

Enhancing Students' Learning Outcomes in Chemistry Learning Through Assessment for Learning

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ABSTRACT: Continuous monitoring of student understanding is crucial because the nature of complex redox reaction materials is one of the primary causes of suboptimal student achievement. This research aims to enhance student learning outcomes through an assessment for learning approach that integrates feedback on an ongoing basis. This investigation employed a pre-experimental one-group pretest-posttest methodology with 36 twelfth-grade learners from one of Surabaya's high schools. The results showed a significant improvement in student learning outcomes, with the average score increasing from 37.22 to 86.04. The average N-gain reached 0.77, indicating high growth in learning achievement, with 88.89% of students attaining the high category. The results of this study show that using assessment for learning, which includes defining learning objectives, creating useful classroom discussions and assignments as evidence of student comprehension, giving continuous feedback, and including students as owners of their own learning process, is effective in improving students' learning outcomes and has a measurable positive impact on concept mastery. These findings suggest that the assessment for learning approach is effective for improving students' understanding of complex topics such as redox reactions.

Keywords: Assessment for Learning, Feedback, Learning Outcomes, N-gain, Redox Reactions.

INTRODUCTION

Chemistry is a field that is highly valued due to its ability to provide a clear understanding of many occurrences in life. It encompasses three aspects of chemical representation: macroscopic (features we can observe), microscopic (the fundamental particles that make up materials like atoms, ions, and subatomic entities), and symbolic (which includes symbols, chemical equations, and the identification of substances) [1, 2]. The subject of redox reactions in chemistry is notably intricate. This intricacy stems from the fact that redox reactions can be analyzed through three different perspectives of chemical representation. Important elements contributing to this complexity include variations in oxidation states, modifications in electron movement, and the reactions themselves [3].

Students frequently encounter challenges when learning about oxidation-reduction reactions, especially with identifying oxidation numbers, analyzing oxidizing and reducing agents, and writing reaction equations [4]. They also struggle with comprehension of half-reactions and balancing electrons in these half-reactions [5, 6]. These challenges further extend to the students' difficulty in recognizing redox agents and their failure to accurately balance redox reaction equations [7]. This situation is reflected in the performance of 36 twelfth-grade students from one of Surabaya's high schools, where only 44.44% achieved the learning objectives set at a score of 78. Meanwhile, 50.00% scored below this threshold, and just 2.78% were precisely at the target achievement level.

The teacher mentioned that the problems the students faced with redox reactions came from how well they understood the concepts. Additionally, students had a limited understanding, and the teaching approach was mainly focused on the teacher. The study also found that teacher factors, teaching methods, teaching materials, language, and external sources contribute significantly to students' misconceptions and misunderstandings of redox reaction materials [2, 6, 8].

As a result, there is a need to enhance the learning experience so that students can grasp the concepts of redox reactions more easily. This can be achieved by providing suitable evaluations during the teaching process. Evaluations, which are a key part of learning, are crucial for improving student understanding, as they help students set goals, track their progress, think about what they have learned, and receive useful feedback to aid their growth [9]. This concept aligns with assessment for learning



(AfL), where continuous assessment of evaluating student learning is obtained by gathering and analyzing evidence to see how much progress has been made and how to move forward effectively [10]. The assessment for learning approach, as defined in [11], involves: 1) define their learning goals and establish success targets, 2) designing class discussions and other activities to show how well students understand the material, 3) engaging students as reciprocal learning resources while providing constructive feedback, and 4) empowering students to take full ownership of their educational progress. These strategies have been tested and proven to positively affect student results [12, 13]. Therefore, enhancing the quality of learning is essential, focusing on both the learning process and the outcomes, which highlights the need to improve assessments, so improvements are needed in learning assessments, one of which is the application of assessment for learning to learning [14].

Assessment for learning is closely tied to feedback, as the main goal of feedback is to enhance learning effectiveness. Therefore, it is essential for teachers to give precise and helpful feedback to boost students' learning results. However, some teachers have not been giving proper feedback [15]. Research before this has shown that 84.4% of students have not received any feedback about their learning, while just 15.6% have had some feedback. This indicates that a strategy for assessment is required to raise students' understanding and knowledge, which can be achieved through formative evaluations, commonly referred to as assessment for learning [16]. As noted in Valdez [17], formative assessments facilitate the immediate recalibration of learning methods and assignments based on the constructive information they provide. By implementing assessments for learning, teachers can better understand the needs of students during lessons and monitor their progress toward achieving set objectives [18]. Thus, assessment for learning (AfL) can be very beneficial to improving students' learning capabilities [16].

According to earlier studies, learning that relies on assessments can lead to better student performance. Research conducted in Safithri [14] demonstrated an improvement in student performance regarding reaction rates through assessment for learning. Their findings revealed that 97.22% of students achieved N-gain score results falling squarely within the highest classification, while 2.78% of students fell into the medium range. The implementation of assessment for learning (AfL) in chemistry lessons positively impacted students' results and enhanced their performance [18]. In the implementation of assessment for learning, there is feedback at each stage which is useful to provide specific information about students' achievement towards learning objectives so that teachers and students can recognize student learning gaps. Timely and detailed feedback is also one of the things that is influential in improving students' understanding and performance in the context of AfL [19]. Additionally, it was revealed in [20] revealed that ongoing reflection and feedback activities significantly contributed to boosting student performance in learning about the elemental periodic system.

