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Development of a Green Chemistry-Based Practicum Module Integrated with Quranic Verses for Reaction Rate Material at SMA IT Darul Hikmah Pasaman Barat

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Abstract. This study aimed to develop a valid and practical green chemistry-based practicum module integrated with Qur'anic verses for teaching reaction rate concepts at SMA IT Darul Hikmah Pasaman Barat This study employed the Research and Development (R&D) method using the 4-D development model, which consists of the Define, Design, Develop, and Disseminate stages. However, this study was conducted only up to the Develop stage. The practicum module was tested on 17 female students from Class XI Akhwat. The research instruments used were validation sheets and practicality questionnaires. The results showed that the developed module received a highly valid category validation with A validity score of 91%. In addition, this module was declared very practical with a percentage of 90% based on educator responses and 86% based on student responses. The conclusion of this research is a practicum module based on green chemistry and integrated with Islamic values that is valid and practical so that it can be used as one of the teaching materials for chemistry learning.

Keywords: Practical Module, Green Chemistry, Integration of Qur'anic Verses, Reaction Rate.

1. Introduction

Chemistry is one of the branches of Natural Sciences (IPA) that can be viewed both as a product and a process. As a product, chemistry encompasses a body of knowledge consisting of facts, concepts, and principles. Meanwhile, as a process, chemistry involves the development of skills and scientific attitudes in acquiring and constructing that knowledge. Therefore, learning chemistry cannot be limited to reading, writing, or listening; it also requires direct experience through practicum activities that allow students to engage actively in the learning process (Wanti et al., 2024).

Practicum has an essential role in science education, particularly in experimental chemistry. It provides a meaningful learning environment where students collaborate to explore scientific phenomena (Mawarnis et al., 2023). Through practicum, students are given the opportunity to construct their own understanding by observing and analyzing phenomena directly. This experiential learning strengthens their conceptual understanding more effectively than passive reception of information through lectures or textbooks (Nur Azizah et al., 2022). One of the core topics in chemistry that heavily depends on experimental observation is reaction rate, which discusses the mechanism of chemical reactions and the factors that influence them. The practicum provides a concrete way for students to observe and analyze changes in chemical reactions (Fitri et al., 2022).

The success of practicum implementation is closely related to the availability of adequate facilities and learning tools, especially practicum modules. These modules serve as structured

guides for both students and teachers to ensure that laboratory activities run effectively, safely, and purposefully (Handayani et al., 2018). In schools with religious foundations, such as SMA IT Darul Hikmah in West Pasaman, chemistry learning is also expected to shape students' character and spiritual values. According to (Harahap et al., 2022) emphasized that integrating Islamic values such as Qur'anic verses into education aligns with national educational objectives. Furthermore, Hadi (2019) highlighted that this integration enriches students' understanding of natural phenomena without diminishing the scientific integrity of chemistry.

However, although numerous studies have acknowledged the benefits of practicum, various obstacles still hinder its optimal implementation. Andani et al. (2023) identified challenges in implementing chemistry practicums, including limited infrastructure and insufficient chemicals (Amset et al., 2023). Meanwhile, Ambarwati et al. (2018) reported the lack of structured modules as a factor that hinders effective laboratory learning (Ambarwati et al., 2018). These problems prevent effective practicum implementation and negatively impact students' learning outcomes (Sainita et al., 2023). Findings from preliminary observations and interviews conducted at SMA IT Darul Hikmah revealed similar problems. Practicum implementation was minimal due to the absence of structured modules and limited availability of chemicals. In some cases, teachers relied on incomplete practicum steps from the internet, which led to student confusion and decreased engagement during practical sessions.

Although the school laboratory is equipped with basic tools, its use is limited to simple practicum activities due to the absence of essential safety infrastructure such as a fume hood. Consequently, hazardous substances like HCl, Na_2SO_3, H_2O_2, $CaCO_3$, and $FeCl_3$ cannot be used safely. The standard textbooks used in class contain practicum activities involving these substances, but teachers avoid them due to safety concerns and lack of waste management guidance. This situation raises the risk of environmental pollution and harm to students if carried out without proper handling. In addition, the chemistry teaching materials currently used at school have not yet been integrated with Qur'anic verses. While there have been occasional efforts to link chemistry concepts with Islamic values, they remain superficial and unstructured. Nonetheless, both educators and students expressed enthusiasm for a more integrated approach that brings together science and religious understanding in a meaningful way.

