Lantanida Journal, 14(2): 248-269 e-ISSN: 2548-9062 p-ISSN: 2356-3133

IMPLEMENTATION OF PEER ASSESSMENT STRATEGY IN STOICHIOMETRY FORMATIVE TESTING TO ENHANCE STUDENT FEEDBACK IN SENIOR HIGH SCHOOL CHEMISTRY LEARNING

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Article History: *Received: June 9, 2026* *Revised: August 3, 2026*
Accepted: August 7, 2026 *Published: December 30, 2026*

DOI: https://doi.org/10.22373/lj.v14i2.35498

ABSTRACT

The purpose of this study was to provide feedback to students with the use of blue-red instruction sheets and peer assessment on formative tests, improve their understanding and learning process, and evaluate the implementation of peer assessment as an effective and innovative formative assessment method. This descriptive study involved grade XII senior high school students, with 82 students participating in the test readability stage and 33 students in the peer assessment implementation stage. The readability results for test packages A and B indicated that the content aspect was categorized as good (70.00%–72.00%), while the presentation, structural, and language aspects were categorized as very good (80.00%–86.00%). Furthermore, 96% of the students agreed that peer assessment could be used to provide feedback in formative assessment. Students' peer assessment ability was classified as very good (36%), good (33%), and adequate (30%). The implementation of peer assessment across six stages was rated very good, with percentages ranging from 89.60%-100.00%. Nevertheless, limited student motivation and insufficient training were identified as factors that reduced the optimal implementation of peer assessment.

Keywords: Feedback, peer assessment, stoichiometry

INTRODUCTION

Assessment plays an important role in education because it is a fundamental component of the learning process, as it determines the quality of students' learning outcomes and must be based on learning objectives while remaining fair and accurate (Ashari et al., 2023; French et al., 2024). Assessment in learning does not only function as a tool to measure learning achievement, but also serves as a basis for evaluating the learning process and the development of educational institutions (Darwin et al., 2023; Malakiano et al., 2026; Gusmaningsih et al., 2023; Karepesina & Tinenti, 2025; Elida & Oktadela, 2025; Nur et al., 2025). The achievement

of learning objectives and the identification of students' learning needs depend heavily on appropriate assessment, making it a strategic element in measuring students' competency achievement (Kristina et al., 2024; Muktamar et al., 2023; Sunaryati & Laelly, 2024).

Assessment is categorized into three types based on its function: assessment as learning, assessment for learning, and assessment of learning (Nur Budiono & Hatip, 2023); Karepesina & Tinenti, 2025). One form of assessment that is oriented toward improving the learning process is assessment for learning, as it emphasizes continuous (formative) assessment and is integrated with the instructional process (Thawabieh, 2017; Astagisa, 2025; Heil & Ifenthaler, 2023). Formative assessment plays an important role in monitoring students' learning progress and providing continuous feedback to help them improve their understanding (Azizah et al., 2020; Kristina et al., 2024; Malakiano et al., 2026; Nurhaibi, 2025; Astagisa, 2025; Hopfenbeck et al., 2023; Elida & Oktadela, 2025; Ramdhani et al., 2024). In addition, formative assessment can assist educators in adjusting the learning process based on students' abilities, and it is considered an effective strategy for improving knowledge and skills (Ariestiara et al., 2025; Sari et al., 2025).

However, in practice, assessment implementation in the field shows that formative assessment and the provision of feedback to students have not been carried out optimally. Assessment results are often not followed up with adequate feedback, so information regarding students' abilities cannot be obtained and utilized effectively (Sari & Setiawaty, 2018). Limited instructional time and the lack of systematic follow-up also cause the feedback provided to students to be brief and less effective in helping them understand the learning concepts that have been taught (Siswaningsih et al., 2013; Komara et al., 2024; Samad et al., 2025).

One alternative form of assessment that can address these issues is peer assessment. Peer assessment is a form of collaborative and cooperative learning aimed at developing knowledge and skills based on predetermined criteria through active participation among students (Topping, 2023; Bhardwaj et al., 2025; Alqassab et al., 2023). It is a type of formative assessment that directly involves students in evaluating their peers' performance based on established criteria (Saptono et al., 2013; Wulandari et al., 2020; Tsai & Piamsai, 2025; Zhan et al., 2023; Topping et al., 2025). Through peer assessment, students not only receive feedback but also learn to provide evaluations objectively and responsibly, which can enhance their active engagement in the learning process (Nahadi et al., 2017; Tsai & Piamsai, 2025; Laxman Bahiram, 2026; Berrezueta-Guzman et al., 2025; Sunaryati & Laelly, 2024). In addition,

feedback from peers can effectively help students improve and enhance their learning outcomes (Nurhayatin, 2022; Lestari et al., 2020; Damanik, 2022).

In chemistry learning, particularly in stoichiometry, conceptual understanding is a crucial aspect; however, it remains difficult for students to achieve. Stoichiometry requires both conceptual understanding and mathematical skills simultaneously, making it a topic that often leads to difficulties and misconceptions among students (Ahmad, 2022; Qorinallah et al., 2025). Therefore, an effective formative assessment strategy is needed, such as peer assessment, which provides feedback to help students improve their conceptual understanding in stoichiometry.

Based on the problems outlined above, this study aimed to describe the implementation of peer assessment in formative stoichiometry assessment by (1) evaluating the readability of formative test items developed for peer assessment, (2) describing the outcomes of peer assessment in providing formative feedback, (3) examining students' ability to apply peer assessment procedures using structured assessment guidelines, and (4) identifying the implementation challenges encountered during each stage of peer assessment.

