

DEVELOPMENT OF A LOCAL WISDOM-BASED E-MODULE USING THE CULTURALLY RESPONSIVE TEACHING (CRT) APPROACH TO IMPROVE CRITICAL THINKING SKILLS AND CHEMISTRY LEARNING OUTCOMES ON REACTION RATE MATERIAL

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Abstract: The purpose of this study was to describe how to create e-modules based on local wisdom, analyze the feasibility of e-modules, evaluate improvements in critical thinking skills, and evaluate improvements in outcomes. The research method employed was Research and Development (R&D) using the 4D procedural model (define, design, development, disseminate). The instruments used in this study included an e-module feasibility validation sheet, a critical thinking skills test, and a learning outcomes test. The e-module data were analyzed empirically using SPSS version 22. The sampling technique applied was purposive sampling, with a sample consisting of 34 eleventh-grade students of SMA Negeri 2 Serui. The results of the study indicated that the e-module was developed through the stages of preparation, production, and finalization by utilizing Canva software and the Heyzine website. The feasibility analysis showed that the average validator assessment score was 92.36%, categorized as highly feasible. The local wisdom-based e-module employing the CRT approach on reaction rate material was practical for use and effective in improving students' critical thinking skills and learning outcomes, with N-Gain scores of 0.72 (high category) and 0.76 (high category), respectively.

Keywords: E-module, local wisdom, Culturally Responsive Teaching (CRT), reaction rate, critical thinking skills, learning outcomes.

1. INTRODUCTION

Education is one of the main pillars of a nation's development. Education equips the younger generation with the knowledge, skills, and attitudes needed to face the global challenges of the 21st century. The rapid advancement of technology is evidence of progress in the world of education, capable of transforming structures and practices across various fields. The world of education must be able to adapt to the times so that the current generation is required to master 21st-century skills (creativity and innovation, critical thinking and problem-solving, communication, and collaboration) and integrate them with advances in science and technology (Siregar, 2021).

21st-century skills such as critical thinking, creativity, collaboration, and communication cannot be separated from efforts to provide relevant and meaningful learning.

One way to do this is by integrating local wisdom as a cultural identity of the nation into learning. Local wisdom, which is often linked to traditional community practices, can serve as a highly valuable learning resource in science education (Tabun, 2024). This aligns with the research by Subiyanto and Siregar (2018), which demonstrated an improvement in chemistry learning outcomes using a learning module based on Papua's local wisdom on the periodic table of elements. Local wisdom that can be integrated into science education comes from Yapen Islands Regency, Papua Province. Examples of this local wisdom include the tradition of making a local beverage (bobo) by mixing *langsat* tree bark, the production of betel lime using coral stones, and the preparation of coconut oil as a hair oil by mixing papaya leaves and unripe papaya fruit—all of which can be integrated into chemistry lessons at school. These local traditions can be explained using the concepts of reaction rate, collision theory, and factors affecting reaction rates.

Reaction rate is an abstract concept that students find difficult to understand. This aligns with Bain K's findings in Tahta (2021), who states that reaction rate is a challenging topic that requires multiple representations for effective learning. Some students struggle when learning about reaction rates because the material involves mathematical and physical chemistry calculations. Reaction rates describe how quickly molecules or ions collide and react with one another. A teaching strategy that teachers can use to integrate culture with the concept of reaction rates is the Culturally Responsive Teaching (CRT) approach.

The CRT approach is used to connect chemistry with students' cultural experiences in a relevant way; this approach requires students to create meaningful chemistry learning and relate it to their own culture (Hardiana, 2023). In the context of this study, CRT was applied by integrating Serui's local wisdom into chemistry instruction. This approach was chosen because, based on data from students at Serui State High School 2, nearly 64.7% are indigenous Papuans and come from tribes in Yapen. The Yapen tribes include the Onate, Pombawo, Busami, Arui Sai, Berbai, Ampari, and 3W (Wondau, Wondei, Wonawa) tribes, while settled tribes include the Biak, Waropen, and Kurudu tribes (which are an assimilation of the Ampari and Biak tribes) (Limbu, 2022).

