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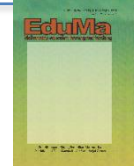
Comparative Study of Indonesian Students' Mathematical Literacy Abilities with Other Countries in Terms of PISA Type HOTS

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a b s t r a c t

Indonesian students often have difficulty in fulfilling mathematical literacy indicators which results in low mathematical literacy abilities of students in Indonesia. Not only that, the PISA study (which tests students' mathematical literacy skills in several countries) states that Indonesia occupies a lower position when compared to other countries. The purpose of this research is to find out several things that need to be improved to welcome the next PISA study. The method used is a literature study that aims to review past phenomena and phenomena that are currently happening. The results obtained in this study are that the mathematical literacy ability of Indonesian students is still low when compared to other countries such as China, Singapore, Japan, and Argentina. The conclusion obtained is that Indonesian students must start getting used to working on math exercise in HOTS (High Order Thinking Skills) type questions which can improve mathematical literacy skills.

K e y w o r d s :

Comparative Study; Mathematical Literacy; PISA

INTRODUCTION

In the book of Golden Generation Indonesia 2045 by the Ministry of Education and Culture, in the future 2030, all students can gain knowledge and skills that are useful for promoting sustainable development in education (Kemendikbud, 2017). Through education, we can learn many aspects such as reading literacy, scientific literacy, mathematical literacy, and global competence (Purwasih, et al., 2018). These aspects is also the main assesment of the PISA study. When viewed from the results of PISA 2018, the mathematical literacy ability score of Indonesian students is still below the average score determined by OECD (Organisation for Economic Co-operation and Development) (OECD, 2019a).

In PISA 2018, Indonesia got an average score of 379 on mathematic skills and Indonesia was the 10th lowest-ranked country among 79 other countries. When compared between the 2018 PISA results and the 2015 PISA results, mathematics scores of Indonesian students have decreased (Natsir & Munfarikhatin, 2021). The research of Purwasih et al., (2018) explain that having high mathematical literacy skills, students will have good competitiveness as well. This statement can be implied in the current situation, if Indonesian students have low mathematical literacy skills, then students in Indonesia can not to compete with other countries. Even though mathematical literacy skills are very important because mathematical literacy skills are one of the global competencies that are assessed in the PISA study every 3 years (OECD, 2020).

Research by Suratno & Sari (2021) discusses about comparison of the Indonesian curriculum with South Korea and Singapore. Presenting the results which is Indonesia's curriculum is still far behind Korea and Singapore. The curriculum of Indonesia tends to be denser than other countries. Meanwhile, the research of Suprapto (2016) discusses about comparison of science abilities of Indonesian students with several other countries in term of PISA 2015 results. The result is Indonesian students had low scientific abilities and their knowledge of science is low too. Indonesia have to learn a lot from other countries regarding science curriculum, qualifications related to pedagogy, implementation of scientific innovation assessments, and others. There is also research from de Vries, et al. (2022) which discusses about the comparison of results PISA 2015 in various countries with diverse cultures. The result is PISA 2015 are considered capable of being used across cultures between countries. Although they are less congruent and invariant, it is advisable to be careful in interpreting the negative relationship that found in PISA study. The weakness in some of these studies is the comparative studies are only related to the mathematics curriculum, the orientation is not based on international studies such as the latest PISA, and some of them do not even discuss about mathematics. Therefore, this study will discusses about "Comparative Study of Indonesian Students' Mathematical Literacy Abilities with Other Countries in Terms of PISA type HOTS" whose literature orientation is based on PISA 2018. The subjects of this research is Indonesian students 15 years old and also students from other countries. The purpose of this study is to determine the mathematical literacy ability of Indonesian students in other countries. This study is aimed to preparing Indonesian students for the upcoming PISA 2024, so that students can have better mathematical literacy skills than the results of previous PISA studies. After knowing the mathematical literacy abilities of students from other countries, Indonesian students are expected to be able to improve these abilities so that they can have good competitiveness in various aspects of daily life, politics, and demands in the world of work (Sari, 2015).

