Algebraic literacy skills of secondary school students

V Angriani, T Herman, and E Nurlaelah
Departemen Pendidikan Matematika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia.

Email: viviangriani@upi.edu

Abstract. The focus of this study is the mathematical literacy in the change and relationships section of the algebra and its use, which is called algebraic literacy. This study aims to obtain a description of algebraic literacy skills of VII grade students, it is analysed based on the mathematical literacy levels and indicators. This study is descriptive qualitative. The participants included 72 students from three secondary schools in Bandung. The data were collected using a test and interview. Based on the analysis, the students’ algebraic literacy skills are found to be low, at levels 1, 5, and 6, due to the lack of understanding of the relationship between arithmetic and algebra, the more complex of problem-solving questions, the structured questions with non-routine type, and the students’ inaccuracy in formulating situations. Moreover, the achievement of ‘formulate’ and ‘interpret’ indicators are found to be lower since the students are less familiar with the concept of symbols used as the substitute for varying quantities, and are less able to contemplate the algebraic solutions, thus the problems cannot be interpreted properly.

1. Introduction
Mathematical literacy constitutes one’s skills in reading, writing, speaking, and listening with mathematical understanding [1], leading to the ability to formulate, use, and interpret mathematics in various contexts which include mathematical reasoning as well as the use of concepts, procedures, facts, and tools in describing, explaining, and predicting phenomena [2–6]. Mathematical literacy becomes one of the skills needed by every individual to meet the needs of being a member of society who is qualified, constructive, caring, willing to think and able to solve mathematical problems in both daily basis and work environments [7–11]. Hence, the skills may help individuals recognize the role of mathematics in the real world by making careful judgments and necessary decisions [3].

However, the current facts indicate that Indonesia’s mathematical literacy, based on the 2015 PISA, is still low, ranking 63 out of 70 participating countries, with an average point of 386. This position has held Indonesia back from the international average of 490 [12]. More specifically, Stacey describes the Indonesian students as lacking the mathematical literacy in association with the concept of change and relationships [7]. This is in line with Firnanda who reveals that a number of students do have difficulty with the concept of change and relationships related to the algebra material, particularly in simplifying algebraic forms [13]. These difficulties, according to Setiawati, Herman, and Jupri, emerge since students often misunderstand the concept of algebra, apply arithmetic operations in algebraic expressions, and interpret symbols from unknown elements in the problems given [11]. This is because the students do not properly comprehend the relationship between algebra and arithmetic [14, 15]. To investigate the factors causing the students’ difficulties in a clearer way, in order to help empower and equip them with the introduction to algebra for meeting the needs in daily basis nowadays and in the future, more specific mathematical literacy skills are needed, namely algebraic literacy.
Algebraic literacy is part of mathematical literacy, therefore, like mathematical literacy, algebraic literacy consists of several levels as well. The mathematical literacy in PISA 2015, implemented in the OECD, are divided into six levels [16]. Each level represents a different extent of mathematical competence achieved by learners. Also, the OECD describes that mathematical literacy consists of three indicators [16]. They are formulating, applying, and interpreting. Thus, the purpose of the present study is to explore the causes of the difficulty of algebraic literacy skills in the VII grade students based on the regulated levels and indicators.

2. Method
The current study used qualitative descriptive approach. The research participants were 72 of VII-grade students from three secondary schools in Bandung. The selection out of the three schools was intended to increase the variety of answers to the algebraic literacy problems among the students through the city. The data were obtained using tests and interviews. The instrument used was the 2012 PISA adapted algebraic literacy test. The test was arranged in 6 levels with 3 indicators, namely formulate, employ, and interpret [16]. The number of questions in this test represented mathematical literacy level. Based on the indicators, questions 1 and 5 represented formulate indicator, questions 2 and 3 represented employ indicator, and question 4 and 6 represented interpret indicator. Each item from the algebra literacy test is shown in Table 1.

| Level | Indicators of Mathematical Literacy | Question |
|-------|--------------------------------------|----------|
| 1     | **Formulate**                        | Uncle Mutu’s age is 4 times of Upin’s age. In the next three years, their total age is 46 years. If Upin's age is x years, which mathematical model represent the situation? (Give your reason). |
|       |                                      | a. \(4x + 3 = 46\) | c. \(5x + 3 = 46\) |
|       |                                      | b. \(4x + 6 = 46\) | d. \(5x + 6 = 46\) |
| 2     | **Employing**                        | Raisa rode her motorcycle for 4 km in the first 10 minutes and 2 km in the next 5 minutes during her trip. Which of the following statement is true? (Give your reason). |
|       |                                      | a. Raisa's average speed in riding her motorcycle in the first 10 minutes is faster than the next 5 minutes. |
|       |                                      | b. Raisa's average speed in riding her motorcycle in the first 10 minutes is as fast as the next 5 minutes. |
|       |                                      | c. Raisa's average speed in riding her motorcycle in the first 10 minutes is slower than the next 5 minutes. |
|       |                                      | d. It is impossible to tell anything about Raisa's average speed in riding her motorcycle from the information provided. |
| 3     | **Employing**                        | Olga cycled for 6 km to her aunt's house. Olga's bicycle speed for the whole trip was 18 km / hour. How much time did Olga need to get to his aunt's house? |
| 4     | **Interpret**                        | The circumference of Pak Harun's rectangular land is 66 meters. If the length of the land is 3 meters longer than the width, what is the land area of Mr. Harun? |
| 5     | **Formulate**                        | Mount Bromo climbing road is about 9 km long. Bromo mountaineers are required to return to the foot of the mountain before 20:00. If Syahrini's speed to climb up the mountain was 1.5 km/hour in average, and her speed to climb down was twice her speed to climb up (this speed included the meal breaks
and rest), then what is the latest time for Syahrini to start walking so that she can return at 20:00?

