

IMPLEMENTATION OF CHEMISTRY AGENT LEARNING MEDIA TO IMPROVE UNDERSTANDING OF MOLE CONCEPTS AND CHEMISTRY CALCULATIONS AT SMAN 11 SURABAYA

Suci Dewi Oktafia^{1*}, Kusumawati Dwiningsih¹, and Bambang Purwantoro²

¹ Department of Chemistry, FMNS, Universitas Negeri Surabaya

² SMA Negeri 11 Surabaya

e-mail: suci.23106@mhs.unesa.ac.id

Abstract

The aims of this research are to analyze the improvement of understanding of mole concepts and chemistry calculations of class X students through the implementation of Chemistry Agent learning media. This study applies a quantitative approach through quasi-experimental methods and nonequivalent control group design. The research subjects include students in class X-2 as an experimental group and class X-4 as a control group at SMA Negeri 11 Surabaya in the 2025/2026 school year. Data was collected using a three-tier diagnostic test instrument in the form of pretest and posttest, which classified students conceptual understanding into three categories: scientific understanding, misconception, and lack of understanding. Data were analyzed by N-gain test, Shapiro-Wilk normality test, and Mann-Whitney test using IBM SPSS application. The results showed that the improvement in understanding of mole concepts and chemical calculations in the experimental class was higher than that of the control class with an N-gain value of the experimental class reaching 0.69 which was included in the medium category, while the control class obtained 0.47 also in the medium category. The results of the normality test showed that the data was not normally distributed, so the Mann-Whitney test was carried out and an Asymp value was obtained. A sig (2-tailed) of 0.005 (<0.05) indicates a significant difference between the experimental class and the control class. Furthermore, the three-tier classification showed that the experimental class achieved higher percentages of conceptual understanding than the control class on almost all posttest items, with conceptual understanding ranging from 45.16% to 83.87% in the experimental class and from 14.29% to 77.14% in the control class. Thus, the implementation of Chemistry Agent learning media is effective to improving the understanding of mole concepts and chemistry calculations of class X students of SMA Negeri 11 Surabaya.

Keywords: educational games, concept understanding, mol concepts, chemistry agent

INTRODUCTION

Chemistry is one of the branches of Natural Sciences that discusses the properties of matter, the structure of matter, changes in matter, and the energy that accompany these changes [1]. In chemistry, the concepts studied are continuous or interconnected, so they must be studied sequentially and continuously so that the concepts can be accepted correctly [2]. Chemistry learning basically learns about the structure, properties, and changes of substances, both through chemical and physical processes [3] [4]. However, most chemical concepts are abstract so they are often difficult for students to understand [5].

In chemistry learning, especially in high school, chemistry is one of the subjects that students do not like [6]. This is due to the lack of student attention during the learning process, the lack of readiness of students to accept new concepts, and students' shallow conceptual understanding. In addition, this can also be caused by teachers who do not use learning media and do not implement various innovative learning that make students active [7]. The difficulty of students in understanding the relationship between chemistry concepts is also one of the reasons why chemistry is considered a difficult subject.

The use of learning media has an important role in supporting students to understand abstract concepts in chemistry learning. Educational game-based learning media can present abstract concepts in a more concrete and engaging way through direct interaction, so that students are actively involved in constructing their own understanding [8]. Learning media is a form of stimulus used to convey learning information. These stimuli can be moving or unmoving images, writing, reality, recorded sound, or human interaction [9].

Understanding concepts is one of the basic skills that must be mastered in learning activities [10]. Understanding concepts is the main foundation for students to understand a subject matter. When students are able to understand a concept, they will find it easier to solve the problems found [11]. In chemistry learning, students not only memorize chemical theories, formulas, and reactions, but also must be able to understand chemical concepts well and accurately [12].

One of the chemical materials that is often considered difficult for students to understand is the concept of moles. The concept of moles which includes relative atomic mass (A_r), relative molecular mass (M_r), and Avogadro's number are the basis for various calculations in chemistry. The concept of moles is related to particles that cannot be observed directly so that it is one of the obstacles that cause students to have difficulty in building an understanding of the material of the mole concept [13]. In addition, students often experience obstacles in understanding the concept of mole because they are not familiar with the material, learning tends to memorize and difficulty in solving problems related to the concept of mole [14]. This material also requires an in-depth understanding of chemical concepts and skills in performing mathematical calculations [15].

