IJCER
p-ISSN 2549-9947 | e-ISSN 2614-1426
doi: 10.20885/ijcer.vol9.iss2.art7
p-ISSN 2549-9947
e-ISSN 2614-1426
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Analysis of Numeracy Literacy Ability of 11th Grade Students on Reaction Rate Material at SMAN 1 Grogol

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Received: July 29, 2025; Accepted: August 21, 2025; Published: October 25, 2025

ABSTRACT: Numeracy literacy skills are abilities that need to be trained and developed, focusing on understanding concepts and mathematical calculations as well as their application in the process of contextual problem-solving. Specifically, the level of numeracy literacy in each school in Indonesia has not yet been identified, particularly in the context of reaction rates in chemistry, which is rarely analyzed. Therefore, this study aims to describe the overall level of students' numeracy literacy on the topic of reaction rates, based on numeracy literacy indicators, gender, and cognitive aspects in Bloom's taxonomy. This research employs a descriptive quantitative approach, involving 60 students as subjects. The research instrument consisted of 20 essay questions about numeracy literacy skills related to the topic of reaction rates, with a reliability of 0.817, categorized as very high. The research results indicate that, overall, the level of numeracy literacy on the topic of reaction rates remains low, with a percentage of 37.74%. Based on indicators, (1) the ability to analyze information in the form of tables, graphs, diagrams, and charts reached 47.09%; (2) the use of numbers and symbols was 36.07%; (3) interpreting analysis results to make decisions was 34.28%. Based on gender, male students achieved a rate of 39.61%, while female students achieved a rate of 37.06%. Based on cognitive aspects in Bloom's Taxonomy, C4 (analyzing) achieved the highest score of 50.44%, followed by C5 (evaluating) at 32.08%, C3 (applying) at 29.70%, and C6 (creating) at 21.50. These findings emphasize the importance of improving numeracy literacy skills in Indonesia, especially in chemistry education. These results can also serve as a basis for teachers in designing learning strategy policies by integrating numerical skills, data interpretation, and logical reasoning to enhance students' numeracy literacy in chemistry learning more broadly.

Keywords: numeracy literacy, reaction rate, gender, bloom's taxonomy

INTRODUCTION

Education is one of the most critical factors in a nation's development. To achieve educational goals, an academic curriculum serves as a framework for designing effective learning. Along with the development of globalization, the independent curriculum is designed to face the challenges of the 21st century, one of which requires students to have numeracy literacy skills. One of the programs focused on strengthening and developing students' numeracy literacy skills in this curriculum is the Minimum Competency Assessment (AKM) program, which replaces the National Examination as a comprehensive strategy for mapping the quality and achievement of education in Indonesia [1]. The policy for this program is based on the results of the 2022 PISA survey, which showed that students' numeracy literacy skills in Indonesia are still classified as low, although there was an improvement of 5 positions compared to the 2018 PISA results, with an average percentage of 82% [2].

Numeracy literacy is defined as the ability to interpret information related to numbers, formulate a problem, analyze it, and find a solution [3]. Numeracy literacy is the ability to apply numerical concepts and arithmetic skills related to everyday life and to interpret quantitative information in one's surroundings [4].

Thus, numeracy literacy is the ability to apply relevant arithmetic concepts in everyday life, as well as the ability to analyze and interpret quantitative information to solve problems. In the context of PISA, numeracy literacy encompasses content, context, and competence components that are

integrated into the problem-solving process, involving the ability to think logically, critically, draw conclusions, and make decisions based on numerical data [5]. Therefore, numeracy literacy plays a vital role in all aspects, including chemistry learning, which involves data and quantitative concepts, such as reaction rates.

Reaction rate is a topic in the chapter on chemical kinetics that includes explanations of concepts, rate equations, reaction orders, collision theory, and factors affecting the rate of a chemical reaction [6]. The material encompasses multiple aspects of representation, including symbolic, macroscopic, and submicroscopic, making it easily understandable to students [7]. Nevertheless, in the context of working on AKM questions, this material is still considered abstract and challenging to understand, both in the concept of changes in substance concentration over time, analyzing experimental data, applying reaction rate equations, and graphs that require arithmetic operation skills and the ability to interpret numerical information with the existing numeracy literacy skills critically. This difficulty can be reviewed based on the results of the numeracy literacy competency profile test in the AKM questions development research on the topic of reaction rate material, where 11th-grade students at SMAN 2 Semarang were able to understand and complete the AKM numeracy instrument questions at a sufficient level, with a large-scale test result percentage of 30% and an implementation test of 26%. The low rate of these competency profile test results is due to students' lack of understanding of the context of the questions, their inability to solve mathematical problems, and the application of questions in everyday life because of insufficient practice with numeracy literacy-based reaction rate questions [8]. Based on the preliminary study conducted by the researchers, it is evident that the chemistry teacher at SMAN 1 Grogol have implemented various exercises that encompass literacy and reading, as well as mathematical calculations related to everyday life, particularly in the topic of reaction rates. However, the teacher has not yet conducted a specific analysis of students' numeracy literacy skills, whether reviewed based on the indicators of student's numeracy literacy skills, gender, and the cognitive aspects of Bloom's taxonomy.

