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# Profiling Students Scientific Literacy Skills in the Reaction Rate Topic through STEM Based E-LAPD

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***Keywords:***
Scientific Literacy
Reaction Rate
E-LAPD
STEM

**ABSTRACT**

*This study aims to determine the profile of the scientific literacy skills of grade XI MIPA students at SMA Muhammadiyah 2 Surabaya in the reaction rate material assisted by STEM-based E-LAPD. This study uses a descriptive qualitative approach, with the main variable being the achievement of student scientific literacy viewed from the competency dimension. The instruments used in this study were a scientific literacy test and a student response questionnaire as part of the pre-implementation activities of STEM based E-LAPD. Based on the results of the questionnaire, information was obtained that 62.5% of students considered the reaction rate material difficult to understand, because the dominant activities were calculating and memorizing. This indicates that students have difficulty in linking abstract concepts to real-life contexts, which should be the main focus of the STEM approach. Students' scientific literacy abilities reviewed from three main competencies showed the following results: 33.3% of students were able to explain scientific phenomena, 16.7% were able to evaluate and design scientific investigations, and 66.7% were able to interpret scientific data and evidence. These findings indicate that students' scientific literacy skills are still low, particularly in evaluation and investigation design competencies, which could be developed through the implementation of STEM-based E-LAPD. Thus, the preliminary results of this study suggest that the integration of STEM-based E-LAPD learning media is essential for improving scientific literacy skills.*

## INTRODUCTION

In the era of the 4.0 industrial revolution and post-pandemic, scientific literacy competencies are becoming increasingly crucial for students to be able to face global challenges and technological developments. Scientific literacy includes the ability to understand scientific concepts, explain phenomena based on evidence, interpret data, and design and evaluate scientific investigations (Pujiati, 2019). Innovative learning approaches, such as STEM (Science, Technology, Engineering, Mathematics), are seen as one of the effective strategies to improve scientific literacy by linking scientific concepts to real life contexts and developing higher order thinking skills (Ayomi, Inggamer, & Mutaqin, 2024). However, the results of the 2022 PISA survey show that Indonesian students' scientific literacy is still low globally, with only 34% achieving the minimum proficiency level (OECD, 2023). These findings are in line with previous research that revealed various weaknesses in students' scientific skills. Nuraini & Hidayah (2022) reported that students' creative thinking skills in chemical bonding material were still low, while Amalia & Hidayah (2020) found that students' scientific process skills in acid base material were not optimal. In addition, Takda et al. (2023) emphasized that the scientific literacy of high school students in Indonesia is generally still in the low category. Based on this problem, learning innovations are needed that can bridge abstract concepts with contextual experiences. One alternative that can be used is the

development of learning media in the form of E-LAPD based on the STEM approach. This approach not only supports conceptual understanding but also trains students to think across disciplines, be creative, and be able to solve problems in everyday life (Ariani et al., 2019). In chemistry learning, especially in reaction rate material, scientific literacy skills are very relevant because this topic requires conceptual understanding as well as scientific process skills through experimental activities and analysis of everyday phenomena (Irmita & Atun 2017). Based on the results of a questionnaire at SMA Muhammadiyah 2 Surabaya, it was found that the majority of students considered this material difficult because of the dominance of calculations and memorization, as well as low achievement in the dimension of scientific literacy competence, such as explaining scientific phenomena and interpreting data. In response to this problem, learning innovation is needed through media that can bridge abstract concepts with contextual experiences. One of them is through the development of E-LAPD based on the STEM (Science, Technology, Engineering, and Mathematics) approach. This approach not only supports conceptual understanding but also trains students to think across disciplines and solve problems creatively (Hariyadi et al, 2023). Through the development of STEM based E-LAPD, it is hoped that students can build a deeper understanding of the concept of reaction rate while demonstrating a stronger profile of scientific literacy skills. Therefore, this study focuses on examining students' scientific literacy profiles in reaction rate material with the help of STEM based E-LAPD, hoping that students can build a deeper understanding of the concept of reaction rate while improving their scientific literacy skills.

