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Development of a PBL Based E-Module for Reaction Rate Material with Integration of Batak Toba Local Wisdom *Dekke Naniura*

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Abstract

The integration of local wisdom into science education can create a meaningful connection between traditional knowledge and scientific concepts, making learning more contextual, engaging, and relevant for students. However, the teaching materials commonly used in schools are still conventional and do not actively involve students in the learning process. This study aims to develop and evaluate the feasibility of a chemistry learning module based on problem based learning integrated with Batak Toba local wisdom, particularly through the cultural context of Dekke Naniura cuisine. The research employed a Research and Development (R&D) approach, referring to the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), which in this study was carried out up to the development stage. The data analysis techniques used included both qualitative and quantitative approaches. The module was validated by three chemistry lecturers and three chemistry teachers, referring to the BSNP feasibility standards. The validation results showed that the average feasibility percentage from the lecturers was 94.2%, while from the teachers it was 94%, both of which are categorized as feasible. Therefore, the developed learning module meets the feasibility standards and is recommended for implementation in chemistry education at schools.

Keywords: E-module, Development, Dekke Naniura, Problem Based Learning, Reaction Rate

1. Introduction

Education is a dynamic process that not only transfers knowledge but also shapes students' attitudes, skills, and character. In the context of science education, particularly chemistry, the main challenge lies in how teachers can deliver abstract material in a contextual and meaningful way. The curriculum used in educational institutions plays a crucial role in determining the quality

of learning. The *Merdeka Curriculum*, as the latest policy, provides teachers with flexibility to develop learning that is relevant to students' lives and the local potential of their respective regions (Rani et al., 2023).

One approach that supports contextual learning is ethnoscience. Ethnoscience integrates scientific knowledge with local cultural practices, enabling students to understand scientific concepts through phenomena that are closely related to their daily lives (Khasanah & Sumarni, 2021; Lia et al., 2016). This approach not only strengthens conceptual understanding but also fosters character development and appreciation for one's own culture. In Regulation of the Minister of Education and Culture (Permendikbud) No. 79 of 2014, local content is recognized as an essential component of the curriculum, as it equips students with knowledge and attitudes relevant to their social and cultural environment.

One form of local wisdom that can be utilized in learning is the culinary culture of the Batak ethnic group, namely the traditional dish *Dekke Naniura*. This typical Batak Toba cuisine uses fresh carp that is processed without cooking, but instead soaked in a mixture of lime juice and various spices. The soaking process causes changes in the protein structure of the fish meat due to chemical reactions triggered by acidic substances, making the fish tender and safe for consumption without heating. A distinctive feature of this reaction is the change in the color of the fish meat to a pale shade, indicating enzymatic protein breakdown. *Naniura* is usually served at various traditional ceremonies such as weddings, thanksgiving events, or religious rituals, and is often eaten with rice or other side dishes (Pakpahan et al., 2020). In the context of chemistry learning in schools, this concept can be applied to teaching the topic of reaction rates, which discusses how chemical reactions are influenced by factors such as temperature, concentration, catalysts, and surface area. One of the difficulties in learning chemistry lies in the fact that chemistry content is often abstract and represented at three levels: macroscopic, submicroscopic, and symbolic (Mashami, 2016; Sutrisno et al., 2020).

Many teachers experience difficulties in integrating these three levels, making chemistry learning seem irrelevant to students (Amelia, 2017). However, by linking topics such as reaction rates with local cultural practices like the preparation of *Naniura*, students can understand that the changes occurring in the fish due to acid are the result of chemical reactions, in which spices and acids act as reactants that accelerate the alteration of protein structures (Pasaribu et al., 2022). In this way, chemistry learning becomes more contextual, concrete, and closely related to everyday life (Priyambodo & Wulaningrum, 2017).

The success of learning is determined by the achievement of instructional objectives, which requires teachers to create an effective learning environment and provide teaching materials that support students' independent learning. However, in chemistry learning, many students struggle to understand concepts because the methods used are still conventional and less engaging. One solution that can be applied is the use of modules, particularly e-modules, which allow students to learn independently with the support of interactive multimedia such as text, images, videos, and animations (Utari et al., 2020). Furthermore, the development of ethnoscience based e-modules is highly relevant as it connects the subject matter with local culture, thereby making learning more contextual and meaningful (Joseph, 2010).

