An analysis of students’ mathematical literacy skills assessed from students’ learning style

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Abstract. This study aims to determine students’ mathematical literacy skills based on their learning styles. This descriptive research used a learning style questionnaire, a students’ mathematical literacy test to determine students’ mathematical skills, and interviews to complement the data. The data analysis included analyzing the learning style and mathematical literacy tests with data validity using the triangulation method. This study revealed several results: 1) The mathematical literacy skills of students with visual, auditory, and kinesthetic learning styles were still deficient, where only 14% of students answering the mathematical literacy questions correctly; 2) The mathematical literacy skills of students with a kinesthetic learning style were better than students’ with visual and auditory learning styles; 3) Students with a visual learning style had been able to formulate the given mathematical problems, while the use of mathematical concepts and interpreting mathematical problems were still lacking; 4) Students with an auditory learning style had the lowest skills in formulating mathematical problems so that they mistakenly used basic mathematical concepts; and 5) Students with a kinesthetic learning style were able to formulate and use mathematical concepts properly and correctly despite still lack of interpreting mathematical problems.

1. Introduction

As cited in the 2012 PISA report, mathematical literacy is defined as an individual’s skill to formulate, apply, and interpret mathematics in various contexts [1]. Mathematical literacy skills are an ability that involves several other skills, including interpreting skills, reasoning skills, comprehension skills, conceptual skills, and the skills to describe, explain, and predict a phenomenon or event [2]. Mathematical literacy skills are highly essential, not only in solving mathematical problems but also in solving problems of everyday life. By having high mathematical literacy skills, students are expected to be able to answer questions in the form of long sentences or story questions, which, in fact, there are still many students who have difficulty solving such problems. Besides, with high mathematical literacy skills, students are also expected to solve the problems they face in their daily lives. In addition, a new regulation that the Minimum Competency Assessment (MCA) will be applied using literacy questions, both language, and numeracy literacy, contributes to the importance of mathematical literacy skills for students.
The importance of students’ mathematical literacy skills in Indonesia is not in line with Indonesia’s achievements related to mathematical literacy skills. It can be seen from a PISA survey in which Indonesia’s score for mathematical literacy skills is below the average international score. In 2000, the mathematical literacy achievement of Indonesian students aged 15 ranked 39 out of 41 participating countries. In 2003, Indonesia ranked 38 out of 40 participants and ranked 50 out of 57 participating countries in 2006. In 2009, Indonesia ranked 61 out of 65 countries with an average score of 371, far below Singapore’s average score of 562, which was the second place. Meanwhile, Indonesia students’ mathematical literacy achievement in 2012 fell further to rank 64 out of 65 countries. This rank was still below Vietnam, where the mathematical literacy of Vietnam ranked 17 out of 65 participating countries with an average score of 511. Meanwhile, Indonesia only obtained an average score of 375 points. And the most recent update in 2018, Indonesia ranked 72 out of 78 participating countries. Based on the PISA survey above, one would conclude that students' mathematical literacy skills from 2000 to 2018 did not experience significant progress. In the last 18 years, Indonesia ranked in the top ten countries with the lowest mathematical literacy skills.

It has certainly raised a concern, especially for mathematics teachers. It is important to note that the mathematics learning process should not only make students proficient in arithmetic but also train skills to understand, reason, solve problems, and apply concepts and others in everyday life. As stated by Hudojo, mathematics is a tool that can be used to develop ways of thinking [3]. Mathematics is a science that cannot stand alone, but it can help humans understand and master economic, social, and natural problems [4].

The researchers conducted interviews at the State Senior High School 2 Sukatani, Bekasi District, and we found that students’ mathematical literacy ability was still low. Based on the interviews with one of the mathematics teachers, there has been no specific research on mathematical literacy skills carried out in the school. Students' mathematical literacy skills at the State Senior High School 2 Sukatani were still considered very low. Students' low ability of mathematical literacy is shown by their inability to solve mathematical problems, including how to formulate problems in the form of mathematical models, reason a mathematical problem, apply mathematical concepts, and interpret mathematics in various contents. Even though there were reading literacy activities in the school, this is not enough to improve the students’ mathematical literacy skills.

Furthermore, Hayati and Kamid, in their study, also reported another fact of the low mathematical literacy ability of students. This research resulted that students majoring in social studies were less good at reasoning and planning to solve mathematical problems and unable to express what they think orally. This similar issue also happens in students majoring in science; they are less able to debate mathematically and express opinions[2].