Students' difficulties in understanding the material of mole concepts and chemical calculations can hinder them in understanding other concepts in chemistry such as chemical kinetics, chemical equilibrium, thermochemistry, and solution chemistry [16]. The continuity between the concept of mole and other concepts causes the understanding of this material to be

important in learning chemistry. Therefore, innovations related to learning on mole concept materials are needed that can help students understand mole concepts more concretely. One alternative that can be used is educational game-based learning media.

Educational game-based learning can make it easier for students to understand abstract concepts through visualization and direct interaction, so that learning can be more engaging and students are more motivated to actively participate in learning activities [17]. Although various learning media have been widely used in chemistry learning, the implementation of educational game-based learning to mole concept materials is still limited. In addition, learning in the era of the Industrial Revolution 4.0 requires learning innovation that is not only centered on the delivery of materials, but also able to create interactive and collaborative learning [18]. Various previous studies have applied the use of game-based learning media in chemistry learning and shown a positive impact on students' understanding of concepts. In addition, the use of a three-tier diagnostic test instrument can help analyze students' concept understanding more deeply [19]. This diagnostic test was specifically utilized to analyze the depth of students' conceptual understanding and to differentiate between scientific understanding, lack of knowledge, and specific misconceptions regarding the mole concept. However, research that specifically applies educational game media to mole concept materials and chemical calculations to improve students' understanding of concepts is still limited. Chemistry Agent facilitates student understanding of the mole concept through interactive features that require students to solve calculation problems in stages (mission), discuss answers with group members, and receive direct feedback when completing each challenge. Because the mole concept involves abstract quantities that cannot be observed directly, such as relative atomic mass (A_r), relative molecular mass (M_r), and Avogadro's number, Chemistry Agent helps students interpret the relationship between mass, amount of substance, Avogadro's number, and the number of particles. Through this active

process, students build a more concrete understanding of the mole concept rather than merely memorizing formulas. In addition, the application of the three-tier diagnostic test instrument to assess the understanding of concepts in the material has also not been widely done.

In this study, Chemistry Agent learning media was used which was designed as a challenge-based card game to help students understand the concept of moles and chemical calculations through concept challenges, group discussion, and problem solving. Media Chemistry Agent is created as a challenge game that requires students to work together to solve problems about the concept of moles and chemical calculations to get points in completing missions, each of which contains a series of mole concept and chemical calculation problems, and earn points for each correctly completed mission. Through this activity students not only focus on solving problems, but also on the active process of understanding concepts. Based on the results of initial observations at SMAN 11 Surabaya, the chemistry learning process is still dominated by teacher-centered learning, resulting in passive student engagement. Furthermore, literature indicates that limited learning media and reliance on traditional lecture methods significantly contribute to students' difficulties in understanding chemistry concepts [20]. As a result, students experience difficulty in understanding the concept of mole and solving chemistry calculation problems.

Thus, this study aims to analyze the improvement of understanding of mole concepts and chemistry calculations of class X students in the experimental class and control class through the implementation of Chemistry Agent learning media.

METHOD

This study uses a quantitative approach with quasi-experimental methods and nonequivalent control group design. There are two research groups, namely the experimental group as the group that is given treatment and the control group as the reference group. This research was carried out in April-May 2026 at SMA Negeri 11 Surabaya.

The Chemistry Agent learning media was developed by the researcher by adapting the concept of the UNO Smart Chemistry Game, an educational card game that combines question cards and mission cards containing puzzle challenges to support active and collaborative learning [21]. In Chemistry Agent, the question cards contain problems on the mole concept and chemical calculations, while the mission cards require students to work in groups to earn points. The media was validated by one chemistry lecturer and one chemistry teacher, obtaining an average validity score of 82.3%, which is included in the very valid category.