Driven by previous data analysis, this research examines how the implementation of assessment for learning can optimize educational quality and strengthen students' conceptual understanding of redox reaction topics. While Assessment for Learning (AfL) has been extensively studied in various science subjects, its specific implementation in addressing the complexities of redox reaction material such as identifying oxidation numbers, analyzing oxidizing and reducing agents, and balancing electrons in half-reactions. This study fills this gap by providing empirical evidence on how systematic AfL can effectively enhance students' concept mastery in this topic.

RESEARCH METHODS

Research Design

TABLE 1. Research Design

Pretest	Treatment	Posttest
O ₁	X	O ₂

Description:

O₁ = Value before being assessment for learning treatment on redox reaction material

X = Assessment for learning treatment on redox reaction material

O₂ = Value after being assessment for learning treatment on redox reaction material

A quantitative method using a pre-experimental design is applied in this research. This study utilizes a one-group pretest-posttest design, which involves one group of subjects, namely the experimental group [21], that is treated using the application of learning with an assessment for learning approach to redox reaction material. In the one-group pretest-posttest, evaluations are conducted before (pretest) and after (posttest) the experiment [22]. Since the treatment looks at the results before and after, it allows for a more accurate understanding of the effects. Through this treatment, the results before and after can be seen. This allows for a more accurate understanding of the impact of interventions on improving student learning outcomes in the classroom. However, it is important to recognize that the

absence of a control group in this one-group pretest-posttest design is a limitation. This suggests that although the results show significant improvements, the findings should be interpreted carefully specifically for this experimental group because of the absence of direct comparisons with other teaching methods. The structure of the study, as detailed in Table 1, illustrates the relationship between the treatment (variable X) and the evaluation (variable O).

Procedures of Treatment

The application of Assessment for Learning (AfL) provides opportunities for students to learn actively, independently, and take responsibility for their learning progress rather than being passive recipients of knowledge. This pedagogical approach follows the systematic stages illustrated in Figure 1, which was adapted from the AfL framework by Black et al. [11].

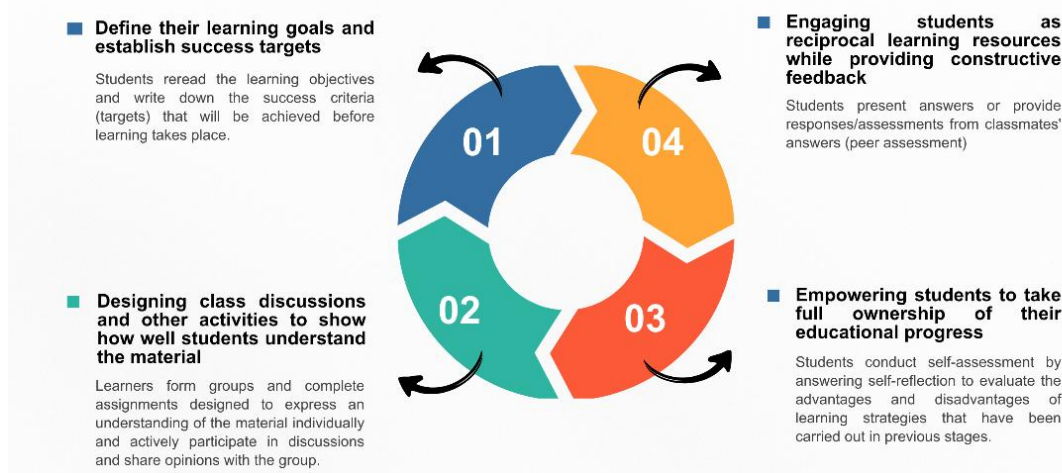


FIGURE 1. Stages of Assessment for Learning

Each stage of this assessment for learning approach is specifically designed to identify students' strengths and weaknesses in mastering redox reactions while improving their learning outcomes. This is in accordance with research [23] that students' participation in reflecting on what they have or have not understood through the implementation of AfL learning has been proven to be able to significantly improve their learning outcomes.

Research Subject

The subject of this study involved 36 twelfth-grade students from one of Surabaya's high schools. Their selection as the research sample was predicated on their prior mastery of foundational topics before entering the redox reaction material, namely the material on the nomenclature of compounds and reaction equations. Mastery of these prerequisite materials is an important basic thing for students in understanding the mechanism of electron transfer and determining the number of oxidations in redox reaction materials.

The subjects were chosen through purposive sampling, where samples were selected based on certain qualifications and factors that align with the study's goals [24]. The primary criteria for choosing the samples include: (1) current students in twelfth-grade who have a solid understanding of foundational material and are engaged in learning about redox reactions, and (2) the presence of sufficient resources to facilitate the assessment for learning (AfL). A pre-experimental design with a single group was utilized to allow researchers to thoroughly observe how effective the assessment for learning approach is in enhancing student performance regarding redox reaction topics.