An e-module is an electronic teaching material that enables students to learn independently with the support of multimedia. Research has shown that e-modules based on PBL and ethnoscience can improve students' critical thinking, scientific literacy, and learning outcomes (Silaban et al., 2025; Awanda, 2024; Yusnidar & Epinur, 2021). PBL encourages students to solve real-world problems, making it suitable for teaching reaction rate topics that are directly connected to local cultural phenomena. The integration of PBL and ethnoscience makes learning more contextual, meaningful, and aligned with students' characteristics (Patricia et al., 2022; Sitepu & Pulungan, 2021).

Preliminary observations at SMA Negeri 18 Medan revealed that chemistry learning has not yet optimally integrated local wisdom. Students have not been encouraged to develop critical thinking skills, and teachers still face challenges in connecting chemistry content with the surrounding cultural context. A majority of students, 95.6%, stated that they need additional teaching materials that are relevant and engaging, while 94.1% agreed on the development of a local wisdom based e-module as a more effective alternative for learning. These findings indicate a genuine need for innovative, contextual, and interactive teaching materials (Lamtiur et al., 2025).

However, previous studies that developed e-modules based on problem based learning or ethnoscience were generally conducted separately and have not specifically integrated particular local cultural contexts into chemistry learning. Research that highlights the local wisdom of the Batak Toba ethnic group particularly through the culinary tradition of *Dekke Naniura* as a contextual medium for teaching reaction rate concepts remains very limited. Moreover, studies on the development and feasibility testing of PBL based e-modules integrated with local ethnoscience in the North Sumatra region are also scarce. This condition indicates the existence of a research gap in the development of contextual learning materials capable of effectively connecting abstract chemical concepts with students' local cultural realities.

The novelty of this study lies in the development of a PBL based e-module integrated with the local wisdom of the Batak Toba ethnic group. The development of this e-module is motivated by the absence of teaching modules on the reaction rate topic that integrate Batak Toba local wisdom, particularly in the context of *Dekke Naniura*. The integration of the problem based learning model with local wisdom in this module is expected to encourage active student engagement in the learning process. This study aims to develop and test the feasibility of a PBL based e-module on reaction rate material integrated with the Batak Toba local wisdom of *Dekke Naniura* for grade XI senior high school students.

2. Methods

This research utilized a Research and Development (R&D) method with the objective of creating and evaluating the feasibility of a product an e-module on reaction rate integrated with Batak Toba local wisdom, specifically *Dekke Naniura*, through the problem based learning approach (Sugiyono, 2016).

The instructional design followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), which offers a systematic framework for producing learning

materials (Rayanto, 2020). Nevertheless, the study was limited to the Development phase. To examine its appropriateness as chemistry teaching material for grade XI senior high school, the e-module was validated by six experts, consisting of three chemistry lecturers and three chemistry teachers.

This research was conducted at SMA Negeri 18 Medan with a sample of 36 grade XI science students, selected through purposive sampling. This technique was used to ensure that the sample had characteristics aligned with the research objectives, namely students who were studying the reaction rate topic and had relevance to the developed e-module.