Therefore, a thorough analysis of the numeracy literacy skills of students at SMAN 1 Grogol is necessary, particularly in terms of reaction rates, gender, cognitive aspects of Bloom's taxonomy, and indicators of numeracy literacy skills. Students' numeracy literacy skills encompass three indicators, namely analyzing information presented in various forms, such as graphs, tables, charts, and so on; being able to use multiple numbers and symbols related to basic mathematics to solve practical problems in various everyday contexts; and interpreting the results of the analysis conducted to make predictions and draw conclusions [9]. Additionally, an analysis of students' numeracy literacy skills, reviewed by gender and cognitive aspect, was conducted to identify potential gaps in thinking patterns that could affect the quality of learning, and to analyze in more detail the extent to which students' numeracy literacy skills developed from low to high levels of thinking.

Therefore, this research is also highly relevant to the global agenda, particularly the Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education), which emphasizes the importance of improving the quality of education, including mastering numeracy literacy as one of the basic competencies to ensure learning quality. Additionally, SDG 5 (Gender Equality), which emphasizes the need for equal achievement between boys and girls in all aspects of education, contributes to efforts to achieve more inclusive and equitable education by analyzing students' numeracy literacy skills based on gender. This research also includes SDG 8 (Decent Work and Economic Growth), which emphasizes future work skills thru good numeracy literacy. Additionally, it incorporates SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by integrating reaction rate material with sustainable science contexts, such as scientific issues aligned with the ReliGreen program: Sustainable Minds, Greener Futures UIN Sayyid Ali Rahmatullah Tulungagung, which emphasizes the importance of environmentally conscious, modern, transformative, and sustainable education.

Thus, this research not only contributes to the development of chemical learning theory and practice but also supports national and global agendas in achieving quality and sustainable education, particularly thru the improvement of numeracy literacy skills. In line with this objective, this study focuses on analyzing the numeracy literacy skills of eleventh-grade students at SMAN 1 Grogol on the topic of reaction rates, by reviewing overall achievement based on the indicators of student's numeracy literacy skills, gender differences, and cognitive aspects in Bloom's taxonomy. Thru this analysis, it is hoped that the research results will be able to make a significant contribution, both in providing an empirical overview of students' numeracy literacy levels and in the process of evaluating and developing more effective, inclusive, and numeracy literacy skills-oriented learning strategies, particularly in chemistry learning.

RESEARCH METHODS

This research is a descriptive study with a quantitative approach. The descriptive research is research that attempts to describe phenomena that occur realistically, truly, and currently, because this research consists of the process of systematically, factually, and accurately creating descriptions, images, or paintings regarding the facts, characteristics, and relationships between the phenomena being studied [1]. Meanwhile, quantitative descriptive research is a type of research used to analyze data by describing or illustrating the data that has been obtained [1]. Based on this definition, this research method aligns with the research objectives the researcher is pursuing, which is to describe the numeracy literacy abilities of eleventh-grade students at SMAN 1 Grogol in the reaction rate material, both overall, by gender, and by cognitive aspect of Bloom's taxonomy. This description is based on the results of an objective analysis of numerical data from tests that have been conducted without any variable manipulation. The test used is a written essay-type test on reaction rate material. The research population consisted of all XI-grade students at SMAN 1 Grogol, with the research subjects being 60 students who had studied reaction rate material, specifically students from classes XI-2, XI-3, and XI-4, selected using a purposive sampling technique.

In data collection, this study employed research instruments in the form of numeracy literacy test items based on the indicators of student numeracy literacy, as outlined by Fauziah et al [9]. Additionally, the study utilized essay forms, interview sheets for preliminary studies, and expert validation questionnaires. The question instruments used have been validated by chemistry lecturers from UIN Sayyid Ali Rahmatullah Tulungagung and chemistry teachers at SMAN 1 Grogol with a validation result of 98%. Following the expert validation test, an empirical test was conducted in class XI-1 to assess the feasibility of the questions, including their validity, reliability, difficulty level, and discrimination power. The empirical test results showed that out of the 30 questions used, 20 were valid and 10 were invalid. The reliability test results, as measured by Cronbach's Alpha, were 0.817, indicating a very high level of reliability. This reliability test categorization is based on the following reliability index criteria [10].

TABLE 1. Criteria for Determining Item Reliability

Score (%)	Category
0,80 – 1,00	Very high
0,60 – 0,80	High
0,40 – 0,60	Enough
0,20 – 0,40	Low
0,00 – 0,20	Very low

The results of the difficulty level test showed that there were 10 questions categorized as easy, 13 questions categorized as medium, and seven questions categorized as difficult. Meanwhile, the analysis of the discrimination power of the questions revealed that seven questions were classified as very poor, five questions as poor, six questions as fair, seven questions as good, and five questions as very good.

