

Effect of the Guided Inquiry Model with Deep Learning Approach on Student Learning Outcomes on Elements and Compounds Material

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Abstract: The 21st-century education requires students to develop critical thinking skills and achieve a deep conceptual understanding. Furthermore, studies integrating the guided inquiry learning model with a deep learning approach in junior high school science education remain limited. Therefore, this study aims to determine the impact and effectiveness of a guided inquiry learning model, integrated with a deep learning approach, on student learning outcomes on the topic of elements and compounds. The study employed a quantitative quasi-experimental design with a nonequivalent control group. The sample consisted of two classes, Class VIII-T1 (experimental group) and Class VIII-T4 (control group), each comprising 32 students. The research instrument was a cognitive learning outcome test consisting of 30 multiple-choice questions administered as both a pretest and a posttest. Data were analyzed using normality and homogeneity tests, an independent sample t-test, and Normalized Gain (N-Gain) analysis with the aid of SPSS version 21. The results showed that the average pretest score for the experimental group rose from 40.5 to 80.9, while the control group increased from 34.8 to 72.3. The independent sample t-test yielded a significance value (2-tailed) of 0.000 (< 0.05), indicating a significant difference between the two groups. Additionally, the N-Gain score for the experimental group was 0.71 (high category), whereas the control group achieved 0.61 (medium category). The novelty of this study lies in integrating the guided inquiry learning model with the principles of mindful, meaningful, and enjoyable learning, enabling students to construct scientific concepts in a more active, reflective, and meaningful manner. These findings indicate that integrating guided inquiry with a deep learning approach can be an innovative strategy to enhance students' conceptual understanding and learning outcomes in science, particularly in the area of elements and compounds.

Keywords: Deep Learning; Elements and Compounds; Guided Inquiry; Learning Outcomes.

Introduction

The demands of 21st-century education extend beyond knowledge acquisition to the development of critical thinking, creativity, communication, collaboration, and problem-solving skills [1]. Consequently, instruction must be designed to be student-centered, enabling students to actively construct knowledge through meaningful, contextual, and reflective learning experiences rather than passively receiving information [2]. In science education, these competencies are crucial, as science instruction is expected not only to facilitate conceptual understanding but also to foster scientific reasoning and the ability to connect scientific concepts with real-world phenomena [3].

Despite these expectations, science instruction in many junior high schools remains teacher-dominated. Learning activities are still conducted through lectures and rote memorization, thereby limiting opportunities for students to investigate, discuss, and independently construct scientific knowledge. As a result, students often experience "surface learning," characterized by rote memorization, fragmented understanding, and a limited ability to apply scientific concepts in different contexts [2-3].

One of the most challenging science topics for eighth-grade students is the study of elements and compounds, a subject that requires simultaneous

understanding of concepts at the macroscopic, symbolic, and submicroscopic levels. Students must connect observable phenomena with chemical symbols, molecular structures, and particle interactions that cannot be directly observed [4].

Preliminary observations and interviews conducted at SMPS Muhammadiyah 1 Medan revealed that many students struggle to grasp the topic of elements and compounds. Students are unable to link chemical symbols and formulas to everyday phenomena and tend to memorize definitions without understanding the underlying concepts. The average science achievement score was 41, far below the school's Minimum Learning Achievement Criterion (KKTP) of 75. Interviews with science teachers also indicated that classroom instruction remains dominated by lecture-based methods, which are perceived as easier to implement, whereas students desire a more interactive and meaningful learning experience.

These findings highlight the need for a learning model that actively engages students in constructing scientific knowledge. One model that has consistently demonstrated a positive impact on science education is Guided Inquiry. Through structured scientific investigation, students are encouraged to observe phenomena, formulate questions, gather evidence, analyze data, and draw conclusions while receiving appropriate teacher guidance.

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This model has been shown to enhance conceptual understanding, science process skills, critical thinking, and learning outcomes, particularly in science education [5-6].

Beyond selecting the right learning model, science education requires an instructional approach that fosters meaningful understanding rather than rote memorization. The Deep Learning approach emphasizes attentive, meaningful, and enjoyable learning, encouraging students to connect prior knowledge with new concepts, critically reflect on their learning experiences, and apply scientific concepts to authentic situations [7-8]. Consequently, integrating Deep Learning into Guided Inquiry has the potential to strengthen students' conceptual understanding by making scientific investigations more reflective, contextual, and meaningful.