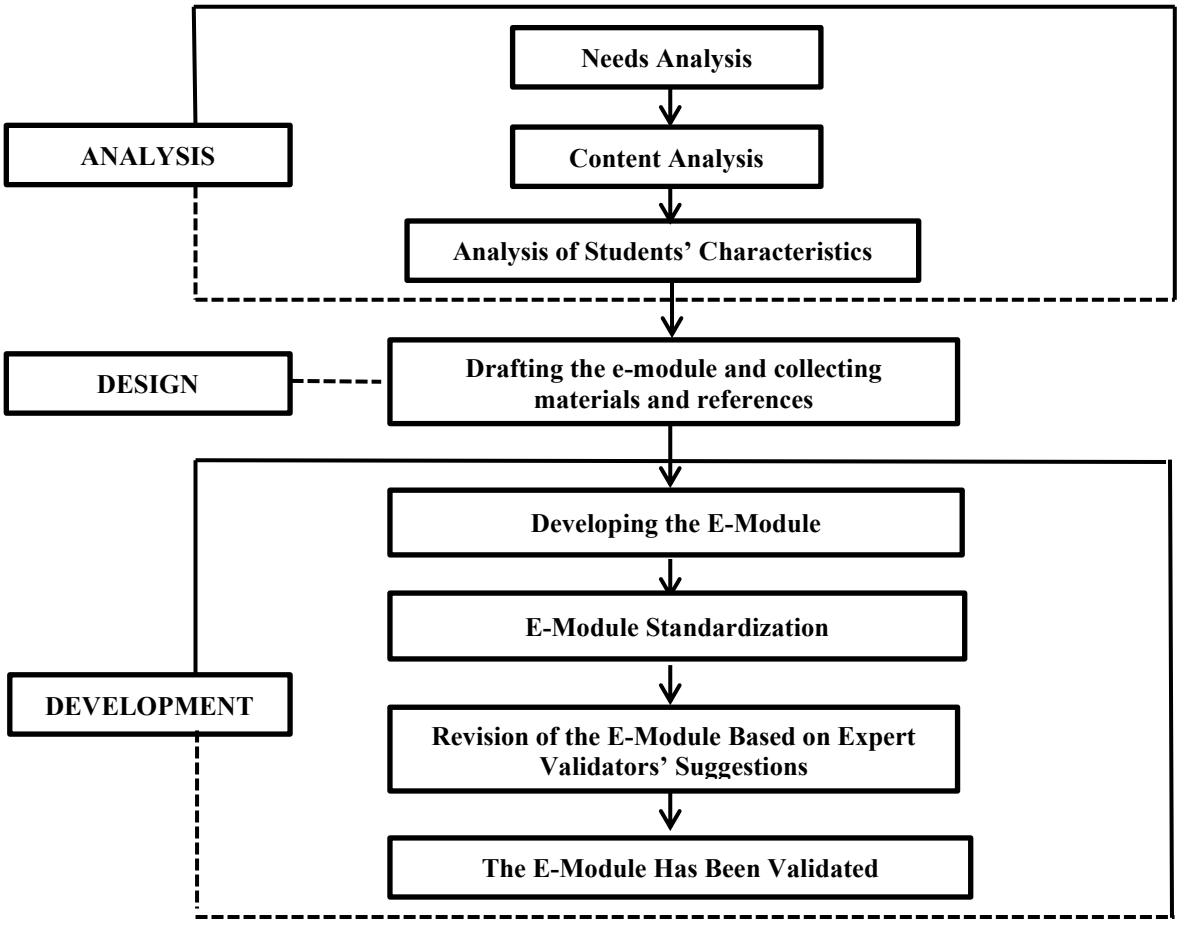
2.1. Data Collection Tools

Data collection was carried out through the following methods:

1. Needs Analysis: Data were collected through the analysis of learning objectives, interviews with teachers, distribution of questionnaires to grade XI students via Google Forms to identify the relevance and necessity of the e-module to be developed, and analysis of textbooks used in schools.
2. Design of Learning Materials and Media: The formulation of learning objectives, content, learning activities, and e-module design was based on the results of the needs analysis conducted previously.
3. E-Module Development: The e-module product was designed by integrating the local wisdom of *Dekke Naniura*, equipped with learning materials, barcodes linked to instructional videos, practice questions, and references to learning resources to enhance students' understanding of the reaction rate concept.

The entire sequence of the ADDIE model research procedure is presented in Figure 1.

Figure 1.
Development Procedure of the Reaction Rate E-Module



2.2. Data Analysis

The data obtained in this study were analyzed using quantitative descriptive techniques. Data collected from the validation questionnaires were analyzed using descriptive percentage techniques to determine the feasibility of the e-module as a teaching material. If the total percentage meets the feasibility criteria, then the reaction rate e-module integrated with Batak Toba local wisdom *Dekke Naniura* using problem based learning is considered feasible for use as teaching material in learning. The product feasibility was calculated using the following formula:

$$\text{Feasibility Percentage} = \frac{obtained\ score}{maximum\ score} \text{ x } 100\%$$

After the percentage results were obtained, the researcher then categorized them into the product feasibility validation criteria. The validity criteria for product feasibility are presented in Table 1.