Based on the results of the empirical test, a numeracy literacy ability test was administered to 60 research subjects, consisting of a valid essay-type test with 20 questions. The data obtained were then analyzed based on the combination of student answers, calculated using the average score, standard deviation, and percentage of students' numeracy literacy skills, as follows. After obtaining the percentage results, the level of students' numeracy literacy skills is then categorized in Tabel 2 [10].

$$\mathrm{NP} = \frac{\mathrm{R}}{\mathrm{SM}} \times 100$$

Explanation: NP = Value/level of students' numeracy literacy
R = raw score obtained
SM = maximum score of students

TABLE 2. Categories Numeracy Literacy Skills

Score (%)	Category
81 – 100	Very good
61 – 80	Good
41 – 60	Enough
21 – 40	Less
< 20	Very lacking

After the results were categorized, each group of student ability levels was then described according to the following categories until a conclusion was reached regarding the numeracy literacy skills of the 11th-grade students on the topic of reaction rates [11].

TABLE 3. Student Ability Level Groups

Group	Formula	Explanation
Low	$< (\mu - 1\sigma)$	X = total score
While	$(\mu - 1\sigma) \leq X < (\mu + 1\sigma)$	σ = standard deviation
High	$(\mu - 1\sigma) \leq X$	μ = mean

RESULT AND DISCUSSION

Based on the research conducted using essay-type tests at SMAN 1 Grogol, the following results were obtained.

Student Numeracy Literacy Skills on Reaction Rate Material Based on Overall Average Percentage

Overall, the level of students' numeracy literacy skills in reaction rate material is still categorized as low or insufficient, with an overall average score of 37.74%, as shown in Figure 1. This low ability aligns with the research conducted by Rosyada et al. [8], which found that numeracy skills on reaction rate material fall into the sufficient (4 categories) or insufficient (5-category scale) category with a percentage value of 36%. Additionally, on other chemistry material, namely salt hydrolysis, it also falls into the low category when viewed based on the 5-category scale as in this study, with an average score of 32% [12].

Based on the analysis of student answers, low numeracy literacy skills are attributed to both skill factors and cognitive factors, namely the students' ability to analyze problem information and relate it to basic concepts of mathematics, as well as their reaction rates in solving problems or questions. Additionally, the students' lack of precision in selecting formulas and performing mathematical operations also impacts the achievement of all indicators. According to Sudirman [13], one of the factors causing the low numeracy literacy skills of students is their lack of meticulousness in reading and understanding word problems. Furthermore, the results of interviews with the chemistry teacher at SMAN 1 Grogol also show that students experience difficulties and a lack of meticulousness in applying mathematical concepts. This is what causes the low numeracy literacy skills of the eleventh-grade students at SMAN 1 Grogol in this reaction rate material.

Student Numeracy Literacy Skills Based on Numeracy Literacy Skills Indicators

Based on the research conducted, the numeracy literacy skills level of students in each category is presented in Figure 1, while the numeracy literacy ability level of students for each indicator is presented in Figure 2. This research refers to three indicators of students' numeracy literacy abilities according to Fauziah et al [9].

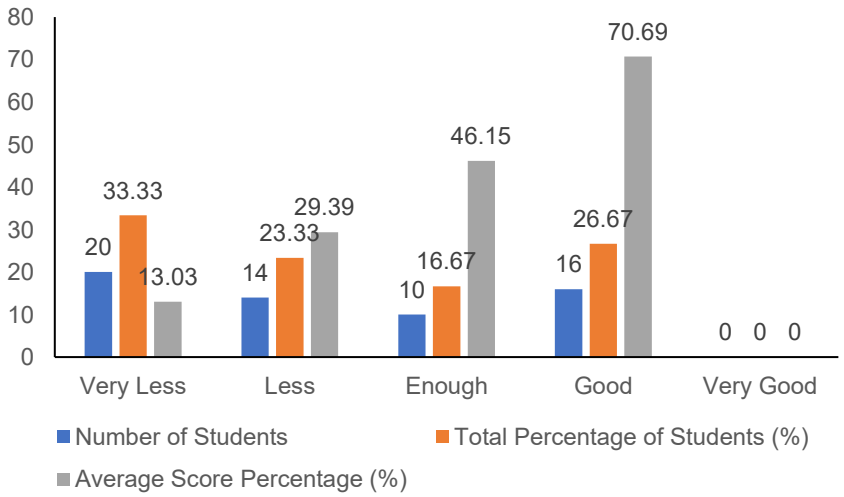


FIGURE 1. Average Percentage Results for Each Category of Student Numeracy Literacy Skills

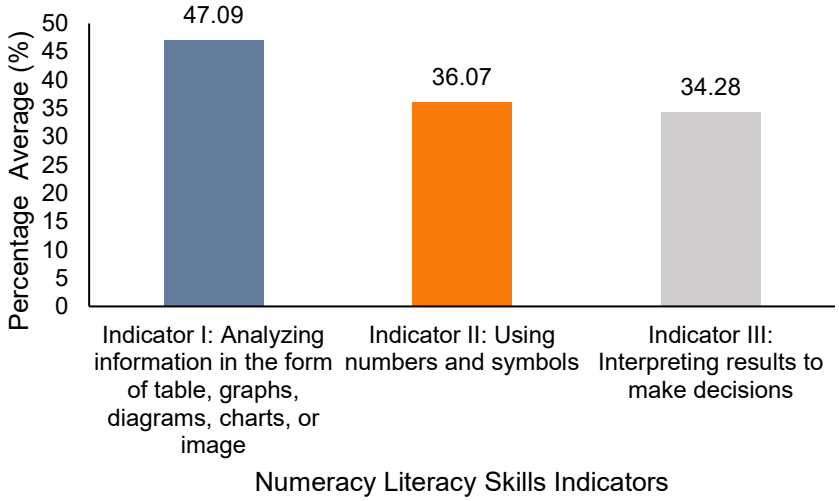


FIGURE 2. Percentage of Students' Numeracy Literacy Skills Based on Indicators of Students' Numeracy Literacy Skills according to Fauziah et. al. [9]