The population used in this study is class X students of SMA Negeri 11 Surabaya for the 2025/2026 Academic Year. The subjects of the study were students in class X-4 which amounted to 35 students as the control class and class X-2 which amounted to 31 students as the experimental class. The data obtained in this study is in the form of data on understanding the concept of moles and students' chemical calculations. Data collection was carried out using a three-tier diagnostic test instrument of 10 questions given to both classes before (pretest) and after (posttest) learning. This instrument was used to classify students into three categories: students who understand the concept (correct answer and correct reason), students who experience misconceptions (incorrect answer or reason but high confidence), and students who lack understanding (incorrect answer or reason with low confidence) [22]

The data of the pretest and posttest results were scored based on the first tier (concept tier) of the three-tier diagnostic test, where one point was awarded for each item with a correct answer. Thus, each students score represents the percentage of correct answers on the concept tier. These scores were then analyzed using the IBM SPSS (Statistical Package for the Social Sciences) application through the N-gain test to measure the improvement in understanding of mole concepts and chemical calculations through the implementation of Chemistry Agent learning media. The interpretation of the N-gain value refers to the criteria for the improvement category presented in Table 1.

Table 1. N-Gain Value Criteria

Average	Criteria
$g > 0,7$	Height
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low
[23]	

Based on these criteria, if the N-gain value < 0.3 is in the low category, $0.3 \leq g \leq 0.7$ is in the medium category, and if the N-gain value > 0.7 is in the high category. Each item in the three-tier diagnostic test consists of three tiers: the first tier is the answer to the concept question, the second tier is the reason for the answer, and the third tier is the level of confidence. For the pretest and posttest, the score used for the N-gain and statistical analysis was the number of correct answers on the first tier (concept tier), while the combination of all three tiers was used to classify students conceptual understanding, misconceptions, and lack of understanding, and the results are reported separately as the percentage of responses in each category. Because the N-gain and Mann-Whitney analyses were computed from the first-tier (concept) scores, they measure the improvement in students' conceptual knowledge, while the full three-tier classification is reported separately as the percentage of students who demonstrate conceptual understanding, misconceptions, and lack of understanding.

Next, a Shapiro-Wilk normality test was carried out to determine the normally or abnormally distributed of data. Besides that, a homogeneity test is also carried out to find out the variation of the data. Both tests are used as a requirement in advanced statistical tests. The normality of the data is determined by the following guidelines [24] :

- Sig. value or significance ≤ 0.05 is abnormally distributed
- Sig. value or significance ≥ 0.05 is normally distributed

Testing the effectiveness of Chemistry Agent learning media in supporting students to understand the concept of moles and chemical calculations was carried out through advanced statistical analysis. If the data is distributed normally and homogeneously, a parametric test will be carried out, namely an independent sample

t-test. In the independent sample t-test, the decision-making criteria are based on the following guidelines [25]:

- If the Sig score ≤ 0.05 , then H_0 is rejected and H_1 is accepted
- If the Sig score > 0.05 , then H_0 is accepted and H_1 is rejected

However, if the data is not normally distributed or does not meet the assumptions of the parametric test, a nonparametric test will be performed, namely the Mann-Whitney. The decision-making criteria for the Mann-Whitney test are carried out with the following guidelines [26]:

- If the probability (Asymp. Sig) ≥ 0.05 , then H_0 is accepted
- If the probability (Asymp. Sig) < 0.05 , then H_0 is rejected

RESULTS AND DISCUSSION

The data used in this study is derived from the results of pretest and posttest assessments conducted in both the experimental control classes. These assessments were based on a three-tier diagnostic test instrument designed to measure students understanding of the concept of moles and chemical calculations. A summary of the students understanding can be found in Table 2.

Table 2. Recapitulation of Student Understanding Results

N	Statistics	Learning Completeness			
		Pretest		Posttest	
		Experiment	Control	Experiment	Control
1.	Average	54.19	49.71	86.45	77.71
2.	Maximum Score	90.00	100.00	100.00	100.00
3.	Minimum Score	0.00	10.00	40.00	40.00
4.	Completeness (%)	29.0%	11.4%	77.4%	62.9%

From Table 2, it is evident that the average learning outcomes of students in both classes improved after the learning process. The

experimental class received an average posttest of 86.45 with a learning completion percentage of 77.4%, while the control class obtained an average posttest of 77.71 with a learning completion percentage of 62.9%. The average score of the posttest and the completeness of learning outcomes in the experimental class showed higher numbers than in the control class. This shows that the improvement in learning outcomes in the experimental class was better than in the control class.

