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Analysis of Mathematical Ability and Learning Outcomes through Inquiry and Discovery Learning Assisted by Wordwall

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Abstract: This study analyzes students' mathematical abilities and learning outcomes through Inquiry Based Learning (IBL) and Discovery Learning (DL) supported by Wordwall on the topic of Basic Laws of Chemistry. This study employed a quantitative experimental approach with two experimental groups consisting of 60 10th-grade students. Grade 10 Science Class 1 participated in IBL supported by Wordwall, while Grade 10 Science Class 2 participated in DL supported by Wordwall. Data were collected using a mathematical ability test and a learning outcome test. The validity and reliability of these instruments had been tested, and the data were analyzed using normality and homogeneity tests, as well as an independent samples *t* test. Descriptively, the mean mathematics proficiency score was 78.33 in the IBL group and 73.66 in the DL group, while the mean learning outcome scores were 77.33 and 65.00, respectively. Statistical analysis revealed a significant difference in learning outcomes between the two groups ($p = 0.001 < 0.05$). These findings indicate that both learning models supported by Wordwall can be used to improve students' mathematical ability and learning outcomes in the subject of Basic Laws of Chemistry.

Keywords: Mathematical skills; inquiry-based learning; discovery learning; Wordwall; learning outcomes

INTRODUCTION

Chemistry learning not only requires students to understand concepts qualitatively but also demands the ability to use quantitative information, perform calculations, understand relationships between quantities, and interpret numerical data (Panggabean et al., 2022). Mathematical proficiency is a crucial aspect of chemistry learning because various topics require the application of mathematical operations and quantitative reasoning to systematically solve problems (Silitonga et al., 2022). However, various empirical findings indicate that the

mathematical proficiency of Indonesian students, particularly in the context of chemistry learning, remains relatively low (Pane et al., 2025). This indicates an urgent need to improve the quality of learning by strengthening mathematical skills while simultaneously increasing students' interest in learning (Putri & Cahayani, 2022).

Mathematical proficiency in chemistry learning is closely related to the topic of Fundamental Laws of Chemistry. This topic requires students to be able to perform calculations, understand quantitative relationships between substances, and relate

mathematical concepts to scientific principles (Habiddin & Nagol, 2023). Thus, understanding the fundamental laws of chemistry cannot be achieved through rote memorization alone but requires strong numerical thinking skills and proportional reasoning (Sari et al., 2018). This situation calls for the implementation of learning models capable of fostering analytical skills, problem-solving, and conceptual discovery through meaningful and exploratory learning activities (Helmiati et al., 2017). One relevant approach is the implementation of the Inquiry-Based Learning (IBL) and Discovery Learning (DL) models. Both models emphasize students' active engagement in the learning process through inquiry, exploration, and reflective thinking (Surur et al., 2024).

In addition to learning models, the use of digital media can provide variety in learning activities and assessment (Ma'arif et al., 2025). Wordwall is a web-based platform that offers various interactive activities, such as quizzes, matching exercises, and practice exercises (Suseno et al., 2025). The use of tools like Wordwall has been shown to increase student participation and provide immediate feedback that helps students identify their mistakes and improve their understanding independently (Guli et al., 2025).

Based on observations at Van Duynhoven High School in Saribudolok, chemistry instruction on the topic of Fundamental Laws of Chemistry still faces challenges, particularly in material involving calculations. Student achievement on this material is reported to be around 50%, while the minimum passing criterion used is 70%. Students also tend to be passive when faced with calculation-based problems. Interviews with teachers revealed that instruction is still dominated by expository methods and problem-solving exercises, while inquiry- and discovery-based learning models and digital media have not yet been utilized optimally.

Previous research has shown that digital-based Discovery Learning can support learning outcomes, while Inquiry-Based

Learning can be used to develop students' thinking skills. The use of Wordwall has also been reported to support student activity and engagement in learning.

LITERATURE REVIEW

Mathematical Ability

Mathematical ability is a fundamental cognitive aspect in chemistry learning, particularly because many chemical concepts are quantitative in nature and require numerical skills (Luthfiah & Muslim, 2026). Students are required not only to understand concepts theoretically but also to be able to perform calculations involving mass, volume, moles, and stoichiometric relationships between substances. Mathematical proficiency is a crucial prerequisite for accurately and rationally understanding and applying the fundamental laws of chemistry (Silitonga & Sitepu, 2022). More than just computational skills, Mathematical abilities include conceptual understanding, procedural fluency, strategic problem-solving skills, adaptive reasoning and a productive attitude toward problem-solving (Herlina & Juandi, 2022).