More specifically, Organization for Economic Co-operation and Development (OECD) explains that aspects of mathematical literacy include the individual’s skills to formulate, identify, understand, and use basic mathematical concepts in various contexts that the individuals need to overcome the problems of daily life. Therefore, mathematical literacy skills include mathematical reasoning, mathematical concepts, procedures, and mathematical facts to explain and predict an event [5].

In mathematical literacy, three skills are emphasized, consisting of the skills to formulate, employ, and interpret [6]. The skills to formulate in mathematics include identifying opportunities to apply and use mathematics to solve particular problems, which then provide a mathematical structure and representation to identify variables and simplify assumptions in solving the problem. The skills to employ in this case include the application of reasoning skills, concepts, procedures, facts, and mathematical tools to obtain mathematical solutions, including the calculation of manipulation of algebraic forms, mathematical equations and models, analyzing information from diagrams or graphs, developing mathematical explanations, and using mathematical tools to find solutions of mathematical problems. While the skills to interpret in mathematics, include the ability to interpret an answer that has been completed according to the context of the problem, reflect on mathematical solutions, evaluate mathematical solutions, and determine or check the truth and reasons for the results obtained [6].
According to Mahdiansyah and Rahmawati, mathematical literacy skills are influenced by several factors [2]. These factors are generally grouped into two categories: internal factors (within students) and external factors (outside students). The factors within students are intellectual, student learning style, numerical, verbal, and non-cognitive aspects, such as interests and motivation. In contrast, the factors outside students include the family environment, school, mass media, and social environment. Based on this statement, the style in the student learning process is a factor within students. Student learning styles can affect students’ mathematical literacy skills. Based on the study conducted by Suryono, learning styles have a significant effect on student learning outcomes [7]. He revealed that the higher the student’s learning style is—visual, auditory, and kinesthetic—the higher the student’s learning outcomes will be. Similarly, Dunn reveals that learning style is a collection of personal characteristics of a person that makes effective learning [7]. According to Hasrul, learning styles are the key to developing work performance in schools [8]. It means that when students have realized how they and others absorb information, they will be able to make learning and communication easier in their own style.

According to Al Ghraibel and Abdullah, the style is not presented as good or bad or as right or wrong. The styles tend to show a presence for mental activities that are different from one another [9]. All three styles tend to remain unchanged. The concept of learning styles refers to as how people prefer to learn or students’ strategies in learning or also the way they like to learn optimally [10]. Lopatin and Sahranli explain that learning style is an action that is considered attractive for students in carrying out learning activities, both when studying individually and studying in groups [11]. According to Hasrul, learning style is a combination of ways that an individual carries out to absorb information that is then managed and processed to produce knowledge for themselves [8]. According to Chania et al., the learning style is the most preferred form and a way for students to learn, and students have different learning styles from one another [11]. This is because each individual has their own preferences and uniqueness, which would not be the same as any other individual. The approach commonly used is learning styles based on sensory modalities, including visual, auditory, and kinesthetic learning styles [12].

Visual learning style is a learning style in which students tend to learn through what they see. Students with a visual learning style will rely on their sense of sight (eyes). Children with a visual learning style must see body language and facial expressions from the teacher who teaches them directly. They can present interesting pictures in the learning process [13]. The characteristics of students with a visual learning style include: 1) prioritizing appearance in clothes or during presentations; 2) quickly remembering what is seen than what is heard; 3) preferring reading rather than listening to stories; 4) reading quickly, carefully, and diligently; and 5) remembering with social associations [13].

Auditory learning style is a learning style in which students tend to be more sensitive to what they hear [10]. Auditory learning styles are very dependent on their sense of hearing (ears), in which they enjoy the time when a person is telling a story [11]. According to Hasrul, the characteristics of students with an auditory learning style are 1) talking to themselves at work, 2) easily getting distracted when there is noise, 3) preferring reading books aloud, 4) can repeat and imitate tone, rhythm, and voice color, 5) having difficulty in writing but great at telling stories, 6) speaking with a patterned intonation, 7) usually like music, 8) learning by listening and remembering what is discussed rather than what is seen, 9) enjoying to discuss and explain something in detail and like spoken jokes rather than reading comics [9].