Improving the understanding of mole concepts and chemical calculations in students is also carried out through the N-gain test. This test aims to find out the extent to which students' understanding has improved in the experimental class and the control class. The results of the N-gain test for the experimental class and the control class can be seen in Table 3.

Table 3. N-Gain Test Result of Mol Concept and Chemical Calculation Understanding

Class	Pretest	Posttest	N-Gain	Category
Control	49.71	77.71	0.47	Medium
Experiment	54.19	86.45	0.69	Medium

Based on Table 3, It was obtained that the results of the N-gain analysis of the understanding of mole concepts and chemical calculations in the experimental class were 0.69 with the medium

category. From 31 students, it was obtained that as many as 21 students were included in the high category, 5 students were included in the medium category, and 5 students were included in the low category. While in the control class, the N-gain score was 0.47 with the medium category. Of the 34 students included in the N-gain calculation (one student with a perfect pretest score was excluded because no further improvement could be measured), it was obtained that as many as 13 students were included in the high category, 11 students were included in the medium category, and 10 students were included in the low category. In the experimental class and the control class, there are similarities in the categories obtained, namely medium. Although the N-gain values of the two classes are in the medium category, there is a difference between the two where the N-gain value in the experimental class is higher than in the control class. This is because the average score in the experimental class has a high difference between the pretest and posttest scores, while in the control class the average difference in pretest and posttest scores is not as high as in the experimental class.

To complement the N-gain analysis, the three-tier diagnostic test results were classified to determine the percentage of students who demonstrated conceptual understanding, misconceptions, and lack of understanding. The results are presented in Table 4.

Table 4. Percentage of Students Conceptual Understanding Based on the Three-Tier Diagnostic Test

Category	Class	Conceptual Understanding (%)		Misconception (%)		Lack of Understanding (%)	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Molar mass	Experiment	29.03	77.41	25.80	12.90	45.16	9.67
	Control	31.42	65.71	34.28	22.85	34.28	11.42
Relationship between moles and mass	Experiment	16.12	70.96	35.48	22.58	48.38	6.45
	Control	5.71	34.28	40	54.28	54.28	11.42
Relationship between moles and number of particles	Experiment	29.03	77.41	22.58	9.67	48.38	12.90
	Control	0	60	45.71	25.71	54.28	14.28
Relationship between number of particles and moles	Experiment	16.12	45.16	29.03	29.03	54.83	25.80
	Control	11.42	14.28	48.57	68.57	40	17.14

Category	Class	Conceptual Understanding (%)		Misconception (%)		Lack of Understanding (%)	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Concept of the mole as a unit of amount of substance	Experiment	32.25	67.74	19.35	29.03	48.38	3.22
	Control	20	34.28	45.71	57.14	34.28	8.57
Mole ratio based on the coefficients of a chemical equation	Experiment	32.25	77.41	19.35	3.22	48.38	19.35
	Control	11.42	54.28	37.14	31.42	51.42	14.28
Mass percentage	Experiment	16.12	74.19	35.48	16.12	48.38	9.67
	Control	25.71	77.14	31.42	17.14	42.85	5.71
Relationship between moles and mass	Experiment	25.80	70.96	29.03	9.67	45.16	19.35
	Control	25.71	62.85	22.85	14.28	51.42	22.82
Relationship between moles and mass	Experiment	19.35	70.96	25.80	6.45	54.83	22.58
	Control	28.57	65.71	17.14	17.14	54.28	17.14
Mass percentage	Experiment	9.67	83.87	41.93	6.45	48.38	9.67
	Control	8.57	71.42	48.57	22.85	42.85	5.71

Based on Table 4, the three-tier diagnostic test results were further analyzed per item to identify the concepts that were most difficult for students. On the posttest, the experimental class showed conceptual understanding ranging from 45.16% to 83.87%, with misconception generally below 30%. In contrast, the control class showed greater variation, with conceptual understanding ranging from 14.29% to 77.14% and persistently high misconception on several items.

