



Classroom Observation of Reaction Rate Teaching Using a Previously Developed Green Chemistry-Based Micromodule

Vika Puji Cahyani, Dewiyanti Fadly *

Departement of Chemistry Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Indonesia

*Email (corresponding author): dewiyanti.fadly@unm.ac.id

Abstract. *This descriptive observational study examined teaching practices during the reported classroom use of a previously developed green chemistry-based micromodule for reaction rates in an Advanced Basic Chemistry course. One non-participating observer assessed one lecturer and 24 students across two 100-minute sessions on April 13, 2026, using a single combined observation form. Of 17 detailed teaching indicators, 16 were marked positive and one negative (94.12% positive); eight separate overall judgments were positive. The negative detailed rating concerned visual aids such as slides or diagrams, whereas the broader instructional-media judgment was positive. Observer feedback noted clear explanations and practical activities and suggested improving time efficiency. The findings describe general instructional practices in the reported micromodule-use context, but the checklist did not document which micromodule sections were used or how students interacted with them. Accordingly, the percentage is not a measure of micromodule implementation fidelity or effectiveness. Green chemistry activities and environmental outcomes were not independently assessed. Further evidence linking observed activities to the existing resource is needed to evaluate its classroom implementation and potential relevance to SDG 4 and SDG 12.*

Keywords: Classroom Observation; Reaction Rate; Chemistry Teaching; Green Chemistry; Micromodule

1. Introduction

Developing learning materials requires an understanding of the teaching context in which they will be used (Amini Amini et al., 2023; Harwood, 2021; Sevia et al., 2018). Classroom observation can describe instructional practices, the use of media, and opportunities for student participation. It can therefore inform needs analysis before a new resource is designed (Al Husna et al., 2025; Asriani et al., 2026; Eradze et al., 2019; Rusman & Suardi, 2026). Observation findings should be interpreted within their actual scope rather than treated as a comprehensive measure of lecturer competence or student learning (Cohen & Goldhaber, 2016; Muijs et al., 2018).

Large-scale observational research in undergraduate STEM education shows that instructional practices can vary substantially within a course (Sbeglia et al., 2021; Stains et al., 2018). This finding supports documenting the number, duration, and context of observed sessions and cautions against generalizing from limited observations. The present study examines one lecturer teaching factors affecting reaction rate in an Advanced Basic Chemistry course. It uses a checklist summary and observer notes to identify aspects of teaching that may benefit from additional learning resources.

Reaction rate teaching links explanations of chemical processes with experimental conditions and observable changes. Supporting resources may help students connect these elements through explanations, visual representations, and carefully specified activities (Fernández et al., 2023; Herunata et al., 2024; Murni et al., 2022; Phajan et al., 2025; Supasorn et al., 2022). Project-based chemistry work also requires preparation for independent investigation (Chu et al., 2023; Love et al., 2024; Perna et al., 2025). Gouger & Mirowsky (2022) organized an undergraduate analytical chemistry project through laboratory-skills preparation followed by application to a research task. Such an approach offers a design consideration rather than evidence that a particular resource is needed in the classroom examined here.

Green chemistry provides a possible context for connecting chemistry activities with environmentally informed decisions. Liu et al. (2023) integrated green chemistry into a project involving electrochemistry and organic synthesis. Y. Liu (2022) investigated students' perceptions and research-skills self-efficacy in a green chemistry laboratory module. These studies illustrate how green chemistry can be embedded in activities and evaluated through defined outcomes. They do not establish the effectiveness of the proposed micromodule in this study.

The objective of this study was to describe the implementation of observed reaction rate teaching and identify preliminary priorities for developing a supporting micromodule. The contribution is a context-specific needs analysis, rather than a test of a developed product. The supplied summary identifies instructional media as an area for improvement, but it also contains inconsistent indicator totals that require reconciliation before the implementation percentage can be finalized.

2. Methods

2.1. Design and teaching Context

A descriptive classroom-observation design was used to examine reaction-rate instruction in which the lecturer was reported to use an already developed green chemistry-based micromodule. The lecturer was purposively selected as the instructor of the course. The available evidence comprised one completed observation instrument documented in three photographs, containing 17 detailed teaching ratings, eight separate general judgments, and handwritten feedback. A single non-participating observer completed one combined form covering two sessions. The existence and classroom use of the micromodule are reported study-context information; the instrument itself did not identify specific pages, tasks, or moments of micromodule use. Consequently, the analysis does not treat general teaching ratings as direct measures of micromodule implementation.

The study took place in the Chemistry Education Study Program at Universitas Negeri Makassar, Indonesia, with 24 students in the observed classes. Two regularly scheduled sessions were observed on April 13, 2026, each lasting 100 minutes. The observer documented teaching without participating. Because the single form summarized both sessions, 16 of 17 detailed indicators were marked positively (94.12%) across the combined observation record. This percentage is not a session-specific rate or a measure of consistency between sessions; behavior present in one session cannot be distinguished from behavior present in both.