Several studies have developed green chemistry-based practicum modules that promote the use of safer and more environmentally friendly materials. Mitarlis et al. (2016) emphasized the importance of using green chemistry principles to minimize hazardous chemical use in education (Mitarlis et al., 2016). Susanti (2022) added that implementing environmentally friendly materials can reduce health risks and support sustainable laboratory practices (Susanti, 2022). However, most of these studies do not specifically address the integration of Islamic values nor are they tailored to the unique challenges faced by Islamic-based schools with minimal laboratory facilities. Additionally, many existing modules still rely on synthetic chemicals or do not directly support specific topics such as reaction rate, which remains abstract for many students without hands-on experience. Furthermore, there is a lack of practicum modules that replace hazardous chemicals with natural materials that are readily available, such as those found in kitchens, gardens, or pharmacies. Most prior studies also do not elaborate on how these green materials can be directly implemented within the school curriculum framework while preserving educational objectives. This approach aligns with (Chasanah et al., 2019), who stated that combining green chemistry with Islamic values supports not only scientific learning but also spiritual and moral development.

This research seeks to address these gaps by developing a green chemistry-based practicum module that is integrated with Qur'anic verses and specifically designed for reaction rate material. The novelty of this study lies in its effort to integrate spiritual values within scientific content in a structured and applicable manner, while also promoting environmental awareness and laboratory safety. The developed module uses safe, local ingredients as alternatives to hazardous chemicals and is intended to be a practical solution for schools with limited facilities. At the same time, it helps students see the relevance of their faith within scientific exploration, thus fostering both intellectual and moral development.

Based on the aforementioned conditions, this research aims to develop a chemistry practicum module on reaction rate material that is valid and practical, based on the principles of green chemistry and integrated with Qur'anic verses. The module is expected to serve as a guide for teachers and students in conducting safe and meaningful practicum, enhance understanding of chemical concepts, promote environmental responsibility, and strengthen the spiritual character of students in accordance with the values upheld by SMA IT Darul Hikmah Pasaman Barat.

2. Method

This type of research is Research and Development (R&D). Development research is a way to produce a product to solve a particular problem (Sugiyono., 2015). This research used the 4-D development model of define, design, develop and disseminate. However, this research only reached the develop stage, given the limited time and resources. The define stage is carried out to find out the existing conditions in the field, for that there are several analyzes carried out at this stage, namely front end analysis, learner analysis, concept analysis, task analysis and formulation of learning objectives (Qonita & Putra, 2023). The design stage was carried out to prepare a green chemistry-based chemistry practicum module framework integrated with Quranic verses on reaction rate material at SMA IT Darul Hikmah as well as validity and practicality test instruments. While the develop stage is carried out to test the validity and practicality of the products that researcher design.

This research was conducted at SMA IT Darul Hikmah Pasaman Barat by involving subjects consisting of class XI Akhwat students. The data used in this development research are qualitative data and quantitative data. Qualitative data obtained from the results of observations and interviews at SMA IT Darul Hikmah as well as suggestions and input from validators. While quantitative data is obtained from the results of validation by experts regarding the products developed and practicality data obtained from respondents through a practicality questionnaire on the products developed. Researcher used instruments in the form of product validation sheets and questionnaire instruments for the responses of educators and students to state whether the products developed were practical or not. After the validator fills in the validation sheet, the data obtained will be calculated and converted into a percentage. The percentage calculation is done using the following formula:

$$P = \frac{\sum Score\ per\ item}{Maximum\ score} \text{ x } 100\ \%$$

The results of the above formula are then defined using Table 1.

Table 1. Category of Validity of the product

Interval Score	Criteria
0-20	Not Valid
21-40	Less Valid
41-60	Fairly Valid
61-80	Valid
81-100	Highly Valid

(Source: Yusri & Husaini, 2017)

To determine the practicality of the product, the results of the educator and learner response questionnaires were analyzed using the formula :

$$P = \frac{\sum Score\ per\ item}{Maximum\ score} \text{ x } 100\ \%$$

The results of the above formula are then defined using Table 2.

