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Implementation of the Guided Inquiry Model with a Deep Learning Approach to Enhance High School Students' Problem-Solving Skills

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Abstract: Students' problem-solving skills in the excretory system topic remain relatively low. Observations and interviews at SMA Negeri 7 Jambi City revealed difficulties in identifying, analyzing, and evaluating solutions to problems. Therefore, an instructional model that enhances student engagement and problem-solving skills is needed, namely Guided Inquiry with a Deep Learning approach. This study aimed to examine its implementation and determine differences in students' problem-solving skills before and after implementation. A quantitative approach with a quasi-experimental method and pretest-posttest control group design was employed. The sample consisted of an experimental class taught using Guided Inquiry with a Deep Learning approach and a control class taught using Problem-Based Learning. Data were collected through essay tests, observations, interviews, and questionnaires. The results showed improved problem-solving skills in both classes, with greater improvement in the experimental class. Thus, Guided Inquiry with a Deep Learning approach positively affected students' problem-solving skills.

Keywords: Deep Learning; Excretory System; Guided Inquiry; Problem-Solving Skills; Problem-Based Learning,.

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Introduction

21st-century education requires students to possess higher-order thinking skills—particularly problem-solving abilities—as a fundamental basis for facing life's challenges. These skills are crucial in science education, as they enable students to grasp concepts, analyze phenomena, and make scientifically grounded decisions. However, problem-solving skills among students in Indonesia remain low. PISA data indicates that Indonesian students' problem-solving proficiency falls into the low category, with an average score of approximately 396 points (Alifa, 2023). Furthermore, research by Melani (2024) reveals that the average problem-solving proficiency of Indonesian students is only 40.4%, with the indicators for defining and diagnosing problems falling into the low category. This situation highlights the need for instructional approaches that foster students' critical thinking and problem-solving skills. Such deficiencies threaten to hinder the achievement of learning objectives, particularly in biology, a subject that demands analytical capabilities and scientific reasoning. These findings align with research by Song et al. (2024), which suggests that poor problem-solving skills can negatively impact students' ability to cooperate and resolve issues collaboratively. Observations and needs analyses indicate that students struggle to identify problems, formulate solutions, and systematically apply problem-solving steps. Students tend to memorize concepts without connecting them to real-world situations. Additionally, instruction remains teacher-centered, limiting student engagement in critical thinking, discussion, and problem-solving. Interviews also reveal that students desire more interactive learning experiences—such as experiments, group discussions, and problem-solving activities—that relate to their daily lives. This aligns with research by Putri (2022), which notes that biology instruction often lacks emphasis on analytical activities and student engagement, thereby preventing the optimal development of critical thinking and problem-solving skills.

Various learning models have been developed to enhance students' problem-solving skills. Among these, the guided inquiry model holds significant potential as it encourages students to actively engage in the processes of inquiry, analysis, and problem-solving. This model actively involves students in the learning process through activities ranging from formulating problems, developing hypotheses, and conducting experiments to drawing conclusions (Nur Azizah, 2019). Guided inquiry is considered capable of boosting student engagement and critical thinking skills, as well as fostering a more systematic approach to problem-solving. Research by Cindikia et al. (2020) demonstrates that the implementation of the guided inquiry model significantly improves students' problem-solving abilities and their active participation in learning.

The deep learning approach has been integrated with various instructional models, such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL), demonstrating potential for developing students' thinking skills. Research on deep learning-based PBL has shown effectiveness in enhancing students' critical thinking and problem-solving abilities,

while the implementation of deep learning-based PjBL has also been reported to support scientific and critical thinking skills. Furthermore, a study by Pakpahana & Suyanti (2025) indicates that combining guided inquiry with a deep learning approach significantly impacts students' Higher-Order Thinking Skills (HOTS) regarding the topic of elements, compounds, and mixtures. However, research specifically examining the combination of guided inquiry and deep learning in relation to problem-solving skills within the context of the excretory system—specifically for high school students—remains limited. Therefore, this study was conducted to investigate the application of this combination in enhancing students' problem-solving abilities.