Table 1.
Product Feasibility Criteria Based on Percentage Scores

Score	Category
80% - 100%	Feasible
60% - 79%	Fairly feasible
40% - 59%	Less feasible
0 ≤ 39%	Not feasible

(Arikunto, 2021)

3. Result and Discussion

3.1. Analysis

The results of observations and needs analysis conducted through interviews, questionnaire distribution via Google Forms at SMA Negeri 18 Medan, and textbook analysis revealed that the chemistry learning process does not yet have a specific program that comprehensively integrates the local wisdom of the Batak Toba ethnic group into classroom activities. The integration of local cultural values so far has only been carried out in a limited way within the Pancasila Student Profile reinforcement project in the local wisdom chapter of Grade X. As a result, chemistry learning tends to remain conventional, with teachers relying mostly on lectures, occasionally supplemented with instructional videos or laboratory activities. In addition, the school has not yet utilized e-modules as teaching media, making the learning approach less attentive to students' interests, motivation, and ability to understand chemical concepts. The dominance of textbook use leads to a learning process that is less varied, less contextual, and monotonous for students. This situation affects students' interest in chemistry and the low scores in daily assessments indicate the need for a more innovative learning approach to enhance students' understanding of the application of concepts in everyday life.

The findings from the questionnaire distributed to students reinforce the results of the observations. A total of 95.6% of students stated that they need additional learning materials in chemistry. Students perceived that the use of more interactive and relevant instructional materials is essential to support conceptual understanding. Furthermore, 73.5% of students indicated the need for an e-module as an alternative learning resource, and 94.1% expressed agreement with the development of a reaction rate e-module based on the local wisdom of the Batak Toba ethnic group. These findings demonstrate a genuine need for the development of contextual and digital learning materials that not only facilitate students' understanding but also enhance learning motivation through a local cultural approach closely related to their everyday lives.

The researcher also conducted an analysis of the textbooks used at the school. The selection of the books was based on the chemistry textbooks used at SMA Negeri 18 Medan, consisting of two books that align with the Independent Curriculum. The two analyzed textbooks are presented in Table 2.

Table 2.
Types of Textbooks Analyzed

Book Title	Author's	Publisher	Year of Publication
Kimia untuk SMA/MA kelas XI	Unggul Sudarmo	Erlangga	2021
Kimia Berbasis Eksperimen 1 untuk Kimia XI SMA dan MA	Sentot Budi Rahardjo	PT Tiga Serangkai Pustaka Mandiri	2023

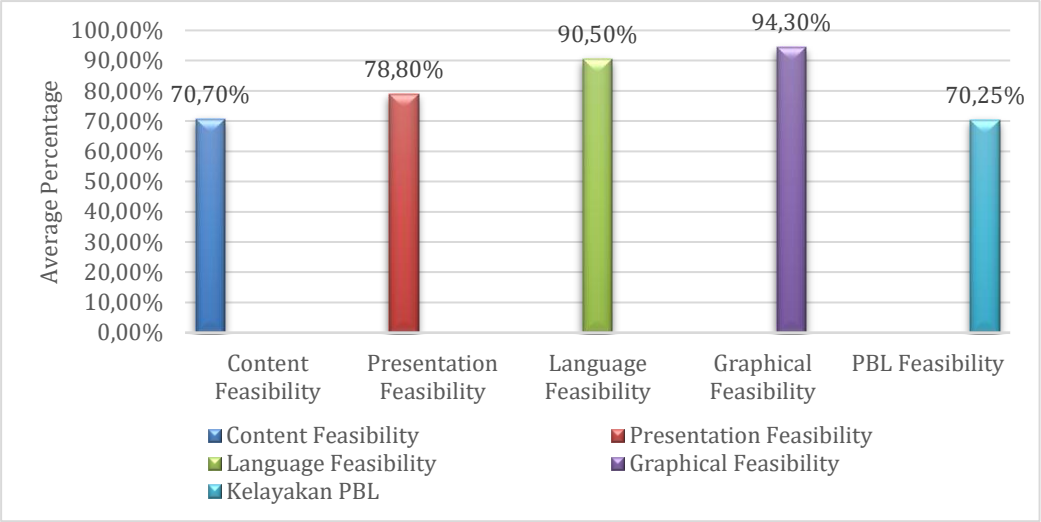
The analysis was carried out using an assessment instrument in the form of a questionnaire, which was adapted from the National Education Standards Agency (BSNP) and covered several aspects, namely content feasibility, presentation feasibility, language feasibility, graphical feasibility, and problem-based learning feasibility. The results of the feasibility analysis of the students' chemistry textbooks are presented in Table 3.