Data Analysis

The approach to data analysis in this study utilizes quantitative methods, assessing the effects of implementing assessment for learning on redox reaction subjects by means of mean difference tests and the N-gain test. Before conducting the average difference test, it is necessary to examine the pretest and posttest outcomes for normality to establish whether the data adhere to a normal distribution. This assessment of normality was conducted using statistical software version. If the data exhibits a normal distribution, a statistical test known as the Paired Sample T-test is performed. Conversely, if the data does not exhibit a normal distribution, a non-parametric test referred to as the Wilcoxon Signed Rank test will be utilized.

$$\langle g \rangle = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{max}} - S_{\text{pre}}} \quad (1)$$

Description:

(g) = N-gain value

Sp_{ost} = Post-test value

Sp_{re} = Pre-test Value

S_{max} = Maximum Value

Additionally, N-gain was applied to assess how effective the learning approach with assessment for learning was by looking at the improvement in students' scores in oxidation-reduction reaction topics. The calculation of N-gain was done using Microsoft Excel software. The formula used is detailed in the Equation (1) [25]. Student achievement of high or medium N-gain scores serves as the benchmark for assessment for learning (AfL) effectiveness, following the classification criteria detailed in Table 2.

TABLE 2. Interpretation of N-gain Score

Percentage (%)	Categories
$g < 0.3$	Low
$0.3 \leq g \leq 0.7$	Medium
$0.7 < g$	High

According to this viewpoint, implementation of the assessment for learning approach to redox reaction materials is deemed successful if at least 85% of the students obtain a learning outcomes score in the high ($0.7 < g$) or medium ($0.3 \leq g \leq 0.7$) range [26].

RESULT AND DISCUSSION

The students' pretest scores before receiving the intervention (pretest) were collected by using a test focused on the learning outcomes related to redox reactions, presented as multiple-choice questions. Subsequently, the experimental treatment consisted of two sessions dedicated to redox reactions, both of which utilized the assessment for learning approach. Afterward, students received a score following the intervention (posttest) by completing a learning outcomes assessment focused on redox reactions, also using multiple-choice questions. The pretest and posttest scores obtained will aid in evaluating the success of the learning outcomes using the assessment for learning (AfL) approach, as depicted in Figure 2.

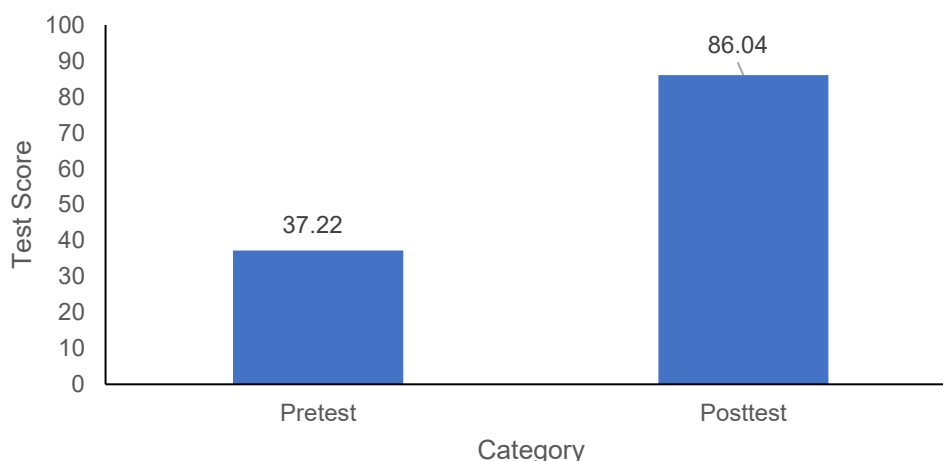


FIGURE 2. The Results of Pretest and Posttest Score Comparison

In addition to the results from the pretest and posttest score comparison, a descriptive statistical examination was carried out to summarize how students performed on redox reaction topics prior to and following the process that employed the assessment for learning approach. This examination was performed using statistical software. The findings from this descriptive statistical examination are presented in Table 3.

TABLE 3. Descriptive Statistics of Pretest and Posttest

Test	N	Minimum	Maximum	Mean	Standard Deviation
Pretest	36	15	60	37.22	9.85
Posttest	36	80	95	86.04	4.28

Based on the data in Table 3, the mean of the students increased from 37.22 in the first test to 86.04 in the last test. Furthermore, the change in standard deviation from 9.85 to 4.28 suggests that the students' abilities became more alike, and the gaps in understanding among them got smaller after the intervention. To determine the consistency of the results, standard deviation is used to calculate the spread of data points around the calculated average. The measure of data spread shows how far the values of that group of data deviate from the mean. If the distribution in a group of data is small, then the data is homogeneous and vice versa [27]. This is clearly reflected by the fact that the lowest score in the last test (80) is significantly higher than the best score in the first test (60), indicating that ongoing feedback and reflection during learning, along with a learning assessment approach, effectively assist all students in reaching common educational goals.