The varying levels of student achievement on each indicator are due to the differing levels of difficulty associated with each indicator. The presence of visual representation in data presentation makes the questions easy for students to understand through C2 cognitive ability [14]. Therefore, the first indicator received the highest percentage value compared to the other two indicators. The achievement of the second indicator requires students to have an understanding of the material concepts and the skills to operate mathematical numbers so that they can apply numbers and symbols correctly in problem-solving [15]. Additionally, it also requires systematic and logical thinking skills, as well as information processing using the correct concepts [16]. Meanwhile, achieving the third indicator requires higher-order thinking skills (HOTS) and problem-solving [17]. Therefore, the average percentage of students' numeracy literacy skills on the reaction rate material is the lowest. Here is one of the answers from Student Number 1, as shown in Figure 3.

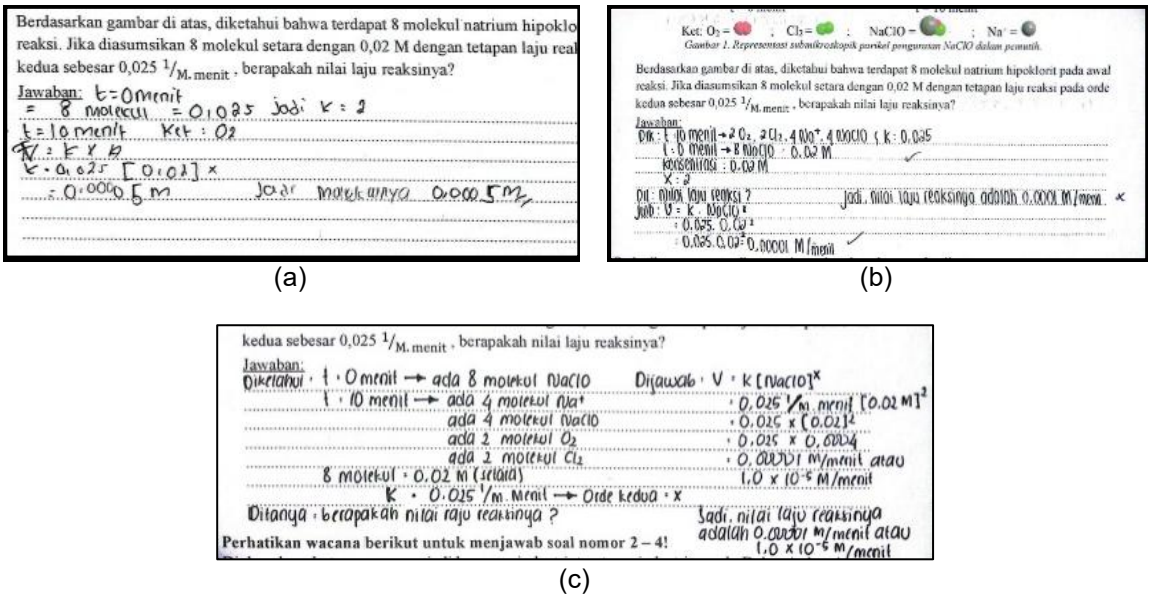


FIGURE 3. Student Group Responses (a) Low, (b) Medium, (c) High

Based on the students' answers in image 3, it can be seen that the entire group of students was able to answer question number 1 with different forms of answers. In this case, the low-achieving students have not yet been able to analyze the presented information, where the description written

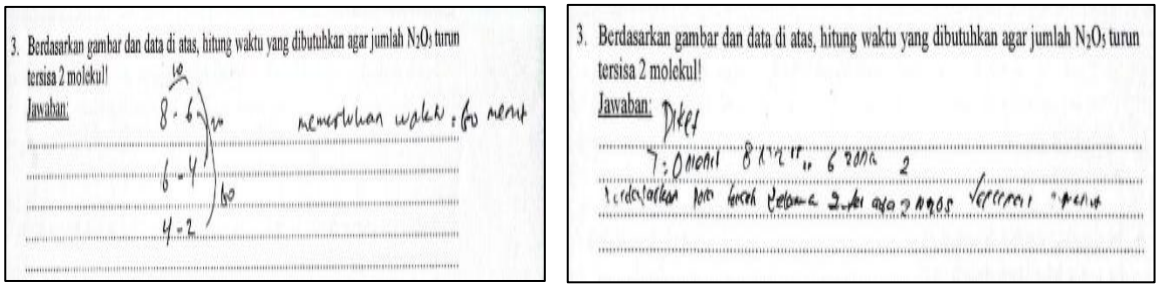
based on the obtained information is less accurate, such as the value of k which should be 0.024 M^{-1}.$minute^{-1}$, while 2 is the order of magnitude. As a result, students struggle to determine the formula and accurately operate with known mathematical numbers; therefore, low-achieving group students have not met all indicators of numeracy literacy skills.