Table 3.
Tabulation of the Evaluation of Two Chemistry Textbooks

No	Evaluation Component	Average Score	Percentage (%)	Feasibility Criteria
1.	Content Feasibility	2,83	70,7%	Fairly feasible
2.	Presentation Feasibility	3,15	78,8%	Fairly feasible
3.	Language Feasibility	3,62	90,5%	Feasible
4.	Graphical Feasibility	3,77	94,3%	Feasible
5.	PBL Feasibility	2,81	70,25%	Fairly feasible
	Average Score	3,23	80,9%	**Feasible**

The graph illustrating the percentage of each aspect evaluated in the assessment of two chemistry textbooks used by students and teachers of the science specialization group (MIPA) at SMA Negeri 18 Medan is presented in Figure 2 below.

Figure 2.
Results of the Feasibility Analysis of Two Chemistry Textbooks



Based on the results of the chemistry textbook analysis presented in Figure 2, the chemistry textbooks from publishers A and B are considered fairly good and sufficiently meet the standards of the National Education Standards Agency (BSNP) as well as problem-based learning. However, several aspects still require further development.

3.2. Design

The design stage of this e-module began with the integration of Batak Toba local wisdom through the traditional cuisine *Dekke Naniura* into the chemistry learning material on reaction rates. The approach applied in the development of this e-module was problem-based learning, which enables students to understand concepts more deeply through real and meaningful contexts. The design was carried out based on the analysis of learning objectives, identification of students' initial needs, and a review of grade XI chemistry textbooks as well as various relevant references, such as university-level chemistry books and scientific journals.

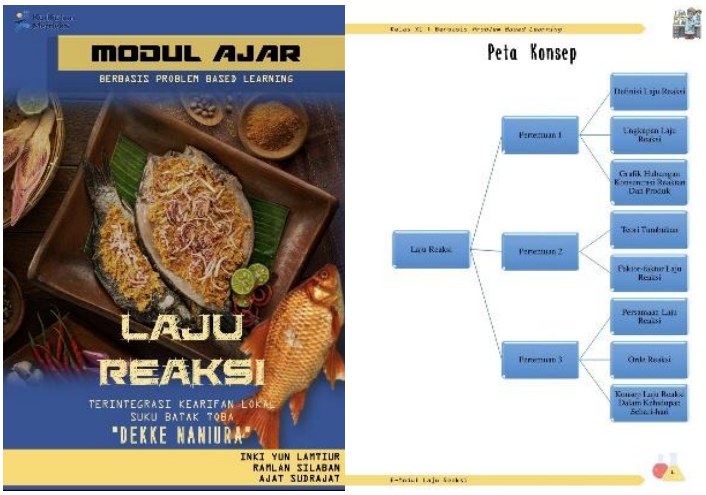
At this stage, the design process focused on systematically structuring and organizing the content of the e-module by taking into account pedagogical, cultural, and technological aspects. Defining the learning objectives was a crucial step, as the competencies to be achieved by students needed to be clearly, measurably, and contextually formulated. These objectives included

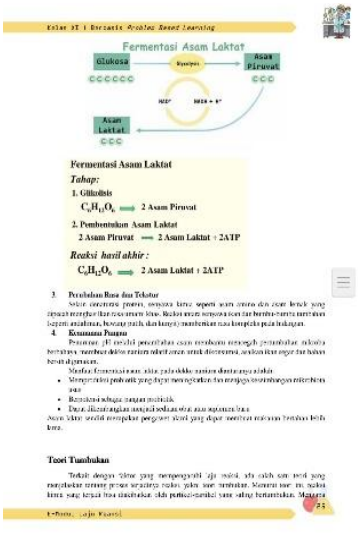
conceptual understanding of reaction rates, the ability to apply concepts in real-life situations, and the integration of scientific concepts with chemical processes occurring in local cultural practices, particularly in the traditional food preparation technique of *Dekke Naniura*.

The structure of the e-module was systematically designed and comprised eighteen main components, namely: cover page, preface, table of contents, concept map, module usage guide, introduction, learning materials, barcodes directly linked to YouTube, sample questions, practice exercises, summary, competency test, scoring guidelines, evaluation questions, answer key, glossary, references, and index. The reaction rate material was presented based on the five syntaxes of problem-based learning, namely: (1) orientation to the problem through a narrative or video on the preparation of *Dekke Naniura*; (2) organizing students into groups to discuss the role of local ingredients; (3) guiding the investigation through interactive simulations in the e-module to analyze the role of spices and traditional techniques in a scientific context (e.g., how *jungga* acid accelerates fish protein denaturation); (4) developing and presenting students' investigation results; and (5) analyzing and evaluating the problem-solving process through a reflective forum.

