistical Education* (pp. 103–121). John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470710470.ch9

Callingham, R., & Watson, J.M. (2017). The development of statistical literacy at school. *Statistics Education Research Journal*, *16*(1), 181–201. https://doi.org/10.52041/serj.v16i1.223

Chick, H.L., & Pierce, R. (2012). Teaching for statistical literacy: Utilising affordances in real-world data. *International Journal of Science and Mathematics Education*, *10*(2), 339–362. https://doi.org/10.1007/s10763-011-9303-2

Dasaprawira, M.N., Zulkardi, Z., & Susanti, E. (2019). Developing mathematics questions of Pisa type using bangka context. *Journal on Mathematics Education*, *10*(2), 303–314. https://doi.org/10.22342/jme.10.2.5366.303-314

Edo, S.I., Ilma, R., & Hartono, Y. (2013). Investigating Secondary School Students' Difficulties in Modeling Problems PISA-Model Level 5 And 6. *Journal on Mathematics Education*, *4*(1). https://doi.org/10.22342/jme.4.1.561.41-58

François, K., Monteiro, C., & Vanhoof, S. (2013). *Mathematical And Statistical Literacy: An analysis based on PISA results*, *4*(1), 1–10.

Gal, I. (2002). Adults' Statistical Literacy: Meanings, Components, Responsibilities. *International Statistical Review*, *70*(1), 1–25. https://doi.org/10.1111/j.1751-5823.2002.tb00336.x

Gal, I. (2004). Statistical Literacy. In *The Challenge of Developing Statistical Literacy, Reasoning and Thinking* (pp. 47–78). Springer Netherlands. https://doi.org/10.1007/1-4020-2278-6_3

Gal, I. (2019). *Understanding statistical literacy: About knowledge of contexts and models* (pp. 1–15).

Garfield, J., & Ben-Zvi, D. (2004). Research on statistical literacy, reasoning, and thinking: Issues, challenges, and implications. In *The challenge of developing statistical literacy, reasoning and thinking* (pp. 397–409). Springer.

Go, S.M., Kim, M.S., Jung, J.K., & Cho, W.Y. (2017). Analysis of the problems in statistics units of middle school textbooks for the 3rd grade in terms of statistical literacy. *School Mathematics*, *19*(4), 731–749.

Gould, R. (2017). Data literacy is statistical literacy. *Statistics Education Research Journal*, *16*(1), 22–25. https://doi.org/10.52041/serj.v16i1.209

Hafiyusholeh, M., Budayasa, K., & Siswono, T.Y.E. (2018). Statistical Literacy: High School Students in Reading, Interpreting and Presenting Data. *Journal of Physics: Conference Series*, *947*, 012036. https://doi.org/10.1088/1742-6596/947/1/012036

Hee, O.C., Ping, L.L., Rizal, A.M., Kowang, T.O., & Fei, G.C. (2019). Exploring lifelong learning outcomes among adult learners via goal orientation and information literacy self-efficacy. *International Journal of Evaluation and Research in Education (IJERE)*, *8*(4), 616. https://doi.org/10.11591/ijere.v8i4.20304

Jailani, J., Retnawati, H., Wulandari, N.F., & Djidu. (2020). Mathematical literacy proficiency development based on content, context, and process. *Problems of Education in the 21st Century*, *78*(1), 80–101.

Jalajakshi, V., & Myna, A.N. (2022). Importance of Statistics to Data Science. *Global Transitions Proceedings*.

Jurečková, M., & Csachová, L. (2020). Statistical literacy of Slovak lower secondary school students. *Technium Social Sciences Journal*, *9*, 163–173. https://doi.org/10.47577/tssj.v9i1.966

Kusuma, D., Wardono, W., & Nur, A. (2022). The Characteristics of Mathematical Literacy Based on Students' Executive Function. *European Journal of Educational Research*, *11*(1), 193–206. https://doi.org/10.12973/eu-jer.11.1.193

Mulya, N., Nurlaelah, E., & Prabawanto, S. (2018). Students' statistical literacy on junior high school. *International Conference on Mathematics and Science Education*, pp. 710–714.

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

Oceans of Data Institute. (2015). *Building global interest in data literacy: a dialogue*. Educational Development Center.

OECD. (2013). *OECD skills outlook 2013: First results from the survey of adult skills*. OECD Publishing.

OECD. (2018). *OECD science, technology and innovation Outlook 2018*. OECD Publishing.

Ojose, B. (2011). Mathematics literacy: Are we able to put the mathematics we learn into everyday use. *Journal of Mathematics Education*, *4*(1), 89–100.

Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 22 Tahun 2016, Jakarta. (2016).

Renz, S.M., Carrington, J.M., & Badger, T.A. (2018). Two Strategies for Qualitative Content Analysis: An Intramethod Approach to Triangulation. *Qualitative Health Research*, *28*(5), 824–831. https://doi.org/10.1177/1049732317753586

Rosana, D., Widodo, E., Setianingsih, W., & Setyawarno, D. (2020). Developing Assessment Instruments of PISA Model to Measure Students' Problem-Solving Skills and Scientific Literacy in Junior High Schools. *Jurnal Pendidikan Sains Indonesia*, *8*(2), 292–305. https://doi.org/10.24815/jpsi.v8i2.17468

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*, *2*(2), 19–37. https://doi.org/10.46303/repam.2020.2

Schield, M. (2004). Statistical literacy and liberal education at Augsburg College. *Peer Review*, *6*(4), 16–19.

Schleicher, A. (2019). *PISA 2018: Insights and Interpretations*. OECD Publishing.

Serap Kurbanoglu, S., Akkoyunlu, B., & Umay, A. (2006). Developing the information literacy self-efficacy scale. *Journal of Documentation*, *62*(6), 730–743. https://doi.org/10.1108/00220410610714949

Sharma, S. (2017). Definitions and models of statistical literacy: a literature review. *Open Review of Educational Research*, *4*(1), 118–133. https://doi.org/10.1080/23265507.2017.1354313

Sproesser, U., Kuntze, S., & Engel, J. (2014). A multilevel perspective on factors influencing students' statistical literacy. *Ninth International Conference on Teaching Statistics: Sustainability in Statistics Education*.

Stacey, K., & Turner, R. (2015). The evolution and key concepts of the PISA mathematics frameworks. In *Assessing mathematical literacy* (pp. 5–33). Springer.

Sudji, S., Munadi, S., Sugiman, S., & Dwi, W. (2020). Design and Validation of Mathematical Literacy Instruments for Assessment for Learning in Indonesia. *European Journal of Educational Research*, *9*(2), 865–875. https://doi.org/10.12973/eu-jer.9.2.865

Sukestiyarno, Y.L. (2020). *Metode penelitian pendidikan*. UNNES Press.

Sutama, Narimo, S., Anif, S., Prayitno, H.J., Sari, D.P., & Adnan, M. (2020). The development of student worksheets: questions of PISA model to analyze the ability of mathematical literacy in junior high school. *Journal of Physics: Conference Series*, *1538*(1), 012065. https://doi.org/10.1088/1742-6596/1538/1/012065

Takaria, J., & Talakua, M. (2018). The ability of statistical literacy student teacher candidate in terms of prior-ability on mathematics. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, *2*(2), 395–408. https://doi.org/10.21831/jk.v2i2.18768

Tarr, J.E., Chávez, Ó., Reys, R.E., & Reys, B.J. (2006). From the Written to the Enacted Curricula: The Intermediary Role of Middle School Mathematics Teachers in Shaping Students' Opportunity to Learn. *School Science and Mathematics*, *106*(4), 191–201. https://doi.org/10.1111/j.1949-8594.2006.tb18075.x

Umbara, U., & Suryadi, D. (2019). Re-Interpretation of Mathematical Literacy Based on the Teacher's Perspective. *International Journal of Instruction*, *12*(4), 789–806. https://doi.org/10.29333/iji.2019.12450a

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*, *9*(2), 181–197. https://doi.org/10.46328/ijemst.1552

Verhoeven, P. (2006). Statistics education in the Netherlands and Flanders: An outline of introductory courses at Universities and Colleges. *7th International Conference on Teaching Statistics*, pp. 60115–62828.

Watson, J. (2013). Statistical literacy, a statistics curriculum for school students, the pedagogical content needs of teachers, and the Australian Curriculum. *Curriculum Perspectives*, pp. 58–69.

Watson, J.M., Callingham, R.A., & Kelly, B.A. (2007). Students' Appreciation of Expectation and Variation as a Foundation for Statistical Understanding. *Mathematical Thinking and Learning*, *9*(2), 83–130. https://doi.org/10.1080/10986060709336812

Weiland, T. (2017). Problematizing statistical literacy: An intersection of critical and statistical literacies. *Educational Studies in Mathematics*, *96*(1), 33–47. https://doi.org/10.1007/s10649-017-9764-5

Ziegler, L., & Garfield, J. (2018). Developing a statistical literacy assessment for the modern introductory statistics course. *Statistics Education Research Journal*, *17*(2), 161–178. https://doi.org/10.52041/serj.v17i2.164