METHODS

This study employed a quantitative descriptive research design to describe the implementation of peer assessment in formative stoichiometry assessment. The participants were Grade XII students from SMA IT Plus BBS and SMA Kosgoro, Bogor, West Java. The study was conducted in two consecutive stages. The first stage involved a readability test of the formative stoichiometry assessment instrument with 82 students to evaluate the quality of the test items before implementation. The second stage involved the implementation of peer assessment with 33 students following the six-stage procedure proposed by Siswaningsih et al. (2013), consisting of student motivation, peer assessment training, administration of the formative test using feedback guidelines, peer assessment implementation, communication of feedback results, and utilization of feedback. Data were collected using readability questionnaires, student response questionnaires, peer assessment sheets, and formative test instruments. Readability data were analyzed using the readability percentage formula (PK) (Sarip et al., 2022) and interpreted according to the criteria of Millah et al. (2012). Student responses regarding peer assessment implementation and implementation challenges were analyzed using the percentage score formula (NP) and interpreted based on Ja'far et al. (2014). Students' peer assessment ability was determined by comparing students' assessment scores with the researcher's scores, and the level of agreement was analyzed using the percentage score

formula (NP) and interpreted according to Purwanto (2012). All results were presented descriptively using percentages and bar charts to facilitate data interpretation. The research flow is shown in Figure 1 below.

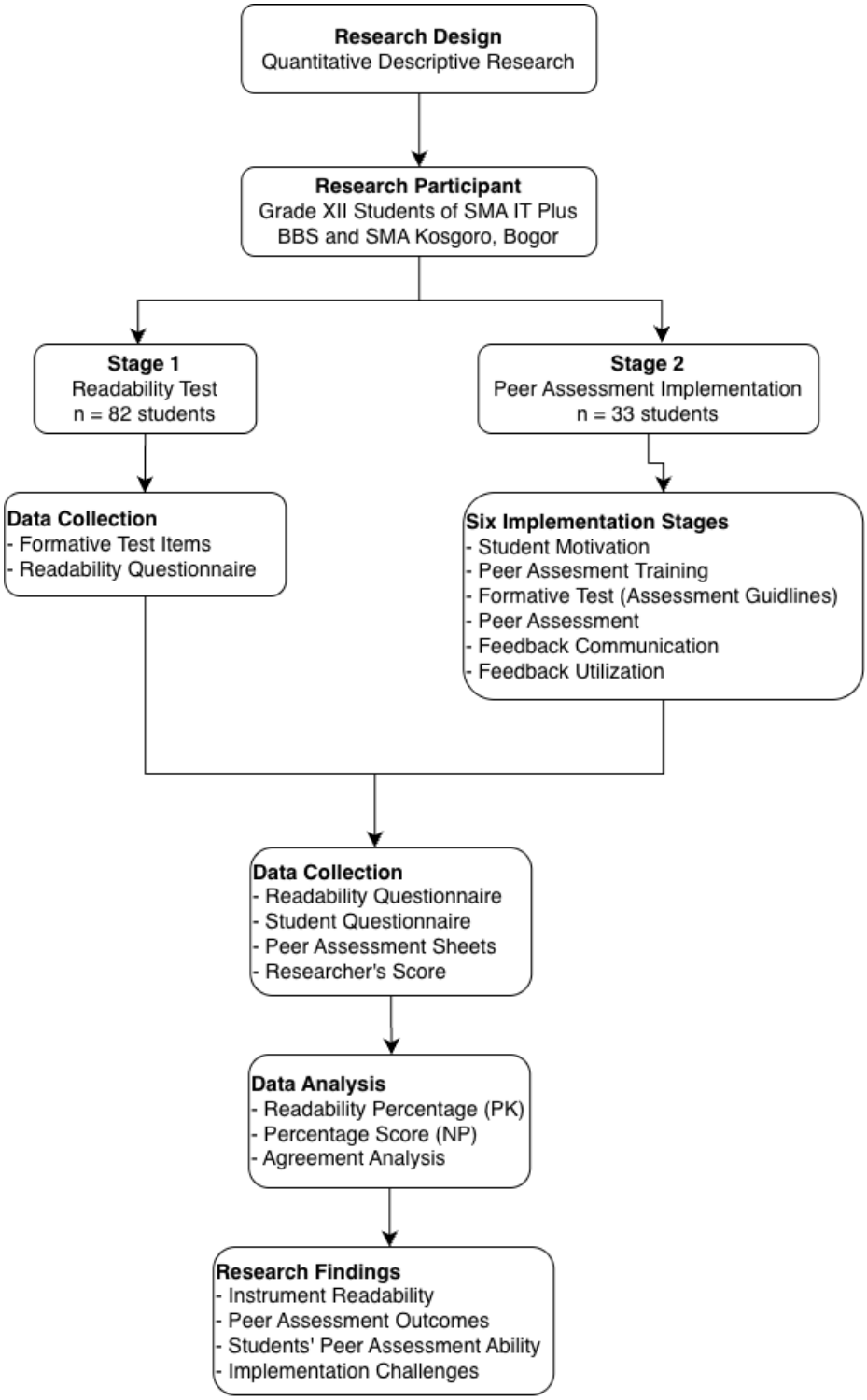


Figure 1. Research Flowchart

RESULTS AND DISCUSSION

Readability of Formative Stoichiometry Test Items in the Implementation of Peer Assessment for Student Feedback

The formative test items used in this study were developed and previously validated in a study conducted by Ahmad Nafran in 2024. In the prior study, validation was carried out through expert judgment involving three university lecturers in the fields of education and chemistry, as well as two chemistry teachers. In addition, the test items were also validated with students to examine their validity and reliability. The results indicated that formative test packages A and B were content-valid and reliable, with Cronbach's Alpha values of 0.79 and 0.82, respectively, both categorized as high.

The test product evaluated for readability consisted of two test packages, namely Package A and Package B, each comprising 20 limited-response (restricted essay) items. The two test packages were evenly distributed across three research classes—12-1, 12-2, and 12-3—where half of the students in each class completed Package A and the other half completed Package B. The total number of students who worked on Package A across the three classes was 41, and similarly, 41 students worked on Package B.

The distribution of the test packages in each class aimed to obtain heterogeneous results in the readability test. The aspects that students were required to consider in evaluating readability consisted of four dimensions: content, presentation, structure, and language. The following section presents the data from the readability test results of formative test Packages A and B.

