

The Effectiveness of a Tomini Bay Maritime-Contextualized E-Module on Reaction Rate in Improving Students' Scientific Literacy

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Abstract

This study aimed to evaluate the effectiveness of a maritime-based e-module contextualized to Teluk Tomini in improving students' scientific literacy on the topic of reaction rates at SMA Negeri 1 Suwawa. A quasi-experimental method employing a posttest-only control group design was utilized. The study involved an experimental group, which was instructed using the maritime-based e-module, and a control group, which received instruction through a conventional e-module. The findings indicate that students who learned using the Tomini Bay maritime-based e-module demonstrated significantly higher levels of scientific literacy compared to those who were taught using the conventional approach. The mean scientific literacy score of the experimental group reached 22.26, substantially exceeding that of the control group, which obtained a mean score of 11.56. Statistical analysis using One-Way ANOVA confirmed a significant difference between the two groups. The study concludes that the implementation of a maritime-based e-module is effective in enhancing students' scientific literacy, increasing student engagement, and facilitating the comprehension of abstract concepts such as reaction rates. Furthermore, the module promotes awareness of local environmental sustainability, thereby integrating contextual relevance with scientific understanding.

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1. INTRODUCTION

Chemistry is a scientific discipline concerned with the properties of matter, its structure, transformations, the laws and principles governing such transformations, and the concepts and theories that explain chemical change (Effendy, 2017). Chemistry possesses several distinctive characteristics: it is inherently abstract, represents a simplification of reality, is systematic and rapidly evolving, extends beyond mere problem-solving, and offers substantial practical benefits (Putri & Mulyanti, 2024).

One topic that exemplifies the abstract nature of chemistry is reaction rate. Reaction rate is considered abstract because it refers to changes in the concentration of substances involved in a chemical reaction over a given period of time. This phenomenon is influenced by

various factors, including temperature, reactant concentration, surface area, and the presence of a catalyst. A decrease in reactant concentration indicates the continuous consumption of initial substances, while an increase in product concentration reflects the progressive formation of reaction products over time (Yuda et al., 2017).

The learning process in reaction rate aims to train students to apply previously acquired chemical concepts to real-life phenomena rather than merely memorizing theoretical principles. The ability to relate and communicate scientific concepts within everyday contexts is referred to as scientific literacy (Maritim et al., 2023).

Scientific literacy is a crucial competency for understanding reaction rate concepts. According to

Banila et al. (2021), scientific literacy encompasses creative skills, communication, critical thinking, and collaboration. Students who demonstrate scientific literacy are able to solve problems using scientific concepts, generate simple technological innovations creatively, and make decisions grounded in societal values and cultural contexts (Pratiwi et al., 2019). More broadly, scientific literacy refers to the capacity to comprehend scientific concepts and processes, solve problems, and draw evidence-based conclusions. This competence supports informed decision-making related to the natural environment (Usemahu et al., 2022). However, scientific literacy among Indonesian students remains relatively low, as evidenced by international assessments such as the Programme for International Student Assessment (PISA), in which Indonesia has consistently ranked among the bottom ten participating countries (Maritim et al., 2023).

One major factor contributing to low scientific literacy is the learning process, which often does not adequately support the development of literacy skills, combined with instructional materials that lack contextual relevance. Data from PISA and TIMSS indicate that Indonesian students' scientific literacy remains below the international average. This condition is closely related to classroom practices that require literacy-related competencies, particularly in chemistry learning (Yuda et al., 2017).

Scientific literacy can be enhanced through the Socio-Scientific Issues (SSI) approach. SSI refers to social problems that are conceptually related to science and characterized by open-ended or debatable solutions. The implementation of the SSI approach can be facilitated through instructional materials aligned with scientific and technological advancements, such as electronic modules. Integrating the SSI approach with e-modules aims to facilitate comprehension by incorporating socio-scientific articles, visual animations, and contextual issues (Shoba et al., 2023).

Electronic modules (e-modules) offer advantages over printed modules due to their interactive features and ability to simultaneously present images, audio, video, and animations. Although the principles of developing electronic and printed modules are similar, the primary distinction lies in their presentation format (Maritim et al., 2023). E-modules are designed as self-instructional materials systematically organized into the

smallest learning units to achieve specific learning objectives in digital format. Each learning activity is interconnected through navigational links, enabling more active student interaction. The presentation is enriched with multimedia features, such as instructional videos and illustrative images, to enhance the learning experience (Hakim et al., 2020).

