Original Article

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LAVOISIER: CHEMISTRY EDUCATION JOURNAL

Vol. 3(2), 2024

Implementation Of Chemistry Learning Through Guided and Open Inquiry Using Small-Scale Laboratory Media on Science Process Skills

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Article History
Received 08 22th 2024
Revised 09 28th 2024
Accepted 12 12th 2024
Available Online 12 20th 2024

Keywords:
Guided inquiry
Open inquiry
Science proses skills

Abstract
Science process skills are crucial for students; however, their optimization remains low due to teacher-centered learning approaches and limited laboratory facilities that hinder practical activities. To optimize and enhance these skills, student-centered learning approaches, such as guided inquiry and open inquiry, are needed, along with the implementation of small-scale laboratory media to support inquiry activities. Guided inquiry and open inquiry are inquiry-based learning models at different levels, with each level training distinct intellectual skills; the higher the level of inquiry, the more complex the skills involved. The purpose of this study is to analyze and compare the levels of science process skills through open inquiry and guided inquiry learning, utilizing small-scale laboratory media. This research employed a quasi-experimental method with a Nonequivalent Control Group Design, where the experimental and control groups were not randomly selected. The study was conducted at SMA Ma'arif Karangawen, with class XI MIPA 3 as the control group and class XI MIPA 4 as the experimental group. Data collection techniques included pretests/posttests and non-test observations. Data were analyzed using n-gain, normality tests, homogeneity tests, hypothesis testing (t-tests), and non-test data analysis. The results show that science process skills through guided inquiry learning were superior to those achieved through the open inquiry method. This was evidenced by a higher average score in the control group taught using the guided inquiry method, which achieved an average score of 55.58 (an improvement of 35.58%) and an n-gain value of 0.44, categorized as moderate. The experimental group, taught using the open inquiry method, achieved an average score of 50.15 (an improvement of 27.57%) and an n-gain value of 0.35, also categorized as moderate.

1. Introduction

Chemistry is a branch of science that connects various science disciplines, often regarded as the central science (Muderawan, 2019). It not only involves problem-solving but also requires students to understand chemical concepts so they can apply them effectively. Chemistry education encompasses three key aspects: knowledge development, fostering science attitudes, and skill training. Science activities such as experiments align well with these objectives (Sasongko, 2020).

Science activities in chemistry learning involve a process known as Science Process Skills (SPS). Science process skills refer to students' ability to apply science methods to understand, develop, and discover knowledge. These skills focus on cognitive and psychomotor abilities to conduct science investigations, discover concepts, principles, and theories, and build on existing concepts (Akani, 2015). Science process skills play a vital role in actively engaging students, creating long-term learning, fostering science habits in problem-solving, planning experiments, and enabling students to not only learn concepts but also apply them in practice. However, the optimization of science process skills remains inadequate (Rifatul, 2019).

One of the reasons for the underdeveloped science process skills is the teacher-centred learning approach, where students predominantly act as listeners and note-takers. This dynamic limits the growth of students' science process skills, which are often neglected (Gasila, 2019). The low mastery of science process skills also results in students being less active in science learning and struggling to solve problems scienceally. This presents a significant challenge in improving the quality of science education in schools.

According to Rifatul (2019), fostering an environment conducive to science process skills requires active student involvement in the learning process. This necessitates student-centred learning models such as inquiry-based learning. The inquiry model, as described by Ariningsih (2013), involves a series of learning activities emphasizing critical and analytical thinking to search for and find answers to problems. Hunaepi (2021) categorizes inquiry into three levels: structured inquiry (first level), guided inquiry (second level), and open inquiry (third level). Each level develops different intellectual abilities; higher levels of inquiry involve more complex intellectual skills and vice versa.

Another contributing factor to the low science process skills is the lack of laboratory facilities, which hampers practical activities. Haddar (2021) highlighted that issues with practical work include insufficient laboratory facilities, expensive equipment and materials, and limited skills and personnel for laboratory management. Schools often rely on large-scale, costly equipment and materials, requiring teachers to allocate additional time for preparation, leading to wasted instructional time. These challenges can be addressed using small-scale laboratory media.

Previous studies have demonstrated that guided and open inquiry models effectively enhance students' science process skills (Ariningsih, 2013; Puspita, 2019). Small-scale laboratories have also proven efficient, eco-friendly, and capable of increasing student participation in practical activities (Istiqomah, 2022). However, implementing effective inquiry models in schools with limited facilities remains a challenge.

Although inquiry-based learning has shown promise, there is limited research analyzing and comparing the effectiveness of guided and open inquiry models using small-scale laboratory media in schools with restricted laboratory facilities. This study aims to fill this gap by examining the impact of these two learning models on students' science process skills.

Guided and open inquiry models allow students to engage in activities such as observation, hypothesis formulation, experimental procedure design, data collection, experimentation, and evaluation. This research is expected to provide a reference for selecting more effective teaching models, especially in resource-limited environments, fostering knowledge construction, enhancing student engagement, and ultimately improving science process skills.

