

# Effectiveness of Interactive Videos with an Assessment for Learning Approach to Improve Students' Learning Outcomes on Chemical Bonding Material

Tiara Puspitasari<sup>ORCID</sup>, Muchlis Muchlis\*<sup>ORCID</sup>

Universitas Negeri Surabaya, Ketintang St., Surabaya, East Java, 60231, Indonesia

\*Corresponding author, email: [muchlis@unesa.ac.id](mailto:muchlis@unesa.ac.id)

<https://doi.org/10.17977/um065.v6.i10.2026.3>

## Article history

Submitted: 19 May 2026

Revised: 13 June 2026

Accepted: 14 June 2026

Published: 15 June 2026

## Keywords

Assessment for learning

Chemical bonding

Interactive video

Learning outcomes

## Abstract

The concepts in the chemical bonding material are abstract, which is why many students find it difficult to understand this subject matter. The learning media commonly used in schools tend to treat students as passive learners, even though a solid understanding of these concepts requires active learning and immediate feedback. Therefore, it is necessary to use effective learning media accompanied by an appropriate learning process to actively engage students and provide feedback to evaluate their learning. Interactive video media is one of the media that can visualize abstract concepts in chemical bonding material. The assessment for learning approach is an approach that encourages students to actively engage and provides feedback used to improve the learning process. The assessment for learning approach can be integrated using interactive video media. This study aims to determine the effectiveness of using interactive video media with an assessment for learning to improve student learning outcomes in chemical bonding material. This study was conducted using a one group pretest posttest design with a quantitative approach. Results indicated that there was an increase of 34.35 points between the mean pretest score and the posttest score. The results of the Wilcoxon signed-rank test showed a significant difference between the pretest and posttest scores, and these results were supported by the N-Gain scores, which showed that 86.7% of students achieved high criteria and 13.3% achieved moderate criteria in their learning outcome improvement. Using interactive videos with an assessment for learning approach is effective in improving student learning outcomes in chemical bond material.

## 1. Introduction

Chemistry subjects at the high school level consist of material that is arranged sequentially and interconnected. This requires students to have a comprehensive understanding of chemical concepts so they do not encounter difficulties in learning chemistry (Vonari et al., 2024). One of the materials studied in chemistry at the high school level is chemical bonding. The topic of chemical bonding explains how atoms form bonds, both with atoms of the same element and with atoms of different elements. Chemical bonds form because the atoms that are bonded show greater stability, due to their lower energy levels compared to the energy levels of the individual atoms when they are separate. The concepts in the chemical bonding material are abstract, which is why many students find it difficult to understand chemical bonding material (Husain et al., 2022). Therefore, chemistry learning requires media that can visualize abstract concepts to make them easier to understand.

Students are often struggle when learning about chemical bonding because they have difficulty distinguishing between compounds with ionic bonds and compounds with covalent bonds (Putri & Yerimadesi, 2025). In addition, students also have difficulty correctly understanding the concept of the octet rule and how metallic bonds form (Umar et al., 2023). These problems also include students' difficulty in understanding the influence of chemical bonds on the physical properties of a compound (Widarti et al., 2018). This situation is reflected in the learning outcomes for the chemical bonding material of 34 eleventh-grade students at a high school in Surabaya, where 59% of them scored below the minimum passing grade of 75 out of 100. It was found that the instructional media used were limited to PowerPoint slides, a whiteboard, and textbooks, resulting in teacher-centered instruction and making it difficult for students to correctly understanding the abstract concept of chemical bonding. Traditional learning media tend to position students as passive observers, whereas a strong understanding of concepts requires an active learning process and immediate feedback. Therefore, the use of effective learning media accompanied by an appropriate learning process is necessary to actively engage students and provide feedback to evaluate their learning.