Problem-Based Chemistry Modules are developed based on the characteristics of problem-based learning, beginning with the presentation of a problem to students. However, such modules have limitations: the problems must be relevant, engaging, and aligned with students' cognitive levels. Problems that are overly complex or abstract may cause confusion, whereas overly simple problems may fail to provide sufficient cognitive challenge (Zulfahrin et al., 2019).

To address these limitations, a maritime-based electronic module contextualized to Teluk Tomini was developed. This module aligns learning with students' natural and socio-environmental contexts. Such an approach is essential for enabling students to better understand their environment and develop the capacity to solve problems that arise within it (Najuah et al., 2021).

The selection of Teluk Tomini as the contextual focus is strategic, given its substantial fisheries potential supported by rich marine and terrestrial biodiversity. The region is also recognized for its remarkable natural beauty, including approximately 1,031 hectares of coral reefs and 785.10 hectares of mangrove forests (Yapanto et al., 2023).

By employing Teluk Tomini as a learning context, students not only gain insight into the region's potential and challenges but also develop critical thinking skills necessary to support environmental sustainability. This objective aligns with the goals of maritime-based modules, namely fostering problem-solving skills through locally relevant approaches and nurturing students' naturalistic intelligence through maritime-oriented education. Furthermore, maritime-based modules positively impact students' scientific literacy by creating communicative, interactive, inspiring, and engaging learning environments. Through this approach, students can more effectively internalize and apply knowledge, values, attitudes, and behaviors rooted in maritime culture (Rohmah & Aulina, 2024).

This study employed a maritime-based electronic module contextualized to Teluk Tomini in

teaching reaction rates. This focus represents a relatively underexplored area requiring further scholarly investigation to provide stronger empirical and theoretical perspectives. Therefore, this research aims to examine the differences in effectiveness between the Teluk Tomini maritime-based e-module and a conventional e-module in enhancing students' scientific literacy on the topic of reaction rates. The module was designed to facilitate the understanding of abstract chemical concepts through interactive, communicative, and contextual learning experiences. Additionally, this approach is expected to promote students' critical thinking, creativity, and environmental sustainability awareness within the framework of maritime culture.

2. METHOD

The research employed a quasi-experimental method utilizing a posttest-only control group design. The study was conducted at SMA Negeri 1 Suwawa during the first semester of the 2024/2025 academic year. The research was carried out from November 1 to December 3, 2024.

The population of this study comprised all Grade XI students of SMA Negeri 1 Suwawa. The sample consisted of 92 students, including 47 students from Class XI A assigned as the experimental group and 45 students from Class XI B designated as the control group. The sampling technique employed was purposive sampling, in which participants were selected based on specific considerations deemed relevant to the objectives of the study (Abraham & Supriyati, 2022).

In this study, two types of instruments were employed: treatment instruments and test instruments. The treatment instruments consisted of a lesson plan in the form of a teaching module implementing the Problem-Based Learning (PBL) approach, along with a maritime-based e-module contextualized to Teluk Tomini. The maritime-based e-module had previously undergone validity and practicality testing.

The validity assessment included content validity, construct validity, and readability testing, conducted by three experts—two lecturers in Chemistry Education from Universitas Negeri Gorontalo and one chemistry teacher from SMA Negeri 1 Suwawa. The validation results from the three experts indicated that the maritime-based e-module was valid and did not require revision.

Furthermore, a practicality test was conducted involving 10 Grade XI students of SMA Negeri 1 Suwawa (limited trial). The results demonstrated strong student enthusiasm toward the phenomena presented in the e-module and successful completion of the assigned tasks, reaching 92.5%. Students were subsequently asked to complete a response questionnaire to evaluate the maritime-based e-module. Overall, the module was categorized as highly practical, with a total practicality score of 95.5%.

The scientific literacy test instrument on the topic of reaction rates consisted of 32 multiple-choice items. The results of content validation indicated that the instrument met the criteria of "highly valid," with a validity percentage of 95%. Item analysis revealed that 30 out of the 32 items were declared valid. All validated items were then used in the scientific literacy test on reaction rates.

The reliability of the scientific literacy test instrument was examined using the internal consistency method. The reliability analysis yielded a Cronbach's alpha coefficient of 0.905 for the 30 validated items. This result indicates that the instrument possesses very high reliability and satisfies the requirements for use as an assessment tool in this study.

The data analysis procedure in this study began with prerequisite tests, namely tests of normality and homogeneity. The normality test was conducted to ensure that the data were normally distributed. Normality was assessed using the Kolmogorov–Smirnov test (One-Sample K–S) in IBM SPSS Statistics version 29.00.