LITERATURE REVIEW

Mathematical literacy is the one of mathematical abilities related to procedures, basic knowledge, competence, and confidence in applying knowledge in everyday life (Abdussakir, 2018). Someone who has mathematical literacy skills will have a sensitivity to mathematical concepts with the problems (Asmara, et al., 2017). At this time, mathematical literacy skills are the main skills that must be possessed to be able to get through life with social, financial, cultural, and economic aspects (Suryaprani, et al., 2016). Mathematical literacy is also one of the mathematical abilities in formulating problems, solving, and interpreting the results in various contexts (OECD, 2020). Therefore, mathematical literacy is not only related to problem-solving but also refers to a higher direction and is more than just understanding, namely interpreting the required results (Wulandari & Azka, 2018). This shows that mathematical literacy skills are consentient with the mathematical ability standards by NCTM (National Council of Teachers of Mathematics). In Masjaya & Wardono (2018), NCTM describes five standards of mathematical ability that must be possessed by students, (1) mathematical problem solving, (2) mathematical reasoning, (3) mathematical communication, (4) connection mathematical, and (5) mathematical representation. The following are some indicators of mathematical literacy skills:

Table 1
Mathematical Literacy Indicator

Indicator	Explanation
Formulating the Problem	Students can understand real problems and formulate them with what is known and what is asked
Using Mathematical Concepts	Students can use some mathematical formulas and concepts from real problems
Interpreting Solutions	Students can solve problems using mathematical concepts appropriately and conclude what has been solved
Evaluating Solutions or Results	Students can re-evaluate the results and be able to re-explain the results that have been completed.

Based on indicators of mathematical literacy ability according to Utami, et al. (2020) shows that Indonesian students must have 4 indicators, so it can be said that students have a mathematical literacy skills. The research by Purwanti, et al. (2021) mentions the same thing with regard to indicators of mathematical literacy, that's the ability to formulate problems, apply mathematical concepts, and able to interpret the results of solutions. Based on Suryapuspitarini, et al. (2018) mathematical literacy is a student's sensitivity to understanding mathematical concepts that are relevant to the phenomenon or problem being faced. Mathematical literacy is a student's ability or capacity to identify the role and reasoning of mathematics in a broad context to solve mathematical problems in everyday life (Riyatuljannah & Fatonah, 2021). According to research by Masfufah & Afriansyah (2021) states that students' mathematical literacy skills are very important and needed in this era, so that students can compete with other countries. Mathematical literacy indicator is consentient with the assessment carried out in the PISA study. The following are the indicators used by the PISA study according to OECD:

Table 2

Table 2
PISA Indicator 2018

Level	Indicator
Level 1	Students can collect existing information and answer questions on command with all relevant information
Level 2	Students can recognize problems, use appropriate formulas to solve problems, and interpret results
Level 3	Students can carry out procedures well, can apply their ability to solve problems with mathematical concepts, and interpret the results.
Level 4	Students can carry out procedures well, apply their ability to solve problems with mathematical concepts and interpret the results.
Level 5	Students can work on problems effectively with concrete and complex models, able to present them in real situations
Level 6	Students can solve complex problems and apply strategies in solving complex problems

In the table, it can be seen that there are many similarities and continuity between indicators of mathematical literacy ability and the level of indicators used by the PISA study. These equations can be seen in mathematical literacy skills, formulating problems at levels 1, 2 and 6, applying concepts that have similarities to levels 2, 3, and 5, solving problems at levels 1 to 6, and for interpreting results with PISA levels 3, 4, and 6. Johar (2012) also explain that the purpose of PISA study is to expect students to have the literacy ability. There's also Mansur (2018) explain to improve mathematical literacy skills is doing a practice of PISA quetion. It's can be indicated that mathematical literacy has a relationship with PISA study. PISA questions can also be categorized as HOTS (High Order Thinking Skill) type questions, because HOTS is not only related to remembering, but also re-expressing or referring to something without processing (Gradini, 2019). According to Sofyan (2019) states that if you experience an error in understanding the HOTS concept, it will affect the error of an unproductive and ineffective in learning. Based on Bloom's taxonomy, according to Anderson (2001) HOTS is abilities consist of analyze, evaluate, and create. The following are Bloom's taxonomy based on Anderson (2001):