The appropriate use of learning media can help improve the effectiveness of the learning process and the delivery of learning content (Wulandari et al., 2023), as well as make it easier for students to understand the

material and will lead to improved student learning outcomes (Hasan et al., 2021). With the development of technology, learning media nowadays are not limited to slides, books, and whiteboards but may also be created in the form of interactive videos. In terms of content, interactive videos are no different from linear videos. The difference lies in how assessment are delivered through interactive features in form of questions, which students answer while the material is playing. The system automatically pauses the video when a question appears and requires students to give an answer before playback can resume. According to research conducted by Waruwu and Sitinjak (2022), interactive media has a positive impact on both students and educators. For students, the quiz feature in interactive videos helps them identify their weaknesses in understanding concepts. For teachers, students' quiz answers provide insight into which concepts students have not yet understood, allowing teachers to focus on those concepts during instruction in a way that aligns with students' current understanding. Research by Hidayah et al. (2023), attempted to integrate interactive videos with a learning model using STAD design, the results showed that the use of interactive videos had an effect on students' conceptual understanding. According to research Rahma et al. (2024) using interactive videos as a learning media can improve student motivation and learning outcomes.

In addition to learning materials, assessment is also necessary during the learning process to determine whether the learning activities implemented have facilitated students in achieving the desired learning outcomes (Anisah, 2022). One assessment approach that actively involves students during the learning process is Assessment for Learning. Assessment for Learning is a type of evaluation conducted during the teaching program designed to monitor students' daily learning engagement in instructional activities, thereby providing feedback to both students and teachers (Maryanti et al., 2022). Feedback in Assessment for Learning helps students reflect on and interpret learning concepts, enabling them to acquire accurate knowledge (Poerwanti & Winarni, 2021). Research has shown that learning based on Assessment for Learning is effective in improving student learning outcomes (Safithri & Muchlis, 2022; Dini & Muchlis, 2022).

According to research conducted by Hidayah and Permatasari (2025), several studies have been conducted on the use of interactive videos in chemistry lessons, but the measured variable is an improved motivation in chemistry learning. While there have been several studies on the application of assessment for learning to improve learning outcomes in chemistry learning (Safithri & Muchlis, 2022; Dini & Muchlis, 2022), but there have been no studies integrate interactive video media with the use of the assessment for learning approach to improve learning outcomes. This study seeks to address this gap by examining how interactive videos, when used with the assessment for learning approach, can enhance student learning outcomes in the topic of chemical bonding.

The aim of this study is to determine the effectiveness of using interactive videos with an assessment for learning approach in improving student learning outcomes on chemical bonding material. Through this study, empirical evidence is expected to be obtained regarding the contribution of integrating the assessment for learning approach into digital media toward strengthening students' conceptual understanding and the achievement of cognitive competencies.

## 2. Method

This study used a pre-experimental design with a one group pretest posttest design employing a quantitative approach. This study involved a single group of subjects, namely the experimental group, which was treated using interactive videos on chemical bonding material using the assessment for learning approach. This design includes a pretest measurement followed by treatment and a posttest measurement for a single group (Creswell & Cresswell, 2017), as illustrated in Figure 1. A one group pretest-posttest design was chosen because it directly measures improvements in learning outcomes by comparing pretest and posttest scores after the same group of subjects received the treatment (Sugiyono, 2019), which aligns with the objectives of this study. Despite the limitations of this study, which stem from the inability to control external factors (Arib et al., 2024), the constraints were primarily due to the classroom environment at the school where the research took place. This setting prevented the randomization of participants or the formation of a control group without interfering with the ongoing educational activities. Research by Pradita et al. (2026) suggests that employing a single group with pre- and post-treatment assessments is more suitable. This approach helps reduce bias from initial group differences and allows for direct observation of changes in learning outcomes.