The most difficult concept for both classes was the relationship between the number of particle and moles. In the experimental class 45.16% of students demonstrated conceptual understanding on this item, whereas only 14.29% of control students did, and 68.57% of control students still held misconceptions compared with 29.03% in the experimental class. A similar pattern was observed for the relationship between moles and mass and the concept of the mole as a unit of amount of substance. In the relationship between moles and mass, the experimental class displayed lower misconceptions compared to the control class, and similar trend was observed for the concept of the mole as a unit of amount substance.

These findings suggest that the implementation of Chemistry Agent learning media not only increased conceptual understanding

but also reduced misconceptions, particularly on abstract concepts involving the conversion between moles, mass, and number of particles. Student still struggled more with the connection between the number of particles and moles. This suggests that this concept may challenging for students that provide more learning activities that explicit connections between symbolic calculation and the underlying chemical concepts.

So based on the results of the analysis of the average value and N-gain, it shows an increase in understanding of the concept of mole and chemical calculations in both classes. However, the increase that occurred in the experimental class was greater than that of the control class. This shows that the use of Chemistry Agent learning media has a better influence on improving student understanding.

The increase can be influenced by the use of Chemistry Agent educational game-based learning media which is interactive and fun, so that it can increase student participation in the learning process. The game is designed based on concept challenges, question cards, and problem-solving missions that require students to understand, discuss, and apply the concepts of moles and chemical calculations directly. Through this activity, students not only passively receive the material but are involved in thinking, discussing,

and designing strategies to overcome challenges in the game.



Figure 1. Implementation of Learning with Chemistry Agent Learning Media

Learning media based on educational games provides opportunities for students to be directly involved in the learning process, so that students' understanding of concepts becomes deeper. This is in line with the results of the research [27] which shows that educational games can improve understanding of concepts and make the learning process more interesting for students. Previous research has also shown that the implementation of game-based learning media can increase students' active participation in the learning process, as students are directly involved in problem solving [28]. Other research shows that the application of interactive learning media to abstract chemistry materials can make it easier for students to understand the relationship between concepts [29].

Mole concept material is often considered difficult material by students. This is because the abstract concept of mole is actually taught by the lecture method, so that learning is still teacher-centered and causes students not to play an active role in analyzing and solving problems [30]. Therefore, the use of educational games supports students in understanding concepts through more contextual and interactive activities.

In addition to increasing student active participation, Chemistry Agent media also encourages the creation of more meaningful learning through group discussion and problem-solving. Students not only gain information, but also develop their own understanding through the learning experiences gained during the game. This statement is in line with the theory of constructivism which explains that students play an active role in building knowledge through social experience and interaction [31].

In the control class, conventional learning methods make students tend to be more passive during the learning process. The lack of student participation in discussion and problem-solving activities causes the understanding of the concepts obtained to be less in-depth than the experimental class.

After obtaining the N-gain value from the experimental class and the control class, then a normality and homogeneity test was carried out as a condition for statistical testing. The test results will be used in analyzing the effectiveness of the Chemistry Agent learning media. The normality test is performed to determine whether the N-gain data from the experimental class and the control class are normally distributed or not, as well as the basis for determining the type of statistical test to be performed for further analysis. The study used the test of normality from Shapiro Wilk with a significance level of 5% (0.05). The results of the normality test can be seen in Table 5.

Table 5. N-Gain Data Normality Test Results

Class	Shapiro Wilk	
	Sig.	Description
Experiment	< 0.001	Abnormal distributed data
Control	< 0.001	Abnormal distributed data

Based on Table 5. The result of the normality test for the experimental class was < 0.001 which stated that the data was distributed abnormally because the value was less than 0.05. Meanwhile, in the control class, the normality test results were obtained with a value of < 0.001, which states that the data is distributed abnormally because it is less than 0.05.

Thus, because the N-gain data is not normally distributed, the assumptions for the parametric test are not met, so homogeneity analysis is not used as a basis for hypothesis test decision-making. Therefore, a hypothesis test was carried out using the Mann-Whitney test. The Mann-Whitney test was conducted to see if there was a significant difference in student comprehension improvements in the experimental and control classes. The results of the Mann-Whitney test can be seen in Table 6.