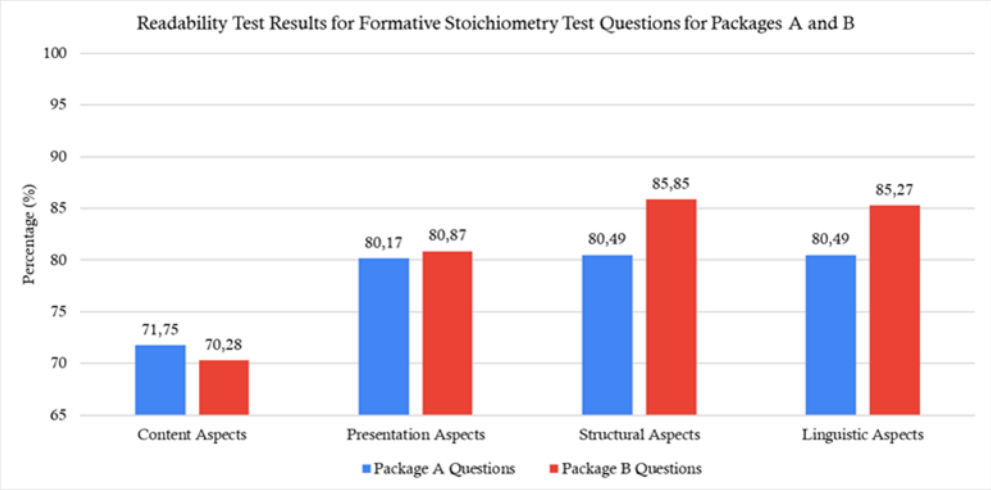


Figure 2. Percentage Results of Readability of Package A and B Formative Test Questions

Based on Figure 2, the readability test results for test packages A and B in the content aspect fall into the good category, according to Millah et al. (2012), with a percentage range of

70.00%–72.00%. Meanwhile, the other three readability aspects—presentation, structure, and language—in both test packages A and B are categorized as very good, with a percentage range of 80.00%–86.00%. These results indicate that the test product can be used in the peer assessment implementation stage for formative tests on stoichiometry, as it meets the criteria of practicality. Apart from fulfilling practical criteria, according to Arikunto (2013), high-quality test items must meet the criteria of validity, reliability, objectivity, practicality (readability), and economy. A test product is considered good if it fulfills the criteria of being valid and practical. This is consistent with Iskandar and Rizal (2018), as cited in Surya et al. (2023), who state that test instruments must meet the requirements of validity and reliability. After it was established that the test product met the criteria of validity and reliability, a readability test was conducted to determine the level of readability of the test instrument. An instrument with a good level of readability can influence readers by increasing their interest in learning. In addition, a test product is considered practical and of good quality if it aligns with students' thought processes, presents clear contextual problems, and is easy to read and understand by the readers or students (Azzahra et al., 2023).

Results of the Implementation of Peer Assessment for Student Feedback in the Formative Test on Stoichiometry

Peer assessment in formative tests is used as a form of feedback for students, aiming to help them identify and understand the strengths and weaknesses of their learning outcomes. The following section presents the results of the implementation of peer assessment in formative tests as feedback for students.

The results shown in Figure 3 indicate that more than 93% of students were satisfied and agreed that the implementation of peer assessment in formative tests on stoichiometry can be used as feedback for students, as they gained benefits in the form of feedback from peer assessment. Peer assessment requires students to provide feedback and assign scores to their peers' work or performance based on predetermined criteria. The use of feedback represents a learning process that involves students in receiving input, enabling them to critically evaluate both their peers' opinions and their own, as well as to correct misunderstandings (Sofyatiningrum et al., 2019; Nilimaa, 2023; Hendraswari et al., 2023; Pinargote-Ortega et al., 2023). The feedback obtained helps students understand both their peers' abilities and their own in solving formative test questions, which can be used as a form of self-reflection to improve cognitive understanding and the learning process. This is consistent with Wijayanti (2022), who

states that peer assessment can be used to measure students' abilities as well as their peers' abilities in the aspects of attitudes, knowledge, and skills. This is because peer assessment not only helps develop students' knowledge and skills competencies but also contributes to the formation of positive character traits.

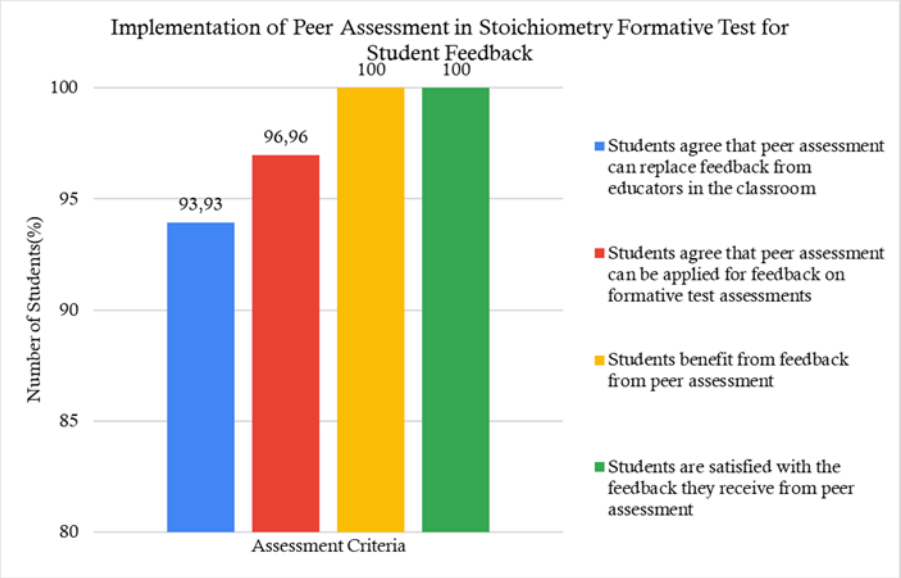


Figure 3. Results of the Peer Assessment Implementation Questionnaire in Formative Tests for Student Feedback

Students' Ability to Apply Peer Assessment in the Formative Stoichiometry Test with Instructions for Feedback

Students' ability to apply peer assessment reflects their capacity to conduct evaluations. The better students are at performing assessments, the better their ability to carry out peer assessment will be. The tendency between students' assessments and the researcher's assessment is illustrated in Figure 4.