Technically, the e-module was packaged using Heyzine Flipbook, which enabled visually engaging and interactive content presentation. Features such as embedded video barcodes, practice questions, and visual illustrations of chemical processes in the context of local culture were designed to enhance students' motivation and conceptual understanding. The initial design layout of the e-module is shown in Figure 3.

Figure 3.
Initial Design Layout of the Reaction Rate E-Module Integrated with Batak Toba Local Wisdom Using Problem-Based Learning





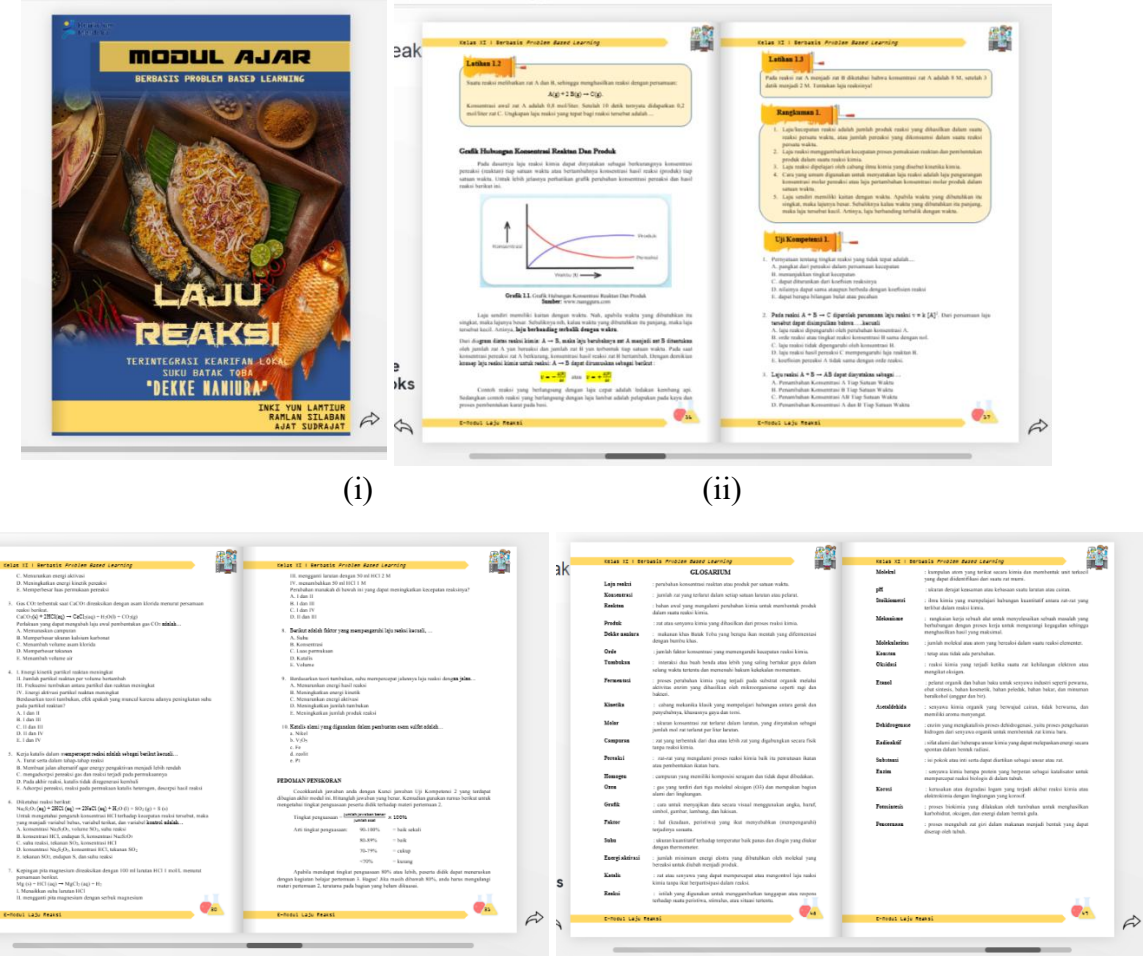
3.3. Development

The development of the module was structured based on the basic competencies to be achieved, which were then formulated into several indicators, namely: (1) explaining the definition of reaction rate; (2) explaining the expression of reaction rate through the e-module; (3) constructing a graph of the relationship between reactant concentration and product yield over time; (4) explaining the factors that influence the reaction rate; (5) describing the determinants of reaction rate based on collision theory; (6) writing reaction equations; (7) calculating the reaction order, rate constant, and reaction rate based on experimental data; and (8) explaining the application of reaction rate concepts in everyday life. Accordingly, the scope of the material was organized as follows: (1) definition and expression of reaction rate; (2) graph of the relationship between reactant and product concentrations; (3) collision theory; (4) factors affecting reaction rate; (5) reaction rate equations; (6) reaction order; and (7) the concept of reaction rate in daily life. The scope of the material was presented using a concept map to provide students with an overview of the topics to be studied in the reaction rate material.

