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Small-Scale Chemistry Experiment in Guided Inquiry Learning to Improve Concept Understanding and Science Process Skills

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis penerapan small-scale chemistry dalam pembelajaran guided inquiry terhadap peningkatan pemahaman konsep dan keterampilan proses sains serta hubungan antara keduanya. Metode penelitian yang digunakan adalah kuasi eksperimen dengan desain pretest–posttest nonequivalent control group. Sampel penelitian terdiri atas dua kelas, yaitu kelas eksperimen yang mendapatkan pembelajaran small-scale chemistry berbasis guided inquiry dan kelas kontrol yang menggunakan pembelajaran konvensional. Instrumen penelitian meliputi tes dua tingkat (two-tier test) untuk mengukur pemahaman konsep dan lembar observasi untuk menilai keterampilan proses sains. Analisis data dilakukan melalui uji normalitas, uji homogenitas, uji-t, serta uji korelasi Pearson. Hasil penelitian menunjukkan adanya peningkatan signifikan pada pemahaman konsep dan keterampilan proses sains di kelas eksperimen dibandingkan kelas kontrol. Peningkatan pemahaman konsep ditunjukkan oleh nilai N-gain kelas eksperimen sebesar 0.60 (kategori sedang), sedangkan kelas kontrol sebesar 0.29 (kategori rendah). Keterampilan proses sains pada kelas eksperimen berada pada kategori "baik", sementara kelas kontrol pada kategori "cukup". Uji korelasi menunjukkan hubungan positif signifikan antara pemahaman konsep dan keterampilan proses sains dengan nilai p < 0.05. Temuan ini mengindikasikan bahwa small-scale chemistry dalam guided inquiry efektif dalam meningkatkan pemahaman konsep dan keterampilan proses sains siswa serta memperkuat keterkaitan antara keduanya.

ABSTRACT

This study aims to analyze small-scale chemistry in guided inquiry to improve the relationship between students' conceptual understanding and science process skills. The research method used is a quasi-experimental design with a pretest-posttest nonequivalent control group design. The sample of this study consisted of two classes: the experimental class, which used small-scale chemistry in guided inquiry, and the control class, which employed conventional learning. The instruments used included a test (two-tier test) to measure conceptual understanding and observation sheets to measure science process skills. Data analysis was carried out using normality tests, homogeneity tests, t-tests, and Pearson correlation tests. The study's results showed a significant increase in understanding and science process skills in the experimental class compared to the control class. The increase in conceptual understanding was evident from the hypothesis test, with the N-gain value of the experimental class at 0.6 (moderate) and the control class at 0.29 (low). Meanwhile, the science process skills obtained t-test results and observation sheets, with an average of "good" in the experimental class and "sufficient" in the control class. The results of the correlation test showed a significant positive relationship between conceptual understanding and science process skills, with a p-value of < 0.05. value.

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INTRODUCTION

The essence of chemistry is divided into chemistry as a product in the form of theories, principles, and others, and chemistry as a process involving skills and attitudes to gain further knowledge. Chemistry learning is closely related to real-life activities. Students' real-life activities are enhanced through scientific learning by conducting experiments or practicums (Ariyaldi, Yunus, & Auliah, 2020). The practicum method develops students' psychomotor, cognitive, and affective skills (Senisum, Susilo, Suwono, & Ibrohim, 2022) . Students are given the opportunity to identify problems, observe, hypothesize, conduct experiments, and apply the information they have according to their needs, which can help develop learning motivation and curiosity, thus supporting students in discovering knowledge through exploration (Candra & Hidayati, 2020).

However, the reality on the ground shows a lack of scientific learning in practical work. Learning is still teacher-centered , limited tools and materials, student passivity, and residual waste from practical work are the reasons for the lack of practical work. Practical learning must provide affordable and sustainable strategies. One strategy suitable for addressing these problems is the small-scale chemistry approach in practical work activities (Listyarini et al., 2019). Small-scale chemistry is used as a practical strategy using tools and materials in small quantities (Imaduddin, Tantayanon, Zuhaida, & Hidayah, 2020). With these small quantities, it can solve problems related to practical waste, thereby reducing the risk of environmental contamination due to waste. Small-scale chemistry can enhance the quality of chemistry teaching from an environmentally friendly perspective by prioritizing work safety, promoting pollution prevention, and minimizing waste, thereby aligning with the principles of education for sustainable development (Syaadah, Mulyono, & Suhanda, 2021).