The results indicate three types of assessment tendencies between students and the researcher: student assessments that are equal to, higher than, and lower than the researcher's assessments. According to Purwanto (2012), students' ability to conduct peer assessment is classified into five categories: "very good," "good," "enough," "less," and "very less." The following section presents the results of students' ability categories in conducting peer assessment, as shown in Figure 5.

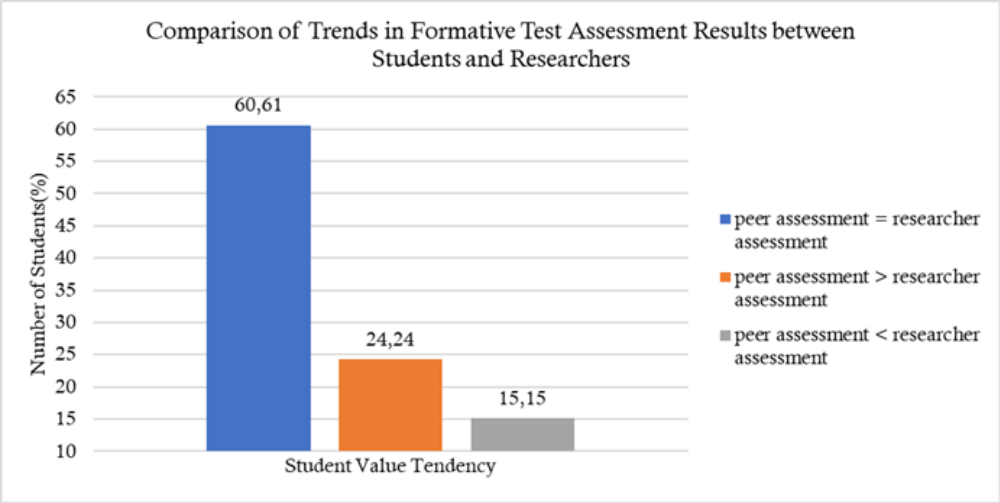


Figure 4. Percentage Results of Assessment Tendencies between Students and Researchers

Three categories of students' ability in applying peer assessment were identified, namely very good, good, and enough. According to Siswaningsih et al. (2013), students' ability to implement peer assessment can be determined by comparing the assessment results given by peers with those provided by the researcher. The differences in students' abilities in implementing peer assessment are influenced by several factors, including students' lack of carefulness in comparing test answers with the scoring rubric. In addition, some students have difficulty understanding the assessment or scoring rubric, which leads to uncertainty and a lack of confidence when evaluating their peers' work. As a result, students may worry about assigning scores that are either too high or too low to their peers' test results (Siswaningsih et al., 2013).

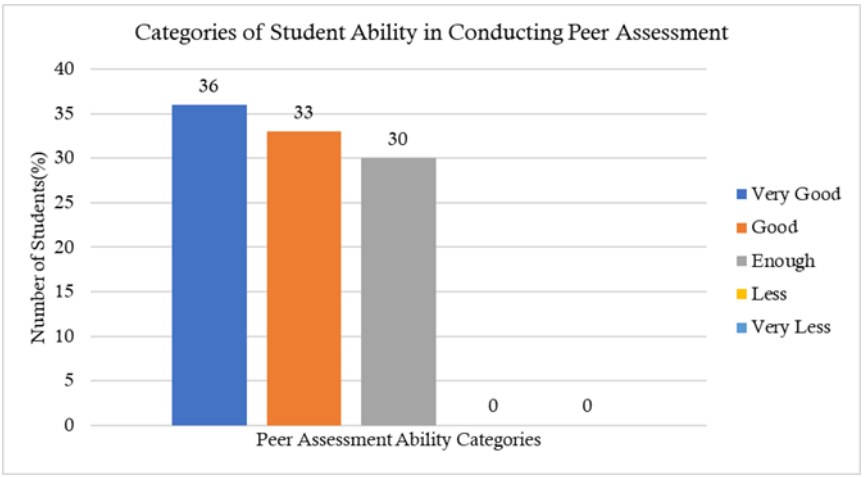


Figure 5. Percentage Results of Student Ability Categories in Implementing Peer Assessment

Implementation and Challenges Faced by Students at Each Stage of Peer Assessment in the Formative Stoichiometry Test

The implementation of peer assessment was carried out in a gradual and systematic manner to ensure that students understood the concepts and procedures and were able to conduct peer assessment objectively. The implementation followed six main stages based on Siswaningsih et al. (2020): the student motivation stage, the peer assessment training stage, the administration of the formative test with guidelines, the implementation of peer assessment, the communication of results, and the utilization of the results.

Student Motivation Stage

This stage represents the initial phase of the peer assessment implementation, in which students are provided with an explanation or introduction to peer assessment, including its definition, objectives, benefits, advantages and disadvantages, as well as its comparison with other forms of assessment. The purpose of this stage is to ensure the effective implementation of peer assessment, as stated by Rintoko and Rochmiyati (2018), who explain that the first step in implementing peer assessment is to communicate its purpose and objectives to students.