2.2. Observation Instrument

The detailed checklist comprised 17 indicators across eight aspects: material delivery (three indicators), instructional media (two), interaction and questions (two), assignments and assessment (two), summarizing the material (two), teaching methods and innovation (two), classroom management (two), and personal skills (two). The media section included both visual-aid use and student involvement; its label therefore does not represent visual media alone. The printed rating column displayed the available check/cross options, while actual detailed ratings were handwritten in the notes column. These handwritten marks were used for transcription.

The instrument also contained eight general judgments under the final lecturer assessment. These addressed material delivery, instructional media, responsiveness to student questions, assignments and assessment, summarizing, varied teaching methods, classroom and time management, and enthusiasm and personal skills. They were recorded separately from the 17 detailed items. The final numerical field labeled total assessment out of 100 was blank; therefore, no observer-assigned numerical score was available.

The observation instrument was developed by the researchers to document the implementation of teaching on factors affecting reaction rate. It comprised 17 detailed indicators across eight instructional aspects and eight separate general judgments. For the detailed indicators, a check mark (✓) indicated that the observer judged the criterion to be fulfilled during the observed lesson, whereas a cross (×) indicated that the criterion was not fulfilled. Ratings were based on the behavior described in each item. The observation was conducted by one observer; therefore, no procedure for resolving disagreements between observers was required, and inter-rater reliability was not assessed. No formal instrument validation or documented observer-training procedure was conducted. These limitations were considered when interpreting the findings. In the completed form, handwritten marks in the “Catatan” column were interpreted as the actual detailed-item ratings, while the printed check/cross symbols in the “Penilaian” column represented the available response options. The transcription identified 16 check marks and one cross. The eight general judgments were recorded separately and were not included in the detailed-item implementation percentage. A reconstructed English transcription of the 17 reported detailed ratings and eight general judgments is supplied as Supplementary Material S1; it is not a facsimile of the original handwritten form. The original photographs should be supplied by the authors for independent verification. The available record does not document how the researchers initially generated, piloted, or checked the indicators for content relevance; no expert review or content-validity index can therefore be claimed. The instrument covers observable general teaching behaviors but does not directly measure reaction-rate understanding or green chemistry practice.

2.3. Analysis

Detailed-item implementation was calculated as $P = (\text{number of positive detailed marks} / \text{total detailed indicators}) \times 100\%$. The photographs contained 16 positive marks and one negative mark across 17 items, giving $P = (16/17) \times 100\% = 94.12\%$. Aspect-level percentages were calculated from the detailed items within each aspect. The eight general judgments were summarized separately and were not added to the detailed-item numerator

or denominator. The calculated percentage is a descriptive count of checklist marks, not the blank observer-assigned score out of 100.

No percentage-based quality category was printed on the photographed instrument. Therefore, the article reports frequencies and percentages without labeling the lecturer's performance "very good." A binary check records an observer judgment about a criterion and does not establish the quality, duration, or frequency of an instructional behavior beyond that criterion.

Handwritten feedback was summarized descriptively under the form's three fields: teaching strengths, areas for improvement, and suggestions for future teaching. The main legible points were paraphrased rather than quoted verbatim because parts of the handwriting were difficult to read. No theme frequencies, formal thematic saturation, independent coding assessment, or inter-rater reliability estimate are reported. The marginal media note was treated cautiously because its complete wording was not fully legible. The interpretations of clear explanations, practical activity, and time efficiency are paraphrases of the legible portions; the exact wording and intended meaning of the marginal media annotation remain uncertain. No direct quotations are attributed to the observer.

3. Results and Discussion

3.1. Implementation Of Detailed Indicators

Table 1 presents the detailed indicator counts transcribed from the completed instrument. Seven aspects had positive marks for all their detailed indicators. In the instructional-media aspect, visual-aid use was marked negatively and student involvement was marked positively. Overall, 16 of 17 indicators were positive (94.12%).

Table 1. Detailed checklist ratings transcribed from the completed instrument

Observation aspect	Items	Yes	No	Yes (%)
Material delivery	3	3	0	100.00
Instructional media	2	1	1	50.00
Interaction and questions	2	2	0	100.00
Assignments and assessment	2	2	0	100.00
Summarizing the material	2	2	0	100.00
Teaching methods and innovation	2	2	0	100.00
Classroom management	2	2	0	100.00
Personal skills	2	2	0	100.00
Total detailed indicators	17	16	1	94.12

Note. Yes = positive handwritten check; No = negative handwritten cross. The percentage is calculated from the 17 detailed indicators and is not an observer-entered score out of 100. The eight final general judgments are reported separately.

All eight end-of-form general judgments were positive (8/8), including the broad judgment concerning instructional media. This is not inconsistent with the negative detailed rating for visual aids: the general judgment captures a wider appraisal, whereas the detailed item specifically asks about slides or diagrams. The media aspect also includes a positively rated student-involvement item. Neither rating should be changed to force agreement, and the findings do not indicate that all instructional media were absent.

The single negative detailed item asked whether the lecturer used visual media such as slides or diagrams to support understanding. It does not mean that no instructional media or practical equipment was used. Positive detailed ratings for student involvement, teaching methods, and innovation, together with the handwritten comments about practical activity, provide context for this distinction.