## RESEARCH METHOD

The purpose of this study is to determine the percentage of scientific literacy skills among students. This study was conducted at SMA Muhammadiyah 2 Surabaya, with 24 students completing a scientific literacy skills test and a student response questionnaire. Teacher interview sheets, student questionnaire sheets, and scientific literacy skills tests were the instruments used in this study. The data obtained were analyzed descriptively. The results of the analysis will be presented in the form of interpretations divided into three categories for each component of science literacy. The results of the categorization of the level of mastery of scientific literacy skills using the formula from Azwar (2010) are as follows:

**Table 1.** Criteria for Achieving Student Scientific literacy Skills

| No | Average Score Percentage (%) (%) | Criteria |
|---|---|---|
| 1. | $X < 32{,}941$ | Low |
| 2. | $32{,}941 \leq X < 67{,}467$ | Medium |
| 3. | $X \geq 67{,}467$ | High |

## RESULTS AND DISCUSSION

This study was conducted with the aim of determining students' scientific literacy achievements in terms of competency dimensions. The test administered to students consisted of four essay questions. The test sheet provided included scientific literacy competency indicators, such as explaining scientific phenomena, evaluating and

designing scientific investigations, and interpreting scientific data and evidence. These scientific literacy competencies are related to the STEM approach, which emphasizes the integration of cross disciplinary knowledge to explain phenomena, design investigations, and interpret data.

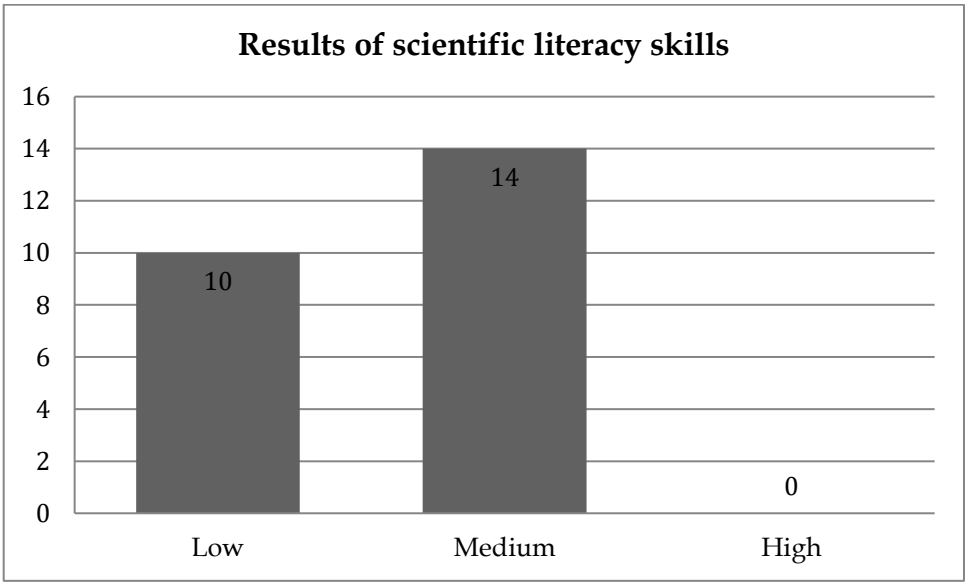



**Figure 1.** Results of Scientific literacy Skills

Based on data obtained from test questions given to 24 students, they were grouped into high, medium, and low categories. Based on the assessment using the above criteria, different skill scores were obtained among the students. Notably, no students managed to achieve the high proficiency level. The distribution of these skills is presented in figure 1.

1. Kak Ros ingin merebus kentang yang telah di beli dari pasar untuk dimakan bersama-sama. Sebelumnya untuk merebus satu kentang utuh membutuhkan waktu selama 10 menit. Apa yang harus dilakukan Kak Ros untuk mempersingkat waktu agar kentang lebih cepat matang? Kaitkan jawaban kamu dengan faktor yang mempengaruhi laju reaksi
**(Menjelaskan fenomena ilmiah + *Science*)**
Jawaban :