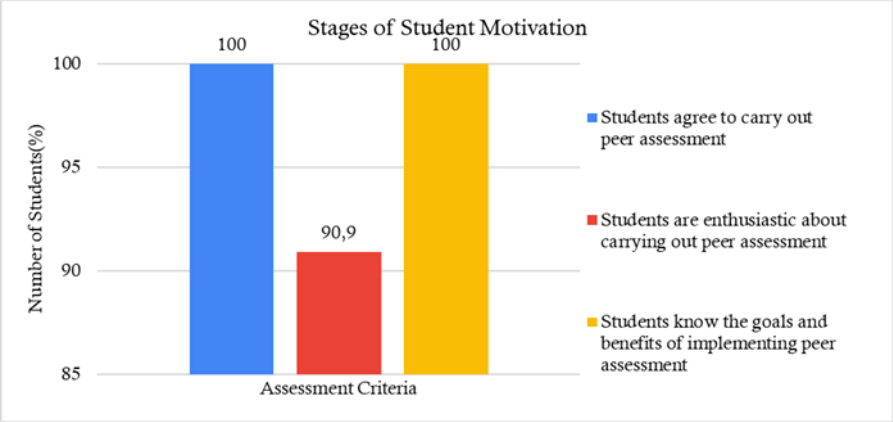


Figure 6. Results of Student Questionnaire at the Motivation Stage

Figure 6 shows that the overall percentage for each assessment criterion in the student motivation stage is 96%, which falls into the very good category according to Ja'far et al. (2014). This indicates that students agreed with, were enthusiastic about, and understood the objectives and benefits of implementing peer assessment. However, a challenge encountered at this stage was that some students were less enthusiastic and did not fully pay attention to the explanations provided.

Peer Assessment Training

At this stage, students were provided with information regarding the procedures to be followed during peer assessment, the criteria used for evaluating the formative test, and the scoring methods through a simulation activity. The peer assessment training stage needs to be properly conducted so that the assessment results obtained are accurate and objective. Students carried out a simulation of completing the test, followed by conducting peer assessment on their peers' responses in accordance with the established procedures and assessment criteria outlined in the peer assessment instrument sheet.

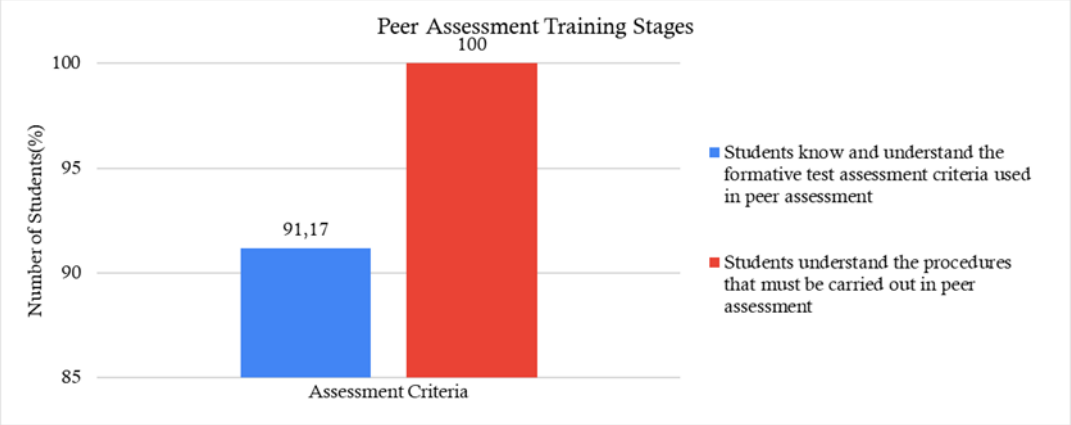


Figure 7. Results of Student Questionnaire at the Peer Assessment Training Stage

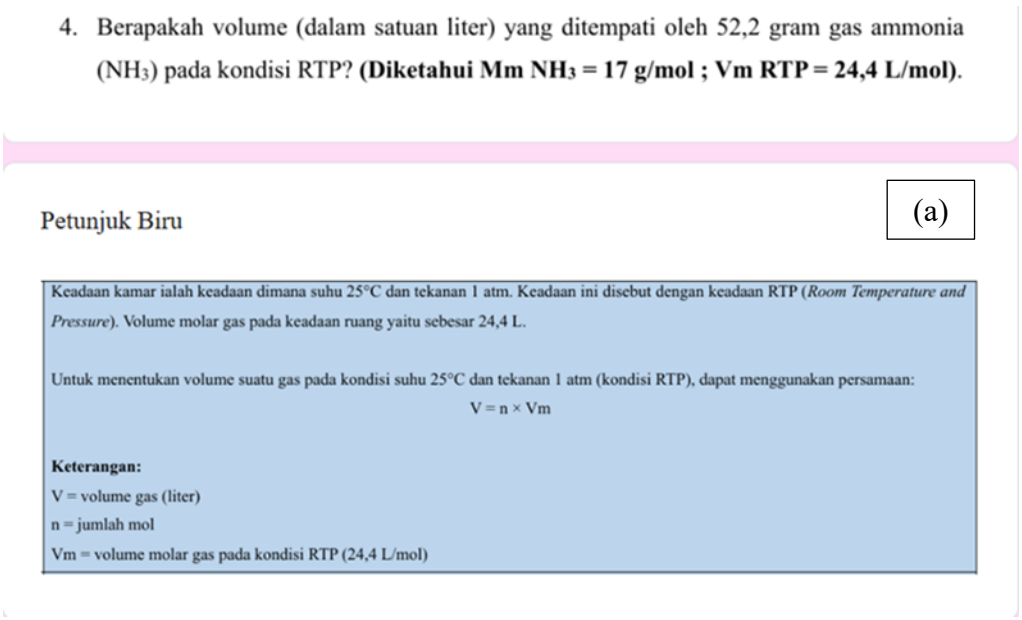
Based on the results shown in Figure 7, the overall percentage for each assessment criterion in the peer assessment training stage is 95%, which falls into the very good category according to Ja'far et al. (2014). This indicates that students understood the procedures and assessment criteria of the formative test in the peer assessment to be conducted. The purpose of this stage is to provide students with initial hands-on experience in conducting peer assessment, so that during its actual implementation they are able to perform assessments properly and accurately.