3.2. Observer Notes And Instructional Priorities

In the teaching-strengths field, the observer described explanations of factors affecting reaction rate as clear and referred to practical activity, student interest, and student understanding. These are observer impressions, rather than independently measured comprehension or achievement. No student learning test was provided.

The explicit improvement field stated that instructional time could be made more efficient. This feedback can coexist with a positive detailed time-management rating; an overall criterion may be marked positively while the observer identifies room for refinement. It should not be recoded as an additional negative checklist item.

The future-teaching suggestion recommended practical methods with continued use of simple equipment. The observer noted that practical activity may take more time but can be more memorable for students. This is the observer's interpretation; retention was not measured. The marginal note on instructional media requires confirmation before direct quotation because its complete wording is not fully legible.

Table 2 connects the documented observation with proposed resource-design responses. The responses are implications for development, not tested outcomes. They address visual support, efficient sequencing of practical activities, and appropriate use of simple equipment.

Table 2. Observation evidence and proposed development responses

Supplied evidence	Interpretation within scope	Aspect of existing micromodule to verify (not observed)
Clear explanation and practical activity described positively.	Observer impression; student achievement was not tested.	Check whether the existing module includes collision-theory explanations and whether the lecturer used them.
Visual-aid item negative; overall media judgment positive.	Specific visual support can need improvement within a favorable general assessment.	Check whether module diagrams address concentration and temperature effects and were referred to in class.
Feedback requests time efficiency and practical methods with simple equipment.	Refinement is recommended; neither time savings nor retention was measured.	Check whether module-guided practical work addresses controlled variables, data recording, safe quantities, and waste handling.

3.3. Interpreting the Use of the Previously Developed Micromodule

The purpose of this study is to characterize reaction-rate teaching in the context of a previously developed green chemistry-based micromodule, rather than to establish a need for

a new micromodule. Positive ratings for explanations, interaction, and teaching methods indicate favorable observer judgments of general teaching behaviors. They do not demonstrate that the lecturer used particular micromodule diagrams, worksheets, or practical instructions. Establishing the extent of implementation would require linking specific observed lecturer and student actions to identified sections of the existing resource. Table 2 therefore offers an evidence-to-resource checking framework rather than claims of implementation fidelity.

The green chemistry orientation of the existing micromodule should be described from the actual resource rather than inferred from its title. For reaction-rate learning, relevant features to verify include small-scale experimental quantities, comparatively safer materials, waste-minimization instructions, and their relationship to concentration, temperature, surface area, or catalysts. None of these features was independently documented by the present general teaching checklist. Thus, the study cannot conclude that green chemistry practices or environmental benefits occurred during the observed lessons (Liu et al., 2023; Supasorn et al., 2022).

Future documentation should identify the micromodule version used, its learning objectives and actual content, and the sequence in which the lecturer and students consulted it. Lesson plans, annotated field notes, and observation items focused on resource use would help distinguish availability, actual use, and quality of implementation. Separate student assessments and environmental measures would be required to examine learning gains or waste reduction; neither was measured here (Liu, 2022).

3.4. Limitations

The study involved one lecturer, 24 students, and two 100-minute sessions on April 13, 2026, documented by one observer in a single combined instrument. Consequently, the data cannot identify differences between sessions, whether each behavior occurred in both sessions, or the frequency or duration of individual behaviors. The observer's characteristics and training were not documented in detail; formal instrument validation, inter-rater reliability, and independent coding were not undertaken. Handwritten feedback was partly difficult to read and was cautiously paraphrased. The findings should not be generalized to other lecturers or courses. Repeated, separately scored observations would improve evidence about instructional variability (Sbeglia et al., 2021; Stains et al., 2018). The checklist's item-construction process and content-relevance checks were not documented; consequently, the 94.12% figure should be interpreted only as a descriptive proportion of this observer's marks, not as a validated estimate of teaching quality. The reconstructed supplement cannot replace examination of the original handwritten evidence.

The checklist measured general teaching behaviors, not specific micromodule-use events, and the resource file was not available for comparison with the observation record. Accordingly, the reported use of the developed micromodule remains contextual information rather than independently verified evidence of particular features or implementation fidelity. Supporting records, including the actual micromodule, lesson plan, and field notes identifying its use, are needed to strengthen this interpretation. No learning or environmental outcomes were measured.

Conclusions

This study described classroom teaching practices in two reaction-rate sessions in which a previously developed green chemistry-based micromodule was reported to be used. The combined observation record contained 16 positive ratings among 17 detailed teaching indicators (94.12%) and eight separate positive general judgments. The sole negative detailed item concerned visual aids such as slides or diagrams and does not establish that all media or the micromodule were absent. Observer notes identified opportunities to improve time efficiency while retaining practical work. Because the checklist was not designed to track use of specific micromodule components, the findings should be interpreted as descriptive evidence about teaching practices in the reported implementation context, not as proof of micromodule fidelity, effectiveness, learning gains, or green chemistry outcomes. Direct documentation of resource use is required for stronger implementation claims.

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