Small-scale chemistry can enhance students' essential scientific skills. These scientific skills are science process skills (Matsna, Rokhimawan, & Rahmawan, 2023). Developing science process skills is crucial because they encompass the ability to observe, analyze, think critically, and solve problems based on data and empirical evidence (Supatmi, 2022). Furthermore, in practice, science is inseparable from investigative methods, which involve collecting and connecting facts to draw conclusions and support students' conceptual understanding. Conceptual understanding encompasses in-depth mastery of the material and the ability to solve problems (Sari, 2021) .

In line with optimizing the improvement of conceptual understanding and science process skills with small-scale chemistry, the use of the guided inquiry learning model is also important. The application of guided inquiry equips students with knowledge and skills according to its syntax. Therefore, this study will analyze the use of small-scale chemistry experiments in guided inquiry learning to improve the relationship between students' conceptual understanding and science process skills.

METHODS

The method employed is a quasi-experimental design with a pretest-posttest, nonequivalent control group. The sample used was class XI MIPA D, as the experimental class employed small-scale chemistry in guided inquiry, and class XI MIPA E served as the control class, which used conventional methods (lectures and discussions), with a total of 72 students. The sample was selected using a purposive sampling technique. Data collection techniques included observation, written tests in the form of pretests and posttests, and documentation. In addition, data were also obtained from non-test instruments, including questionnaires and observation sheets, for science process skills. The pretest and posttest questions used were 25 items in the form of a two-tier multiple-choice. These questions have passed the test using the Rasch Model analysis, so they are declared valid for use. The data were analyzed using normality tests, homogeneity tests, hypothesis tests, Pearson correlation tests, N-Gain tests, and analysis of science process skills observation sheets and student response questionnaires. The normality test and homogeneity test concluded that the data obtained were normally distributed and homogeneous, so the next statistical test used was a parametric test. The hypothesis tests and correlation tests used were the paired sample t-test and the independent sample t-test.

RESULTS AND DISCUSSION

This study presents two types of data: test results and observation sheet data. Prior to data collection, a pilot test of the instrument was conducted on a class of 12 students who were not included in the study. The pilot test showed a Cronbach's Alpha value of 0.86, indicating high reliability. In addition to reliability, instrument validation, difficulty level, and discriminatory power were also calculated, resulting in 25 valid and suitable items for use as an instrument.

Improved Conceptual Understanding

The improvement in conceptual understanding was seen from the difference in the average scores of the control and experimental classes, the increase in each indicator, the N-gain value, and the hypothesis test. The experimental class obtained an average score of 26.75, ranging from 53.00 to 79.75, while the control class experienced an increase of 13.41, from 53.17 to 66.58. The average value of conceptual understanding of experimental class students was higher than that of the control class. This finding aligns with Sholahuddin et al. (2023), who reported that the experimental class outperformed the control class in implementing guided inquiry-based practicums. The improvement was also seen in the percentage results of each indicator in Table 1.

Table 1. Shows the average results of *the pretest* and *posttest* of all students on each indicator. Based on Table 1, the pretest data of the experimental class obtained the highest percentage, namely on the indicator restating the concept of 63% and posttest data of 83% on the indicator classifying objects according to

certain properties while the lowest percentage in the pretest data was on the indicator developing necessary or sufficient conditions of the concept of 42% while in the posttest data obtained the highest value of 83% from the indicator classifying objects. In the pretest data of the control class, the indicator with the highest value was restating the concept with a percentage of 67% posttest data of 68% on the indicator restating the concept and the indicator using, utilizing, and selecting certain procedures/operations. The lowest percentage in the pretest was on the indicator presenting concepts in various forms of mathematical representations of 42% and posttest data on the same indicator of 46%. So the difference in the percentage of the value of each indicator is presented in Figure 1.