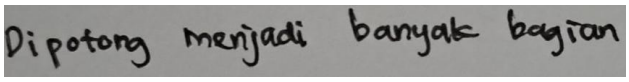
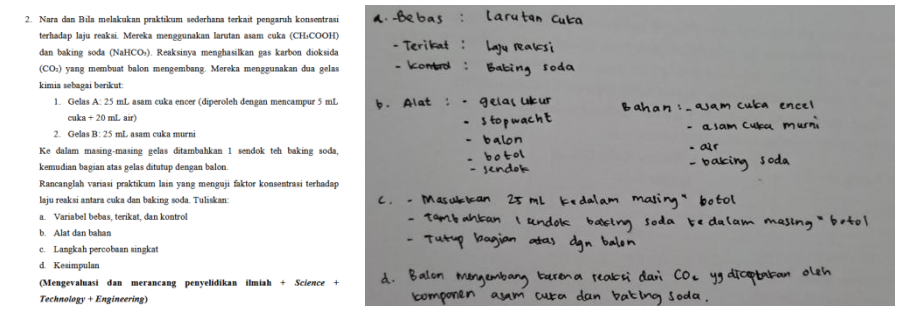



**Figure 2.** Question and answers to indicators explaining scientific phenomena

As seen in the sample question and answer figures 2, students could provide relevant responses for example cutting potatoes to speed up cooking. However, their answers were often incomplete because they failed to explicitly link their reasoning to the underlying scientific concept in this case, the factor of surface area affecting reaction rate. This indicates a superficial conceptual understanding and difficulty applying knowledge to new contexts.



2. Nara dan Bila melakukan praktikum sederhana terkait pengaruh konsentrasi terhadap laju reaksi. Mereka menggunakan larutan asam cuka ($CH_3COOH$) dan baking soda ($NaHCO_3$). Reaksinya menghasilkan gas karbon dioksida ($CO_2$) yang membuat balon mengembang. Mereka menggunakan dua gelas kimia sebagai berikut:
   1. Gelas A: 25 mL asam cuka encer (diperoleh dengan mencampur 5 mL cuka + 20 mL air)
   2. Gelas B: 25 mL asam cuka murni

   Ke dalam masing-masing gelas ditambahkan 1 sendok teh baking soda, kemudian bagian atas gelas ditutup dengan balon.
   Rancanglah variasi praktikum lain yang menguji faktor konsentrasi terhadap laju reaksi antara cuka dan baking soda. Tuliskan:
   a. Variabel bebas, terikat, dan kontrol
   b. Alat dan bahan
   c. Langkah percobaan singkat
   d. Kesimpulan

   **(Mengevaluasi dan merancang penyelidikan ilmiah + *Science* + *Technology* + *Engineering*)**

a. - Bebas : larutan cuka
   - Terikat : laju reaksi
   - kontrol : baking soda

b. Alat : - gelas ukur
   - stopwacht
   - balon
   - botol
   - sendok

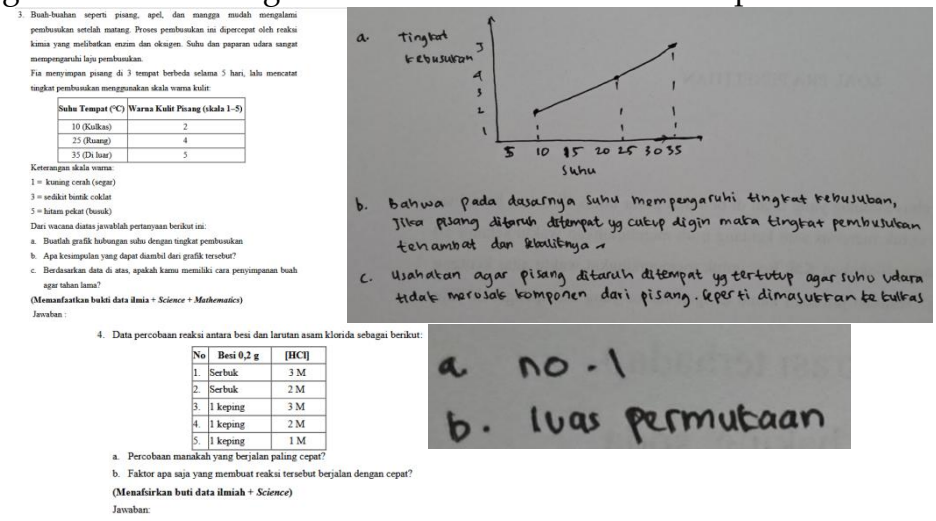
   Bahan : - asam cuka encel
   - asam cuka murni
   - air
   - baking soda

c. - Masukkan 25 mL kedalam masing" botol
   - tambahkan 1 sendok baking soda kedalam masing" botol
   - Tutup bagian atas dgn balon

d. Balon mengembang karena reaksi dari $CO_2$ yg dihasilkan oleh komponen asam cuka dan baking soda.