Table 2. Category of Practicality of the product

Interval Score	Criteria
0-20	Not Practical
21-40	Less Practical
41-60	Fairly Valid Practical
61-80	Practical
81-100	Highly Practical

(Source: Yusri & Husaini, 2017)

3. Result and Discussion

Define Stage

The Define stage serves as the foundation for designing an effective and relevant chemistry practicum module at SMA IT Darul Hikmah. This stage is critical in identifying real challenges faced in the field and aligning the instructional design with actual learning needs. Through comprehensive analysis, this phase ensures that the development process is grounded in data and directly addresses gaps in the current educational setting. The Define stage encompasses five key components: front-end analysis, learner analysis, concept analysis, task analysis, and the formulation of learning objectives.

1. Front-End Analysis

This analysis begins with a series of structured interviews with chemistry educators at SMA IT Darul Hikmah. Findings reveal that while the school follows the Merdeka Curriculum, which encourages flexibility and student-centered learning, the practical implementation of hands-on activities is minimal. The root causes include the unavailability of standardized practicum modules and concerns over student safety when handling hazardous chemicals. Teachers often rely on practicum guides freely available online; however, these resources are generic, not contextualized to the students' characteristics, and often do not comply with proper safety procedures or the Merdeka Curriculum's principles. As a result, students miss critical experiential learning opportunities, which are essential for mastering chemistry concepts.

2. Learner Analysis

Interviews and informal assessments with students, particularly from Class XI Akhwat, indicate a diversity of learning preferences and cognitive abilities. A significant number of

students exhibit a kinesthetic learning style, meaning they learn best through physical activities and hands-on involvement rather than passive listening. While a few students show enthusiasm and a high level of motivation, many express feelings of boredom or even fatigue during traditional lecture-based sessions. This aligns with the findings of Supit et al. (2023), which suggest that kinesthetic learners thrive in learning environments that incorporate direct manipulation and physical engagement with learning materials. Thus, the absence of laboratory activities directly impacts student engagement and achievement.

3. Concept Analysis

The topic of reaction rate involves complex and abstract scientific concepts, such as the collision theory, factors affecting reaction rates, and activation energy. These concepts are often challenging for students to visualize and comprehend without the aid of demonstrations or hands-on experiments. Purely theoretical instruction tends to be less effective in facilitating meaningful understanding of such invisible phenomena. Without concrete experiences or simulations, students struggle to internalize these foundational chemical principles, leading to superficial comprehension and limited retention.

4. Task Analysis

Further examination of classroom activities and assessment methods reveals that students experience difficulties in applying theoretical knowledge to real-world contexts. The lack of structured, practical learning tasks contributes to this gap. Tasks that currently exist in the module or are given by teachers primarily focus on rote memorization or conceptual recall, with little emphasis on analysis, synthesis, or evaluation. Additionally, students rarely perform lab work that would help them connect theoretical content to observable chemical behavior. This limits their opportunity to develop essential scientific process skills such as hypothesizing, experimenting, observing, and interpreting data.

5. Learning Objective Formulation

Based on the insights gained from the above analyses, the formulation of learning objectives is directed at bridging the gap between theory and practice. Objectives are derived from the competency standards outlined in the Merdeka Curriculum, with a particular focus on the topic of reaction rates. The learning goals emphasize enhancing students' conceptual understanding and scientific thinking through the integration of contextual, hands-on experiments. Moreover, the module is designed to utilize safe and easily obtainable local materials, ensuring both feasibility and safety in classroom implementation. These objectives are expected to support the development of critical thinking, collaboration, and inquiry skills aligned with 21st-century learning demands.

Design Stage

The design stage is carried out after the define stage with the aim of designing a chemistry practicum module and research instruments in the form of validation sheets and practicality questionnaires. The chemistry practicum module was prepared using Canva and Microsoft Word applications. This module is based on green chemistry which is integrated with Al-Qur'an verses on reaction rate material. The design includes the selection of teaching materials, formats, and initial designs, and follows the main components of the practicum module referring to research which includes the title of the practicum, objectives, theoretical basis, tools, materials, experimental procedures, observation sheets, and discussion materials. The integration of green chemistry is applied in the selection of environmentally friendly materials and safe practicum procedures. This module also includes symbols of hazardous materials, laboratory equipment, rules of conduct, and the introduction of 8 of the 12 green

chemistry principles adopted in compiling the chemistry practicum module. The principles of green chemistry implemented in this module are preventing process waste, designing safe chemical products, designing safe synthesis processes, using renewable raw materials, using catalysts, using safe solvents, designing chemicals that are easily degraded and minimizing potential accidents. The design is adjusted to the learning outcomes of the Merdeka Curriculum to be in line with the demands of the curriculum. The material included in the designed practicum module is reaction rate material. In each material presented, it is integrated with verses from the Qur'an. How to integrate material with Quranic verses is shown in Table 3.