Table 3
Bloom's Taxonomy

Phase			Description
Low Order Thinking Skills	C1	Remember	Remember some basic concepts and knowledge
	C2	Understand	Able to explain some basic ideas, facts or concepts
	C3	Apply	Using information obtained in new situations
High Order Thinking Skills	C4	Analyze	Correlate between ideas with each other
	C5	Evaluate	Define a decision or procedure
	C6	Create	Produce something new and original

The relationship between HOTS and levels in the PISA study that C4, C5, and C6, have pairs at levels 4, 5, and 6 in the PISA study (Kurniati, et al., 2016). Hartini, et al. (2018)

explained that HOTS at the PISA level can be seen from formulating complex problems in level 6 PISA, it's also found in HOTS at C6 Bloom's Taxonomy. The following is the relationship between mathematical literacy, PISA study, and HOTS:

Table 4.
Relationship between Mathematic Literacy, PISA Study, and HOTS

	Formulating the Problem	Using Mathematical Concepts	Interpreting Solutions	Evaluating Solutions or Results
PISA level and Bloom's Taxonomy	1,2,6	2,3,5	1,2,3,4,5,6.	3,4,6.

HOTS in Bloom's Taxonomy are found at C4, C5, and C6. In this case, it can be seen that mathematical literacy ability has a relationship with PISA levels 1-6. There are also Levels 4,5,6 and C4, C5, C6, in each mathematical literacy indicator, which indicate that each has something in common. Dinni (2018) which states that the PISA questions can be used as a tool to measure students' abilities in HOTS or LOTS (Low Order Thinking Skill).

METHODS

This research belongs to the qualitative approach and the type of research used is a literature study. According to Surani (2019), research with literature studies aims to describe phenomena that occurred in the past or those that occur in the present. The source of this research data comes from several journals resulting from PISA 2018 study by the OECD.

RESULT AND DISCUSSION

PISA is an international study established by the OECD as an event to highlight students' mathematical literacy skills in several participating countries in the 21st century (Wulandari & Azka, 2018). As for Johar (2012) who supports this statement, that PISA has a goal, specifically to pay attention to 15 year old students learn in school. PISA was first held in 2000 and continues to be held in every 3 years (Stacey, 2011). The results of the PISA study are also able to have an impact on participating countries, if the results obtained are good, then the country has educational standards that are in accordance with the needs of the international market (Hewi & Shaleh, 2020). Not only that, The Minister of Education Nadiem Makarim also said that by participating in PISA study, Indonesia was able to carry out evaluation actions related to the quality of education (Zahid, 2020). In PISA 2018, Indonesia received an average math score of 379 (Natsir & Munfarikhatin, 2021). This score is below the average score that has been set by the OECD, which is 489 (OECD, 2019a). The following are the results of several countries that have the highest average math scores in PISA 2018:

Table 5
Highest score on PISA 2018 study results

Country	2018 PISA Average Score
B-S-J-Z China	591
Singapore	569
Macau (China)	558
Hongkong (China)	551
China Taipei	531
Japan	527

Based on the table related to the average score of PISA 2018 results, we can conclude that China get the first rank, the second rank is Singapore, the third rank is Japan, and South Korea has a fourth rank. Meanwhile, Indonesia get ranked 69th among 79 countries with an average score of 379 (OECD, 2019a). Among the four countries that ranked highest in PISA 2018, we can compare the mathematical literacy abilities of students in these countries based on level 2 and level 5. OECD (2019a) classifies these differences into level 2 or above. According to research Zulkardi & Kohar (2018) mention that level 2 can be categorized in LOTS and level 5 into HOTS. The following table shows the differences in the learning systems applied in each country:

Table 6
Differences in mathematical literacy ability in each country

Country	Students who have math skills at level 2 or more	Students who have math skills at level 5 or more
China	98%	44%
Singapore	93%	37%
Japan	89%	18%
Argentina	31%	1%
Indonesia	28%	1%

The table presents the results of students' mathematical abilities in several countries based on the results of PISA 2018. The average determined by the OECD, at least 76% of students in a country must have mathematical literacy skills on PISA 2018 questions level 2 or more. For PISA 2018 questions level 5 or more, the average determined by the OECD is 9% of students must have mathematical literacy skills (OECD, 2019a). In China, 98% of students are able to work on PISA level 2 questions or more. As for 44% of students are able to work on PISA questions at level 5 or more (OECD, 2019b). In addition, students in China have good mathematical literacy skills, because in the habit of practicing math problems, they have mathematical literacy indicators, namely identifying, applying concepts, and providing solutions (Purnama, et al., 2020). According to research by Fang (2021) stated that formulating problems and applying concepts in mathematics since elementary school is very important to build good mathematical literacy skills. Therefore, China has good literacy skills in PISA 2018. According to Yudi, et al. (2020) China has literacy education levels and China also emphasizes students to use the right mathematical language, using the HOTS earning method, prioritizing mathematical thinking, logical reasoning in every lesson (Sulistyo & Dwidayati, 2021). China has also learned a lot from PISA study to improve students' mathematical literacy skills by conducting a Compulsory Education Quality Monitoring Program (CEQMP) by paying attention to characteristics suitable for China (Chen, 2020). The thing that makes China get first place in mathematical literacy compared to other countries is carried out using large-size mathematice classroom which makes students able to understand mathematics using their own language and create

something new from the discussions (Dong, et al., 2019). This is included in the HOTS with C6 category which is to produce something new and original Anderson (2001).

There is also Singapore which occupies the second position as the country with the highest average score in the PISA 2018. Singapore is the country that still a younger from Indonesia, but it is possible for Singapore get the second highest score in the PISA 2018 (OECD, 2019a). As many 93% of students in Singapore were able to solve PISA 2018 questions at level 2 or more, then 37% of students in Singapore were able to solve PISA questions at level 5 or more (OECD, 2019d). Indonesia and Singapore have learning with the same cognitive level, which emphasizes memorization, but what makes Singapore different from Indonesia is that Singapore uses more open-ended questions (Sianturi, et al., 2021). This allow students being able to answer mathematical problems using their own language which is one of the indicators found in mathematical literacy (Utami, et al., 2020). Singapore has learned a lot from the results of the previous PISA 2015 by improving the curriculum and bringing up Science, Technology, Engineering, and Mathematics (STEM) education as the secret to the success of students in Singapore in PISA 2018 results (Tan, et al., 2021). The curriculum in Singapore is also realting one of the teaching methods explicitly in critical and creative thinking (Sa'adah, 2019). This explicit teaching is consentient with research of Astuti (2018) which explain that critical thinking and creative thinking are related to mathematical literacy skills. The study explains that creative thinking is needed to formulate and make decisions on mathematical problems, while creative thinking is needed to bring up creative ideas that exist in students in order to provide solutions to mathematical problems in the real world. Suprapto (2016) explains that the education system in Singapore also emphasizes students' habituation of HOTS type questions in learning which results in Singapore getting a high average score on the results of the PISA 2018. HOTS is more dominant at the C4, then followed by C6, while C5 is not too much in each practice question (Manopo & Rahajeng, 2020)