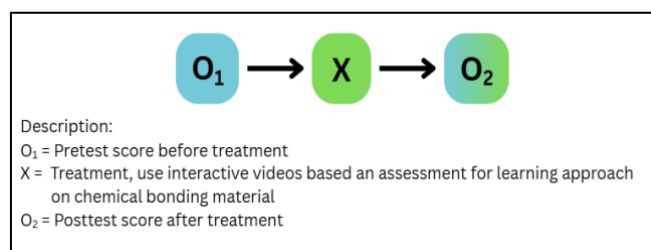


Figure 1. Research Design

The population for this study consisted of 11th-grade science students at a high school in Surabaya, Indonesia, who were studying chemistry. From this population, one class with 30 students was selected as the research sample to serve as the single experimental group in accordance with a one group pretest-posttest design. The sampling technique used was purposive sampling, which involves selecting a sample based on specific criteria that align with the research objectives (Khoiroh et al., 2026). The criteria used for selecting the sample were that the students had already studied the basic material before beginning the study of chemical bonding, specifically atomic structure, electron configuration, valence electrons, and the periodic table of elements, and that each student had an electronic device to access interactive video content. In this study, two sessions were held, with each session focusing on one interactive video. Interactive video 1 provided an introduction to chemical bonds and ionic bonds in 9 minutes, while interactive video 2 covered covalent bonds and metallic bonds in 14 minutes. The interactive videos are used on the Wayground platform.

This study used a test method to measure students' learning outcomes on the topic of chemical bonding. This test method consisted of a cognitive test on chemical bonding, consisting of 16 pretest questions and 16 posttest questions, both in multiple-choice format, and the validity of the test instrument had been verified. After obtaining the pretest and posttest scores, an analysis was conducted to determine the effectiveness of interactive videos with an assessment of learning approach on the subject of chemical bonding in improving learning outcomes, which can be seen from the increase in pretest-posttest scores. The pretest and posttest results were analyzed using statistical tests and N-Gain analysis. The statistical test used was the Wilcoxon Signed-Rank test, because the data were not normally distributed (Fitri et al., 2023). In addition, an N-Gain analysis was also conducted to determine the detailed improvement in learning outcomes for each student. The N-Gain analysis is calculated using Equation 1. The N-Gain scores were then analyzed based on the criteria for improvements in student learning outcomes as shown in Table 1. The use of interactive videos with an assessment of learning approach on chemical bonding material can be considered effective if at least 76% of students achieve an N-Gain score of  $\geq 0.3$  on the medium and/or high criteria.

$$N - Gain (g) = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}} \quad (1)$$

**Table 1. Criteria Improvement of Learning Outcomes Based on N-Gain**

N-Gain	Criteria
$g > 0.7$	High
$0.7 \geq g \geq 0.3$	Medium
$g < 0.3$	Low

### 3. Results and Discussion

#### 3.1. Results

##### 3.1.1. Pretest-Posttest Scores

The learning outcome data in this study were obtained through tests administered before (pretest) and after (posttest) the use of interactive video media with an assessment for learning approach on chemical bonding material. The scores of 30 students in one of the 11th-grade classes are presented in graphical form in Figure 2 and in descriptive statistics form in Table 2.

As shown in Figure 2, each student's pretest score improved compared to their posttest score. This improvement occurred after the students learned about chemical bonding using interactive videos with an assessment for learning approach.

**Table 2. Descriptive Statistics of Pretest-Posttest Scores**

Variable	N	Mean	Minimum Score	Maximum Score	Std. Deviation
Pretest Scores	30	61.41	6.25	94.00	25.88
Posttest Scores	30	95.76	75.00	100.00	6.04

Based on Table 2, it can be seen that the use of interactive videos with an assessment for learning approach has proven to have a significant positive impact on student learning outcomes. This improvement is shown in the average score, which increased from 61.41 to 95.76. Additionally, the minimum student score also saw a drastic increase from 6.00 to successfully reach the minimum passing score of 75.00, followed by the highest score reaching a maximum score of 100.00.