Interpret
There were 3,200,000 followers in Atta Halilintar’s Instagram account in May. If the growth of Atta’s followers always increases by 5% every month, how many followers at the end of August?

3. Result and Discussion
The results of algebraic literacy test were obtained by determining the frequency of students’ correct answers according to the levels and indicators of algebraic literacy in the question items. The percentage of correct answers of the whole 72 participants was then calculated, presented in Table 2, based on the indicators and levels.

| Tabel 2. Percentage of Algebraic Literacy Test Result |
|------------------------------------------------------|
| Level of Algebraic Literacy | Percentage |
| 1                          | 47.22%      |
| 2                          | 61.11%      |
| 3                          | 68.06%      |
| 4                          | 69.44%      |
| 5                          | 54.17%      |
| 6                          | 12.50%      |

| Indicators of Algebraic Literacy | Percentage |
|----------------------------------|------------|
| Formulate                        | 50.69%     |
| Employ                           | 64.58%     |
| Interpret                        | 40.97%     |

3.1. The Analysis of Algebraic Literacy Test based on Literacy Level
Based on the percentage of algebraic literacy test result in Table 2, the students’ achievement on algebraic literacy was better, observed from students’ ability to solve algebraic literacy questions at level 4. However, the students’ achievement on algebraic literacy in level 5 and 6 percentages are lower than level 4. It was due to algebraic literacy non-routine problem-solving questions that were more complex with non-routine types. Therefore, it required further thinking and extraordinary procedures which involved several mathematical operations to solve problems with structured questions at this level. Prakitipong and Nakamura also agreed that the majority of student errors occurred in structured questions [17].

The interview result with AY, SA, and MD indicated that they had low capability in using reasoning and generalizing problem situations with mathematical models autonomously, thus making mistakes during the processes of transferring the situations to Mathematics symbols. This mistakes was considered as an error in the MATH category, in which committed during the re-organization process in the mathematical system [18, 19]. This was due to students’ inaccuracy to formulate the given situations into algebraic forms. Therefore, students could not interpret and argue on the situations well. Therefore, it is suggested that the students should be accustomed to solving the type of problems that can improve their skills in interpreting the results and reflecting the conclusions in their daily life.

Not only at level 5 and 6, students’ algebraic literacy skills in level 1 was also lower than level 2, 3, and 4. The result of 2015 PISA also indicated that the recapitulation of international student average achievement at level 1 was 23.4% lower than level 2, 3, and 4 [16]. In their interview, BK, YD, and MD stated that they were not really capable of using mathematical knowledge to solve general problems with the given information. This was caused by the students’ inability to find arithmetic and algebraic relationships and regularities, and their mistakes in transforming real-world situations into mathematical models. Therefore, algebraic literacy was very important for students, to help them understand the relationship and different characteristics between arithmetic and algebra.
3.2. The Analysis of Algebraic Literacy Test based on Literacy Indicators

Based on the percentage of algebraic literacy test result in Table 2, it can be identified that students were more dominant in algebraic literacy question with employ indicator. In this indicator, most students could apply the concepts, facts, procedures, and algebraic reasoning, and imply strategies for finding conclusions. Nevertheless, the interesting point about the results of this analysis was that students were still not doing mathematical formulation or modeling from real problem situations to algebraic situations. This can be observed from the lower percentage of formulate indicator than the percentage of employ indicator.

In completing formulate problems, SA was able to formulate the situations into mathematical models and prove her answer. But AY and MD solve the problems by guessing the right answer without doing any procedure of formulating problem into algebra form. AY could not even formulate problems into variable as the substitute for varying quantities. It was unfortunate for students to have such achievement in mathematical literacy, especially in algebraic topics in Indonesia, because mathematical literacy was closely related to mathematical modeling concepts [20, 21]. The relationship occurred because the process of formulating mathematical modeling concepts involves real situations to make assumptions in acquiring the solutions [22]. Thus, this phenomenon should be a reference for teachers and researchers to introduce the concept of symbols as a substitute for varying quantities better.

Beside formulate indicator, interpret indicator had the lowest percentage compared to the other indicators. The students who take algebra literacy test were considered as having capability to draw conclusions. However, some of them had not been able to provide right arguments and solution steps, so it is not appropriate to support the conclusion of the provided real problems. BK, YD, and MD were less capable of thinking the algebraic solutions well, so that the problem was not interpreted properly. BK and YD answered the level 6 question by wrote “3 × 5% × 3,200,000” to find out the follower growth in 3 months. On the other hand, MD used “5% × 3,200,000” to count the follower growth for 1 month, and the followers’ growth is similar with the growth in the following month. Although using different method, the three students provided wrong solution. The solution of this problem was based on the development of followers in every month, so that the followers’ growth in the following month was not the same as the previous month. Mistakes during thinking process for finding solution can diminish slowly if students get used to solve various contextual problems in various ways.

4. Conclusion

Based on the findings, it can be concluded that students’ algebraic literacy was low at level 1, 5 and 6. This was due to students’ inability to find the relationships and regularities of arithmetic and algebra, more complex algebraic literacy questions in non-routine problem solving and structured questions, and students’ inaccuracy in formulating the situations. This can be overcome if students understand the relationship and different characteristics of arithmetic and algebra, and their habits in solving questions which should interpret the results and reflect the conclusions. The results of the analysis illustrated that students were more dominant in algebraic literacy with employ indicator. Students’ achievement of formulate indicator was low because they were not familiar with the concept of symbols as a substitute for varying quantities. Moreover, students also acquired low interpret indicator due to their inability to think the algebraic solutions well, so the problems were not well interpreted. These errors could slowly diminish, if students were accustomed to solve various contextual problems in various ways.

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