Alzaid (2017), as cited in Adawiyah (2022), also states that there are two important aspects in implementing peer assessment: training students' peer assessment skills and comparing students' assessments with those of the teacher. A challenge encountered at this stage was that some students did not participate in the assessment simulation due to their mobile phone batteries running out, so they only observed the simulation conducted by their peers.

Implementation of the Formative Stoichiometry Test with Blue and Red Instructions for Student Feedback

At this stage, students completed a formative test on stoichiometry consisting of 20 limited-response (restricted essay) questions, divided into two test packages, A and B. The formative test items were accompanied by blue and red guidelines for providing feedback to students on each question, as illustrated in Figure 8.

The blue and red guidelines contain instructions or steps for solving the questions. The blue guidelines provide general feedback in the form of hints or procedural steps, while the red guidelines offer feedback in the form of ideal answers to the given questions. Students may choose to complete the questions without using the guideline sheets; however, the blue and red guidelines can be utilized when students encounter difficulties in answering the questions. The use of the guideline sheets should begin with the blue guidelines before proceeding to the red ones.



4. Berapakah volume (dalam satuan liter) yang ditempati oleh 52,2 gram gas ammonia (NH_3) pada kondisi RTP? **(Diketahui Mm NH_3 = 17 g/mol ; Vm RTP = 24,4 L/mol)**.

Petunjuk Biru

(a)

Keadaan kamar ialah keadaan dimana suhu 25°C dan tekanan 1 atm. Keadaan ini disebut dengan keadaan RTP (*Room Temperature and Pressure*). Volume molar gas pada keadaan ruang yaitu sebesar 24,4 L.

Untuk menentukan volume suatu gas pada kondisi suhu 25°C dan tekanan 1 atm (kondisi RTP), dapat menggunakan persamaan:

$$V = n \times Vm$$

Keterangan:

V = volume gas (liter)

n = jumlah mol

Vm = volume molar gas pada kondisi RTP (24,4 L/mol)

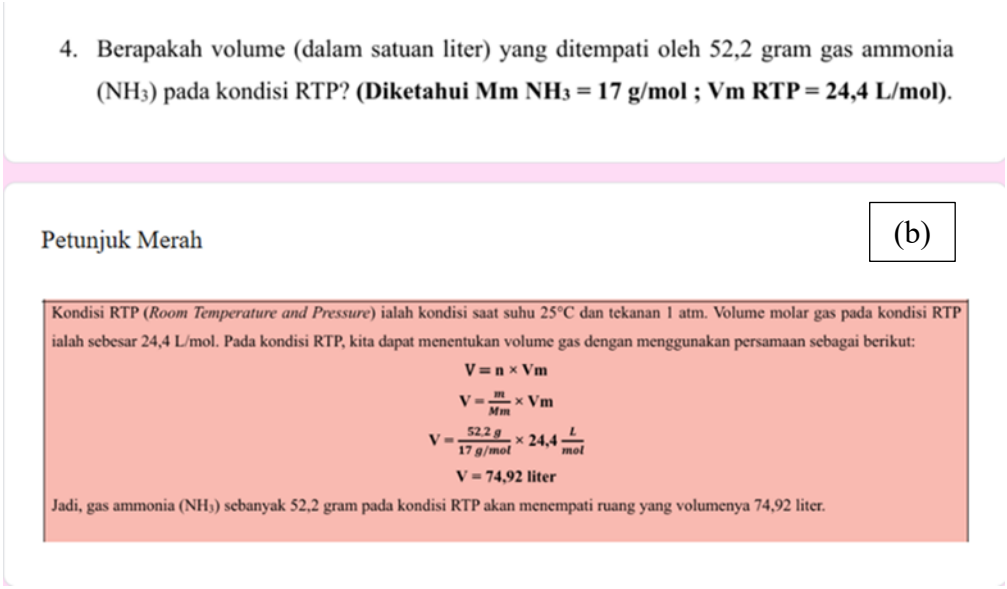


Figure 8. Blue (a) and Red (b) Instruction Sheets on the Stoichiometry Formative Test

Students' identities were also written using codes that had been previously confirmed with each student. This was intended to anticipate one of the weaknesses of peer assessment, namely the potential for conflicts among students that may affect their cooperation and performance (Adawiyah, 2022; Nilimaa, 2023).

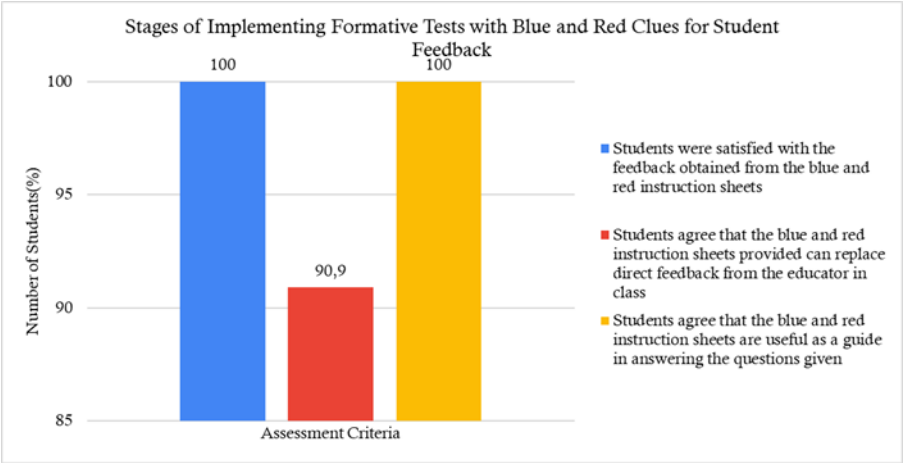


Figure 9. Results of Student Questionnaires at the Formative Test Implementation Stage with Instructions