Table 6. Mann-Whitney Test Result

Asymp. Sig (2-tailed)	Description
0.005	H ₀ is rejected and H ₁ is accepted

Based on the results of the Mann-Whitney test in Table 6. Significant results were obtained for Asymp. Sig (2-tailed) is 0.005 or less than 0.05 so that H₀ is rejected and H₁ is accepted or there is a difference in the improvement in understanding of mole concepts and chemical calculations between students from the experimental class using Chemistry Agent media and students from the control class who apply conventional learning. Therefore, the use of Chemistry Agent learning media has proven to be effective in improving students' understanding of mole concepts and chemistry calculations. The findings in this study are in line with previous research that showed that the implementation of game-based learning media in chemistry learning can improve students' understanding of concepts.

Based on all the results of the analysis, it can be concluded that the Chemistry Agent learning media has a positive influence on improving the understanding of class X students at SMA Negeri 11 Surabaya on the mole concept material and chemical calculations. The implementation of educational game-based learning media can produce more active, interactive, and meaningful learning, thereby helping students to better understand abstract chemistry concepts.

CONCLUSION

Based on the results of the research, it can be concluded that the implementation of Chemistry Agent learning media has an impact on improving the understanding of mole concepts and chemistry calculations of class X students at SMA Negeri 11 Surabaya. This is shown by the increase in the average value of the posttest and the N-gain in the experimental class which is higher than the control class as well as the Mann-Whitney test which shows a significant difference between the two classes, namely the Asymp value. Sig. (2-tailed) reaches 0.005 (<0.05).

Thus, the Chemistry Agent learning media is effective in improving understanding of the concept of moles and chemical calculations as shown through the N-gain value of the

experimental class of 0.69 and the results of the Mann-Whitney test of 0.005 (<0.05). In addition, the three-tier diagnostic test classification showed that the percentage of students conceptual understanding in the experimental class was higher than in the control class on almost all posttest items, which further supports the effectiveness of the Chemistry Agent learning media in improving students' understanding of the mole concept. This research has limitations, namely focusing only on one material (the concept of moles and chemical calculations) and only being carried out in two classes in one school, so the generalization of the results is still limited. In addition, this study has not explored other factors such as deeper learning motivation or long-term retention of students after the learning process. Based on these limitations, it is suggested that further research can expand the material analyzed, involve more samples from various educational institutions, and explore the impact of Chemistry Agent learning media on other variables such as learning motivation, critical thinking skills, or concept memory in the long term.

REFERENCES

1. Dewi, D. P. D. P., Subagia, I. W., and Wiratini, N. M. 2026. Analisis Penguasaan Konsep Dasar Ilmu Kimia Siswa Kelas XII SMA Analysis of Basic Chemistry Concept Mastery Among Grade XII Students at SMA. *Jurnal Riset dan Praktik Pendidikan Kimia*, Vol. 14, No. 1, pp. 38–49.
2. Nurisah, R. P., Agustina, W., Nurma, D., and Indriyanti, Y. 2019. Penerapan Model Pembelajaran Discovery Learning Berbantuan Lembar Kerja Siswa (LKS). *Jurnal Pendidikan Kimia*, Vol. 8, No. 2, pp. 259–266.
3. Arnita, B. D. A. 2026. Pengaruh Penggunaan Nitrogen Cair dalam Demonstrasi Edutainment Kimia terhadap Pemahaman Konsep Suhu dan Perubahan Wujud Zat. *Journal of Science and Technology: Alpha*, Vol. 2, No. 1, pp. 10–15.
4. Rahmadhea, S. 2026. Implementasi Laboratorium Virtual dalam Pembelajaran Sains untuk Meningkatkan Pemahaman Konseptual Peserta Didik. *JSE: Journal Sains and Education*, Vol. 4, No. 1.
5. Fatihah, W., and Wiji. 2026. Implementasi Deep Learning pada Pembelajaran Kimia: Tantangan, Urgensi dan Transformasi Pedagogik. *Jurnal Riset dan Praktik Pendidikan Kimia*, Vol. 14, No. 1, pp. 1.