Table 1. Percentage Results of Concept Understanding Values

Concept Understanding Indicators	***Pretest***	***Posttest***	***Pretest***	***Posttest***
	control		**experiment**	
Restating the concept	67%	68%	63%	82%
Provide examples and non-examples of the concept	45%	63%	46%	78%
Classifying objects according to certain properties	54%	64%	53%	83%
Developing necessary or sufficient conditions of the concept	43%	64%	42%	80%
Presenting concepts in various forms of mathematical representation	42%	46%	57%	64%
Using, utilizing, and selecting certain procedures/operations	56%	68%	48%	76%
Applying problem-solving concepts or algorithms	52%	67%	56%	82%

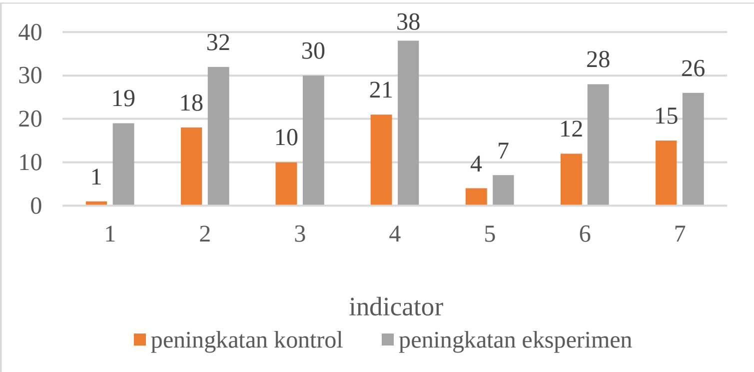

Figure 1. Percentage difference in the value of each indicator of conceptual understanding

From the data above, it can be concluded that each indicator in the experimental class increased more than in the control class. This increase is also seen in the N-Gain value in Table 2.

Table 2. N-Gain Values

Class	***Pretest* Average**	***Posttest* Mean**	**N-Gain**	**Category**
Experiment	53.00	79.75	0.57	Currently
Control	53.17	66.58	0.29	Low

Based on the calculation of the N-Gain test, the conceptual understanding score obtained an average gain index of 0.57 in the experimental class and 0.29 in the control class. The guided inquiry learning model encourages students to be more active in exploring, observing, and drawing their own conclusions through more systematic scientific stages, so that it is more effective in building a deep understanding of concepts. Golinski (1999) said that the practicum was carried out so that students could verify the theories they had received and then after that they could rebuild their understanding . The presence of small-scale chemistry also provided new innovations in the learning process, so that the experimental class experienced an increase in the N-gain value.

The hypothesis test states that the data shows a difference in the improvement of conceptual understanding. This is proven by the results of Sig. 0.000 < 0.05, so H_0 is rejected and $H_1$is accepted. This shows that there is a significant difference in results between the experimental class and the control class. In addition, the total value of $T_{Calculation}$ is 9.778, meaning $T_{Calculation} > T_{Table}$ (1.994) thus strengthening the decision to reject H_0 and accept H_1 . The results identify that guided inquiry with small scale chemistry provides a significant increase in conceptual understanding compared to the control class that uses conventional practicum methods.

Improving Science Process Skills

The results of the improvement in students' science process skills are seen from the observation data in the control and experimental classes through observation sheets. The results of the science process skills observation obtained information that in the experimental class there were 12 students who obtained a score in the very good category, 18 students obtained a good category, and 6 students obtained a sufficient category, while in the control class all students obtained a sufficient category. The average percentage of observation scores for the experimental class was higher at 80% than the control class at 57%. Therefore, it can be said that classes that apply small-scale chemistry in guided inquiry learning and classes that apply conventional approaches have differences in science process skills. Classes that apply small-scale chemistry in guided inquiry have stronger science process skills than classes that apply conventional methods.

During the learning process , students in the class showed more active engagement, both in individual activities and group discussions. However, participation in the control class was lower. This low level of engagement is thought to be caused by a learning approach that does not support active student involvement. Guided inquiry encourages students to be more active, so that students' science process skills will be more prominent, resulting in an increase in science process skills. This improvement is also seen in the improvement of science process skills aspects. Data from the results of the science process skills research on the observation sheet in the acid solution material can be seen in Figure 2.