The validation process employed instruments based on the standards of the *Badan Standar Nasional Pendidikan* (BSNP) with assessment aspects covering content feasibility, presentation, language, integration of local culture, and problem based learning components. Based on the evaluation results, the subject matter experts provided several important suggestions for improving the e-module. In general, the e-module was deemed suitable for use in chemistry learning; however, several revisions were recommended to make the material more comprehensive, contextual, and easier for students to understand. The feedback included adding more detailed explanations of the collision theory concept to help students understand the relationship between activation energy and particle collision frequency, incorporating examples of reaction rate, reaction order, and rate constant calculations based on simple experimental data, and strengthening the connection between

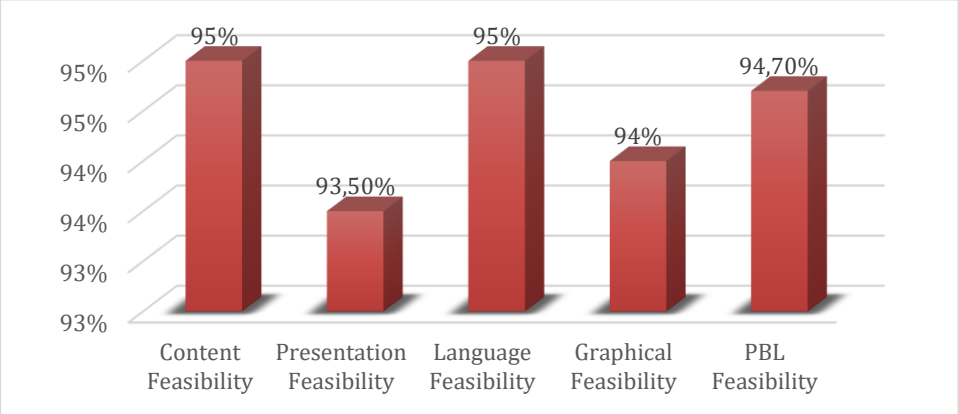
chemical concepts and Batak Toba cultural contexts particularly the chemical processes involved in the preparation of *Dekke Naniura*. The experts also suggested refining the practice questions and evaluation items to better align with learning indicators, as well as adjusting the layout and visual design to make the e-module more engaging and readable. All of these recommendations were incorporated into the revised version of the e-module, which now features improved material explanations, additional contextual examples, and enhanced language and visual presentation. The final version of the e-module is shown in Figure 4.

Figure 4.
Display of the Reaction Rate E-Module Integrated with Batak Toba Local Wisdom Using Problem Based Learning: (i) initial display; (ii) content display; (iii) evaluation display; and (iv) final display.



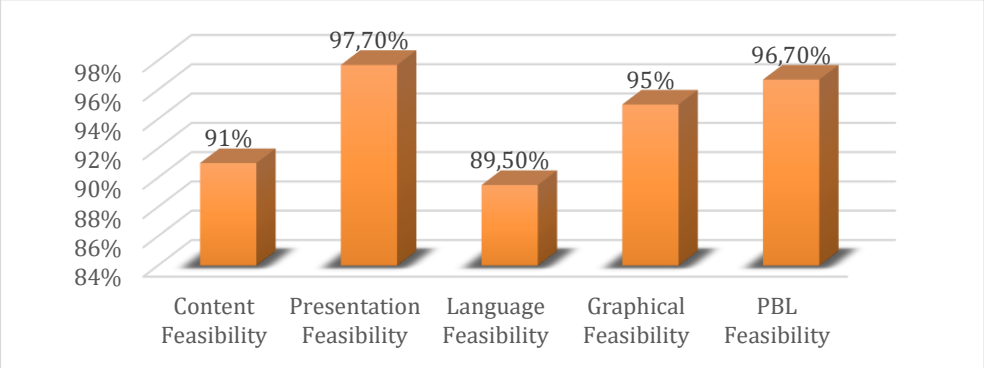
The reaction rate teaching module integrated with the local wisdom of the Batak Toba ethnic group *Dekke Naniura* and developed using the problem based learning approach was subsequently validated by three expert lecturers and three chemistry subject teachers. A feasibility test was conducted to determine the percentage of the module's eligibility through a validity assessment. The module validation was carried out using an instrument in the form of a questionnaire designed based on the modified standards of the *Badan Standar Nasional Pendidikan* (BSNP). The average percentage results from the expert lecturers' validation are presented in Figure 5.