**Figure 3.** Question and answers to indicator evaluating and designing scientific investigations.

For the experiment design question figures 3, students showed a basic understanding of variables. However, the designed procedures were unsystematic and lacked detail, and the conclusions drawn did not accurately reflect the relationship between the tested variable and the observed outcome reaction rate or $CO_2$ volume. This competency requires higher order thinking skills that are still under developed.



3. Buah-buahan seperti pisang, apel, dan mangga mudah mengalami pembusukan setelah matang. Proses pembusukan ini dipercepat oleh reaksi kimia yang melibatkan enzim dan oksigen. Suhu dan paparan udara sangat mempengaruhi laju pembusukan.
   Fia menyimpan pisang di 3 tempat berbeda selama 5 hari, lalu mencatat tingkat pembusukan menggunakan skala warna kulit:

| Suhu Tempat (°C) | Warna Kulit Pisang (skala 1–5) |
|---|---|
| 10 (Kulkas) | 2 |
| 25 (Ruang) | 4 |
| 35 (Di luar) | 5 |

   Keterangan skala warna:
   1 = kuning cerah (segar)
   3 = sedikit bintik coklat
   5 = hitam pekat (busuk)
   Dari wacana diatas jawablah pertanyaan berikut ini:
   a. Buatlah grafik hubungan suhu dengan tingkat pembusukan
   b. Apa kesimpulan yang dapat diambil dari grafik tersebut?
   c. Berdasarkan data di atas, apakah kamu memiliki cara penyimpanan buah agar tahan lama?

   **(Memanfaatkan bukti data ilmia + *Science* + *Mathematics*)**
   Jawaban :

a. Tingkat kebusukan



b. bahwa pada dasarnya suhu mempengaruhi tingkat kebusukan, jika pisang diletak ditempat yg cukup digin maka tingkat pembusukan tenambat dan kualitnya ~

c. Usahakan agar pisang diletak ditempat yg tertutup agar suhu udara tidak merusak komponen dari pisang. seperti dimasukkan ke kulkas

4. Data percobaan reaksi antara besi dan larutan asam klorida sebagai berikut:

| No | Besi 0,2 g | [HCl] |
|---|---|---|
| 1. | Serbuk | 3 M |
| 2. | Serbuk | 2 M |
| 3. | 1 keping | 3 M |
| 4. | 1 keping | 2 M |
| 5. | 1 keping | 1 M |

   a. Percobaan manakah yang berjalan paling cepat?
   b. Faktor apa saja yang membuat reaksi tersebut berjalan dengan cepat?

   **(Menafsirkan buti data ilmiah + *Science*)**
   Jawaban:

a. no. 1
b. luas permukaan

**Figure 4.** Question and answers on the indicator of interpreting scientific data evidence

As seen in the data interpretation questions figures 4 students could generally read graphs, draw simple conclusions from tabular data, and identify patterns**.** Nevertheless, the scientific explanations behind their conclusions were often insufficient. For example, they concluded that low temperatures slow decay but did not elaborate on how temperature affects activation energy or enzymatic reaction rates.