The era of globalization and the Fourth Industrial Revolution demands that the education system be able to adapt quickly to technological changes. The development of e-modules on reaction rates based on local wisdom using the CRT approach offers an innovative solution to address existing learning challenges. According to Ennis (2011), critical thinking is a rational, reflective process focused on deciding what to believe or do. The aspects of critical thinking according to Ennis (2011) include (1) Elementary Clarification (brief explanation); (2)

Basic for Decisions (basis for decision-making); (3) Inference (drawing conclusions); (4) Advanced Clarification (further explanation); (5) Supposition and Integration (estimating and combining).

An interview with a chemistry teacher at SMA Negeri 2 Serui who teaches in Phase F revealed several findings, including: (1) student learning outcomes on reaction rate material remain low, as indicated by 78% of students failing to meet the minimum competency standard; (2) the teacher has not yet optimally utilized technology-based learning media integrated with local wisdom; (3) The teaching materials used have not fully stimulated students' critical thinking skills. A literature review also indicates that no one has yet developed a chemistry e-module based on the local wisdom of the Yapen community. Based on the description of the problems faced above, the researcher conducted a study titled "Development of a Local Wisdom-Based E-Module Using the Culturally Responsive Teaching (CRT) Approach to Improve Critical Thinking Skills and Chemistry Learning Outcomes on Reaction Rate Material."

2. RESEARCH METHODS

An electronics module based on local wisdom, utilizing a Culturally Responsive Teaching (CRT) approach, was created and developed to measure improvements in students' critical thinking skills and learning outcomes. The research design employed is Research and Development (R&D) using the 4D model proposed by Thiagarajan (1974). The 4D model consists of four development stages: define, design, develop, and disseminate, as shown in Figure 1 below:

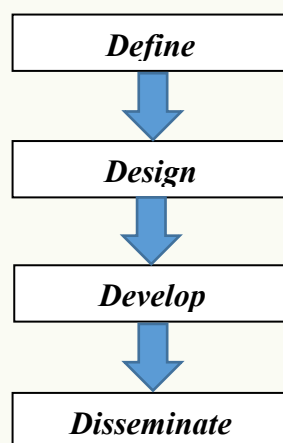


Figure 1. Diagram of the 4D model

Figure 1 define phase involves a needs analysis that includes an analysis of the curriculum, student culture, and instructional materials. The design phase involves preparing the conceptual framework of the model and instructional materials. The develop phase, which is the development stage, involves validation testing or assessing the suitability of the media, making revisions, and conducting limited trials. The disseminate phase involves implementation with the actual target audience, namely the research subjects.

The subjects in this study were 11th-grade students in Class 2 at Serui State High School 2 for the 2025/2026 academic year. Data were collected quantitatively by conducting a feasibility test of the e-module with three validators. The three validators were Master's degree faculty members in Science Education who possessed expertise in subject matter, media, and language. Additionally, questionnaires were administered to two chemistry teachers and students to gauge their responses to the e-module. The validation criteria from the validators, as well as the responses from teachers and students, are presented in Tables 1 and 2 below:

Table 1. Criteria for the Validity of E-Modules (Arikunto, 2015)

Score Range (%)	Criteria
$75\% < \text{score} \leq 100\%$	Highly recommended
$50\% < \text{score} \leq 75\%$	Recommended
$25\% < \text{score} \leq 50\%$	Not highly recommended
$0\% < \text{score} \leq 25\%$	Not recommended

The data obtained from the research findings were then processed and converted into percentages using the following formula:

$$\% \text{ Eligibility} = \frac{\text{Maximum score}}{\text{Total score}} \times 100\%$$

Table 2. Criteria for Teacher and Student Responses (Ridwan, 2012)

Score Range (%)	Criteria
$81\% < \text{score} \leq 100\%$	Excellent
$62\% < \text{score} \leq 81\%$	Good
$43\% < \text{score} \leq 62\%$	Fair
$25\% < \text{score} \leq 43\%$	Not good

The calculation of the analysis of improvements in critical thinking skills and student learning outcomes using normalized gain (n-Gain) according to Hake (1999) uses the following formula:

$$n - Gain = \frac{\text{Posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}$$