6. Sari, R. N., and Maharani, E. T. W. 2019. Minat Belajar Kimia Siswa Kelas X MIPA di Madrasah Negeri Kota Semarang. *PRISMA, Prosiding Seminar Nasional Matematika*, pp. 552–561.
7. Prayunisa, F. 2026. Analisa Kesulitan Siswa Kelas XI dalam Pembelajaran Kimia di SMAN 1 Masbagik. *Journal of Classroom Action Research*, Vol. 4, No. 3, pp. 147–150.
8. Byusa, E., Kampire, E., and Mwesigye, A. R. 2022. Game-based Learning Approach on Students' Motivation and Understanding of Chemistry Concepts: A Systematic Review of Literature. *Heliyon*, Vol. 8, No. 5, e09541, pp. 1–10.
9. Rahman, M., Nursyabilah, I., Astuti, P., Syam, M. I., Mukramin, S., and Kurnawati, W. O. I. 2026. Pemanfaatan Media Sosial Sebagai Media Pembelajaran. *Journal on Education*, Vol. 5, No. 3, pp. 10646–10653.
10. Harefa, D., Sarumaha, M., Fau, A., Telaumbanua, T., Hulu, F., Telaumbanua, K., Lase, I. P. S., Ndruru, M., and Ndraha, L. D. M. 2022. Penggunaan Model Pembelajaran Kooperatif Tipe Jigsaw Terhadap Kemampuan Pemahaman Konsep Belajar Siswa. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, Vol. 8, No. 1, pp. 325–332.
11. Indiaty, P., Puspitasari, W. D., and Febriyanto, B. 2026. Pentingnya Media Tangram Terhadap Kemampuan Pemahaman Konsep Bangun Datar. *Prosiding Seminar Nasional Pendidikan*, pp. 290–294.
12. Sihaloho, M., Latief, S. A., Pikoli, M., Laliyo, L. A. R., Isa, I., and Thayban, T. 2023. Analisis Penguasaan Konsep Siswa Kelas XI IPA dalam Menyelesaikan Soal Kimia pada Materi Konsep Mol. *Jambura Journal of Educational Chemistry*, Vol. 5, No. 1, pp. 60–66.
13. Siahaan, T. P. T., Maharaja, E., Siburian, G. R. L., Sitinjak, H., Siregar, M. A. F., Andini, P., Yusufiani, M. 2026. Peningkatan Hasil Belajar Siswa pada Materi Konsep Mol dengan Model Pembelajaran Problem Based Learning (PBL) di Kelas XI SMA. *Jurnal Ilmiah FKIP Universitas Mandiri*, Vol. 12, No. 2, pp. 318–322.
14. Qasimah, E. E. R., Hadinugrahaningsih, T., and Suryani, E. 2025. Analisis Pemahaman Konseptual Peserta Didik pada Materi Konsep Mol melalui Model Pembelajaran 5E (Engage, Explore, Explain, Elaborate, Evaluate). *JRPK - Jurnal Riset Pendidikan Kimia*, Vol. 15, No. 2, pp. 102–117.
15. Buangmanalu, E. A. W., and Herawati, N. 2026. Penerapan Model PBL untuk Meningkatkan Aktivitas Belajar Peserta Didik pada Materi Konsep Mol. *Jurnal Pendidikan dan Profesi Keguruan*, Vol. 2, No. 2, pp. 174–181.
16. Husna, H., and Minda, A. 2024. Pengembangan Flipped Classroom Berbasis Inkuiri Terstruktur Menggunakan LMS Moodle Materi Konsep Mol Fase F. *Chemistry Education Practice*, Vol. 7, No. 2, pp. 315–324.
17. Ningtyas, W. S. R., and El-Yunusi, M. Y. M. 2024. Keaktifan Siswa melalui Pembelajaran Permainan Edukatif di SD Dumas Surabaya. *Walada: Journal of Primary Education*, Vol. 3, No. 2, pp. 89–100.
18. Darma, I. K., Karma, I. G. M., and Santiana, I. M. 2020. Blended Learning, Inovasi Strategi Pembelajaran Matematika di Era Revolusi Industri 4.0 bagi Pendidikan Tinggi. *PRISMA, Prosiding Seminar Nasional Matematika*, Vol. 3, pp. 527–539.
19. Kamila, N. F., and Jumaeri. 2020. Desain E-Diagnostic Test untuk Analisis Pemahaman Konsep pada Materi Redoks dan Tata Nama Senyawa. *Jurnal Phenomenon: Jurnal Pendidikan MIPA*, Vol. 10, No. 2, pp. 177–190.
20. Febriani, F., Hayyun, H., Nilawati, R., and Abdullah, A. 2024. Analysis of Comprehension Difficulties in Chemistry and Their Impact on Student Interest in Learning. *Jambura Journal of Educational Chemistry*, Vol. 6, No. 2, pp. 103–112.
21. Lisdiana, L., Windayani, N., and Helsy, I. 2025. Making UNO Smart Chemistry Card Game Media based on the Nomenclature of Hydrocarbon Compounds. *Orbital: Jurnal Pendidikan Kimia*, Vol. 9, No. 1, pp. 43–55.
22. Christiani, M., Munzil, M., and Yulianti, E. 2021. Identifikasi Miskonsepsi Materi Getaran dan Gelombang pada Siswa SMP Kelas VIII Menggunakan Three-Tier Test. *Jurnal MIPA dan Pembelajarannya*, Vol. 1, No. 4, pp. 304–321.