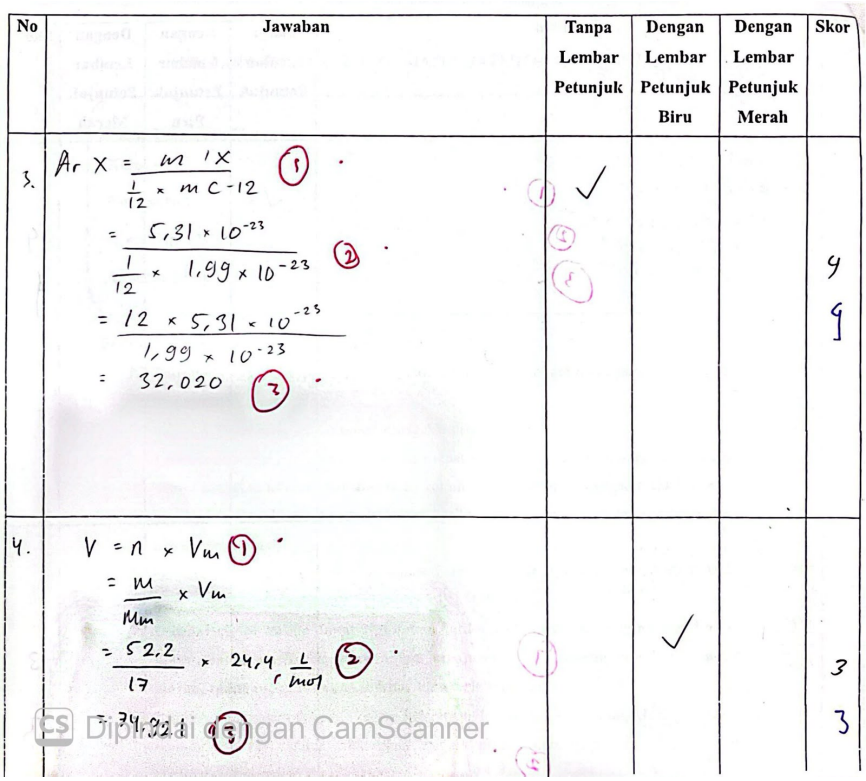
Based on the results shown in Figure 9, the overall percentage for each assessment criterion in the stage of implementing the formative test with blue and red guidelines is 96%, which falls into the very good category according to Ja'far et al. (2014). This indicates that students were satisfied and agreed that the blue and red guideline sheets were useful as

feedback, serving as a substitute for direct feedback from the teacher in the classroom, as well as providing guidance in answering the questions.

The provision of blue and red guideline sheets as feedback in formative tests was a new experience for students. Typically, during tests, students only answer the questions without receiving any supporting guidance. The absence of such guideline sheets is common, making this approach different from their usual experience. A challenge encountered at this stage was that some students experienced difficulties accessing the formative test and the blue and red guideline sheets due to network issues.

Implementation of Peer Assessment for Student Feedback

At this stage, students reviewed their peers' work by referring to the provided peer assessment instrument sheet and gave written feedback on their peers' formative test results on the answer sheets. Feedback was provided when the solution did not align with the ideal answers in the peer assessment sheet, in the form of comments on the appropriate steps for solving the questions according to the expected answers (Heil & Ifenthaler, 2023). The following section presents examples of students' answer sheets from the formative test and the peer assessment sheets used by students in conducting the evaluation:



No	Jawaban	Tanpa Lembar Petunjuk	Dengan Lembar Petunjuk Biru	Dengan Lembar Petunjuk Merah	Skor
3.	$Ar\ X = \frac{m\ 1X}{\frac{1}{12} \times m\ C\text{-}12}$ (1) $= \frac{5{,}31 \times 10^{-23}}{\frac{1}{12} \times 1{,}99 \times 10^{-23}}$ (2) $= \frac{12 \times 5{,}31 \times 10^{-23}}{1{,}99 \times 10^{-23}}$ $= 32{,}020$ (3)	✓			4 4
4.	$V = n \times V_m$ (1) $= \frac{m}{M_m} \times V_m$ $= \frac{52{,}2}{17} \times 24{,}4\ \frac{L}{mol}$ (2) $= 34{,}32$ (3)		✓		3 3

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Figure 10. Student Answer Sheet

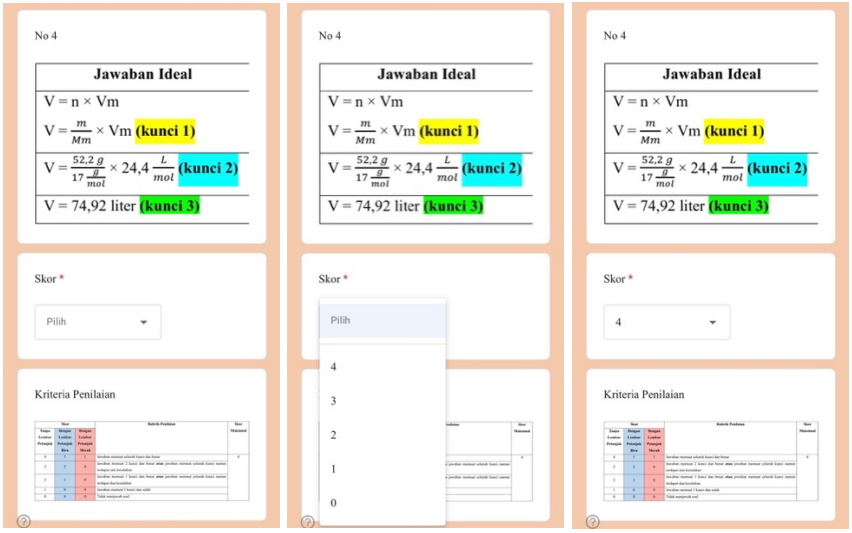


Figure 11. Peer Assessment Sheet

The assessment conducted by students on their peers' answer sheets, as shown in Figure 10, was compared against the scoring rubric provided in the peer assessment sheet presented in Figure 11. The use of a scoring rubric is considered effective for evaluating the quality of students' performance based on predetermined criteria (Panadero et al., 2023; To et al., 2022). Each answer in the rubric consists of three key terms. The maximum score is 4, with a deduction of 1 point depending on the number of key terms included and the use of guidance provided in the answer sheet. This is because each approach taken in answering the questions affects the score obtained.