Previous research has consistently demonstrated that Guided Inquiry enhances students' conceptual understanding and science process skills. More recent studies have integrated Guided Inquiry with digital technologies—such as PhET simulations, online learning environments, and virtual laboratories resulting in significant improvements in student engagement, higher-order thinking skills, and learning outcomes [6], [9]. Furthermore, recent reviews conclude that well-coordinated Guided Inquiry fosters conceptual understanding, scientific reasoning, motivation, and meaningful participation, provided that appropriate instructional guidance is offered at each phase of the inquiry process [10]. Similarly, the Deep Learning approach has been recognized as an effective pedagogical framework for developing deeper conceptual understanding through meaningful and reflective learning experiences [7-8].

However, significant research gaps remain. First, while previous studies have largely integrated Guided Inquiry with learning technologies or digital media, few have incorporated the pedagogical principles of Deep Learning into every phase of the Guided Inquiry process [9-10]. Second, most existing research focuses on enhancing science process skills, scientific literacy, or higher-order thinking skills; relatively few studies investigate how integrating Guided Inquiry with Deep Learning can simultaneously improve conceptual understanding and cognitive learning outcomes. Third, research examining this integrated approach within junior high school science education, particularly regarding the abstract topics of elements and compounds, remains scarce [10-11].

Therefore, this study proposes integrating the Guided Inquiry learning model with the Deep Learning approach by embedding the principles of mindful, meaningful, and enjoyable learning into each phase of Guided Inquiry. Unlike previous studies that primarily combined Guided Inquiry with technological media, this study integrates a pedagogical framework designed to facilitate deeper conceptual understanding throughout the inquiry process. This integration is expected to enhance students' active participation, improve conceptual understanding of elements and compounds, and boost cognitive learning outcomes. The findings are expected to contribute theoretically to the development of student-centered science instruction and practically offer an innovative teaching alternative for junior high school science education.

Research Methods

This study employs a quantitative quasi-experimental design with a nonequivalent control group pretest–posttest design, which is suitable for testing the effects of educational interventions when random assignment of participants is not feasible [12-13]. This design compares students' learning outcomes before and after the implementation of the Guided Inquiry learning model integrated with a Deep Learning approach.

The research was conducted at SMPS Muhammadiyah 1 Medan, located at Jl. Demak No. 3, Sei Rengas Permata Village, Medan District, Medan City, North Sumatra Province, Indonesia, during the second semester of the 2025/2026 academic year (February–April 2026). The study focuses on science instruction, specifically the topic of elements and compounds for eighth-grade students.

The population consisted of 318 eighth-grade students distributed across ten classes. The sample was selected using cluster random sampling, with each class representing a single cluster [14]. Two classes were randomly selected: Class VIII-T1 served as the experimental group and Class VIII-T4 as the control group, each comprising 32 students.

The independent variable is the Guided Inquiry learning model integrated with the Deep Learning approach, while the dependent variable is the students' cognitive learning outcomes regarding the topic of elements and compounds. Cognitive learning outcomes were measured based on the revised Bloom's taxonomy, encompassing students' abilities to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6) through objective test items [15].

The instructional intervention was implemented over four sessions. In the experimental class, Guided Inquiry-Based Learning was integrated with principles of Deep Learning, specifically, mindful learning, meaningful learning, and enjoyable learning. During the problem orientation phase, students observed contextual phenomena related to elements and compounds and identified scientific problems (mindful learning). During the hypothesis formulation and experimentation phases, students collaboratively designed investigations, gathered evidence, and tested their hypotheses (meaningful learning). During the data analysis, conclusion, and reflection phases, students interpreted experimental results, connected them to scientific concepts and daily life, reflected on their learning experiences, and communicated their findings in a collaborative and engaging classroom atmosphere (enjoyable learning). Meanwhile, the control class received conventional direct instruction consisting of teacher explanations, demonstrations, question-and-answer sessions, and individual assignments, without inquiry-based activities.

The research instrument consisted of 30 multiple-choice questions administered as pre- and post-tests to measure students' cognitive learning outcomes. Prior to implementation, the instrument was validated through expert assessment and empirical testing. Item validity was assessed using the Pearson Product–Moment correlation at a significance level of $\alpha = 0.05$. The results showed that all 30 items were valid, with correlation coefficients exceeding

the critical value ($r_{\text{calculated}} > r_{\text{table}}$). The lowest validity coefficient was obtained for Item 1 ($r_{\text{calculated}} = 0.617$), confirming that even the weakest item met the validity criteria [16]. Reliability analysis using Cronbach's Alpha yielded a coefficient of 0.864, indicating high internal consistency as it exceeded the recommended threshold of 0.70 [17]. Thus, the instrument was deemed suitable for assessing students' cognitive learning outcomes.