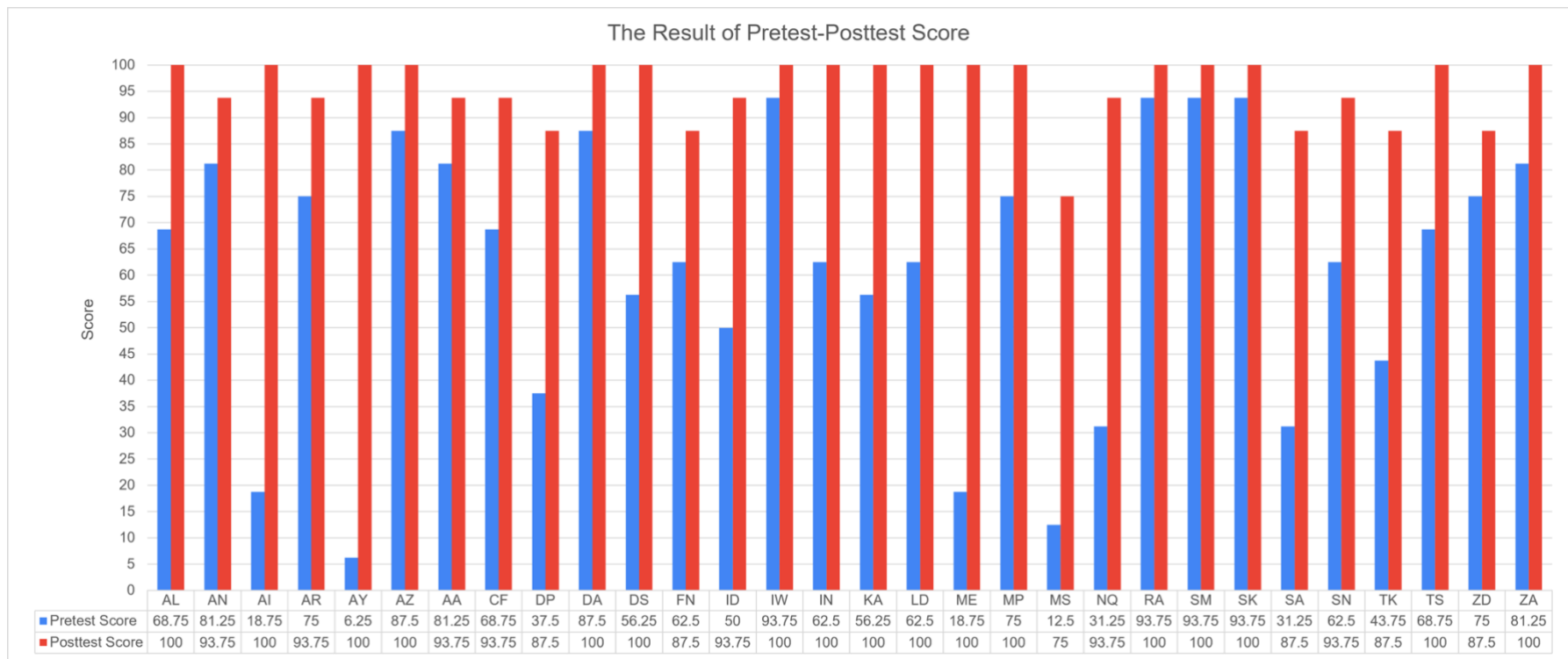


Figure 2. The Results of Pretest and Posttest Scores

### 3.1.1 Statistical Test Result

The Wilcoxon Signed-Rank test was conducted, resulting in a Sig. value of 0.000; if the Sig. value is less than 0.05, it indicates a significant difference between the posttest and pretest scores (Ahmadi et al., 2024). The results indicate that there is a significant difference in student learning outcomes after using interactive videos with an assessment for learning approach on the chemical bonding material.

### 3.1.2 N-Gain Analysis Result

The Wilcoxon Signed-Rank Test is a test that can only indicate the presence of a significant difference between two variables (Ahmadi et al., 2024). In order to determine whether there has been an improvement in learning outcomes, further analysis using N-Gain analysis is required. The recapitulation of N-Gain results is presented in Table 3.