23. Harahap, F. S. W., Simbolon, H. Y., and Fitri, Y. 2026. Efektivitas Pembelajaran Python terhadap Pemahaman Pecahan dan Desimal: Analisis N-Gain. *Jurnal Pendidikan Indonesia*, Vol. 4, No. 1, pp. 139–156.
24. Tamara, W., and Saumi, F. 2020. Menguji Perbandingan Rata-Rata Produksi Tanaman Padi Sawah Menurut Kecamatan pada Tahun 2017-2018 di Kabupaten Langkat. *Jurnal Matematika dan Terapan*, Vol. 2, No. 1, pp. 7–10.
25. Widiastuti, B., and Nindiasari, H. 2022. Penerapan Pembelajaran Matematika Realistik untuk Mengembangkan Kemampuan Pemecahan Masalah Matematika Peserta Didik Sekolah Dasar. *Jurnal Pendidikan Matematika*, Vol. 6, No. 3, pp. 2526–2535.
26. Mubarak, A., Sahroni, and Sunanto. 2021. Mann Whitney Test in Comparing the Students' Consultation Results of Entrepreneurial Practice between Male and Female Lecturers in Economic Faculty of Pamulang University. *Procuratio: Jurnal Ilmiah Manajemen*, Vol. 9, No. 1, pp. 9–15.
27. Fatakay, H. S., Nirmalasari, M. A. Y., and Sulystyaningsih, S. N. T. 2026. Pengaruh Penggunaan Media Wordwall dalam Model Pembelajaran Langsung terhadap Pemahaman Konfigurasi Elektron Kelas X SMA Negeri I Lebatukan. *Jurnal Pendidikan MIPA*, Vol. 16, No. 1, pp. 38–44.
28. Wahyuning, S. 2022. Pembelajaran IPA Interaktif dengan Game Based Learning. *Jurnal Sains Edukatika Indonesia (JSEI)*, Vol. 4, No. 2, pp. 1–5.
29. Sinaga, W. S. E., Yusnaidar, Y., Syahri, W., and Muhaimin. 2023. Pengembangan Multimedia Interaktif Berbentuk Aplikasi Android Berbasis Multipel Representasi pada Materi Keseimbangan Kimia. *Jurnal Inovasi Pendidikan Kimia*, Vol. 17, No. 2, pp. 81–91.
30. Manampiring, G., Santoso, I., Kapahang, A., Belajar, H., and Mol, K. 2026. Penerapan Metode POGIL pada Materi Konsep Mol di Kelas X IPA SMA Negeri 2 Langowan. *Journal of Chemistry Education*, Vol. 1, No. 2, pp. 72–76.
31. Azzahra, N. T., Ali, S. N. L., and Bakar, M. Y. A. 2025. Teori Konstruktivisme dalam Dunia Pembelajaran. *Jurnal Ilmiah Research Student*, Vol. 2, No. 2, pp. 64–75.