Data were collected through the administration of pretests and posttests. Prior to hypothesis testing, the data were checked for statistical assumptions using the Shapiro–Wilk test for normality and Levene's test for homogeneity of variance [18]. The research hypothesis was tested using an independent-samples t-test at the 0.05 significance level to determine whether learning outcomes differed between the experimental and control groups. Furthermore, the effectiveness of the Guided Inquiry learning model integrated with a Deep Learning approach was evaluated using the Normalized Gain (N-Gain) index, which classifies learning gains into high, medium, and low categories [19].

Results and Discussion

Student learning outcomes were measured using a pretest and a posttest, each administered as a 30-question objective test. The pretest was conducted to assess students' initial abilities before the learning intervention, while the posttest was used to measure improvements in student learning outcomes after the intervention. The pretest results indicated that students' initial abilities in both the experimental and control classes were relatively low and had not yet met the minimum completion criteria.

Table 1. Mean and Standard Deviation of Student Learning Outcomes

No	Class	Pre-test Mean	SD	Post-test Mean	SD
1	Control	34.8	8.06	72.3	8.17
2	Experimental	40.5	10.44	80.9	5.99

Based on Table 1, the average pretest score for the experimental class was 40.5, and for the control class, 34.8. This indicates that the initial learning abilities of students in both classes were still relatively low and comparable. After receiving the learning treatment, the experimental class implementing the guided inquiry model with a deep learning approach experienced greater improvement, with an average posttest score of 80.9, while the control class using conventional learning achieved an average score of 72.3. These results indicate that implementing the guided inquiry learning model with a deep learning approach has a greater impact on student learning outcomes for elements and compounds than conventional learning. This confirms that active student involvement in the directed inquiry process can help students understand concepts more deeply, thus impacting learning outcomes.

The homogeneity test was conducted to determine whether the variances of the data in the experimental and control classes were similar. This test used Levene's test with a significance level of 0.05. The results of the homogeneity test are presented in Table 2.

Table 2. Homogeneity Test Results

Data	Levene Statistic	Sig.
Pretest	.770	.063
Posttest	2.930	.092

Based on Table 2, the significance value for the pretest data was 0.063, and for the posttest data, 0.092. Because both significance values were greater than 0.05 (Sig. > 0.05), it can be concluded that the data variances in the experimental and control classes were homogeneous. Therefore, the assumption of homogeneity was met, making the data suitable for further parametric statistical analysis, such as hypothesis testing using the Independent Sample t-test.

Hypothesis testing was conducted using an independent sample t-test on posttest scores to determine the effect of the guided inquiry learning model with a deep learning approach on student learning outcomes.

Table 3. Independent Sample T-Test Results

Class	N	Sig.
Control	32	0.000
Experimental	32	

Based on the analysis, a 2-tailed significance value (Sig.) of 0.000 was obtained, which is less than the 0.05 level of significance ($0.000 < 0.05$). Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_a) is accepted. This indicates a significant effect of applying the guided inquiry learning model with a deep learning approach on student learning outcomes in the topic of elements and compounds. The effectiveness of the guided inquiry learning model with a deep learning approach in improving student learning outcomes was further measured using the N-Gain test, which compares pretest and posttest scores in the experimental and control classes to determine the extent of improvement.

Table 4. N-Gain Test Results

Class	N-Gain (%)	Interpretation
Control	61	Quite Effective
Experimental	71	Very Effective

The N-Gain test results showed that the experimental class experienced a greater increase in learning outcomes than the control class. The experimental class achieved an N-Gain score of 71%, considered high, whereas the control class achieved 61%, considered moderate. Although both classes showed similar improvements in learning outcomes, the experimental class consistently demonstrated greater gains on both posttest and N-Gain scores. This indicates that implementing a guided inquiry learning model with a deep learning approach is more effective than conventional learning at improving student learning outcomes in elements and compounds. These findings indicate that active student involvement in a directed inquiry process, coupled with meaningful, in-depth learning, can help students better understand concepts, leading to optimal learning outcomes.

The improvement in learning outcomes can be attributed to the application of the Guided Inquiry syntax, integrated with principles of mindful, meaningful, and enjoyable learning. During the problem-orientation stage,

students observe contextual phenomena such as rusting iron and the differences between metals and non-metals through images and videos. Initially, students assume that all shiny substances are elements. Through teacher-led questioning and discussion, they reconstruct their understanding by linking observable phenomena to scientific concepts. This meaningful learning process enables students to activate prior knowledge and reduce misconceptions, thereby enhancing conceptual understanding [20].

In the hypothesis-formulation stage, students discuss potential explanations regarding the characteristics of elements and compounds before conducting experiments. For instance, some groups hypothesize that substances attracted to magnets are compounds. Upon investigation, students discover that magnetic properties do not determine whether a substance is an element or a compound. This reflective process exemplifies mindful learning, wherein students consciously evaluate and revise their initial ideas based on scientific evidence. Such cognitive conflict fosters deeper conceptual change than rote memorization [20].