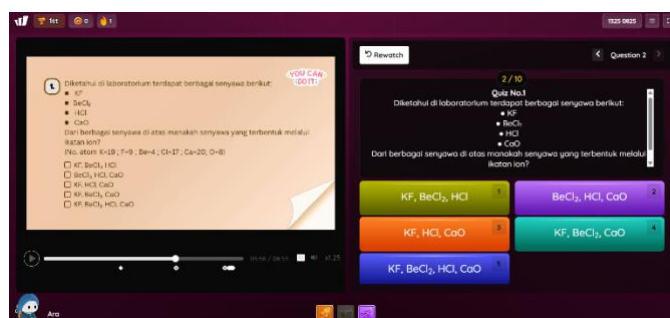
**Table 3. Recapitulation of N-Gain Score Results**

N-Gain Scores	Criteria	Frequency	Percentage (%)
0.70 – 1.00	High	26	86.7
0.30 – 0.69	Medium	4	13.3
0.00 – 0.29	Low	0	0

Table 3 shows that 86.7% of students achieved high criteria and 13.3% achieved moderate criteria in terms of improvement in learning outcomes, and there were no students who achieved low criteria. These results indicate that the use of interactive videos with an assessment for learning approach is effective in improving learning outcomes in the subject of chemical bonding.

## 3.2 Discussion

This study was conducted to learn about chemical bonding using interactive video media with an assessment for learning approach. Because it used an assessment for learning approach, the learning process involved several stages, including students setting learning goals, asking questions to assess students' understanding during the learning process, providing feedback based on students' answers, and reflecting on the learning process to improve future learning (Black & Wiliam, 2009). The use of interactive video media is integrated with the assessment for learning stages from the first through the fourth stage, with the interactive video media utilizing the Wayground platform. The first stage involves an interactive video featuring open-ended questions that students answer to set their own learning goals; this helps motivate students to achieve their goals while learning (Zhang et al., 2025). The second stage consists of multiple-choice questions in the interactive video, which are used to directly assess students' understanding after they have watched the video material. According to research Ramasany et al. (2022), inserting questions at key moments in the video encourages students to actively process information, so that interactive videos can increase student interest while helping them become more active in the classroom. The question interface in the interactive video is shown in Figure 3. The third stage involves providing feedback using the automatic feedback feature in the interactive video. This automatic feedback feature has been set up for each answer option in the multiple-choice quiz. Immediate feedback provided when answering quizzes in interactive videos is intended to help students understand what they need to pay more attention to if their answer is incorrect, and to reinforce concepts for better understanding. The quickness of feedback helps maintain students' attention and relevance, addressing the conventional weakness of delayed feedback, which can diminish students' interest in learning (Rahmasari, 2025). The feedback screen that appears after answering a question in the interactive video is shown in Figure 4. The fourth stage is to reflect on the learning process that has occurred in order to improve future learning. At this stage, an interactive video concludes with an open-ended question asking students to reflect on their own performance, identify their strengths and weaknesses in learning, and design strategies for future learning. The purpose of this is to ensure that students are no longer passive receivers of information but are actively involved in the assessment process, so that they can manage, monitor, and evaluate their learning progress based on the feedback they receive (Suciati & Mulyani, 2025).