Table 3. How To Integrate The Material With Alqur'an

No	The materials	Verses or hadiths that are integrated	Method of Integration
1	Concept of reaction rate	Q.S. Al-A'raf : 34	Complementation
2	Collision theory	Q.S. Al-Furqan: 25	Comparison
3	Factors that affect the reaction rate		
	a. Concentration	Q.S. Ar-Rum : 41	Comparison
	b. Surface area	HR. At-Tirmidzi dan Abu Dawud	Comparison
	c. Temperature	H.R Muslim	Comparison
	d. Catalyst	Q.S. Ali Imran : 191	Complementation

Development Stage

The purpose of this development stage is to produce a green chemistry-based chemistry practicum module integrated with Qur'anic verses on valid and practical reaction rate material. The chemistry practicum module that has been designed is tested for validity and practicality. Before the validity test instrument is used, the instrument is validated first to see the validity of the statement items on the practicum module validation sheet. The validation aspects of the chemistry practicum module carried out by the validity test consisted of 3 aspects, namely: 1) material feasibility aspects, 2) media feasibility aspects, 3) integration feasibility aspects (Wardianingsih et al., 2024). The validity test of the practicum module was carried out by 4 (four) validators, namely two lecturers of UIN Mahmud Yunus Batusangkar, one chemistry lecturer at Padang State University and one chemistry educator at SMA IT Darul Hikmah. The results of the chemistry practicum module validity test can be seen in Table 4.

Table 4. Validity Test Result of Chemistry Practicum Module

No	Aspects validated	Total score	Max score	%	Description
1	Aspects of material feasibility	157	168	93%	Highly valid
2	Aspects of media feasibility	65	72	90%	Highly valid
3	Aspects of integration feasibility	46	56	82%	Highly valid
Average		268	296	91%	Highly valid

Based on Table 4, it can be said that in the validity test of the green chemistry-based chemistry practicum module integrated with Qur'anic verses on reaction rate material as a

whole obtained a percentage of 91% which was categorized as very valid. In the validation process, researchers also asked for suggestions from each validator.

The validity test of the material feasibility aspect shows a validity level of 93%, which is included in the very valid category. The practicum module has met the assessment indicators, such as the accuracy of the material, conformity with the principles of green chemistry, and its ability to stimulate analytical thinking. This module covers the main components of the practicum, including the introduction of hazardous material symbols, laboratory equipment, and 12 principles of green chemistry. The reaction rate material in the module is compiled in full with illustrations and quick tricks to facilitate students' understanding, and is equipped with evaluation questions to measure their understanding.

The validity test of the media feasibility aspect obtained a result of 90%, which included a very valid category. The practicum module has fulfilled the media feasibility indicators, such as completeness of components, concept conciseness, size, cover and content design, and display quality. This module is prepared with A4 paper format, Arial font size 12, and 1.5 spaces. According to (Salma, 2022) on the deepublish publisher's website, the module format with scientific publication standards uses A4 paper size, Times New Roman or Arial font with size 12, and space between paragraphs of 1.5, so it can be concluded that the chemistry practicum module is in accordance with scientific publication standards. The module design uses attractive colors according to the theme of green chemistry and is equipped with pictures and illustrations to facilitate students' understanding. This is in line with research (Augia, 2017) that the appearance of images on the material presented can facilitate students in understanding the learning material.

The validity test of the feasibility aspect of integration obtained a result of 82%, which included a very valid category. The practicum module has met the indicators of content and language quality, with the selection of Al-Qur'an verses that are in accordance with chemical material and the integration of Islamic values to improve the religious attitude of students. As explained in the research (Hadi et al., 2021) that integrating the Quran as a source of instilling positive values. In addition, the language used in the module has been adjusted to the rules of good and correct Indonesian to avoid misunderstandings in understanding the material.

Furthermore, the practicality stage aims to determine the level of practicality of the chemistry practicum module from the aspects of ease of use, language, time efficiency, graphics, and benefits. Practicality tests were carried out by educators and students. The following are the results of the analysis of the educator's response questionnaire in Table 5.