Moreover, the pretest and posttest scores were subjected to a mean difference analysis to gauge the overall impact of the implemented assessment for learning (AfL). A normality test is a crucial step to verify that the data meet the normality condition needed for parametric statistical analysis, which helps determine if the data has a normal distribution [28]. Before applying the mean difference test, a normality test must be satisfied preliminarily. The Shapiro-Wilk test was selected as the primary normality assessment, given that the class has fewer than 50 students [29]. Table 4 shows the results of the normality test analyzed with the statistical software.

TABLE 4. Normality Test Results

Test	Mean	Standard Deviation	N	Sig.
Pretest	37.22	9.85208	36	0.773
Posttest	86.04	4.28348	36	0.039

The determination of the normality test relies on the assumption that the data follows a normal distribution if the significance level exceeds 0.05, and is not normally distributed if the value is below 0.05 [30]. As illustrated in Table 4, the pretest result in this study met this criterion (Sig. = 0.773), and the posttest results (Sig. = 0.039) indicated a departure from normality. A non-parametric test is performed due to the fact that one of the data groups does not follow a normal distribution. This decision aligns with the recommendation by Sari et al. [31] to use methods independent of distribution assumptions when data transformation is not performed.

Consequently, the statistical test is conducted using the Wilcoxon Signed Rank test, a non-parametric statistical test, which is an alternative to the independent t sample test at a significance level of 0.05 [32]. The study tests the null hypothesis (H₀), which posits no significant difference between pretest and posttest scores following the assessment for learning intervention, against the alternative hypothesis (H₁), which suggests that a significant difference exists. Decisions are made using asymptotic values. Sig. (2-tailed) using the criteria that if the value of Asymp. Sig. (2-tailed) > 0.05, then H₀ is accepted and H₁ is rejected, while if Asymp. Sig. (2-tailed) < 0.05, then H₀ is rejected and H₁ is accepted. The outcomes of the Wilcoxon Signed Rank Test are shown in Table 5.

TABLE 5. Wilcoxon Signed Rank Test Results

Z	Wilcoxon test (Asymp. Sig. 2 tailed)
-5,238	0.000

The Wilcoxon test is used to compare two sets of paired data to identify any significant differences. As shown in Table 5, results from the Wilcoxon Signed Rank test reveal that the Asymp. Sig. (2-tailed) value is below 0.05. This suggests that the null hypothesis can be dismissed and the alternative hypothesis accepted, revealing a difference between the students' scores on the pretest and posttest after they learned through an assessment-for-learning approach.

TABLE 6. Completeness Score Recapitulation

Number of Students	Completeness Pretest	Completeness Posttest
36	Not Complete	Complete
	Complete: 0 (0%)	Complete: 36 (100%)
	Not Complete: 36 (100%)	Not Complete: 0 (0%)

Additionally, after confirming that a significant difference was present in student learning results following the intervention, an N-gain analysis was performed to measure the extent of improvement in these results. Following the assessment of the experiment's influence, the N-gain test was applied to determine how effective the experiment was [33]. The calculations were performed using Microsoft Excel. The learning outcomes assessed were the cognitive performance of students measured through

multiple-choice questions given in both the pretest and posttest. Table 6 offers a recapitulation of the scores for those students who fulfilled the criteria for achieving the learning goals.

According to the recapitulation in Table 6, the pretest placed at least 36 students in the category of incomplete with a score of less than 78. After that, in the posttest, 36 students earned a score of 78 or higher. According to these findings, at least 85% of the students in an experimental class have been declared complete. The average N-gain score of students' learning reached a high level, with an average value of 0.77. Detailed findings in Table 7 further clarify that the students' progress was categorized within the medium-to-high range.

TABLE 7. N-gain Criteria for Students' Learning Outcomes

N-gain score	Normalized Gain Criteria	Frequency	Percentage (%)
$g < 0.3$	Low	0	0
$0.3 \leq g \leq 0.7$	Medium	4	11.11
$0.7 < g$	High	32	88.89

Figure 3 demonstrates that the efficacy of the assessment for learning (AfL) in redox reaction lessons is evidenced by the fact that 88.89% of students reached a high level of improvement, with the rest (11.11%) categorized as medium range. This collective performance results in a 100% completion rate, far surpassing the required 85% benchmark. Consequently, the study confirms that this approach serves as a robust strategy for boosting student achievement in complex chemistry subjects.

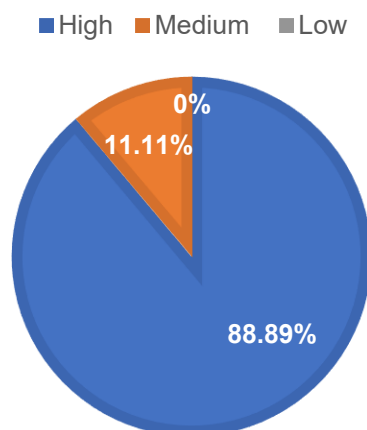


FIGURE 3. Classification Diagram N-gain of Students

When using a learning approach focused on assessment for learning, particularly in redox reactions, there are several steps. These steps include analyzing what is needed, setting goals, creating formative plans, communicating with students, executing the plans, and evaluating and adjusting the plans in a continuous loop [34]. In the first step, students define their learning goals and establish success targets before starting their lessons. This stage helps students make key decisions and take full ownership of their own growth [35]. Next, in the second step, designing class discussions and other activities to show how well students understand the material. Here, students' skills are developed through helpful feedback and step-by-step tasks. This gives them clear indications of how to succeed and helps them see that their skills are improving progressively [36, 37].