**Figure 3. The Question Interface in Interactive Video**

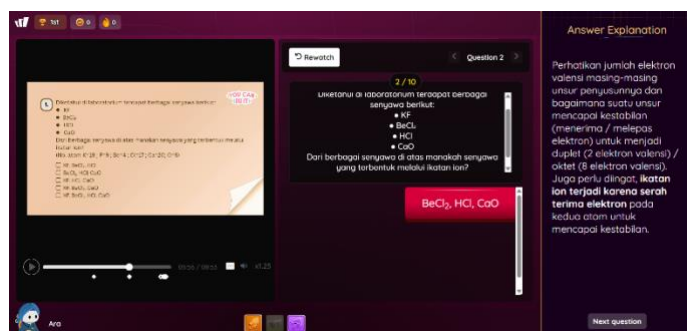


Figure 4. The Feedback Screen After Answering Question

The findings of this study indicate that the use of interactive videos with an assessment for learning approach has a significant impact in improving students' learning outcomes on chemical bonding material. This is evidenced by the N-Gain analysis results presented in Table 3, which show that 100% of students achieved moderate or high categories. The visualization of abstract concepts in chemical bonding material, combined with the integration of interactive features within the video such as embedded questions that provide immediate feedback, applies the core principles of assessment for learning can increase the learning outcomes. The immediate feedback in interactive videos allows students to independently assess their conceptual understanding before moving on to more complex concepts. These findings are supported by research by Erawati (2025), which states that the use of audiovisual and interactive media, such as interactive videos, can strengthen conceptual understanding through direct experience and motivate students with a more engaging learning approach. Learning using assessment for learning, which involves students completing several stages, such as setting learning goals, answering questions based on their understanding, receiving feedback to improve their understanding, and self-reflection, can improve student learning outcomes (Fitria & Muchlis, 2026; Nisa et al., 2026). Thus, the use of interactive videos with an assessment for learning approach can effectively improve students' learning outcomes on chemical bonding material.

### 3.3 Implications

Theoretically, research findings indicate that the use of instructional media integrated with an assessment for learning approach can support effective learning processes. In practice, for teachers and educators, this can save valuable face-to-face time in the classroom, instead of spending time on one-way lectures that make students less active, teachers can use interactive videos to deliver concepts in a self-directed manner, so that class time can be allocated for higher-level discussions or collaborative projects. For students, this media implies the growth of learning independence, where they have full control over their own learning pace without fear of being left behind by their friends.

### 3.4 Limitations

Author realize that this study has several theoretical and methodological limitations that must be taken into consideration when interpreting the results. The main limitation stems from the use of a one group pretest-posttest design. The limitations caused by the classroom conditions at the school where the research was conducted, which made it impossible to randomize subjects or form a control group without disrupting the ongoing teaching and learning process. Without an equivalent control group, the significant increase in scores from the pretest to the posttest cannot be attributed purely and absolutely to the learning intervention (treatment) that was provided. From a cognitive psychology perspective, this design is highly sensitive to threats to internal validity, such as the testing effect and the pretesting effect. According to Mera et al. (2025), completing pretest questions, even though subjects make many errors because they have not yet been exposed to the material, naturally triggers the pretesting effect. This process cognitively activates prior knowledge, focuses the subjects' attention, and optimizes the encoding of new information when they encounter it during the treatment. Furthermore, administering a posttest also leverages the testing effect or retrieval practice, in which the subjects' memory is reinforced through repeated access to a similar assessment instrument (pretest-posttest).

## 4. Conclusion

This study concluded that the use of interactive videos with an assessment for learning approach is effective in improving student learning outcomes on chemical bonding material. Through interactive videos with assessment for learning, students can identify their strengths and weaknesses in learning, enabling them to create better learning plans to achieve their goals. This effectiveness is shown by the N-Gain scores, where 100% of students achieved an N-Gain score higher than 0.3, with 86.7% of students achieved high criteria and 13.3% achieved moderate criteria. These research results can be used by teachers and educators as a consideration for using learning media based on assessment for learning in teaching, as well as by researchers to develop other

learning media based on assessment for learning or to conduct replication using a true experimental design to test students' long-term memory retention more comprehensively.

## Author Contributions

Tiara Puspitasari: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Visualization, Roles/Writing - original draft. Muchlis: Supervision, Validation, Writing - review & editing.

## Funding

No funding support was received.

## Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

## Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

## Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

## Acknowledgement

The authors would like to express their gratitude for the assistance and support provided by various parties in this study, including to the head of the chemistry education program, the validators, the observers, the chemistry teacher and the students of Class XI-8 at the school where this study was conducted. The authors would especially like to thank their family and colleagues, who have consistently supported and accompanied the authors in the preparation of this article.