The experimental class achieved a higher average score than the control class. The highest percentage scores in the experimental class were for asking questions (83%), planning experiments (82%), and planning experiments (82%). Meanwhile, the lowest score indicators were interpretation (78%) and prediction (79%). The control class achieved lower percentages on all indicators. The highest scores were for classifying (63%) and asking questions (61%), while the lowest were for prediction (53%) and interpretation (54%). Based on the percentages obtained for each aspect of science process skills, the experimental class achieved higher scores than the control class. This proves that small-scale chemistry in guided inquiry learning can improve students' science process skills. These results are consistent with the results of research conducted by (Khotijah, 2023), which concluded that practicum-based inquiry has an influence on students' science process skills. Therefore, with the experimental class achieving a score in the good average category, it can be concluded that the guided inquiry model Inquiry can improve students' science process skills. Furthermore, (Handayani, 2019) also emphasized the conclusion that the implementation of the guided inquiry learning model contributes to the development of students' science process skills through green chemistry -based practical activities using small-scale chemistry .

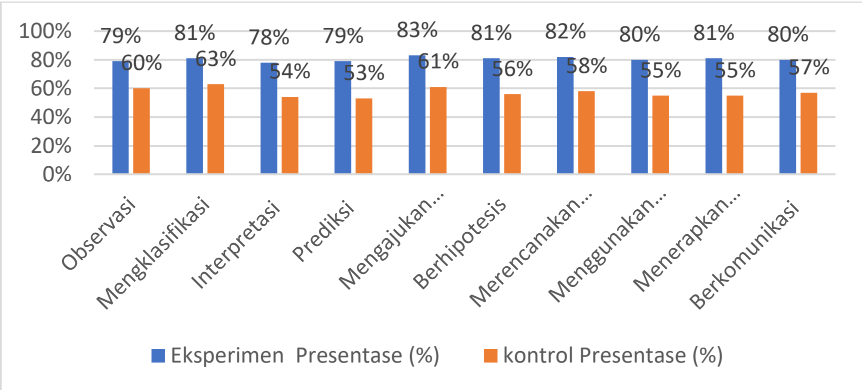

Figure 2. Results of the percentage of science process skills scores

A T-test was also conducted to determine the difference in improvement in science process skills. This was evidenced by the Sig. 0.000 < 0.05, which means H_0 is rejected and H_1 is accepted. This indicates a significant difference in results between the experimental and control classes.

The Relationship Between Conceptual Understanding and Science Process Skills

understanding and science process skills after the implementation of small-scale chemistry in guided inquiry . This is done by using a Pearson correlation test . The results of the Pearson correlation test are presented in Table 3.

Based on Table 3, a significant value of 0.000 was obtained. A value of 0.000 <0.05 means that H_1 is accepted and H_0 is rejected, so the significant value indicates that there is a significant relationship between conceptual understanding and science process skills. In addition, the Pearson correlation obtained a value of 0.573 which has a moderate correlation but with a positive value, meaning that the relationship between conceptual understanding and science process skills has a unidirectional relationship. This shows that the relationship between the two variables is not only statistically significant, but also has a relationship in a practical context in the classroom.

Table 3. The results of the Pearson correlation test are presented in

		Concept Understanding	Science Process Skills
Conceptual understanding	Pearson Correlation	1	0.573
	Sig. (2-tailed)		0,000
Science Process Skills	Pearson Correlation	0.573	1
	Sig. (2-tailed)	0,000	

This is evidenced by the increasing achievement of conceptual understanding scores, followed by science process skills scores. Theoretically, the relationship between conceptual understanding and science process skills can be explained because science process skills, such as observing, interpreting data, and communicating results, require a strong foundation of conceptual understanding. Conversely, the scientific activities students undertake in lab work can also strengthen conceptual construction through direct experience. Thus, this relationship is mutually supportive and reinforcing in the science learning process.

CONCLUSION

The results of the analysis show that Small Scale Chemistry in guided inquiry learning can improve students' conceptual understanding and science process skills. This is evidenced by the difference in the increase in the average posttest value of conceptual understanding, namely in the experimental class, 26.75 and N-Gains 0.6 (moderate), while the control class, 13.41 and N-Gain value 0.29 (low). Strengthened by testing the hypothesis of conceptual understanding with the results of Sig. (2-tailed) 0.000, which means <0.05. The difference in values obtained from the observation sheet showed a higher average percentage of observation scores for the experimental class, namely 80% than the control class of 57%. In addition, the t-test results with sig. 0.000 on science process skills. So it can be concluded that there is an increase in conceptual understanding and science process skills. In addition, there is a relationship between conceptual understanding and science process skills, with the results of the Pearson correlation test of significance. 0.000 with a value (r) of 0.573 in the moderate relationship category. This indicates that there is a positive relationship between the two variables.

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