In the third stage, students support each other as learning resources and give feedback that guides their classmates in a positive direction. This stage fulfills the need for connection by incorporating peer assessments and teamwork in the classroom. As a result, students can feel a sense of unity and support from both their peers and teachers [38, 39]. Moreover, during the fourth stage, students become responsible for their own learning. In this final stage, they take charge of utilizing feedback and planning for improvements, while also understanding their strengths and weaknesses in what they have learned. It was discovered in Lin [40] that self-assessment and reflection can enhance students' academic well-being by boosting their motivation. Implementing the assessment for learning (AfL) approach through previous stages has a notably positive effect on students' academic performance. This is shown by the rise in average test scores from 37.22 before the test to 86.04 after, resulting in an improvement of 48.82 points. This significant increase in student learning outcomes is obtained by applying the AfL

stages [11]. In addition, timely and detailed feedback in all four stages allows students to immediately identify and bridge their learning gaps in redox reaction material [19]. Through this process, the implementation of AfL can improve learning outcomes and move students from initial misunderstandings to higher levels of mastery.

The findings in this study show a significant increase of 48.82 points, which is in line with the findings of Syah and Muchlis [20] that AfL improves cognitive learning outcomes. In contrast to previous studies that tended to focus on the result, this study emphasizes that the improvement is specifically driven by the implementation of systematic AfL stages and the provision of timely feedback. However, the limitation of this study is the use of a single-group (pre-experimental) design without a control class, so that the improvement of student learning outcomes may also be influenced by other external factors. Thus, the improvement of learners' learning outcomes after conducting AfL approached learning is in line with recent studies showing that an assessment approach to learning that emphasizes the delivery of constructive feedback, promotes student engagement, utilizes formative practices, and ensures consistent self-assessment, can improve academic achievement while strengthening the foundation of intrinsic motivation by meeting psychological needs students [41, 42, 43].

CONCLUSION

This study concludes that the application of assessment for learning (AfL) on redox reaction materials is efficacious in improving student learning outcomes. This is shown by the difference and increase in pretest and posttest scores due to the feedback systematic, timely, and detailed as the main driver in bridging the gap between students' initial misconceptions and redox reactions. These results encourage chemistry educators to integrate assessments for learning (AfL) into their teaching plans, as through this approach students can become active, independent, and responsible learners of their own learning through goal setting, peer evaluation, receiving feedback and input, and conducting reflective self-assessments. Despite these positive results, the limitations in the design of this study form the basis for future research recommendations to strengthen the generalization of further findings.

RECOMMENDATION

According to the findings of this study, it is highly recommended for chemistry educators to apply the assessment for learning (AfL) approach systematically, especially on redox reaction materials. In addition, teachers must also provide immediate and specific feedback to overcome student misunderstandings during the learning process as the main driver of improving learning outcomes. Due to the limitations of this study using a pre-experimental design with a single group, these findings cannot be overgeneralized due to the potential for internal and external validity. Therefore, future studies are recommended using a quasi-experimental experimental design involving control groups as a stronger comparison to the application of AfL than other external factors. Further research should also consider the use of a larger, more diverse sample of students in different school contexts to improve the generalization of outcomes.

Authors' contribution

- **Conceptualization:** Maulida;
- **Data curation:** Maulida;
- **Formal Analysis:** Maulida;
- **Funding acquisition:** Maulida;
- **Investigation:** Maulida;
- **Methodology:** Muchlis;
- **Project administration:** Muchlis;
- **Resources:** Maulida;
- **Software:** Maulida;
- **Supervision:** Muchlis;
- **Validation:** Muchlis;
- **Visualization:** Maulida;
- **Writing – original draft:** Maulida;
- **Writing – review & editing:** Muchlis;

All authors have read and agreed to the published version of the manuscript.

Ethics Statement

This research involved human subjects who had given informed consent to participate. All participants received treatment in accordance with their rights, dignity, and applicable research ethics principles.

Data availability statement

The data will be available upon request.

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Conflicts of Interest

The authors declare no conflicts of interest.