The homogeneity test was performed to determine whether the variances between groups were homogeneous. Homogeneity of variance was examined using Levene's Test in IBM SPSS Statistics version 29.00. The results indicated that the scientific literacy test scores on the topic of reaction rates were normally distributed and homogeneous. Therefore, the data met the assumptions required for parametric analysis. Subsequently, the analysis was continued using One-Way ANOVA to examine differences in mean scores between groups.

3. RESULT AND DISCUSSION

3.1. Result

The results of students' scientific literacy test on the topic of reaction rates are presented in Table 1. This table provides a descriptive statistical overview of the

performance of both the experimental and control groups after the implementation of their respective instructional treatments. The data include the number of students in each group, the mean scores obtained, and the standard deviations, which together offer an initial indication of differences in students' scientific literacy achievement following the learning intervention.

Table 1. Students' Scientific Literacy Test Results on Reaction Rates

Group	n	Mean	Standard Deviation
Experimental	47	22.2553	3.942
Control	45	11.5556	4.319

As shown in Table 6, the experimental group, consisting of 47 students who were taught using the maritime-based e-module contextualized to Teluk Tomini, achieved a mean score of 22.2553 with a standard deviation of 3.942. In contrast, the control group, comprising 45 students who learned through the conventional e-module, obtained a considerably lower mean score of 11.5556 with a standard deviation of 4.3199.

The substantial difference in mean scores between the two groups suggests that the instructional treatment had a notable impact on students' scientific literacy performance. Although both groups displayed some variability in their scores, as reflected in their respective standard deviations, the experimental group demonstrated not only higher average achievement but also relatively consistent performance across students.

This tendency is further supported by the observed differences in scientific literacy scores between the two groups, as illustrated in Figure 1.

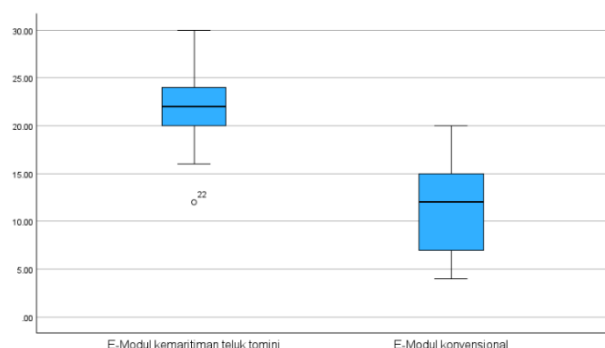


Figure 1. Observed Differences In Scientific Literacy Scores Between The Two Groups

Based on Figure 1, it can be assumed that the difference in students' scientific literacy on the topic of reaction rates between the two classes is substantial. This finding suggests that the use of the Teluk Tomini maritime-based e-module is more effective than the conventional e-module in improving students' scientific literacy on the topic of reaction rates.

The effectiveness of the maritime-based e-module contextualized to Teluk Tomini compared to the conventional e-module in enhancing students' scientific literacy on the topic of reaction rates was examined using a One-Way Analysis of Variance (One-Way ANOVA). Prior to conducting the ANOVA, prerequisite assumption tests were performed to ensure the appropriateness of parametric statistical analysis.

The normality test, conducted using the Kolmogorov–Smirnov test, yielded a significance value greater than 0.05, indicating that the scientific literacy scores were normally distributed. Similarly, the homogeneity of variance test using Levene's Test produced a significance value greater than 0.05, demonstrating that the variances between the experimental and control groups were homogeneous. These results confirmed that the data met the necessary assumptions for conducting One-Way ANOVA.

The ANOVA results revealed a significance value (Sig.) of less than 0.001. Since this value is lower than the predetermined alpha level of 0.05, the null hypothesis was rejected. This finding indicates that there is a statistically significant difference in students' scientific literacy on the topic of reaction rates between those who were taught using the Teluk Tomini maritime-based e-module and those who were taught using the conventional e-module.

In other words, the observed difference in mean scores between the experimental and control groups is not due to random variation but reflects a meaningful effect of the instructional treatment. The maritime-based e-module demonstrated greater effectiveness in improving students' scientific literacy compared to the conventional e-module. These results provide empirical support for the integration of locally contextualized, maritime-based digital learning materials in chemistry instruction, particularly for abstract topics such as reaction rates.

3.2. Discussion

The findings on students' scientific literacy in the topic of reaction rates, as presented in Table 1, indicate a significant difference between the experimental group that utilized the maritime-based e-module contextualized to Teluk Tomini and the control group that employed the conventional e-module. The experimental group, consisting of 47 students, achieved a mean score of 22.26 with a standard deviation of 3.94. In contrast, the control group, comprising 45 students, obtained a mean score of 11.56 with a standard deviation of 4.32. The substantial disparity between these mean scores suggests that the maritime-based e-module was considerably more effective in enhancing students' scientific literacy in the context of reaction rates than the conventional approach.