## References

- Ahmadi, R., Murah, & Sulaiman. (2024). *Statistik nonparametrik*. Lembaga Yasin ALSys.
- Anisah, G. (2022). Kerangka konsep assessment of learning, assessment for learning, dan assessment as learning serta penerapannya pada pembelajaran. *Al-Aufa: Jurnal Pendidikan dan Kajian Keislaman*, 3(2), 65–76. <https://doi.org/10.32665/alaufa.v3i2.1201>
- Arib, M. F., Rahayu, M. S., Rusdy, A. S., & Afgani, M. W. (2024). Experimental research dalam penelitian pendidikan. *Journal of Social Science Research*, 4(1), 5497–5511. Retrieved from <https://j-innovative.org/index.php/Innovative/article/download/8468/5784/13529>
- Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, 21(1), 5–31. <https://doi.org/10.1007/s11092-008-9068-5>
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE Publications.
- Dini, P. C., & Muchlis, M. (2022). Peningkatan hasil belajar peserta didik melalui implementasi pembelajaran berbasis assessment for learning pada materi kesetimbangan kimia. *PENDIPA Journal of Science Education*, 6(2), 565–572. <https://doi.org/10.33369/pendipa.6.2.565-572>
- Erawati, D. (2025). Integrasi media dalam pembelajaran: Pendekatan konstruktivisme Vygotsky. *Anterior Jurnal*, 24(3), 1–7. <https://doi.org/10.33084/anterior.v24i3.9726>
- Fitri, A., Rahim, R., Nurhayati, Aziz, Pagiling, S. L., Natsir, I. Anugrah, N. E. (2023). Dasar-dasar statistika untuk penelitian . Medan: Yayasan Kita Menulis.
- Fitria, M. R., & Muchlis. (2026). Enhancing students' learning outcomes in chemistry learning through assessment for learning. *IJCER: International Journal of Chemistry Education Research*, 10(1), 25–34. <https://doi.org/10.20885/ijcer.vol10.iss1.art3>
- Hidayah, F. N., & Permatasari, R. E. (2025). The effectiveness of using interactive video-based media to improve motivation in chemistry learning: A literature review. *Proceeding of International Joint Conference on UNESA*, 3(1), 1–7. Retrieved from <https://proceeding.unesa.ac.id/index.php/pijcu/article/view/7105>
- Hidayah, N., Pamungkas, S. J., & Alamsyah, M. R. N. (2023). Pengembangan video pembelajaran interaktif materi fungi dalam desain STAD serta pengaruhnya terhadap pemahaman konsep siswa kelas X SMA Assalam Tempuran. *Jurnal Sains dan Edukasi Sains*, 5(2), 72–80. <https://doi.org/10.24246/juses.v5i2p72-80>