REFERENCES

- [1] S. Nugrohadhi and I. Chasanah, "Identifikasi Miskonsepsi Siswa Kelas X pada Pembelajaran Reaksi Redoks di Kurikulum Merdeka," *J. Pendidik. Mipa*, vol. 12, no. 4, pp. 1085-1093, 2022, doi: [10.37630/jpm.v12i4.746](https://doi.org/10.37630/jpm.v12i4.746)
- [2] G. Marumure and J. Kriek, "Teachers' Teaching Strategies, Opportunities, and Challenges When Developing Conceptual Understanding of Redox Reactions," *Sci. Educ. Int.*, vol. 36, no. 3, pp. 289–298, 2025, doi: [10.33828/sei.v36.13.4](https://doi.org/10.33828/sei.v36.13.4)
- [3] V. F. Harfiah and S. Rahmawan, "Pengaruh Metode Pembelajaran Focus Group Discussion terhadap Kemampuan Kognitif dan Keterampilan Kerja Sama Siswa pada Materi Redoks," *Prisma Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, vol. 13, no. 2, pp. 175–185, 2025, doi: [10.33394/j-ps.v13i2.14412](https://doi.org/10.33394/j-ps.v13i2.14412)
- [4] K. Adu-Gyamfi, J. G. Ampiah, and D. D. Agyei, "Participatory teaching and learning approach: A framework for teaching redox reactions at high school level," *Int. J. Educ. Pract.*, vol. 8, no. 1, pp. 106–120, Feb. 2020, doi: [10.18488/journal.61.2020.81.106.120](https://doi.org/10.18488/journal.61.2020.81.106.120)
- [5] Z. Muttaqin, L. Hanum, and M. Nazar, "Pengembangan Handout Berbasis Guided Note Taking Pada Materi Reaksi Reduksi-Oksidasi Sebagai Sumber Belajar Kelas X MAN 2 Aceh Timur," *J. Ilm. Mhs. Jur. Pendidik. Kimia*, vol. 4, no. 2, pp. 17-26, 2020. [Online], Available: <https://jim.usk.ac.id/pendidikan-kimia/article/view/16139/7417>
- [6] M. Owusu, H. D. Assem, T. A. Ossei-Anto, and F. O. Ansah, "Challenges in Understanding the Mole Concept Among Level 200 Students in Science Colleges of Education in Ghana," *High. Educ. Res.*, vol. 9, no. 5, pp. 116–130, 2024, doi: [10.11648/j.her.20240905.14](https://doi.org/10.11648/j.her.20240905.14)
- [7] L. F. Goes, C. Fernandez, and I. Eilks, "The Development of Pedagogical Content Knowledge about Teaching Redox Reactions in German Chemistry Teacher Education," *Educ. Sci.*, vol. 10, no. 6, pp. 1–23, 2020, doi: [10.3390/educsci10070170](https://doi.org/10.3390/educsci10070170)
- [8] W. S. Apriana, W. Wiji, and T. Widhiyanti, "Diagnosing and Remediating Electrochemical Misconceptions Using a Multi-Tier Test to Improve Students' Understanding of Redox Reaction, Voltaic Cells, and Electrolysis," *J. Educ. Sci.*, vol. 9, no. 6, pp. 6274-6289, 2025, doi: [10.31258/jes.9.6.p.6274-6289](https://doi.org/10.31258/jes.9.6.p.6274-6289)
- [9] S. Luo, J. Huang, and X. Ma, *Promoting Learning: Formative Assessment in Second Language Teaching*. Beijing: Foreign Language Teaching and Research Press, 2020.
- [10] D. Rosana, E. Widodo, W. Setianingsih, and D. Setyawarno, "Pelatihan Implementasi Assessment Of Learning, Assessment For Learning Dan Assessment As Learning Pada Pembelajaran IPA SMP di MGMP Kabupaten Magelang," *J. Pengabd. Masy. MIPA dan Pendidik. MIPA*, vol. 4, no. 1, pp. 71–78, 2020, doi: [10.21831/jpmmp.v4i1.34080](https://doi.org/10.21831/jpmmp.v4i1.34080)
- [11] P. Black and D. Wiliam, "Classroom Assessment and Pedagogy," *Assess. Educ. Princ. Policy Pract.*, vol. 25, no. 6, pp. 551–575, 2018, doi: [10.1080/0969594X.2018.1441807](https://doi.org/10.1080/0969594X.2018.1441807)