This finding aligns with the study conducted by Kristyowati and Purwanto (2019), which, based on a literature review, concluded that utilizing environmental contexts in scientific literacy instruction leads to improved student learning outcomes. Students tend to be more actively engaged in learning activities and demonstrate deeper understanding when instructional materials are closely connected to their surrounding environment. Therefore, the integration of environmental context is considered highly appropriate for scientific literacy learning.

The graphical representation in Figure 1 further supports this conclusion by illustrating the clear and pronounced difference in scientific literacy scores between the two groups. The visual comparison reinforces the descriptive statistical findings and highlights the magnitude of the gap between the experimental and control classes. These results imply that the maritime-based e-module not only facilitates a stronger conceptual understanding of reaction rates but also enhances student engagement, which ultimately contributes to improved literacy outcomes. This observation is consistent with prior research emphasizing the importance of contextual relevance in instructional materials, as relevance has been shown to significantly increase student engagement and comprehension (Kristyowati & Purwanto, 2019). Students are more likely to connect with and retain information when it is presented in a meaningful and memorable manner linked to their real-life experiences.

The hypothesis testing conducted using One-Way ANOVA further substantiates the effectiveness of the Teluk Tomini maritime-based e-module. The prerequisite tests of normality and homogeneity confirmed that the data met the assumptions required for ANOVA analysis. The ANOVA results yielded a significance value of less than 0.001, leading to the rejection of the null hypothesis. This statistical evidence confirms that there is a significant difference in students' scientific literacy abilities between those taught using the maritime-based e-module and those taught using the conventional e-module. The difference observed is therefore not attributable to chance but reflects the genuine impact of the instructional intervention.

These findings are consistent with the broader body of literature supporting innovative instructional approaches that integrate real-world applications and interdisciplinary perspectives. Such approaches have been shown to enhance students' critical thinking skills and scientific literacy (Thahir et al., 2021). Moreover, the implications of this study extend beyond the immediate context of teaching reaction rates. The results suggest the need for a broader pedagogical shift toward incorporating context-rich and locally relevant materials in science education. As highlighted by Wulandari (2016), the integration of contextual elements into instruction not only improves knowledge retention but also fosters deeper conceptual understanding of scientific principles. This is particularly relevant within the Indonesian educational landscape, where strengthening students' scientific literacy is essential to prepare them for the complex challenges of the twenty-first century (Hidayah, 2019).

In light of these findings, educators are encouraged to adopt more innovative and contextually relevant teaching strategies. The success of the maritime-based e-module underscores the potential of leveraging local contexts and resources in science education to create more engaging and meaningful learning experiences. This approach is consistent with constructivist learning theory, which emphasizes active student participation and the construction of knowledge through authentic, real-world experiences (Windyariani, 2018).

Furthermore, the positive outcomes associated with the Teluk Tomini maritime-based e-module suggest that similar contextualized approaches may be beneficial across other domains of science education. For example,

integrating local environmental issues or cultural contexts into curricula may enhance student engagement and conceptual understanding across various scientific disciplines (Sujarwanto, 2023). Such integration not only strengthens scientific literacy but also fosters a sense of environmental awareness and cultural relevance, thereby contributing to more holistic and sustainable science education practices.

4. CONCLUSION

The findings of this study demonstrate that the use of a maritime-based e-module contextualized to Teluk Tomini significantly enhances students' scientific literacy in the topic of reaction rates compared to the conventional e-module. These results confirm the pedagogical value of integrating locally relevant and context-rich digital learning materials into chemistry instruction, particularly for abstract concepts. The maritime-based approach not only strengthens conceptual understanding but also fosters greater student engagement and meaningful learning experiences.

This study contributes to the growing body of literature on effective science education practices by providing empirical evidence supporting the integration of contextual and environmental elements into instructional design. Furthermore, it underscores the critical role of relevance and authenticity in teaching materials, particularly in improving students' scientific literacy and higher-order thinking skills.

Future research should explore the application of similar innovative instructional approaches across different scientific topics, educational levels, and learning environments to further validate their effectiveness and broader educational impact. Expanding the scope of implementation would provide stronger generalizability and deeper insights into how context-based digital modules influence diverse student populations. Additionally, longitudinal studies are recommended to examine the sustained effects of such interventions on students' scientific literacy, critical thinking skills, and environmental awareness.

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