2. Materials and Methods

This study employed a quasi-experimental design using the Nonequivalent Control Group Design model. This model involved two groups: the experimental group, which used the open inquiry learning model, and the control group, which used the guided inquiry learning model. The study's subjects were 11th-grade science students (XI MIPA) at SMA Ma'arif Karangawen. A purposive sampling technique was used to select XI MIPA 3 as the control group and XI MIPA 4 as the experimental group. A total of 64 students participated in the study, with 32 students in each class.

Data collection techniques included both tests and non-test methods. The test consisted of pretest and posttest assessments to measure students' science process skills before and after the intervention. Non-test methods involved direct observation during the learning process to evaluate students' science process skills based on predetermined indicators. The instruments used included pretest and posttest questions, which were identical and consisted of 30 valid and reliable multiple-choice questions, as determined through prior validity and reliability testing using the science process skills framework. The test items were designed to measure various aspects of science process skills. Observation sheets included indicators of science process skills, such as formulating scientific questions, hypothesizing, designing experiments, conducting experiments, analyzing data, and communicating results.

Data analysis techniques involved several steps. An **n-gain analysis** was performed to calculate the improvement in science process skills based on pretest and posttest results. Normality and homogeneity tests were conducted to ensure that the data met the assumptions of normal distribution and homogeneity, prerequisites for hypothesis testing. A **t-test** was used to compare the mean post-test scores of the control and experimental groups to evaluate the effectiveness of the learning models. Descriptive analysis was employed to analyze the observational data.

3. Results and Discussions

This study aimed to evaluate the effectiveness of guided and open-inquiry learning models in enhancing students' science process skills. The experimental class implemented the open inquiry learning model, where students were encouraged to independently design and conduct experiments based on problems presented by the teacher. The learning syntax in this model involved aspects of science process skills, including observing, classifying, interpreting, predicting, posing questions, hypothesizing, planning investigations, using tools/materials, applying concepts, and communicating results.

The control class used the guided inquiry learning model, where students followed teacher-prepared experimental procedures. The learning syntax in this model also encompassed science process skills but involved teacher guidance for activities such as observing, classifying, interpreting, predicting, posing questions, hypothesizing, planning investigations, and using tools and materials based on instructions, as well as applying concepts and presenting findings. Both classes utilized small-scale laboratory media consisting of simple teaching aids to support experiments.

The instructional steps prepared for the research procedure utilized learning tools, including lesson plans (RPP) and pretest and posttest items that had been validated for content and reliability. Content analysis validation by expert lecturers showed high scores, confirming the suitability of the lesson plans and test items. Subsequently, validation was conducted by testing the items on 32 students from Grade XII MIPA 2 at SMA Ma'arif

Karangawen. Student responses were analyzed using science process skills. Of the 30 items tested, 20 were deemed valid and 100% reliable.

After confirming the validity and reliability of the instruments, a homogeneity test was conducted on samples from Grades XI MIPA 3 and XI MIPA 4 based on population distribution and average daily test scores. The two classes were found to be homogeneous. As a result, Grade XI MIPA 3 was designated as the control class, which received guided inquiry-based instruction, while Grade XI MIPA 4 became the experimental class, which received open inquiry-based instruction.

Before treatment, students' initial science process skills were measured through a pretest. The pretest results in Table 1 showed an average score of 20 for the control class and 22.57 for the experimental class, indicating that students' science process skills were very low. This could be attributed to several factors, such as limited laboratory facilities, a lack of student-centred learning, and insufficient resources and learning materials. This aligns with Khaerunnisa's (2016) findings, which suggest that the low level of science process skills may be influenced by factors such as curriculum, teaching methods and models, facilities, and learning resources.

Following the pretest, the treatment phase was conducted, with the control class employing the guided inquiry model and the experimental class utilizing the open inquiry model. A posttest was then administered using the same items as the pretest. The data collected were analyzed to determine the improvement in students' science process skills in both classes, with the results presented as follows:

Table 1. Table Pretest Posttest Average Analysis

Class	**Mean Pretest**	**Mean Posttest**	**N-Gain**	**Changes (%)**	t-test
Control	20,00	55,58	0,44	35,58%	0,000 < 0,05 $H_0$1 rejected
Experiment	22,57	50,15	0,35	27,57%	0,000 < 0,05 $H_0$2 rejected

Based on Table 1, the analysis of pretest and post-test results indicates an improvement in students' science process skills. Posttest scores were higher than pretest scores, as evident from the average student scores in each class. In the control class, the average pretest score was 20.00, while the average posttest score was 55.58. Meanwhile, in the experimental class, the average pretest score was 22.57, and the average posttest score was 50.15. This demonstrates that both classes experienced an increase in science process skills after the treatment.

The improvement in science process skills was further analyzed using n-gain values derived from pretest and posttest results. In the control class, the n-gain value indicated a moderate improvement of 0.44, while the experimental class showed a moderate increase of 0.35. These improvements are attributable to the applied learning methods—guided inquiry and open inquiry—that provided students with opportunities to construct their knowledge.