- [12] D. P. Pratama and Muchlis, "Student Worksheet Oriented on Assessment for Learning to Improve Learning Outcome on Acid Base Titration," *Hydrogen J. Kependidikan Kimia*, vol. 11, no. 4, p. 485, 2023, doi: [10.33394/hjkk.v11i4.8154](https://doi.org/10.33394/hjkk.v11i4.8154)
- [13] G. T. A. Sudarsono and Muchlis, "Kelayakan LKPD Berorientasi Assessment for Learning (AfL) untuk Meningkatkan Hasil Belajar Peserta Didik pada Materi Larutan Penyangga," *J. Pendidik. Kimia*, vol. 8, no. 2, pp. 95–108, 2023, doi: [10.36709/jpkim.v8i2.27](https://doi.org/10.36709/jpkim.v8i2.27)
- [14] D. L. Safithri and Muchlis, "Implementation of Assessment for Learning-Based Learning to Improve Student Learning Outcomes on Reaction Rate Materials," *PENDIPA J. Sci. Educ.*, vol. 6, no. 2, pp. 547–555, 2022, doi: [10.33369/pendipa.6.2.547-555](https://doi.org/10.33369/pendipa.6.2.547-555)
- [15] S. Gunawan and R. H. Soesanto, "Keakuratan Umpan Balik Asesmen Terhadap Hasil Belajar Kognitif Siswa Pada Pengerjaan Formatif Secara Daring," *Refleksi Edukatika J. Ilm. Kependidikan*, vol. 13, no. 1, pp. 10–19, 2022, doi: [10.24176/re.v13i1.6852](https://doi.org/10.24176/re.v13i1.6852)
- [16] H. N. Karimah, S. Windyariani, and H. Aliyah, "Penggunaan Assessment for Learning Berbasis Comment Only Marking Terhadap Hasil Belajar Kognitif Siswa," *BIODIK*, vol. 6, no. 3, pp. 255–265, 2020, doi: [10.22437/bio.v6i3.9578](https://doi.org/10.22437/bio.v6i3.9578)
- [17] J. M. L. Valdez and E. G. Pineda, "La Evaluación Socioformativa en la Cultura Digital: Un Enfoque Inclusivo y Accesible," *Rev. Veritas de Difusão Científica*, vol. 6, no. 2, pp. 1–15, 2025, doi: [10.61616/rvdc.v6i2.792](https://doi.org/10.61616/rvdc.v6i2.792)
- [18] S. A. Hasanah and M. Muchlis, "The Effect of Assessment for Learning in Chemistry on Students' Learning Outcomes," *J. Penelit. Pendidik. IPA*, vol. 10, no. 8, pp. 5992–6000, 2024, doi: [10.29303/jppipa.v10i8.7611](https://doi.org/10.29303/jppipa.v10i8.7611)
- [19] C. Campbell, C. DeLuca, D. LaPointe-McEwan, M. Ceau, and N. Rickey, "Teacher-Led Learning Circles for Formative Assessment: Full Report of International Research Findings. Education International". Brussels, Belgium: Education International, 2024. [Online]. Available: <https://www.ei-ie.org/en/dossier/1542:teacher-led-learning-circles-for-formative-assessment/1544:publications>
- [20] G. F. Syah and Muchlis, "Development of the Student Worksheets Based on Assessment for Learning (AfL) to Improve Student Learning Outcomes of the Elements Periodic Table," *J. Penelit. Pendidik. IPA*, vol. 11, no. 3, pp. 826–836, 2025, doi: [10.29303/jppipa.v11i3.10899](https://doi.org/10.29303/jppipa.v11i3.10899)
- [21] W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 5th ed. Thousand Oaks, CA: SAGE Publications, 2018.
- [22] L. Rahmawati and A. T. A. Hardini, "Pengaruh Model Pembelajaran Inquiry Berbasis Daring Terhadap Hasil Belajar Dan Keterampilan Berargumentasi pada Muatan Pelajaran IPS di Sekolah Dasar," *J. Basicedu*, vol. 4, no. 4, pp. 1035–1043, 2020, doi: [10.31004/basicedu.v4i4.492](https://doi.org/10.31004/basicedu.v4i4.492)
- [23] P. C. Dini and Muchlis, "Peningkatan Hasil Belajar Peserta Didik melalui Implementasi Pembelajaran Berbasis Assessment for Learning pada Materi Kesetimbangan Kimia," *PENDIPA: J. Sci. Educ.*, vol. 6, no. 2, pp. 565–572, 2022, doi: [10.33369/pendipa.6.2.565-572](https://doi.org/10.33369/pendipa.6.2.565-572)
- [24] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2019.
- [25] T. Wijayanto, B. Supriadi, and L. Nuraini, "Pengaruh Model Pembelajaran Project Based Learning dengan Pendekatan Stem Terhadap Hasil Belajar Siswa SMA," *J. Pembelajaran Fisika*, pp. 113-120, 2020, doi: [10.19184/jpf.v9i3.18561](https://doi.org/10.19184/jpf.v9i3.18561)
- [26] K. Sirianansopa, "Evaluating students' learning achievements using the formative assessment technique: A retrospective study," *BMC Med. Educ.*, vol. 24, no. 1, 2024, doi: [10.1186/s12909-024-06347-5](https://doi.org/10.1186/s12909-024-06347-5)
- [27] S. Febriani, "Analisis Deskriptif Standar Deviasi," *J. Pendidik. Tambusai*, vol. 6, no. 1, pp. 910–913, 2022, doi: [10.31004/jptam.v6i1.8194](https://doi.org/10.31004/jptam.v6i1.8194)
- [28] P. Elmawati, Musfirah, and Y. S. Pasinggi, "Pengaruh Penggunaan Media Video Animasi Powtoon Terhadap Hasil Belajar Siswa Sekolah Dasar Kelas Lima di Kabupaten Barru," *Pinisi J. Educ.*, pp. 10-19, 2021. [Online]. Available: <https://ojs.unm.ac.id/PJE/article/view/26598>
- [29] Hardani, *Metode Penelitian Kualitatif & Kuantitatif*. Yogyakarta: CV Pustaka Ilmu, 2020.