Figure 5.
Graph of the Validation Results by Expert Lecturers



Based on Figure 5, the percentage of content feasibility is 95%; presentation feasibility is 93.5%; language feasibility is 95%; graphical feasibility is 94%; and problem-based learning feasibility is 94.7%. The overall average feasibility percentage is 94.2%, which falls into the "feasible" category. Meanwhile, the validation results from chemistry subject teachers are presented in Figure 6.

Figure 6.
Graph of Validation Results by Chemistry Teacher Validators



Based on Figure 6, it can be observed that the feasibility percentages obtained were as follows: content feasibility at 91%, presentation feasibility at 97.7%, language feasibility at 89.5%, graphical feasibility at 95%, and PBL feasibility at 96.7%. Thus, the average feasibility percentage across the five assessment aspects was 94%, which falls into the *feasible* category.

The development of a chemistry e-module integrated with local wisdom through a problem based learning approach represents an innovative strategy to improve the quality of science education in Indonesia. The PBL model emphasizes a student centered learning process, positioning students as active subjects in solving contextual problems. When integrated with elements of local wisdom, this approach functions not only as a cognitive learning medium but also as a means of cultural preservation and a way to enhance students' contextual awareness of their social environment.

In line with other studies on the development of innovative teaching modules that integrate PBL with local wisdom in chemistry topics, such as food additives, the application of this model has been shown to be effective in improving learning outcomes, with N-Gain values ranging from moderate to high. Students also responded very positively to modules that connected chemistry material with cultural aspects, such as ethnoscience in traditional food (Arrozaqu & Setiawan, 2022; Sulastri et al., 2025), which is similar to the chemical processes involved in preparing *Dekke Naniura*. This integration is expected to enhance students' critical and collaborative thinking skills.

Further research by Silaban et al. (2025) developed an innovative e-module based on project-based learning (PjBL) in stoichiometry integrated with ethnopedagogy, highlighting the cultural practice of betel chewing and its spiritual values. The module was validated by experts with very high results (93.99% for content and 88.1% for media) and received highly positive responses from both students and teachers, with average ratings above 82%, categorized as highly engaging and feasible for use in learning. Other studies on the effectiveness of e-modules integrating PBL and local wisdom, such as that of Putri & Santosa (2023), demonstrated that interactive e-modules containing local cultural elements such as Banten traditions using a PBL approach achieved strong validity, high practicality, and considerable effectiveness in improving students' problem-solving abilities. Similarly, a PBL model integrated with local wisdom, developed by Silaban et al. (2020), supported the 2013 Curriculum by fostering scientific problem-solving and enhancing learning outcomes. Moreover, Rusli et al. (2024) found that a PBL based e-module on chemical equilibrium

helped teachers in Penang, Malaysia, overcome resource limitations while promoting students' analytical thinking, highlighting the importance of active engagement in relevant and challenging learning experiences. Finally, the study by Zulfahrin (2019) reinforced the view that chemistry e-modules based on PBL significantly improve students' conceptual understanding while providing a flexible, efficient, and effective alternative learning resource in the context of modern chemistry education.

4. Conclusion

The researcher has successfully developed a teaching module on reaction rates integrated with the local wisdom of the Batak Toba ethnic group *Dekke Naniura* using the problem-based learning approach. The average feasibility percentage from three chemistry lecturers was 94.2%, while validation by three chemistry teachers resulted in an average percentage of 94%. These findings indicate that the developed module is categorized as highly feasible for use in chemistry learning.

The use of this teaching material is believed to contribute to enhancing students' motivation and learning outcomes. For future research, it is recommended that the study be extended to the stages of implementation and evaluation. This will allow for a more comprehensive understanding of the module's effectiveness in real classroom settings and provide insights into the extent to which the teaching material can generate positive impacts on students' learning experiences.

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