- Husain, A., Nurjanah, A. S., Azimaturaviah, Priyadi, D., Ghofur, M. A., & Mulyani, S. (2022). Review literatur: Analisis media pembelajaran terhadap pemahaman konsep siswa pada materi ikatan kimia. *Prosiding Seminar Nasional*, 32–52.
- Khoiroh, U., Nashrullah, & Anam, S. (2026). Analisis teknik sampling dalam penelitian kuantitatif dan pengaruhnya terhadap kualitas data. *Pediaqu: Jurnal Pendidikan Sosial dan Humaniora*, 5(1), 1418–1424. Retrieved from <https://publisherqu.com/index.php/pediaqu/article/view/3914>
- Maryanti, S., Hartati, S., & Kurniawan, D. T. (2022). *Assessment for learning: Educandy & Wordwall*. Yayasan Rumah Rawda Indonesia.
- Mera, Y., Dianova, N., & Marin-Garcia, E. (2025). The pretesting effect: Exploring the impact of feedback and final test timing. *Journal of Cognition*, 8(1), 1–21. <https://doi.org/10.5334/joc.455>
- Nisa, T. A. K., Muchlis, & Adam, A. S. (2026). Assessment for learning in chemistry learning: One of the best ways to improve learning outcomes. *Journal of Environment and Sustainability Education*, 4(2), 267–277. <https://doi.org/10.62672/joease.v4i2.243>
- Poerwanti, J. I. S., & Winarni, R. (2021). Pelatihan dan pendampingan merancang instrumen assessment for learning berbasis portofolio pada guru-guru sekolah. *Jurnal Widya Laksana*, 10(1), 44. <https://doi.org/10.23887/jwl.v10i1.28423>
- Pradita, E. S., Muchlis, & Nisa, K. (2026). The effectiveness of student activity sheets with assessment for learning approach in improving students' problem solving skills on reaction rate materials. *Jurnal IPA & Pembelajaran IPA*, 10(1), 70–84. Retrieved from <https://publications.usk.ac.id/index.php/jipi/article/view/622>
- Putri, Y. E., & Yerimadesi. (2025). Analisis hasil belajar peserta didik pada materi ikatan kimia fase F SMA/MA. *SCIENCE: Jurnal Inovasi Pendidikan Matematika dan IPA*, 5(3), 1417–1426. <https://doi.org/10.51878/science.v5i3.6830>
- Rahma, M. A., Supriyatno, T., & Gafur, A. (2024). Revolution in learning moral beliefs: Development of interactive video media to improve student motivation and learning outcomes. *Educazione: Journal of Education and Learning*, 2(1), 25–37. <https://doi.org/10.61987/educazione.v2i1.545>
- Rahmasari, T. P. (2025). Wordwall: Evaluasi pembelajaran berbasis gamifikasi dalam mendukung deep learning. *Jurnal Pengabdian Masyarakat dan Riset Pendidikan*, 4(1), 3840–3844. <https://doi.org/10.31004/jerkin.v4i1.2192>
- Ramasany, V., Md Noor, N., & Mohd Zaid, N. (2022). Effects of learning using EdPuzzle interactive video application on students' interest, engagement and achievement in science subjects. *Innovative Teaching and Learning Journal*, 6(2), 59–72. <https://doi.org/10.11113/itlj.v6.111>
- Safithri, D. L., & Muchlis, M. (2022). Implementasi pembelajaran berbasis assessment for learning untuk meningkatkan hasil belajar peserta didik pada materi laju reaksi. *PENDIPA Journal of Science Education*, 6(2), 547–555. <https://doi.org/10.33369/pendipa.6.2.547-555>
- Suciati, & Mulyani. (2025). Assessment for learning: Continuous improvement dalam pembelajaran. *Jurnal Ilmu Pendidikan*, 7(5), 1297–1307. Retrieved from <https://www.edukatif.org/edukatif/article/view/8589>
- Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, R&D*. Alfabeta.
- Umar, A. S., Lukum, A., Dilapanga, W., Kilo, A. L., Aman, L. O., Alio, L., ... Pahrnun, A. W. (2023). Identifikasi pemahaman konsep siswa pada materi ikatan kimia menggunakan tes diagnostik three-tier multiple choice. *Jambura Journal of Educational Chemistry*, 5(1), 67–82. <https://doi.org/10.34312/jjec.v5i2.13255>
- Vonari, I., Sidauruk, S., & Asi, N. B. (2024). Analisis kesulitan siswa dalam memahami konsep ikatan kimia: Systematic review. *Jurnal Ilmiah Kanderang Tingang*, 15(1), 215–225. <https://doi.org/10.37304/jikt.v15i1.228>
- Waruwu, A. B. C., & Sitingjak, D. (2022). Penggunaan multimedia interaktif dalam meningkatkan minat belajar siswa pada pembelajaran kimia. *Jurnal Pendidikan MIPA*, 12(2), 298–305. <https://doi.org/10.37630/jpm.v12i2.589>
- Widarti, H. R., Safitri, A. F., & Sukarianingsih, D. (2018). Identifikasi pemahaman konsep ikatan kimia. *J-PEK: Jurnal Pembelajaran Kimia*, 3(1), 41–50. <https://doi.org/10.17977/um026v3i12018p041>
- Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiyah, Z. (2023). Pentingnya media pembelajaran dalam proses belajar mengajar. *Journal on Education*, 5(2), 3928–3936. <https://doi.org/10.31004/joe.v5i2.1074>
- Zhang, H., Quan, J., Zhang, N., & Zhang, L. (2025). Investigating the effects of formative assessment on EFL students' achievement and motivation: A Self-Determination Theory perspective. *Frontiers in Psychology*, 16, 1–15. <https://doi.org/10.3389/fpsyg.2025.1664871>