Operationally, mathematical ability in this study focuses on several key indicators, namely the ability to understand quantitative concepts in the laws of chemistry, the ability to apply stoichiometric calculations, the ability to analyze numerical data from experiments, and the ability to draw logical conclusions based on calculation results. These indicators reflect the analytical and quantitative skills that students need to comprehensively understand chemical concepts (Savitri & Ad'hiya, 2025).

Inquiry Based Learning

The Inquiry Based Learning (IBL) model is a learning approach that emphasizes the process of seeking and discovering knowledge through scientific activities and active student exploration (Panggabean et al., 2023). Based on constructivist theory, this approach views knowledge as being constructed independently through interaction with the environment, so that students act as

active agents in understanding concepts, rather than merely as recipients of information (Salma et al., 2025). Through this process, IBL is able to develop higher-order thinking skills, such as scientific reasoning, metacognition, and critical reflection (Devega et al., 2025)

In general, IBL involves systematic stages that include problem orientation, hypothesis formulation, conducting investigations, data analysis, drawing conclusions, and communicating results (Kartiningih, 2022). This model is student-centered, emphasizes the scientific process, fosters curiosity, and involves problem-based learning and hands-on experiences carried out collaboratively (H. L. Damayanti & Anando, 2021)

The strength of IBL lies in its ability to enhance students' critical thinking, conceptual understanding, and scientific skills. However, its implementation requires more time, strong teacher facilitation skills, and adequate resource support (Sayani & Sutiani, 2020). Overall, IBL not only contributes to cognitive development but also holistically fosters students' scientific attitudes and practical skills (Maharani & Muliati, 2025)

Discovery Learning

The Discovery Learning (DL) model is a learning approach that positions students as active participants in discovering concepts, principles, and procedures through guided exploration activities (Siregar & Panggabean, 2019) In this model, the teacher acts as a facilitator who guides students in building their own understanding, thereby enabling them to develop scientific thinking skills and a lifelong learning attitude (Sunarto & Amalia, 2022).

Discovery Learning involves complex cognitive activities such as formulating problems, developing hypotheses, collecting and analyzing data, and drawing conclusions based on empirical evidence (Meylani, 2021). Operationally, this model is implemented through six main stages: stimulation, problem

identification, data collection, data processing, verification, and generalization, which gradually guide students in systematically building knowledge (Ginting et al., 2022)

The main characteristics of Discovery Learning include student-centered learning, encouraging active exploration, and emphasizing independence in building conceptual and applied understanding (Prasetyo & Abduh, 2021). The strength of this model lies in its ability to enhance students' reasoning, engagement, and independence in learning. However, its implementation requires a relatively longer time and careful planning to ensure that the discovery process runs effectively (Panggabean & Harahap, 2020).

Wordwall

Wordwall is a web-based digital learning platform that facilitates the delivery of learning materials through interactive and engaging activities (Hadi et al., 2024). With its simple and accessible interface, Wordwall serves as a flexible tool for use in face-to-face, online, and hybrid learning (Wijayanti, 2026).

As an interactive tool, Wordwall not only serves as a medium for delivering content but also as a formative assessment tool capable of providing immediate feedback (Jannah & Masnawati, 2024). Features such as quizzes, random games, grouping activities, and puzzles allow students to actively engage in the learning process. This leads to increased motivation, engagement, and conceptual understanding among students because learning is presented in a more engaging and less monotonous format (Sinaga & Soesanto, 2022).

Learning Outcomes

Learning outcomes are key indicators for assessing the success of the learning process, reflecting changes in students' abilities after participating in learning activities. These changes encompass the cognitive, affective, and psychomotor domains, which can be observed and measured as a form of development from not

knowing to knowing, and from being unable to being able (Rahman, 2021). In the context of education, learning outcomes also serve as the basis for evaluation to determine students' achievement levels while assessing the effectiveness of the learning that has been implemented (Masithoh, 2022).

Conceptually, learning outcomes encompass three main aspects. The cognitive aspect relates to thinking skills, which include knowledge, understanding, application, analysis, synthesis, and evaluation (Fauzi & Inayati, 2023).

Various internal and external factors contribute to students' learning outcomes. (Dewayani et al., 2024). Students' learning outcomes are influenced by internal factors such as cognitive abilities, interest, motivation, and physical condition, as well as external factors such as the family environment, school setting, and teachers' instructional approaches (Salsabila & Puspitasari, 2020).