3. RESULTS AND DISCUSSIONS

This e-module was developed based on an analysis of the chemistry curriculum and the cultural background of students at Serui State High School 2. The results of a questionnaire distributed to students showed that 64.7% of the students' fathers and 58.8% of their mothers are from Yapen Islands Regency. The results are shown in Figures 2 and 3 below:

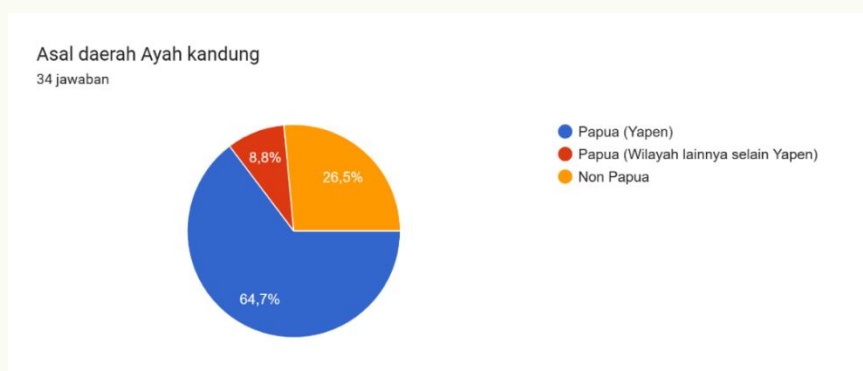


Figure 2. Distribution diagram of the biological father's region of origin

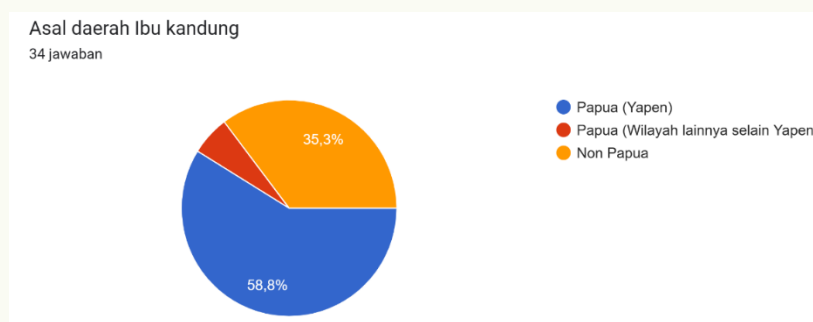


Figure 3. Distribution diagram of the biological mother's region of origin

These results indicate a strong connection to Yapen culture through both the paternal and maternal lines. Therefore, the local wisdom integrated into the lesson materials also originates from the Yapen region, including the preparation of bobo drink using a mixture of langsung bark, the production of betel lime from coral stone, and the making of hair oil from coconut oil. This context serves as a crucial foundation for adopting the CRT approach as a contextual and culturally relevant learning method tailored to students' socio-cultural backgrounds.

How to Create an E-Module Based on Local Wisdom Using the CRT Approach for the Topic of Reaction Rates

The e-module was created through three stages: (1) the preparation stage, (2) the production stage, and (3) the finalization stage. During the preparation stage, the software and

hardware to be used in creating the e-module were set up, including laptops, a Wi-Fi network, Microsoft Word, and the Canva website. During the production stage, the e-module was designed and developed using Canva. The reaction rate material is then incorporated into a digital format according to the designed structure, starting from the cover page, introduction, concept map, core content, integration of local wisdom, to the learning assessment. In the final completion stage, a thorough review is conducted to ensure the accuracy of the content, conceptual clarity, linguistic appropriateness, and design consistency.

Feasibility Analysis of an E-Module on Reaction Rates Based on Local Wisdom Using a Culturally Responsive Teaching (CRT) Approach

The analysis process was conducted through validation by subject matter experts, media experts, and education practitioners with expertise in chemistry education. The results of the e-module validation analysis are shown in Figure 4 below:

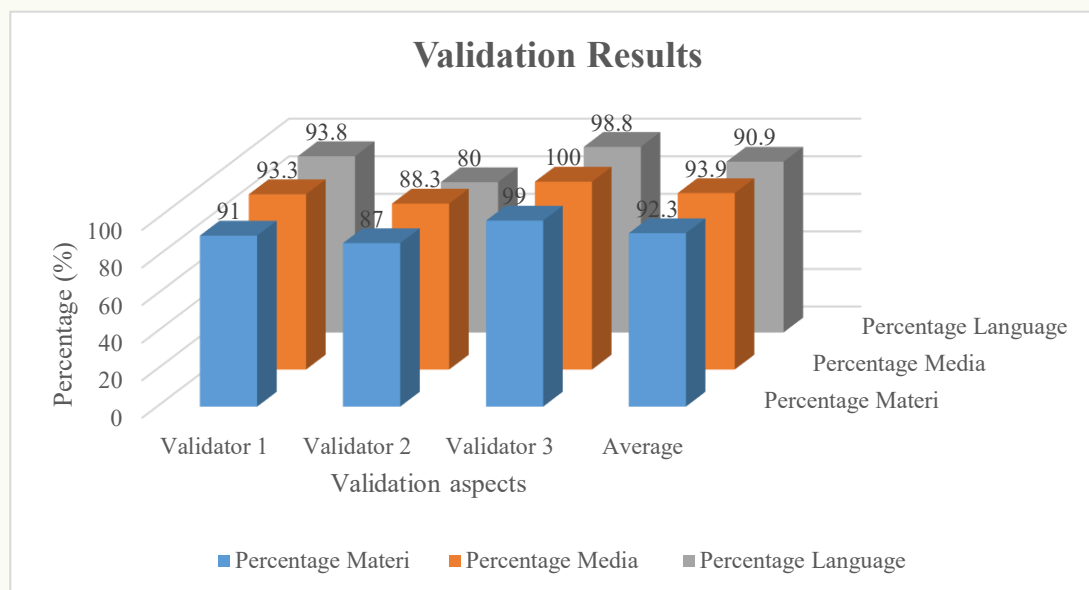


Figure 4. Diagram of e-module validation results

Figure 4 shows the results of the e-module validation by the three validators. The results indicate that not all validators gave the maximum score of 100%, but the average score falls within the “very acceptable” category. This is because there were several suggestions for revisions that the researcher must make to the e-module before it can be used.

The validated e-modules were distributed to students and teachers to gauge their response to the e-modules. The results of the student questionnaire analysis can be seen in Figure 5 below:

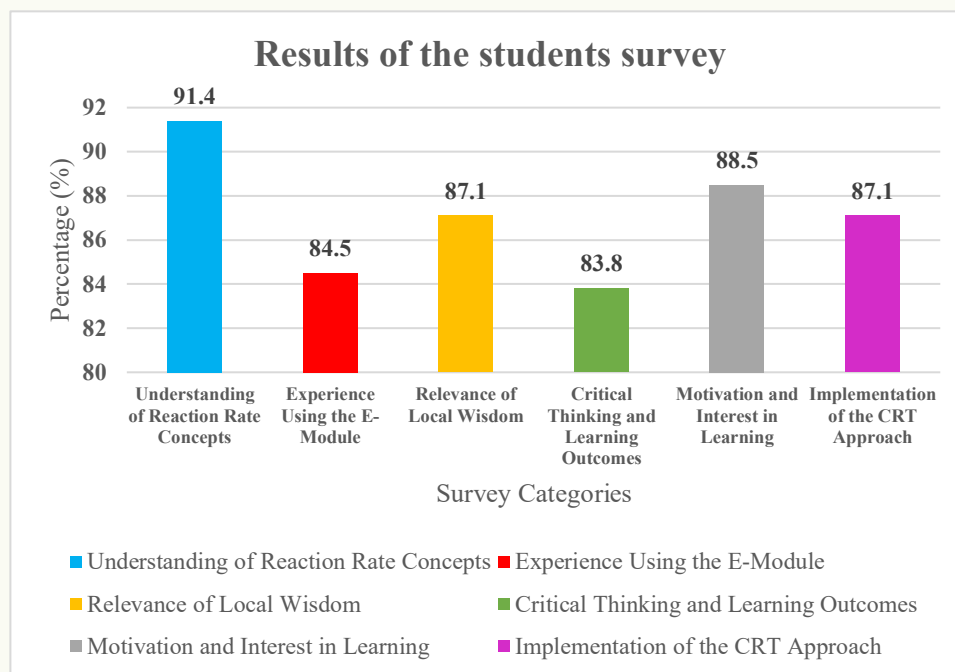


Figure 5. Diagram of student response survey

Figure 5 shows that, in general, the percentage of student responses above 80% falls into the “very good” category. The highest percentage was found in the aspect of understanding the concept of reaction rate, at 91.4%. In addition to the students, a response questionnaire was also administered to the chemistry teachers at Serui State High School 2. The results of the responses from these two chemistry teachers can be seen in Figure 6 below:

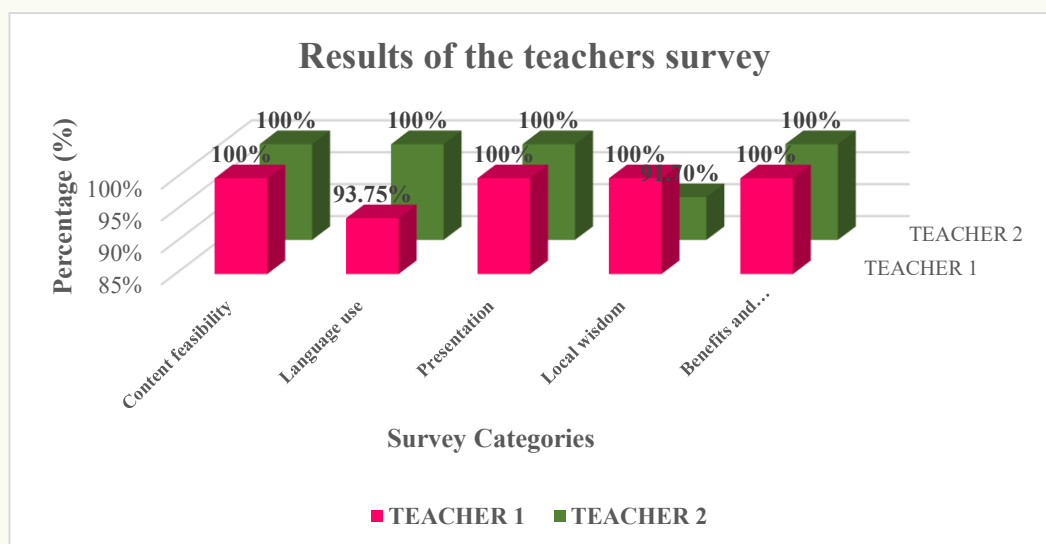


Figure 6. Diagram of the results of the teachers response survey

The results of the second questionnaire on chemistry teachers’ responses regarding the suitability of the locally-based reaction rate e-module using the CRT approach, as shown in Figure 6, indicate very high ratings across all measured aspects. This is evidenced by the percentages given by both teachers, which approached or even reached 100%. The highest

percentages were found in the aspects of content feasibility (100%), presentation (100%), and usefulness and implementation (100%).

Evaluation of the Improvement in Critical Thinking Skills Through the Use of a Reaction Rate E-Module Based on Local Wisdom Using a Culturally Responsive Teaching (CRT) Approach

The data was obtained from the results of critical thinking assessments, which encompass five stages: basic clarification, building foundational skills, drawing conclusions, advanced clarification, and applying strategies and tactics. The average critical thinking test scores are shown in Figure 7 below:

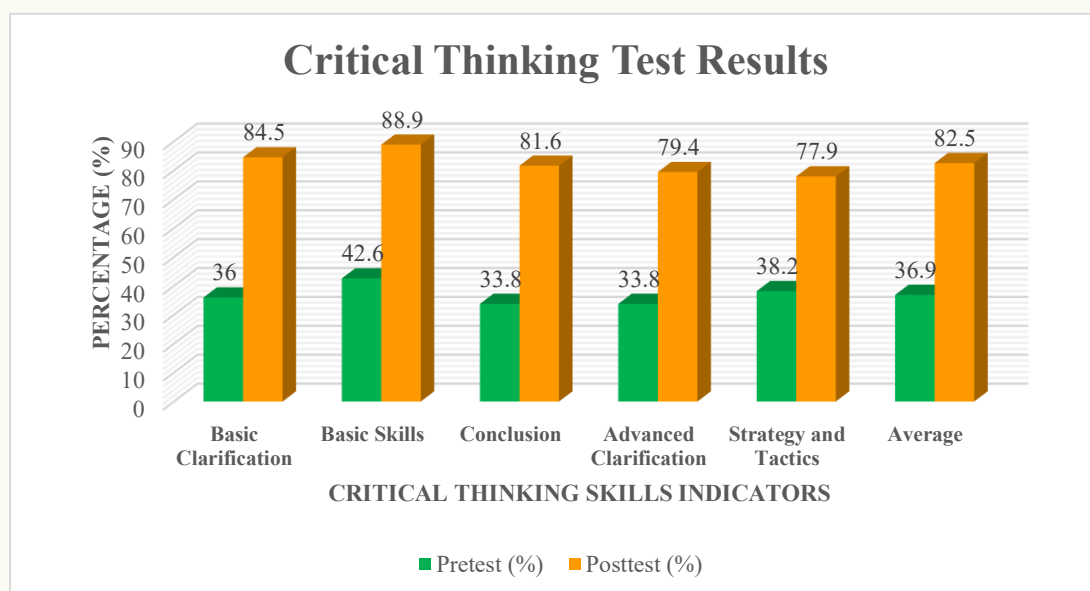


Figure 7. Diagram of critical thinking test results

Figure 7 shows that, overall, the average pretest score of 36.9% increased to 82.5% on the posttest. There was an increase of 45.6 points, indicating a significant improvement in critical thinking skills following instruction using the e-module. Scores that were initially in the low category improved to the high category by the end of the instruction.

The results of the N-Gain test for critical thinking skills using SPSS 22 can be seen in Figure 8 below:

	N	Minimum	Maximum	Mean	Std. Deviation
NGAINSKOR	34	.33	1.00	.7225	.15962
NGAINSKORPERSEN	34	33.33	100.00	72.2541	15.96232
Valid N (listwise)	34				

Figure 8. N-gain test for critical thinking

Based on the results of the descriptive statistical analysis (8) of the critical thinking ability test regarding N-Gain scores after three learning sessions using the e-module, the sample size (N) was 34 students. The minimum N-Gain value was 0.33 and the maximum was 1.00. The average N-Gain was 0.72, falling within the range of $g \geq 0.7$, leading to the conclusion that

the N-Gain falls into the high category. When converted to a percentage, the average increase reached 72.2%. This figure indicates that, in general, learning using e-modules based on local wisdom with a CRT approach has a strong impact on the development of students' critical thinking skills.

This improvement in critical thinking skills is closely tied to the learning activities designed in the e-module, where students not only receive information but also analyze phenomena related to Yapan's local wisdom in each session. The integration of local cultural context allows students to connect scientific knowledge on reaction rates with experiences encountered in daily life, such as making bobo drink using langsung bark, making betel lime from coral stone, and making hair oil from coconut oil. When students discuss and explain these local phenomena based on the concept of reaction rates, they are indirectly trained to perform the processes of analysis, interpretation, and logical conclusion-drawing. The results obtained by the researchers are consistent with the study by Parwiti Endang et al. (2024), titled "Development of a STEM-Based Thermodynamics E-Module Integrated with Problem Solving to Improve Critical Thinking Skills and Learning Outcomes," which also states that the use of e-modules can enhance critical thinking skills, as evidenced by an N-Gain value of 0.53. These results also align with the findings of Jannah et al. (2023) in their study titled "Improving Critical Thinking Skills and Biology Learning Outcomes Using the PjBL Model and the CRT Approach," which indicates that students' critical thinking skills improved after implementing instruction using the PjBL model and the CRT approach in biology lessons.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

Based on the results of the validation analysis of the e-module on reaction rates based on local wisdom using the Culturally Responsive Teaching (CRT) approach, the e-module was deemed suitable for use, with an average approval rating of 92.36% from validators, falling into the "highly suitable" category. The use of a local wisdom-based e-module employing the CRT approach in reaction rate material effectively enhances students' critical thinking skills.

SUGGESTIONS

E-modules based on local wisdom that utilize the Culturally Responsive Teaching (CRT) approach can be used by teachers as a learning tool.

5. ACKNOWLEDGMENTS

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