As for the medium group, students can analyze the presented information accurately. In addition, they are also able to determine formulas and operate mathematical numbers accurately and meticulously, enabling them to solve problems precisely. However, there was a lack of precision in drawing conclusions, where 0.00001 M/mol was incorrectly written as 0.001 M/mol. As a result, the students have not yet met the third indicator with accurate conclusions.

In the high group, students have accurately met all the indicators of their numeracy literacy skills. Students are able to analyze the presented information, apply formulas and operate mathematical numbers, as well as draw accurate and precise conclusions. This indicates that high-achieving students possess strong critical thinking and visual representation skills, which also contribute to effective problem-solving abilities related to numeracy literacy.

Numeracy Literacy Skills of Students Based on Gender

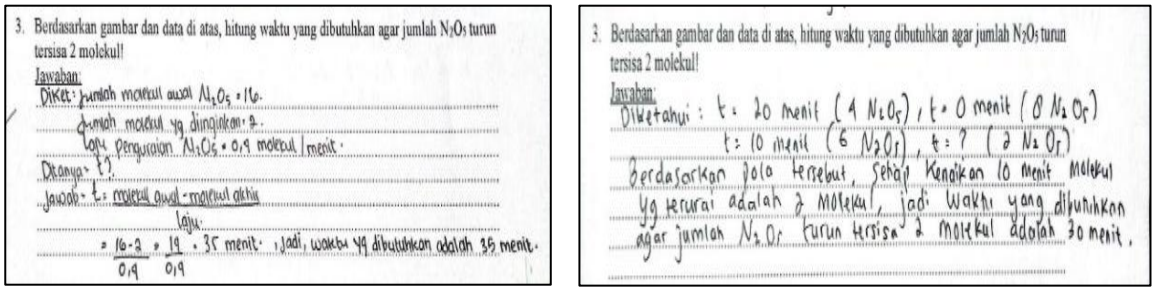
Based on the research conducted, it is evident that the numeracy literacy skills of both male and female students are classified as low (poor), with average percentage scores of 39.61% and 37.06%, respectively. These research findings align with the study by Alfarisi et al., where male students outperformed female students, as male students have better reasoning and understanding of mathematical concepts than female students [18]. Additionally, the results of the 2012 PISA survey in Indonesia also show that the achievements of male students are higher than those of female students, with average scores of 377 for males and 374 for females, resulting in an overall average of 375 [19]. Here is one of the students' answers to question 3 as shown in Figure 4.



(a) (b)

FIGURE 4. Student Responses (a) Female, (b) Male in the low group

Based on Figure 4, it can be seen that the numeracy literacy skills of male and female students in the low group do not differ significantly. However, female students can write down the information from the presented submicroscopic image, but they cannot yet interpret the pattern in that information, resulting in less accurate conclusions. On the other hand, male students can identify a pattern in the presented submicroscopic image, but they are less likely to write down their answers.

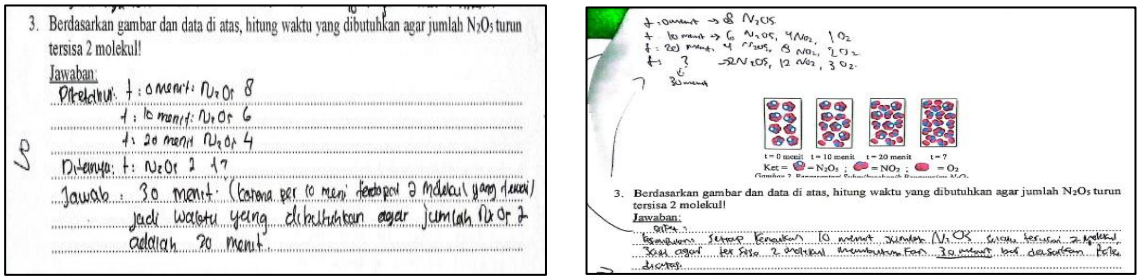


(a) (b)

FIGURE 5. Student Responses (a) Female, (b) Male in the medium group

Based on Figure 5, it is evident that there is a difference in answers between male and female students. Male students can solve the problem accurately based on the presented information and

apply the concepts they have understood. Meanwhile, female students have not yet been able to accurately solve this problem, as they are less precise in analyzing the presented submicroscopic information, which leads to difficulties in determining the pattern in the image and solving the problem in this question.



(a) (b)

FIGURE 6. Student Responses (a) Female, (b) Male in the tall group

Based on Figure 6, it can be seen that the numeracy literacy abilities of male and female students in the high group do not differ significantly, as both are able to interpret the patterns present in the submicroscopic images and draw accurate conclusions. However, a slight difference is observed, namely that male students are more detailed and meticulous in analyzing the information presented in the representation than female students. Specifically, male students are able to write down all the information about the types of molecules in the image at each time, along with their quantities. In contrast, female students only wrote down the number of unbroken N_2O_5 molecules to help create the pattern. Nevertheless, both male and female students in the high group have quite good numeracy literacy skills in this reaction rate material.