METHODS

This study employed a quantitative approach using a two-group pretest-posttest quasi-experimental design. The study was conducted at Van Duynhoven High School, Saribudolok, Simalungun Regency, North Sumatra, during the first semester of the 2025/2026 academic year. The study population consisted of 175 tenth-grade science students. The sample was determined through purposive sampling, with two intact classes selected as the experimental groups, comprising 60 students in total, 30 students in each group. Grade 10 Science Class 1, as the IBL group, received Inquiry Based Learning (IBL) supported by Wordwall, while Grade 10 Science Class 2, as the DL group, received Discovery Learning (DL) supported by Wordwall. The two groups were taught by the same teacher and were provided with identical curriculum, learning materials, and instructional time. The study began with a pretest on followed by instruction according to each model, and concluded with a posttest. The use of whole classes and purposive

sampling was considered part of the field conditions of the study; therefore, the results must be interpreted within the context of the groups under study.

Data were collected using a mathematics ability test and a learning outcome test on the topic of Basic Laws of Chemistry. The initial instruments consisted of 20 items for the mathematics ability test and 40 items for the learning outcome test. Validity test results indicated that 16 mathematics ability items and 27 learning outcome items were deemed valid. Subsequently, 10 mathematics ability items and 20 learning outcome items were selected based on validity, difficulty level, discriminative power, and distractor effectiveness. Reliability was calculated using the KR-20 method, yielding a coefficient of 0.8175 for mathematics ability and 0.9037 for learning outcomes. The learning tools included worksheets, teaching materials on the Basic Laws of Chemistry, laptops or computers, an internet connection, and Wordwall.

The data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were employed to summarize students' pretest and posttest performance in mathematical skills and learning outcomes. Data normality was evaluated using the Shapiro-Wilk test, while homogeneity of variance was tested using Levene's test, with a significance level of 0.05. An independent-samples t-test was employed to examine differences in learning outcomes between the two groups at a significance level of 0.05. Mathematical ability was not tested using an inferential difference test in this study; therefore, the comparison is presented descriptively.

RESULT AND DISCUSSION

RESULTS

Mathematics Proficiency Data

A summary of the pre-test and post-test data for experimental groups 1 and 2 is shown in Figure 1.

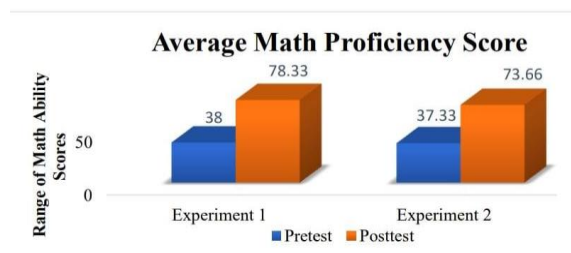


Figure 1. Average Math Proficiency Score

Based on Figure 1, it is evident that the average pre-test and post-test scores in Experiment I were 38.00 and 78.33, respectively. Meanwhile, in Experiment II, the average pre-test score was 37.33 and the post-test score was 73.66. These results indicate that learning achievement in Experiment Class I was higher than that in Experiment Class II.

Learning Outcome Data

Based on Figure 2, it is evident that the average pretest and posttest scores for Experiment I were 38.66 and 77.33, respectively. Meanwhile, for Experiment II, the average pretest score was 37.16 and the posttest score was 65.00. These data indicate that the average student learning outcomes in Experimental Class I tended to be higher than those in Experimental Class II. Furthermore, a summary of the descriptive statistics regarding the average student learning outcomes in both experimental classes is presented in Figure 2.

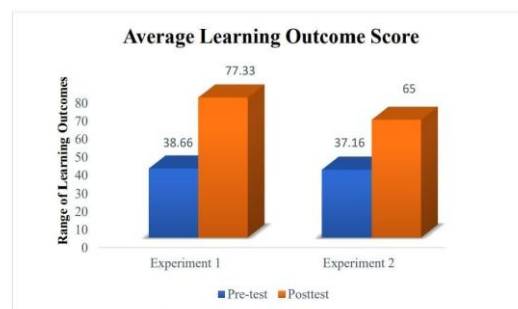


Figure 2. Average Learning Outcome Score

Prerequisite Tests for Analysis

According to the Shapiro-Wilk test, the significance values for all mathematical ability and learning outcome data exceeded 0.05. Thus, the data meet the assumption of normality. The Levene test also shows significance values of 0.950 for initial mathematical ability, 0.859 for final mathematical ability, 0.638 for pretest learning outcomes, and 0.789 for posttest learning outcomes. All values are greater than 0.05, so the data across groups meet the assumption of homogeneity. The results of the homogeneity test are presented in the following table 1.

Table 1. data homogeneity results

Data	Sig	α	Description
Initial Mathematical Ability	0.950	0.05	Homogeneous
Final Math Ability	0.859	0.05	Homogeneous
Pretest Learning Outcomes	0.638	0.05	Homogeneous
Posttest Learning Outcomes	0.789	0.05	Homogeneous

Test of Differences in Learning Outcomes

The analysis aimed to determine whether there were differences in students' learning outcomes between Experimental Class I and Experimental Class II. Table 2 presents the results of the Hypothesis test.