The most significant learning gains occur during the experimentation stage. Students directly observe samples of iron, copper, sulfur, carbon, salt, and sugar; identify their physical properties; and, using worksheets, classify them as elements or compounds. Active participation in observation, discussion, and data collection fosters an enjoyable learning environment in which students collaboratively construct scientific concepts rather than passively receive information. This active engagement explains why the experimental class achieved higher post-test scores (80.9) compared to the control class (72.3).

During the data analysis stage, students compare their experimental findings with their initial hypotheses and explain why specific substances fall into the categories of elements or compounds. This analytical activity requires students to interpret evidence, identify relationships between concepts, and scientifically justify their conclusions. Consequently, students develop a deeper conceptual understanding than simply memorizing definitions. These findings support previous research reporting that inquiry-based analysis enhances critical thinking and conceptual understanding [19].

Finally, during the conclusion and reflection stage, each group presented its findings and reflected on how their understanding had evolved after completing the investigation. Students realized that elements consist of only one type of atom, whereas compounds are composed of two or more different elements chemically bonded together. The reflection activity also encouraged students to connect scientific concepts with everyday phenomena, thereby reinforcing long-term conceptual retention. This combination of Guided Inquiry and Deep Learning enabled students not only to acquire scientific knowledge but also to understand how to apply that knowledge in authentic contexts [21].

These research findings are consistent with previous studies reporting that Guided Inquiry enhances conceptual understanding, science process skills, and cognitive achievement [22]. Similarly, research on Deep Learning approaches has shown that meaningful, reflective, and student-centered learning environments foster deeper understanding and knowledge transfer [23]. However, unlike previous studies that primarily integrated Guided

Inquiry with digital media or virtual laboratories, this study incorporated the principles of mindful, meaningful, and enjoyable learning at every stage of the inquiry process. This pedagogical integration provides a more comprehensive learning experience by simultaneously fostering scientific inquiry, conceptual understanding, and reflective thinking.

From a pedagogical perspective, these findings suggest that science teachers should not implement Guided Inquiry-based learning merely as a series of inquiry activities. Instead, each stage of inquiry should be designed to encourage students to think mindfully, connect scientific concepts with everyday experiences, and reflect on their learning processes [24-25]. Such integration creates a more meaningful and student-centered learning environment that supports the achievement of higher-level cognitive learning outcomes in science education.

Despite the successful implementation, several challenges were identified. Some students initially struggled to formulate research questions and hypotheses because they were accustomed to teacher-centered instruction. Furthermore, implementing a deep learning approach requires students to possess adequate critical thinking and independent learning skills, which vary among individuals [26-27]. Therefore, teachers need to provide scaffolded support, examples, and continuous guidance during the initial stages of learning until students become more independent learners.

Conclusion

Based on the study's findings, the Guided Inquiry learning model, integrated with a Deep Learning approach, significantly improved Grade VIII students' learning outcomes on the topic of elements and compounds at SMP Muhammadiyah 1 Medan. The experimental class achieved a higher average post-test score (80.9) compared to the control class (72.3), with an N-Gain of 71% (high category) versus 61% (medium category) in the control class. These findings indicate that integrating Guided Inquiry with the principles of mindful, meaningful, and joyful learning fosters a more effective learning experience by encouraging active participation, reflective thinking, meaningful conceptual understanding, and scientific reasoning. The study also makes a theoretical contribution by demonstrating that applying Deep Learning principles at each stage of Guided Inquiry strengthens student-centered science learning and offers an innovative pedagogical framework that goes beyond merely integrating inquiry with instructional media or technology. From a pedagogical perspective, the findings suggest that integrating Guided Inquiry with a Deep Learning approach serves as an effective teaching strategy for enhancing science learning, particularly for abstract topics such as elements and compounds in junior high schools. However, the study was limited to a single school, a relatively small sample, and a short implementation period, while focusing solely on cognitive learning outcomes. Therefore, future research should involve larger, more diverse samples, extend the implementation period, and examine additional variables such as learning motivation, critical thinking skills, scientific literacy, problem-solving abilities, and learning engagement to provide a more comprehensive

understanding of the effectiveness of this integrated learning model across various educational contexts.

Author's Contribution

A. F. Hasibuan: Designed the research, developed the instruments, conducted the research, collected and analyzed data, and prepared the thesis report. A. S. S. Pulungan: Provided guidance, academic guidance, and direction in the methodology design and preparation of the thesis. S. H. Sahputra: Provided data support and assisted with implementation in the learning process during the research.

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