Based on the description of Figures 4-6, it can be shown that there is no significant difference in the numeracy literacy skills of male and female students in this reaction rate material. Male students are able to answer in more detail and with greater accuracy, utilizing better thinking processes, analysis, representation, reasoning, and mathematical operations, compared to female students. Based on the Cognitive Differences Theory, these differences are caused by variations in information processing, where males tend to excel in visual-spatial reasoning, problem-solving, and mathematical logic, including symbolic and numerical representation, while females tend to excel in verbal skills and reading comprehension [20]. Some psychological theories also explain that women have lower spatial abilities compared to men [21]. Furthermore, men also possess greater logical-mathematical intelligence and higher levels of self-confidence than women [22].

Students' Numeracy Literacy Skills Based on Cognitive Aspects in Bloom's Taxonomy in Numeracy Literacy Ability Test Items

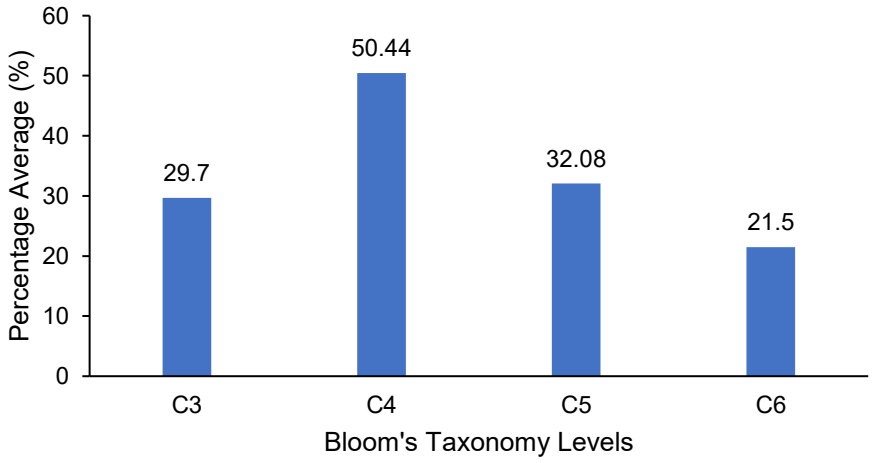
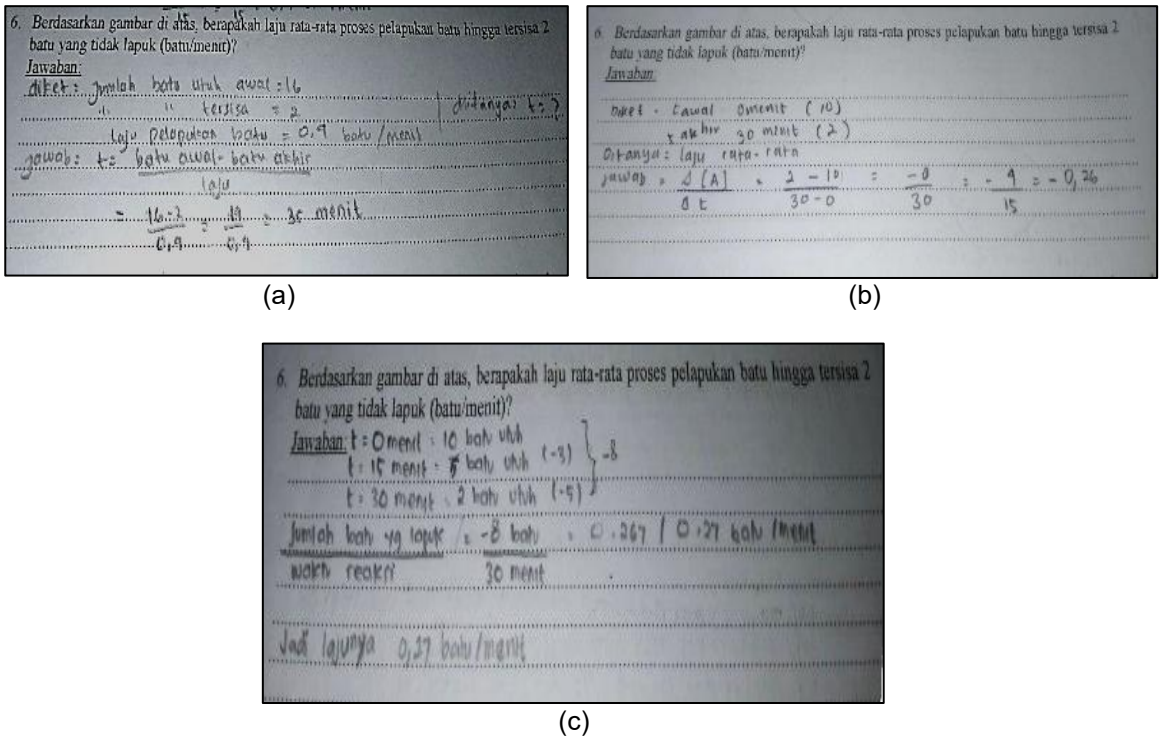


FIGURE 7. Average Percentage of Students' Numeracy Literacy Skills

The questions tested in this research were developed based on the cognitive aspects in Bloom's taxonomy, which include levels C3, C4, C5, and C6. The cognitive aspect at the C3 level is applying

or application, which requires students to use the thinking process by implementing ideas, methods, theories, and principles in new and concrete situations. The cognitive aspect at the C4 level is analyzing, which requires students to break down a specific situation into its constituent elements. The cognitive aspect at the C5 level involves synthesizing, which requires students to combine several elements or parts into a unified whole. Meanwhile, the cognitive aspect at the C6 level is evaluation, which requires students to evaluate a situation, statement, condition, or concept based on certain criteria [23]. Based on the research conducted, the percentage results as shown in Figure 7 indicate that the cognitive aspects of students in C3, C5, and C6 are still lacking, while the C4 aspect falls into the sufficient category.