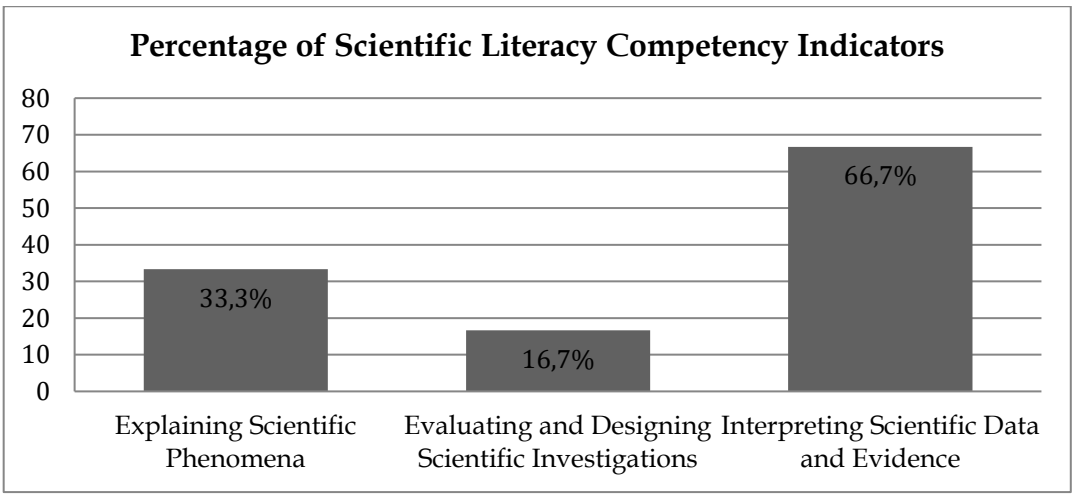



**Figure 5.** Percentage of Scientific literacy Competency Domain Indicators

The results in figure 5 show that the scientific literacy abilities of students, as assessed based on three main competencies, are as follows: 33.3% of students are able to explain scientific phenomena, 16.7% are able to evaluate and design scientific investigations, and 66.7% are able to interpret scientific data and evidence.

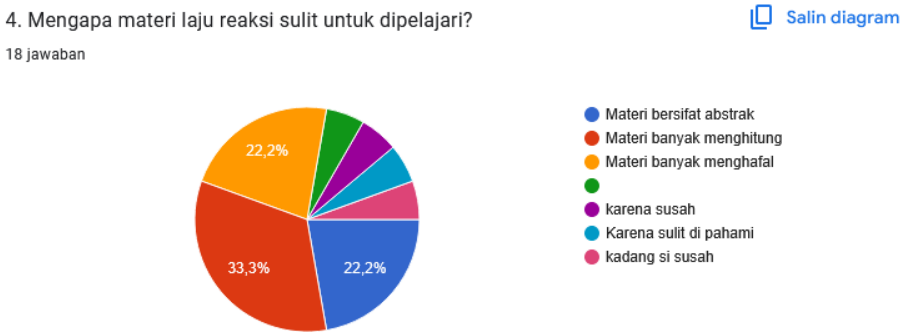



**Figure 6.** Diagram showing the difficulty of studying reaction rates

Based on figure 6, it can be concluded that reaction rates are not an interesting subject to study because the material is abstract, involves a lot of memorization and calculations, and is difficult to understand.


**Figure 7.** Students' opinions on E-LAPD

Based on figure 7, it can be concluded that students agree that chemistry learning in the classroom should use E-LAPD, which contains summaries of material, questions, and simple practical exercises related to existing problems.

These findings are consistent with prior research (Irmita & Atun, 2017; Nisa et al., 2015), which states that students tend to find it easier to interpret concrete data than to design investigations requiring complex planning and reasoning. The low skills in designing investigations and explaining phenomena scientifically confirm the initial questionnaire results, where students complained about the abstract and rote nature of the material. Consequently, the introduction of STEM based E-LAPD is highly relevant. This media, which integrates summaries, guiding questions, and simple practical work, can scaffold students' understanding of concepts, guide them to design investigations with structured steps, and connect findings with scientific explanations. Support from the student questionnaire figure 7, which showed strong agreement for using E-LAPD, and teacher interviews, which stated that E-LAPD based STEM encourages student activity, further strengthens the potential of this media as an innovative solution.

## CONCLUSION

Based on the results of this study, it can be concluded the profile of students' scientific literacy skills in reaction rate material is polarized between the medium and low categories, with a complete absence of high level proficiency. Among the three competency indicators, the highest achievement was in interpreting scientific data and evidence 66.7%, while the lowest was in evaluating and designing scientific investigations 16.7%. The low performance in the first two competencies indicates that students are not yet fully able to construct and apply scientific knowledge independently. Therefore, implementing STEM based E-LAPD as a learning innovation is essential to train these skills in a more structured and contextual manner. It is expected that this approach can enhance students' scientific literacy skills more comprehensively and balanced across all competencies.

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