Furthermore, there is Japan which gets an average score of 527 on the results of the 2018 PISA study (OECD, 2019a). There are 89% of students in Japan who are able to work on PISA 2018 questions at level 2 or more, while 18% of students are able to work on PISA 2018 questions at level 5 or more (OECD, 2019c). Students in Japan have a recent learning culture, namely the importance of being able to formulate problems, apply concepts, and provide solutions using communicative language in mathematics learning which is an indicator of mathematical literacy (Shinno, et al., 2014). Based on Tasaki (2017) research explain that students in Japan learn a lot of competencies in PISA including mathematical literacy skills so they are able to achieve high scores in PISA 2018. This study is consentient with research from Montanesa, et al., (2021) who explained that students in Japan are mostly taught to solve a problem and think critically in learning mathematics. Not only that, the education system in Japan also prioritizes affective, cognitive, and psychomotor aspects which resulted in students in Japan being able to achieve high scores in PISA 2018. It also consentient with research of Azmi, et al. (2020) which explain that mathematical literacy skills also require high-level mathematical abilities or used HOTS in solving PISA questions. Students in Japan also mention that the ability to create or C6 category on HOTS is very important in learning mathematics (Shinno, et al., 2014).

There is also Argentina which has the same math score as Indonesia with a score of 379 (OECD, 2018). The percentage of students at level 5 or above is 1% the same as students in Indonesia. The difference lies in the percentage of students who are able to complete level 2 or more, which is 31%. This percentage is bigger than Indonesia's which is 28% only. This could be due to the fact that mathematics learning carried out in Argentina includes several practice questions and the realization of the problem into an

mathematic problem and some object in math exercise (D'Amelio, 2010). Therefore, this learning is able to trigger students to have all the indicators contained in mathematical literacy. The research from Pamungkas, et al. (2019) also states that problem-based learning can improve students' mathematical literacy skills at school. There's also about student answers in the book of ICME (2020), it shows that students are able to answer mathematical problems by creating answers in their own way and this ability is included in HOTS C6. While in Indonesia, students have difficulty in adapting PISA level 3 which is also the C3 level which is included in the LOTS (Purwasih, et al., 2018). In the research of Utami, et al. (2020) also stated that 16 out of 30 students had no mathematical literacy skills at all, which indicated a lower percentage in level 2 or above compared to Argentina in PISA 2018 despite having an equivalent math score (OECD, 2019a).

CONCLUSION AND IMPLICATION

Conclusion

The conclusion from this article is students in Indonesia are not able to work on mathematical literacy questions, which results in them not having any mathematical literacy skills at all. It causes Indonesia to have a low score in PISA 2018. Several other countries that got the highest score in the 2018 PISA study, such as China, which scored 591 and had 98% of students who were able to work on PISA level 2 questions or more. For students in China who are able to work on PISA questions at level 5 or more, there are 44%. Student in China also had an ability in mathematic literacy which is identifying, applying concepts, and providing solutions. In learning mathematics, Chinese uses large classrooms that allow students to understand mathematics using their own language and create new things from discussions which are included in HOTS category C6. As for Singapore, which scored 569, there's 93% of students were capable of level 2 or more, and 37% of students were capable of level 5 or more. Singapore used Open Ended Question that can made student had 4 indicator of mathematic literacy. Not only that, Singapore used HOTS too and more dominant at the C4, then followed by C6. Furthermore, Japan obtained a score of 527, there's 89% of students with ability level 2 and more, and 18% for students with ability level 5 or more. Students in Japan have a recent learning culture, namely the importance of being able to formulate problems, apply concepts, and provide solutions using communicative language in mathematics learning which is an indicator of mathematical literacy. Also Students in Japan also mention that the ability to create or C6 category on HOTS is very important in learning mathematics. There is also Argentina which got a score of 379 same as Indonesia. There's as many as 39% have abilities at level 2 or more, and only 1% of students are capable at level 5 or more. In math literacy, student in Argentina can reach all the indicator of mathematic literacy because they able to solve math realistic problem in C6 cathegory of Taxonomy Bloom. Meanwhile, Indonesia as many as 28% of students were capable of level 2 or more, and only 1% of students were capable of level 5 or more. In math literacy, there's student students who do not even have mathematical literacy skills and are only able to work on C3 level questions on Bloom's taxonomy which means in LOTS only. Therefore, Indonesia has a lot to learn from the results of the 2018 PISA study. Indonesia students must be able to follow other countries by habituating students in working on HOTS type questions to improve the mathematical literacy skills.

ACKNOWLEDGMENTS

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