Several studies indicate that guided inquiry can enhance students' problem-solving skills and engagement in learning. Dwi et al. (2024) demonstrated that guided inquiry applied to the topic of the excretory system improves students' ability to contextualize problems. Safitri et al. (2025) also noted that biology instruction has yet to optimally develop students' higher-order thinking skills. Meanwhile, integrating guided inquiry with a deep learning approach is showing potential for fostering higher-order thinking skills. Problem-Based Learning (PBL) has also been utilized to cultivate students' problem-solving abilities. Therefore, this study examines the differences in students' problem-solving skills when using guided inquiry with a deep learning approach versus PBL within the context of the excretory system.

Methods

This study employs a quantitative approach using a quasi-experimental method with a pretest-posttest control group design. The research involves two groups: an experimental group taught using the guided inquiry model combined with a deep learning approach (GI+DL), and a control group taught using the problem-based learning (PBL) model. The GI+DL model was selected because it encourages students to actively engage in inquiry, problem-solving, meaningful understanding, and reflection, while PBL was used as a comparison due to its shared focus on problem-solving. The independent variables in this study are the GI+DL and PBL learning models, whereas the dependent variable is students' problem-solving ability regarding the excretory system. Measurements were conducted via a pretest prior to the intervention and a posttest following the intervention to assess changes and differences in problem-solving abilities between the two groups.

The study was conducted at SMAN 7 Jambi City, Jambi Province, during the even semester of the 2025/2026 academic year—specifically from January 12 to March 27, 2026. The research participants were Phase F students from two classes. The sample was selected using a purposive sampling technique, taking into account the classes' characteristics and their suitability for the research objectives. The experimental group consisted of 33 students, while the control group comprised 29 students, totaling 62 students.

In the experimental group, instruction employed guided inquiry integrated with deep learning principles. The learning stages included orientation via excretory system phenomena (mindful); problem interpretation using student worksheets, investigation through observation, a urine test simulation using saline solution, and literature review, followed by data analysis and solution formulation (meaningful); and finally, presentation and reflection (joyful). The teacher acted as a facilitator during the investigation process.

In the control group, instruction utilized Problem-Based Learning (PBL) through stages comprising problem orientation, student organization, investigation, results presentation, and evaluation. Students identified problems, sought information, analyzed data, formulated solutions, and presented results in groups. Both groups received the same instructional content and time allocation, differing only in the learning model employed.

Research instruments consisted of both test and non-test measures. The test component involved pretest and posttest essay questions based on Mourtos's six problem-solving indicators: define the problem, explore the problem, plan the solution, implement the plan, check the solution, and evaluate/reflect. Non-test instruments included observations, interviews, and questionnaires to gather data on implementation, student activities, the learning process, and student responses. All instruments were validated by experts, and the test instrument underwent validity and reliability testing prior to use.

Data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to characterize pretest and posttest scores via mean values, standard deviations, and minimum and maximum scores. Inferential analysis employed One-Way ANCOVA to determine differences in problem-solving abilities between the experimental and control groups, using pretest scores as a covariate. Prior to the ANCOVA, data were subjected to tests for residual normality, homogeneity of variance, linearity of the relationship between the covariate and the dependent variable, and homogeneity of regression slopes. Once all assumptions were met, the analysis proceeded with ANCOVA. The magnitude of the treatment effect was calculated using effect size and interpreted based on Cohen's d criteria to determine the strength of the treatment's influence on students' problem-solving abilities. The effect size calculation is based on the Cohen's d formula, as follows:

$$d = \frac{postest - pretest}{standar\ deviasi}$$

After obtaining the effect size value, the next step is to examine the Cohen's d value category to assess the impact of the applied model; the Cohen's d classification categories are as follows:

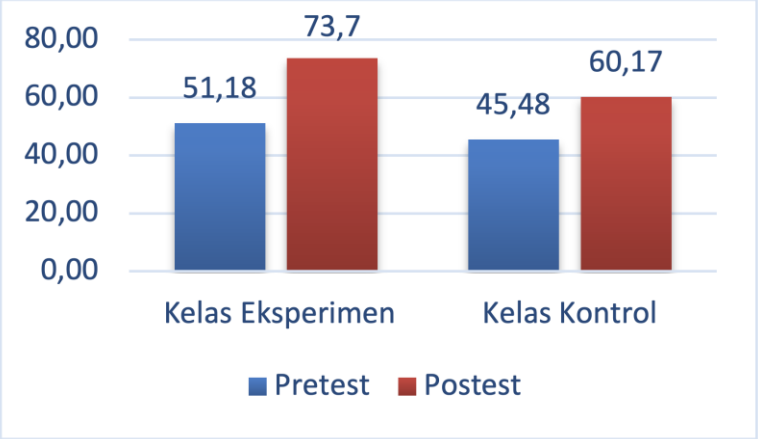
Tabel 1.
Interpretasi *Effect Size Cohen's d.*

Effect Size	Interpretasi
0 < d < 0,2	Kecil
0,2 < np2 ≤ 0,5	Sedang
0,5 < d ≤ 0,8	Besar
d > 0,8	Sangat besar

Results & Discussion

Based on the pretest and posttest results, there was a difference in the average student learning outcomes between the experimental and control classes following the application of different instructional treatments. The pretest results showed an average score of 51.18 for the experimental class and 45.48 for the control class, while the posttest results showed an average score of 73.7 for the experimental class and 60.17 for the control class. Furthermore, data analysis indicated that the instructional model influenced students' problem-solving learning outcomes. A comparison of the pretest and posttest scores is presented in Figure 1 below.

Gambar 1.
Perbandingan nilai pretest dan posttest.



Subsequently, a One-Way ANCOVA was conducted because the post-test mean scores of the two groups differed; ANCOVA was employed to assess and test the treatment's effect on the dependent variable while controlling for other variables that could influence the outcomes. The univariate One-Way ANCOVA results [$F(1, 59) = 22.512$, $p < 0.001$] indicated a significant treatment effect. A subsequent effect size analysis revealed a moderate effect on the problem-solving learning outcomes of students using the guided inquiry model, whereas students using the problem-based learning model showed a small effect, after controlling for initial problem-solving learning outcomes.

In the experimental class, the guided inquiry model was implemented through stages comprising orientation, problem interpretation, observation, data analysis, and results presentation. During the orientation stage, students were guided to observe phenomena related to excretory system disorders using "trigger questions," enabling them to identify problems relevant to their daily lives. This activity demonstrates the application of a deep learning approach—specifically the aspect of mindful learning—as students were trained to focus and gain a profound understanding of the issues. The guided inquiry model also

assisted students in formulating problems and hypotheses based on the observed phenomena (Nur Azizah et al., 2019).

During the observation and urine test simulation (using saltwater) stages, students actively conducted observations, recorded data, and discussed results within their groups. These practical activities made learning more engaging and meaningful, reflecting the principles of joyful learning. However, some students still struggled to independently draw conclusions from their observations and present data systematically. This situation indicates that teacher guidance remains essential for the optimal development of students' thinking and analytical skills.

Results from the student worksheets (LKPD) revealed that groups actively following teacher guidance achieved better outcomes compared to those less engaged during the inquiry process. Highly engaged groups were able to analyze practical results and accurately link them to concepts regarding excretory system disorders. Conversely, less active groups faced difficulties during the observation, data analysis, and conclusion-drafting stages. This demonstrates that teacher guidance within the guided inquiry model plays a crucial role in helping students think systematically and solve problems in a more focused manner.

Overall, guided inquiry and problem-based learning models foster a more active learning environment than conventional instruction. However, learning effectiveness depends on the proper execution of the model's syntax, time management, and student engagement at each stage of the process. This aligns with Kusumawati (2024), who stated that consistent implementation of the instructional syntax can boost student motivation and active participation.