Kinesthetic learning style is a learning style in which students like the learning process through touch or movement [10]. Individuals with kinesthetic learning styles will learn better when they are physically involved directly in the learning process [11]. Children with this learning style usually cannot sit quietly during the learning process because they desire to do activities [11]. Hasrul suggests that the characteristics of a kinesthetic learning style are as follows: 1) speaking slowly, 2) responding to physical attention, 3) touching someone to get attention, 4) standing close when talking to others, 5) always physical-oriented and moving a lot, 6) learning through manipulation and practice, 7)
memorizing by walking and seeing 8) using fingers to point to reading, 9) using a lot of body gestures, 10) uncomfortable to sit still for a long time, 11) unable to remember geographical location unless they have visited the place, 12) using words that contain action, 13) reflecting action with gestures while reading, and 14) want to do something and like busy games [9].

2. Research Method
This study used a descriptive approach. This study describes how students' mathematical literacy skills are if reviewed from the students' learning style. To obtain data related to student learning styles, the researchers provided a questionnaire to categorize students based on their learning styles, visual, audio, or kinesthetic. This instrument was initially tested on 28 different students to determine its validity and reliability. The scale to determine student learning styles used a Likert scale, consisting of a series of statements that have positive and negative meanings. The choices for the statements included strongly agree (SA), agree (A), disagree (DS), strongly disagree (SDS). For positive statements, the choices of SA, A, DS, and SDS scored 4, 3, 2, 1, respectively. For negative statements, the choices of SA, A, DS, and SDS scored 1, 2, 3, and 4, respectively. After that, the validity is calculated by comparing the t count and t table.

The researchers initially made 32 statements embedding three learning styles—audio, visual, and kinesthetic—where each learning style had four indicators. However, after calculating, only 21 statements were valid. Then these valid statements were calculated for their reliability using the Kuder-Richarson formula. From the tests carried out, the reliability value obtained the score of 0.94295, which is, based on the instrument's criteria, considered highly reliable. It means that if the test or instrument is distributed to other respondents, the results obtained will not be different or often said to have very high consistency.

Besides, to determine students’ mathematical literacy skills, the researchers used a question instrument that contained three mathematical literacy skills indicators. Before the instrument was used in the research, a trial was conducted first. From the five questions tested, four questions were valid, and one question was invalid. Of the four valid questions, the reliable value is calculated. The results obtained the reliability value of 3.07 while the t table for alpha 0.5 and 26 degrees of freedom is 1.706. If it is compared to the two, it can be concluded that t arithmetic is greater than t table, which means that the reliability of the five questions is high. Therefore, the instrument is considered reliable, meaning that if we re-test the instrument, it will get the same results.

The data source in this study was twelfth-grade students of the State Senior High School 2 Sukatani. Of the five classes given the questionnaire, 90 students were selected with a classification of 38 students with a visual learning style, 25 students with an auditory learning style, and 27 students with a kinesthetic learning style. The selection of the 90 students was obtained from the results of interviews and recommendations from the mathematics teacher at the school. According to the mathematics teacher, the 90 students represented the mathematics skills in Grade 12 of the Mathematics and Natural Sciences program. Then, the 90 students were given instruments about the students' mathematical literacy skills. However, of the 90 students, only three students representing each learning style were interviewed by the researchers. The selection to interview the three students was based on high, moderate, and low literacy test scores.

3. Results and Discussion
Before discussing the results of the study, it is worth to share the process of collecting data. We found it challenging to distribute question instruments. In these current conditions, schools in Indonesia, especially where the researchers conducted the study, were affected by the Covid-19 outbreak. Since the schools carried out an online learning or distance learning, the researchers used several applications in collecting research data, including the Google Classroom application as a forum for sharing mathematical literacy instruments and collecting answer sheets, the Zoom meeting application in monitoring the instrument tests carried out, Google Form in filling out a learning style questionnaire
and the video call feature in the WhatsApp application in the interview data collection process. By using the online application, this study process could be run smoothly.

The research instrument for the aspects of visual learning styles, auditory learning styles, and kinesthetic learning styles has seven valid items. Thus, the highest ideal score for each learning style is $7 \times 4 = 28$, and the lowest ideal score is $7 \times 1 = 7$. The ideal mean is $\frac{1}{2} (28 + 7) = 17.5$ and an ideal $SD= \frac{1}{6} (28 - 7) = 3.5$. The learning style tendency of students can be seen from the highest number of scores [13].