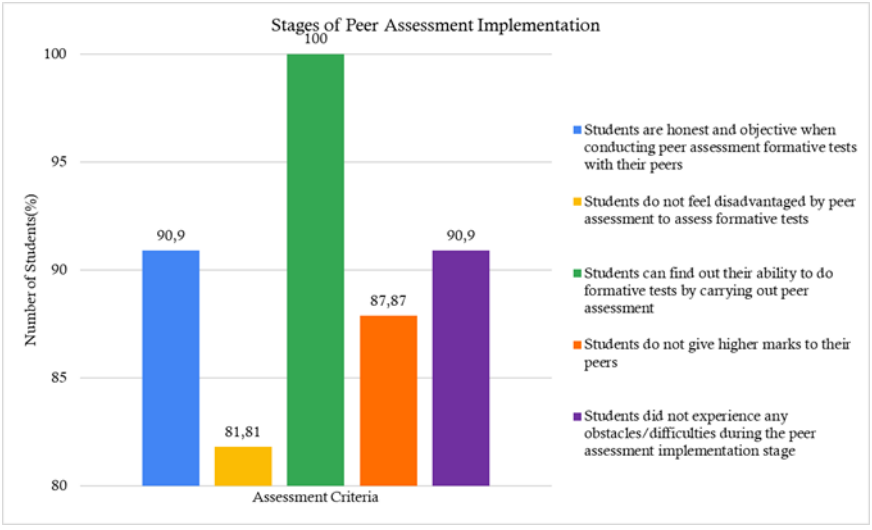


Figure 12. Results of Student Questionnaires at the Peer Assessment Implementation Stage

Figure 12 shows that the overall percentage for each assessment criterion in the peer assessment implementation stage is 90.29%, which falls into the very good category according to Ja'far et al. (2014). At this stage, by conducting peer assessment of formative tests after the test has been completed, it is expected that students can learn from their mistakes and shortcomings, as well as from their peers' test results.

Through the implementation of peer assessment, more optimal evaluation results are achieved, and students are encouraged to become more motivated and develop greater awareness to improve their learning process. However, a challenge encountered at this stage was the discrepancy between the assessment results of students and those of the researcher. This occurred because some students did not pay close attention during the scoring instructions. In addition, the training stage, which was not conducted regularly, also contributed to students feeling less confident, hesitant, and uncertain when assigning scores.

Communication of Results for Student Feedback

The result communication stage aims to provide feedback to students, with the expectation that they can correct their mistakes and shortcomings and become motivated to improve their understanding and learning process. The feedback received by students includes verbal feedback on their formative test results delivered and explained by the teacher, written feedback provided during peer assessment through comments or appropriate solution steps written on their peers' answer sheets, the return of answer sheets along with the scores after evaluation, and immediate feedback during the formative test through the use of blue and red guideline sheets.

At this stage, discussions also take place, allowing students to critically reflect on and evaluate the results they have received and communicated. A challenge encountered during this stage was that some students did not pay sufficient attention to the explanations provided, resulting in discussions that did not fully involve all students.

Utilization of the Results

The findings indicate that peer assessment can be effectively utilized to provide formative feedback in stoichiometry learning. As presented in Figure 3, 96% of the students agreed that peer assessment was beneficial for providing feedback during formative assessment. This high level of agreement suggests that students positively accepted peer assessment as part of the learning process and perceived it as a valuable source of feedback.

The positive perception of peer assessment is likely associated with the opportunities it provides for students to evaluate their peers' work while simultaneously reflecting on their own understanding. Through this process, students become more aware of their strengths and areas requiring improvement, enabling them to regulate their learning and enhance their conceptual understanding. This finding supports the principles of formative assessment, which emphasize feedback as a mechanism for reducing the gap between current performance and intended learning goals rather than merely measuring achievement.

The present findings are consistent with previous studies reporting the educational benefits of peer assessment. Adawiyah (2022) found that peer assessment encourages students to identify their strengths and weaknesses while fostering greater responsibility for learning. Similarly, Kerman et al. (2024) reported that peer assessment promotes deeper learning, meaningful engagement, and independent learning by actively involving students in evaluating learning outcomes. The high level of student acceptance observed in this study further suggests that peer assessment guidelines may facilitate students in providing more consistent and meaningful feedback, thereby increasing their confidence in the peer assessment process.

Furthermore, no substantial challenges were identified during the utilization stage, indicating that students were able to use the feedback generated through peer assessment without significant difficulty. This finding implies that, once students have received adequate preparation and training, peer assessment can be integrated into formative assessment practices with minimal implementation barriers. Therefore, structured peer assessment has the potential to serve not only as an alternative feedback strategy but also as a practical approach to promoting students' reflective learning, self-regulation, and active participation in chemistry classrooms.

CONCLUSION

Based on the research findings and discussion, it can be concluded that the readability test results of formative test packages A and B for the content aspect fall into the good category, with a percentage range of 70.00%–72.00%. In terms of presentation, structure, and language aspects, both formative test packages A and B are categorized as very good, with a percentage range of 80.00%–86.00%. Therefore, formative test packages A and B are suitable to be used as research instruments in the peer assessment implementation stage for formative tests on stoichiometry to provide student feedback. Furthermore, more than 93% of students expressed satisfaction and agreement that the implementation of peer assessment can be used to provide

feedback in formative tests on stoichiometry. Students' ability to conduct peer assessment is distributed into three categories: very good (36%), good (33%), and fair (30%). The implementation of peer assessment was carried out through six stages, all of which were categorized as very good, with a percentage range of 89.60%–100.00%. However, some students still experienced difficulties in understanding the assessment criteria of the formative test and encountered challenges during the scoring process. The findings indicate that peer assessment in formative tests on stoichiometry, supported by blue and red guidelines, can provide positive feedback for students. Therefore, peer assessment in formative tests offers a valuable and innovative assessment approach to enhance students' engagement in the learning process.

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