- [30] A. Suparno and A. D. Nusantara, *Perancangan Percobaan Aplikasi Minitab, SAS, CoStat dalam Analisis Data*. Bandung: Alfabeta, 2021.
- [31] A. P. Sari, Haeruudin, and G. Y. Saputra, "The Effect of Using Powtoon Interactive Learning Media to Improve Learning Outcomes in Class X Informatics Subjects at SMK Kesehatan Samarinda," *Tepian*, vol. 5, no. 1, p. 568760, 2024, doi: [10.51967/tepian.v5i1.2214](https://doi.org/10.51967/tepian.v5i1.2214)
- [32] F. B. Kembaren and Nuryadi, "Efektivitas Pengembangan LKPD Berbasis Etnomatematika untuk Meningkatkan Kemampuan Problem Solving dan Keaktifan Belajar," *JKPM (J. Kajian Pendidik. Mat.)*, vol. 9, no. 2, pp. 223–236, 2024, doi: [10.30998/jkpm.v9i2.23592](https://doi.org/10.30998/jkpm.v9i2.23592)
- [33] S. Wahyuni and W. Fadly, "Penggunaan Aplikasi Padlet Sebagai Alat Refleksi Praktik Mengajar Guru IPA: Pembelajaran Metode Campuran," *Prisma Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, vol. 13, no. 2, pp. 204–220, 2025, doi: [10.33394/j-ps.v13i2.14942](https://doi.org/10.33394/j-ps.v13i2.14942)
- [34] N. Mahapoonyanont, "Educational Innovation Based on Assessment for Learning Concepts: A Guide to Drive Education 4.0," *Global J. Bus. Soc. Sci. Rev.*, vol. 8, no. 2, pp. 132–143, 2020, doi: [10.35609/gjbssr.2020.8.2\(6\)](https://doi.org/10.35609/gjbssr.2020.8.2(6))
- [35] H. Zhang, J. Quan, N. Zhang, and L. Zhang, "Investigating The Effects of Formative Assessment on EFL Students' Achievement and Motivation: A Self-Determination Theory Perspective," *Front. Psychol.*, vol. 16, pp. 1–17, 2025, doi: [10.3389/fpsyg.2025.1664871](https://doi.org/10.3389/fpsyg.2025.1664871).
- [36] M. Dumitru and V. D. Dragomir, "Assessment-Focused Pedagogical Methods for Improving Student Learning Process and Academic Outcomes in Accounting Disciplines," *Educ. Sci.*, vol. 15, no. 3, p. 263, 2025, doi: [10.3390/educsci15030263](https://doi.org/10.3390/educsci15030263)
- [37] S. D. Jonge, E. Opdecam, E. A. Patall, and L. Haerens, "Goal Clarification and Process Feedback Matter: Reducing Test Anxiety in Low-Stakes Testing," *J. Exp. Educ.*, pp. 1–21, 2025, doi: [10.1080/00220973.2025.2549870](https://doi.org/10.1080/00220973.2025.2549870)
- [38] S. Baines, S. Chauhan, and P. C. J. Otermans, "Students' Perception of Authentic Assessment in Higher Education: Exploring The Relationship between Assessment Preference and Motivation in Higher Education," *Cogent Educ.*, vol. 12, no. 1, pp. 1-13, 2025, doi: [10.1080/2331186X.2024.2441067](https://doi.org/10.1080/2331186X.2024.2441067)
- [39] M. Y. Soylyu, J. Lee, J. T. Hung, C. Z. Cui, and D. Joyner, "AI literacy as a key driver of user experience in AI-powered assessment: insights from Socratic mind," *Interact. Learn. Environ.*, pp. 1–17, 2025, doi: [10.1080/10494820.2025.2564739](https://doi.org/10.1080/10494820.2025.2564739)
- [40] Y. Lin, "A Reflection of Learners' Motivation to Read, Self-Assessment, Critical Thinking, and Academic Well-Being in Extensive and Intensive Reading Offline Instruction: A Focus on Self-Determination Theory," *L MOT*, vol. 89, no. 102093, 2025, doi: [10.1016/j.lmot.2024.102093](https://doi.org/10.1016/j.lmot.2024.102093)
- [41] J. A. Jaison, K. A. Cruz, and Y. Liu, "Investigating Students' Academic Motivation, Homework, and Academic Achievement in an Online General Chemistry II Course," *J. Chem. Educ.*, vol. 102, pp. 485–494, 2025, doi: [10.1021/acs.jchemed.4c00736.s002](https://doi.org/10.1021/acs.jchemed.4c00736.s002)
- [42] O. M. Oyinloye and S. N. Imenda, "The Impact of Assessment for Learning on Learner Performance in Life Science," *EURASIA J. Math. Sci. Technol. Educ.*, vol. 15, no. 11, pp. 1–11, 2019, doi: [10.29333/ejmste/108689](https://doi.org/10.29333/ejmste/108689)
- [43] R. J. Pat-El, N. De Hoog, M. Segers, and P. Vedder, "Exploring The Impact of Student Perceptions of Assessment for Learning on Intrinsic Motivation," *Stud. Educ. Eval.*, vol. 83, no. 101420, 2024, doi: [10.1016/j.stueduc.2024.101420](https://doi.org/10.1016/j.stueduc.2024.101420)