Based on Cognitive Aspects in Bloom's Taxonomy, here are one student's answers from each of the low, medium, and high groups on each aspect of Bloom's cognitive taxonomy.



(a) (b)

(c)

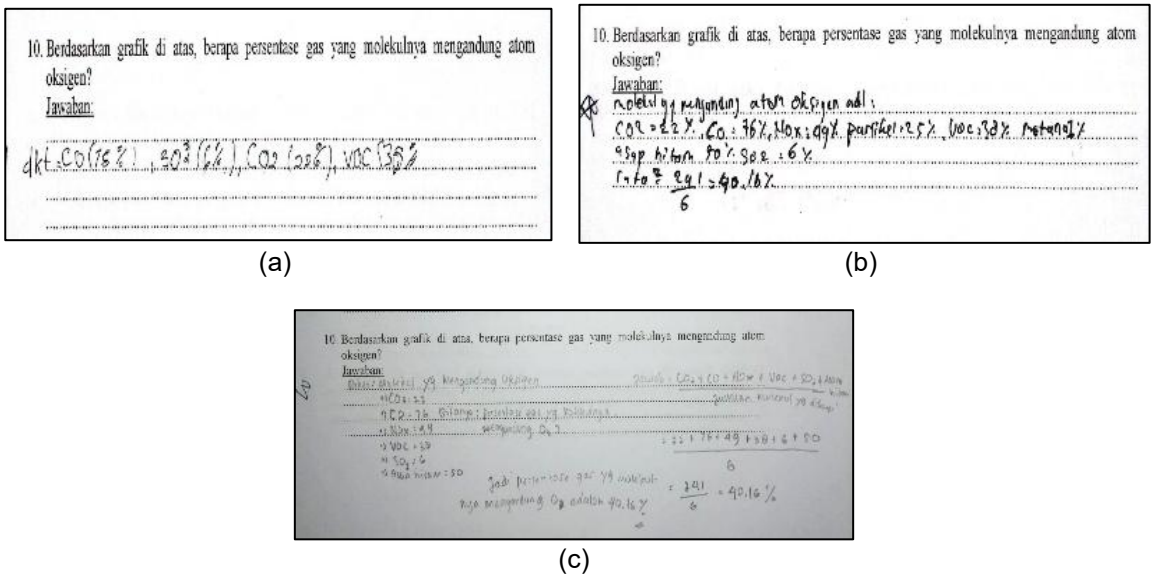
FIGURE 8. Student Group Answers (a) Low, (b) Medium, (c) High on Bloom's Taxonomy Level C3

Based on Figure 8, it is evident that the students' abilities in the three groups differ. Whereas in the low group, students have not yet been able to analyze the information presented based on the known and asked details. As a result, some students struggle to accurately apply the reaction rate concept they have learned, including determining procedures (formulas) and correctly operating with mathematical numbers, which leads to low achievement in the C3 cognitive aspect. This is evident from the answers of the low-achieving students, where they have difficulty analyzing the presented information. As a result, students had difficulty determining the formula used, causing the problem to be solved incorrectly and all indicators of numeracy literacy skills to be unmet.

As for the medium and high groups, students were able to answer the questions correctly. Students analyze the known and asked information, accurately understanding the concepts, which enables them to perform mathematical calculations using the correct formulas. Indicators of numeracy literacy, the medium group students have not yet met the third indicator because they are not yet able to draw conclusions from the interpretations and calculations made, whereas the high group has met all three indicators [9].

Based on Figure 9, it can be seen that some students still struggle to analyze the graph and relate it to the presented statements, making it difficult for them to solve the problem. This is what causes the students' achievement in the C4 cognitive aspect of this question to be quite lacking. If we examine Figure 9, it is evident that the low-achieving students can recall some of the information based on the analysis of the presented diagram; however, they have not yet addressed the question or problem posed. According to Fauziah et al. [9], low-achieving students have not yet been able to meet all the indicators maximally because the process of diagram analysis and the use of numbers

and symbols have not been fully developed, resulting in incomplete mathematical calculations and inconclusive results. As for the medium and high groups, students are able to answer the questions accurately.