A hypothesis test was conducted by comparing the pretest and posttest results between the control and experimental classes using a t-test, yielding a significance value of 0.000 < 0.05. This indicates that both the guided inquiry and open inquiry learning models, utilizing small-scale laboratory media, had a significant impact on students' science process skills. The analysis revealed that the control class showed a higher improvement in science process skills, with an increase of 35.58%, compared to the experimental class, which improved by 27.57%. Thus, the research hypotheses (Ha1, Ha2, Ha3) were accepted.

The improvement in science process skills can be explained by the active role of students during the learning process, as illustrated in the following observation graph:

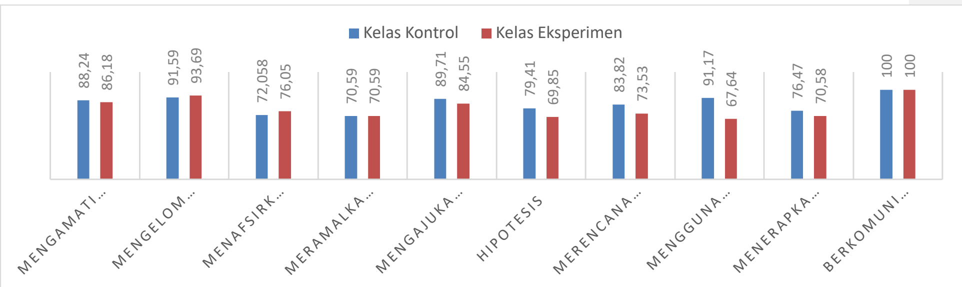

Figure 1. Observation results of science process skills

Based on the observation data in Figure 1, the science process skills demonstrated after implementing the guided inquiry learning model were superior to those observed with the open inquiry learning model. According to Puspita (2019), inquiry learning encompasses three levels: structured inquiry as the first level, guided inquiry as the second level, and open inquiry as the highest level. As the level of inquiry increases, the intellectual skills required of students become more complex. However, the data from this study indicate that students' science process skills were higher with guided inquiry compared to open inquiry.

The phases of observing, predicting, asking questions, hypothesizing, planning experiments, using tools and materials, and applying concepts showed higher results in the control class, which used the guided inquiry model. This can be attributed to the fact that these activities were relatively new for the students in the studied school. The unfamiliarity with the applied learning model caused some confusion among students in executing each step. On the other hand, the phases of classifying and interpreting showed higher results in the experimental class, which implemented the open inquiry model.

Questioning skills in the guided inquiry class were higher than in the open inquiry class. This difference is due to the distinct treatments in each model: in guided inquiry, students are guided to ask questions related to observed phenomena, which are then formulated into hypotheses. Conversely, in open inquiry, students are given the freedom to formulate questions about the phenomena, but this freedom sometimes led to confusion among students in asking relevant questions or designing and formulating hypotheses.

Planning and conducting experiments are activities that directly involve students in higher-order cognitive activities, encouraging critical thinking. The ability to plan experiments in the open inquiry class was lower than in the guided inquiry class. In open inquiry, students were given the freedom to design experiments, but limited access to references for experiment planning posed a challenge. Additionally, the execution of experiments using tools and materials in open inquiry was also lower because many students were unsure about what to do during the experiments, how to use the tools and materials, and their specific functions. As a result, some students in the open inquiry class conducted experiments that did not align with their plans.

The guided inquiry learning model was found to be more effective than the open inquiry model due to differences in treatment during the learning phases. This finding aligns with the study by Sulistina (2019), which concluded that guided inquiry is more effective than open inquiry. The difference in effectiveness is attributed to the novelty of several stages in open inquiry for students, making teacher guidance essential. According to Dewi (2016), students' unfamiliarity with the applied learning stages can lead to confusion in implementing learning steps.

This study has several limitations that should be noted. The relatively short duration of the research limited the time available for students to further explore the learning material and prevented a longitudinal evaluation of the development of science process skills. Not all indicators were evaluated in depth, which may have resulted in some aspects being overlooked. Additionally, the variation of small-scale media used may not have encompassed all exploration aspects required for specific science process skills.

5. Conclusions

The findings of this study indicate that the open inquiry learning model is less effective than the guided inquiry model in improving students' science process skills. This is evidenced by the higher average score in the control class, which employed the guided inquiry method, achieving an average score of 55.58 with an n-gain value of 0.44 (moderate category), representing a 35.58% improvement. In contrast, the experimental class, which used the open inquiry method, obtained an average score of 50.15 with an n-gain value of 0.35 (moderate category), indicating a 27.57% improvement. These results highlight the need for consistent practice to enhance students' critical thinking and scientific information processing skills. This would enable the broader implementation of the open inquiry model to improve students' critical and scientific thinking abilities.

The recommendations from this study include conducting long-term research to optimize the open inquiry learning model for enhancing science process skills and extending the observation period to evaluate the sustained impacts of open inquiry implementation in science learning. Additionally, incorporating technology-based learning media could be considered to enhance the effectiveness of the exploration and data analysis phases.

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