Table 5. Analysis of Educator Response Practicality Sheet Result

No	Practicality aspect	Total score	Max score	%	Description
1	Ease of use	14	16	88%	Highly practical
2	Language	11	12	92%	Highly practical
3	Time efficiency	4	4	100 %	Highly practical
4	Graphics	14	16	88 %	Highly practical
5	Benefits	18	20	90 %	Highly practical
Total		61	68	90%	Highly practical

The results of the analysis of the students' response questionnaire is shown in Table 6.

Table 6 Analysis of Student Response Practicality Sheet Result

No	Practicality aspect	Total score	Max score	%	Description
1	Ease of use	223	272	82%	Highly practical
2	Language	176	204	86%	Highly practical
3	Time efficiency	63	68	93%	Highly practical
4	Graphics	232	272	85%	Highly practical
5	Benefits	303	340	89%	Highly practical
Total		997	1156	86%	Highly practical

The results of the practicality test showed that the chemistry practicum module was included in the very practical category, with a response percentage of 90% from educators and 86% from students. This module is considered easy to use, easy to understand, and can be utilized independently at any time. These findings are supported by (D.A et al., 2022), who emphasized that a practical learning product should be usable by the target users with minimal external assistance. Furthermore, the language used in the module is clear, simple, and in accordance with the Indonesian Spelling Guidelines (PUEBI), which facilitates understanding.

According to (Makkadafi et al., 2017), good language and well-structured sentences that are easy to understand help deliver the intended concepts effectively to the readers. Clear instructional language is a key component in enhancing students' cognitive processing and reducing extraneous load (Dasuki et al., 2024), thus supporting the module's practicality. In terms of time efficiency, the practicum activities designed in the module are straightforward and can be completed within a relatively short duration. This approach aligns with the principles of efficient instructional design, which emphasize concise and targeted learning experiences without compromising conceptual understanding. By ensuring that the procedures are simple and not time-consuming, the module increases its usability in real classroom settings with limited time allocation.

This is in line with research (Sukardi, 2023) which says that simple practicum procedures allow practicum implementation to not take a long time, thereby increasing the efficiency of learning time. The graphical aspect is also considered attractive with a design that fits the theme of green chemistry and text that is easy to read. This is in line with research (Fatihah, 2023) which states that an attractive and relevant module design can increase students' interest in learning and plays an important role in the success of the learning process. In addition, this module is useful in increasing students' understanding, interest in learning, and linking chemistry material with relevant Al-Qur'an verses to strengthen Islamic values. This integration not only supports the cognitive aspect of learning but also the affective and spiritual domains, in line with holistic education goals.

Overall, this module meets the criteria of practicality which include ease of use, clarity of understanding, time efficiency, and accessibility for both educators and students. Beyond its immediate classroom application, the development of this module has potential long-term impacts on future chemistry education by promoting contextual, value-based learning that aligns with the demands of 21st-century education.

In the context of 21st-century skills, this module fosters independent learning, critical thinking through experimental activities, and value-based reasoning through its Qur'anic integration. The ability to relate scientific concepts to students' daily lives and belief systems contributes to meaningful learning. As chemistry education evolves, instructional materials

like this module can serve as models for integrating scientific literacy with character education, thus preparing students not only to master scientific knowledge but also to become responsible, ethical individuals.

The following is a visual representation of the developed product, designed based on the research objectives and development procedures.

Figure 1 Various Displays of The Developed Product

4. Conclusion

Based on the research findings and data analysis, it can be concluded that the development of a green chemistry-based chemistry practicum module integrated with Qur'anic verses on reaction rate material is both theoretically and practically feasible. The module demonstrated a very high level of validity and practicality, indicating that it is not only scientifically sound but also effective and user-friendly for both educators and students.\

These findings imply that incorporating Qur'anic integration and green chemistry principles in science education can enhance the relevance and values-based learning

experience, while also promoting sustainability and environmental awareness. The practicality shown by the module suggests its potential to be implemented more widely in Islamic schools or other educational institutions with similar orientations.

For future researchers, it is recommended to test the module in a broader scope, such as different regions, educational levels, or through long-term classroom implementation to evaluate its impact on students' cognitive and affective outcomes. Researchers can also explore the integration of other Islamic values in various chemistry topics, or further develop modules that combine science and character education to respond to the demands of 21st-century learning.

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