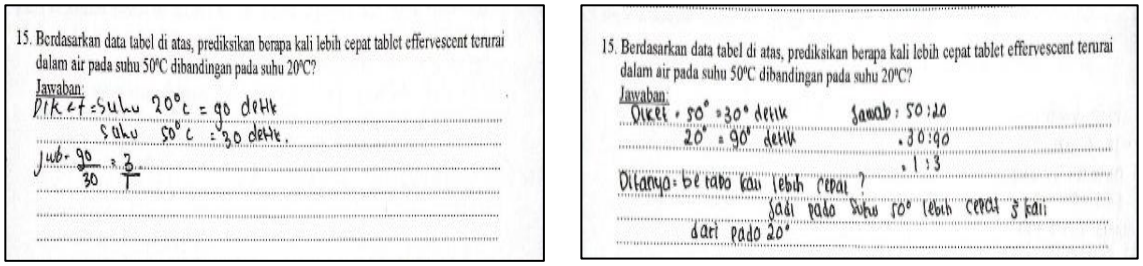


(a) (b)

(c)

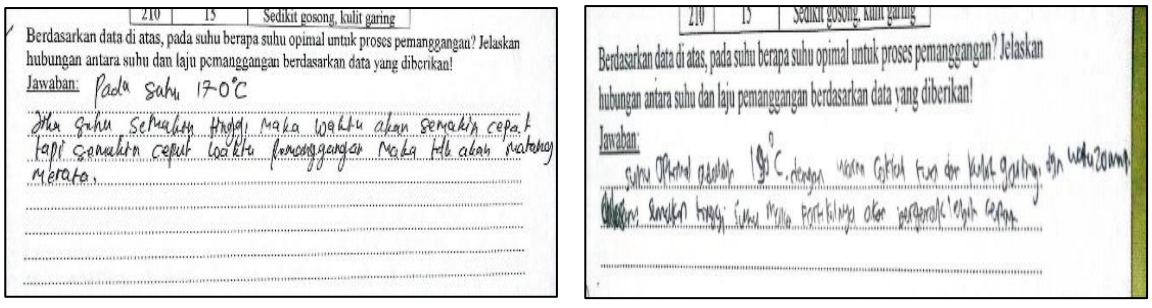
FIGURE 9. Student Group Answers (a) Low, (b) Medium, (c) High on Bloom's Taxonomy Level C4

Students are able to analyze the given and asked information, relate concepts, and operate mathematical numbers accurately. However, when associated with the third indicator of numeracy literacy, according to Fauziah et al. [9], the medium group students have not yet met the third indicator because they are unable to interpret the calculations that have been performed. In contrast, the high group has already met all three indicators.



(a) (b)

FIGURE 10. Student Responses Group (a) Medium, (b) High at Bloom's Taxonomy Level C5



(a) (b)

FIGURE 11. Student Responses Group (a) Medium, (b) High on Bloom's Taxonomy Level C6

Based on Figure 10, it can be seen that no students from the low group are able to answer question number 15. Meanwhile, students in the medium and high groups are quite capable of answering the question correctly. Students are able to understand the statements presented and the

problems asked in the questions. With the conceptual understanding they possess, students can predict the correct steps to solve the problems by operating with mathematical numbers accurately. However, when related to the indicators of numeracy literacy according to Fauziah et al. [9], the medium group students have not yet met the third indicator because they are unable to conclude from the results of predictions and interpretations of the calculations made. In contrast, the high group has already met all three indicators.

Based on Figure 11, there are no low-achieving students who can answer question number 20. As for the medium group students, they have not yet been able to solve the problem with the C6 cognitive aspect content accurately. This is because the students have not yet grasped the statements in the presented discourse and are less accurate in connecting the statements to the given table data. Additionally, students tend to use reasoning processes in concluding.

High-achieving students can accurately solve problems with cognitive aspects at the C6 level. This can be seen from the students' answers, who can connect the statements with the presented table, allowing them to draw conclusions accurately and relate them to the concept of reaction rate factors correctly as well. If linked to the indicators of numeracy literacy according to Fauziah et al. [9], where this question includes the first and third indicators, then the medium group students have not yet met the indicators. At the same time, the high group students have already met both indicators.

CONCLUSION

Based on the explanation above, it can be concluded that overall, the level of students' numeracy literacy skills on the reaction rate material at SMAN 1 Grogol is still considered low, with a percentage of 37.74%. When viewed based on numeracy literacy ability indicators, in the first indicator, students' ability is considered sufficient (47.09%); in the second indicator, it is considered lacking (36.07%); and similarly, in the third indicator, it is also considered (34.28%). Based on gender, male and female students have low numeracy literacy skills in the reaction rate material, with scores of 39.61% and 37.06% respectively. Based on the Cognitive Aspect in Bloom's Taxonomy, students' numeracy literacy abilities in the reaction rate material are still categorized as low at levels C3, C5, and C6, with scores of 29.70%, 32.08%, and 21.50% respectively, and classified as sufficient at level C4 with a score of 50.44%. These results are in line with the PISA results and support the achievement of SDG 4 (quality education) and SDG 5 (gender equality), and are relevant to the ReliGreen program at UIN Tulungagung, which is oriented toward sustainable education (SDG 12 and SDG 13). This result also underscores the need to strengthen numeracy literacy skills in chemistry learning thru critical thinking processes, logical reasoning, and the effective use of visual representations, particularly in the concept of reaction rates. This has implications for the need for more integrated and inclusive curriculum planning.

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