Based on the analysis of the learning style questionnaire, it showed that students at the State Senior High School 2 Sukatani had different learning styles. The results of the questionnaire resulted in categories of visual, auditory, and kinesthetic learning styles. Although some students had more than one dominant learning style, the ones analyzed were students with one dominant learning style. Based on the categorization results, the visual learning style was dominant among students at the State Senior High School 2 Sukatani. The results of the student learning style test can be seen in Table 1.

| Learning Style       | Number of Students |
|----------------------|--------------------|
| Visual               | 38                 |
| Auditory             | 25                 |
| Kinesthetic          | 27                 |
| Visual-Auditory      | 4                  |
| Visual-Kinesthetic   | 2                  |
| Auditory-Kinesthetic | 2                  |

Based on Table 1, most of the students (38.78%) used visual learning styles, 25.51% had an auditory learning style, and 27.55% possessed a kinesthetic learning style. These results are the same as the results of the study conducted by Edimuslim et al. (2019) and Nariyat et al. (2010). The two studies showed that visual learning style dominated the sample. Edimuslim et al. (2019, 100) reported that students with a visual learning style were 37.5%, students with an auditory learning style were 31.2%, and students with a kinesthetic learning style were 21.8%. Meanwhile, Nariyati et al. (2010) found that students with a visual learning style were 40.91%.

Based on the analysis results, less than 50% of students answered the mathematical literacy questions correctly. Only 20% of kinesthetic students, 13% of visual students, and 11% of auditory students were able to answer all literacy questions correctly. These percentages showed that students with a kinesthetic learning style had higher mathematical literacy skills than students with auditory and visual learning styles.

However, overall, students’ mathematical literacy skills remained very low because, of the entire sample, only 14% of students answered correctly, which was far from our expectations. The following will explain students’ answers regarding literacy questions according to their learning styles.
Figure 1 shows a student’s answer with a kinesthetic learning style. In the figure, it can be seen that the student with the kinesthetic learning style was able to formulate and use mathematical concepts properly and correctly even though he was still lacking in interpreting mathematical problems. Based on the answers, it can be seen that the student had been able to properly formulate or had been able to reason the problems in the questions, which they could then change to the form of a mathematical model and determine the mathematical concepts used in the explanation of the problem. Also, there were several students with kinesthetic skills trying to explain well, but there were more students who could not explain the solution to mathematical problems well.

Figure 2. A student’s answer with a visual learning style
Figure 2 shows a student’s answer with a visual learning style. Based on the answers given, the student with the visual learning style had formulated the mathematical problems. However, the use of mathematical concepts and explaining or interpreting mathematical problems was still lacking. Based on the answers given, it can be seen that the student had been able to change the problem into mathematical variables. But, when doing calculations, the student made mistakes and ended up with the wrong conclusions.

Based on Figure 3, it can be seen that the student with an auditory learning style had such low skills in formulating mathematical problems that he misused basic mathematical concepts. Based on the student’s answers and interviews with several students with the auditory learning style, these students were still confused in translating the problems into mathematical symbols as something that is known because they still had difficulty in reasoning. These students had difficulty determining the basic concepts used as a calculation, and in the end, the students had difficulty explaining the mathematical problem.

4. Conclusion

Mathematical literacy ability is an ability that involves several other abilities, including the ability to interpret, reasoning abilities, comprehension skills, conceptual use abilities, and the ability to describe, explain and predict a phenomenon or event. Mathematical literacy focuses mostly on three abilities: formulating, employing, and interpreting. These three abilities are then used as indicators in research on mathematical literacy abilities. The ability of mathematical literacy is influenced by several factors. One of them is the student's internal factor, to wit, the student learning style factor. In general, approaches often used regarding student learning styles are learning styles based on sensory modalities, namely visual learning styles, auditory learning styles, and kinesthetic learning styles. The higher the student's learning style is—visual, auditory, or kinesthetic—the higher the learning outcomes or the abilities he/she gets, including students' mathematical literacy abilities. Students with kinesthetic learning styles have better mathematical literacy skills than students with auditory and visual learning styles. However, overall, students' mathematical literacy skills in this study in terms of their learning styles were still considered very low.

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