Table 2. Hypothesis Test Results

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hasil Belajar	Equal variances assumed	.073	.789	5.656	58	.000	12.333	2.191	7.968	16.698
	Equal variances not assumed			5.656	57.937	.000	12.333	2.191	7.968	16.698

The independent-samples t-test revealed a significance value of 0.001 ($p < 0.05$), indicating a statistically significant difference in learning outcomes between the Wordwall-assisted IBL and DL groups. Descriptively, the IBL group achieved an average score of 77.33, while the DL group achieved an average score of 65.00.

DISCUSSION

The research results show that both groups experienced an improvement in mathematical ability and learning outcomes after learning the material on the Fundamental Laws of Chemistry. Descriptively, the average posttest score for mathematical ability in the IBL group was 78.33, while that of the DL group was 73.66. Mathematical ability is a crucial component of the Basic Laws of Chemistry curriculum because students need to understand quantitative relationships, process data, perform calculations, and draw conclusions based on the results of those calculations (Sihaloho et al., 2024). Mathematical ability is one of the skills essential for learning chemistry.

These differences in descriptive achievements can be understood by examining the characteristics of learning activities in both groups. In IBL, students are guided to understand problems, formulate problems, develop hypotheses, collect data, analyze data, and draw conclusions (Sartika, 2025). This sequence of activities provides students with the opportunity to use data as the basis for inquiry and to connect it to the concepts being studied. In DL, students go through the stages of stimulus presentation, problem identification, data collection and processing, verification, and drawing conclusions (E. Damayanti et al., 2022). Both models involve active engagement and information processing, but the sequence of inquiry activities and hypothesis formulation in IBL provides a different context for students in processing problems. These differences in achievement are descriptive in nature because the study did not conduct a specific inferential test of differences in mathematical ability.

The mean posttest score for learning outcomes was 77.33 in the IBL group and 65.00 in the DL group. The independent-samples t-test showed a statistically significant difference between the groups ($p < 0.001$). One possible explanation is the nature of IBL activities, which provide students with more explicit opportunities to formulate problems, propose hypotheses, gather evidence, and analyze data before drawing conclusions (Yulnafitra & Putri, 2025). This process is relevant to the nature of the Basic Laws of Chemistry material, which requires connections between concepts, data, and calculations. These results are consistent with the study (Simbolon et al., 2026), which reported the use of inquiry-based learning in science or chemistry instruction to support learning activities and outcomes. However, the differences in results in this study cannot be entirely separated from the characteristics of the classes involved.

Wordwall was used in both groups primarily as a supporting tool for reinforcement and assessment. Interactive activities can provide variety in exercises and assist in the implementation of learning assessments (Stefania et al., 2025). Since the same medium was used in both groups, this study could not determine Wordwall's specific contribution to the differences in learning outcomes. Thus, the observed differences should be interpreted primarily as differences in achievement between the two groups that underwent the IBL and DL models with the same media support.

Overall, the findings indicate a statistically significant difference in learning outcomes between the two groups, while the differences in mathematical ability are presented descriptively. These findings must be understood within the context of the study because the sample was selected purposively from a whole class and not through individual randomization. Therefore, the results should not be interpreted as absolute proof of causality that one model is always better than the other. Furthermore, the study was limited to the subject of Basic Laws of Chemistry, two

groups of students, and the learning context at Van Duynhoven High School in Saribudolok.

CONCLUSION

Mathematics achievement improved descriptively in both groups. The posttest mean for the IBL group using Wordwall was 78.33, while that for the DL group using Wordwall was 73.66. Since the study did not conduct an inferential test of differences in mathematics achievement, this difference is not stated as statistically significant.

Learning outcomes also improved in both groups. The average posttest score for the IBL group was 77.33, and for the DL group, it was 65.00. The results of the independent-samples t-test showed $p < 0.001$, indicating a significant difference in learning outcomes between the two groups on the topic of Basic Laws of Chemistry. These findings suggest that IBL and DL supported by Wordwall can be used in teaching this material, though the interpretation is limited by the use of a whole class and purposive sampling.

Wordwall served as a supporting medium for reinforcement and assessment in both groups. The practical implication of this study is that teachers can integrate inquiry-based or discovery based activities with the same digital medium to support the teaching of Basic Chemistry, particularly when students need to understand and process quantitative information. Future research could use a larger sample and a stronger design to test differences in mathematical ability and learning outcomes more comprehensively.

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