These findings are also supported by research conducted by Hidayat (2022), which demonstrated that the guided inquiry model is effective in enhancing students' metacognitive skills and cognitive learning outcomes. Furthermore, Hutama (2024) states that guided inquiry and problem-based learning offer advantages in enhancing student learning activity, although challenges persist during the investigation and data processing stages. Thus, implementing guided inquiry using a deep learning approach can help improve student engagement and problem-solving skills regarding the excretory system (Margayu et al., 2020).

In the control class, literature-based learning helped students grasp concepts in a more structured and systematic manner. Improvements were observed in initial indicators such as defining and exploring the problem. However, students still struggled with the solution application and evaluation stages due to a lack of hands-on learning experience. This situation aligns with research by Denisa et al. (2024), which indicates that a lack of practical activities hinders the optimal development of students' application abilities and process skills.

Meanwhile, in the experimental class, the urine test simulation practicum helped students grasp concepts in a more contextual manner and enhanced their engagement in the learning process. Students appeared more active in discussing ideas, analyzing

observations, and formulating solutions based on the data obtained. Improvements were observed in the indicators for implementing the plan, checking the solution, and evaluating/reflecting. These findings align with research by Yusuf (2020), which states that practicum-based learning can boost higher-order thinking skills and help students construct a more meaningful understanding. Furthermore, Khadijah et al. (2025) noted that practicums provide students with hands-on experience in testing hypotheses and evaluating problem-solving outcomes.

However, the implementation of the practicum in the experimental class also faced challenges, such as time constraints and the need for optimal classroom management to ensure all students could participate actively. Additionally, some students still required guidance in formulating problem-solving plans and drawing conclusions. This highlights the crucial role of the teacher as a facilitator in guiding students' thinking processes during instruction (Sanjaya, 2016).

The research results indicate that the guided inquiry model is more effective than problem-based learning in enhancing students' problem-solving skills. Guided inquiry assists students in constructing knowledge independently through structured learning stages, thereby fostering more optimal development of higher-order thinking skills (Muntamah et al., 2022). These findings are consistent with research by Samsudin (2020), which suggests that guided inquiry is particularly effective for students who require directed guidance during the learning process. Moreover, Gusmaneli et al. (2024) stated that guided inquiry fosters active student engagement, leading to more optimal development of problem-solving abilities. This is further supported by research from Sado et al. (2020), indicating that science process skill-based guided inquiry enhances students' ability to design and evaluate solutions in a structured manner.

Practicum activities and guided inquiry also helped students develop a more meaningful understanding of the excretory system. Students do not merely memorize concepts but are able to connect theory with excretory disorders such as diabetes mellitus. These findings are supported by research by Anna (2025), which demonstrates that guided inquiry can enhance students' scientific argumentation skills based on experimental data. Furthermore, Agustina et al. (2020) state that experimental activities within guided inquiry can improve problem-solving skills, as students are directly involved in hypothesis testing. A deep learning approach also encourages students to think reflectively and analytically, thereby making learning more meaningful (Daud, 2024).

In problem-based learning classes, students appear active in discussions and in expressing their views regarding contextual problems. This model helps students develop critical thinking and collaborative skills during the learning process. Research by Sariningrum et al. (2018) also indicates that problem-based learning can enhance students' scientific literacy, as the learning is linked to everyday life phenomena. However, students' problem-solving skills have not yet fully developed, particularly during the solution evaluation and reflection stages (Siti et al., 2024).

Conclusion & Recommendation

Research findings indicate that the implementation of guided inquiry using a deep learning approach results in a difference in students' problem-solving abilities compared to Problem-Based Learning (PBL) when studying the excretory system. Guided inquiry with a deep learning approach offers an alternative instructional method that fosters active student engagement in understanding problems, conducting investigations, designing solutions, and evaluating problem-solving outcomes.

This study has several limitations. Limited instructional time meant that inquiry and discussion activities within some groups were not fully optimized. Furthermore, the urine test simulation utilized a saline solution, so the practical experience did not entirely reflect real-world conditions. Future research could expand the application of guided inquiry using a deep learning approach to different subject matter and educational levels, incorporate more optimal timeframes and inquiry activities, and examine other ability-related variables to yield more diverse results.

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