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Scientific Skills Through Guided Inquiry: A Case Study of Briquette Production from Corncob and Coffee Grounds

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Abstract
This study aims to develop students' scientific performance with the help of guided inquiry-based learner worksheets (LKPD) in developing students' scientific skills in making briquettes from corncob waste and coffee grounds. The issue of low utilization of agricultural waste and lack of integration of real context in chemistry learning. The method used was pre-experimental with a One-Shot Case Study design, involving three groups of students in class XI Industrial Chemical Engineering. The assessment focused on the six stages of guided inquiry, namely observation, formulating problems, making hypotheses, conducting experiments, analyzing data, and drawing conclusions. The results showed that student activity reached 90.3 while scientific skills showed excellent results, with scores between 83-91.7. This is a novelty with the application of guided inquiry-based worksheets in a real context, namely the processing of organic waste into briquettes, which has not been widely explored in chemistry learning. This finding shows that applying LKPD in making corn stover and coffee grounds briquettes with a guided inquiry learning model is proven effective in developing students' scientific skills.

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INTRODUCTION

Indonesia is one of the countries that has enormous renewable energy potential, but its utilization is still not optimal. Meanwhile, energy demand is increasing every year, along with the increase in human activities (Arake, 2017). Indonesia ranks 5th in global coffee consumption, along with the rapid growth of coffe shops. This condition produces much waste on coffee grounds; about 90% of coffee grounds are not utilized. To reduce this waste, coffee grounds can be utilized as an environmentally friendly briquette-making material (Khoiroh et al., 2024). Based on data from the Central Statistics Agency (BPS), Indonesia produces 5.7 million tons of corncob waste yearly. However, most of the waste has not been optimally utilized. It tends to be thrown away or burned, which can cause environmental pollution and impact greenhouse gas emissions and global warming (Pratama, 2023).

Several of studies have shown that corncob waste can be processed into charcoal briquettes as an environmentally friendly alternative fuel. Corn waste is a lignocellulosic waste from the agricultural sector that contains main components such as cellulose, hemicellulose, and lignin. Its chemical composition comprises of approximately 23.3% lignin, 44.9 cellulose, and 31.8% hemicellulose. In addition, corn stover also has a high calorific value (Suherman et al., 2022)

In the world of education, integrating environmental issues such as agricultural waste management into teaching activities is crucial because not many have integrated guided inquiry learning models. Guided inquiry can improve students' higher-order thinking skills, such as critical thinking, and help them develop scientific skills (Azizah et al., 2019). One of the

learning to improve students' understanding and concept discovery (Wahyuni & Witarsa, 2023). Questions will guide learners in understanding the problem to be solved, formulating hypotheses, collecting data, analyzing data, and making conclusions (Puspitasari et al., 2019). The Guided Inquiry approach encourages students to be directly involved in the scientific process deepen chemical understanding while improving critical thinking and metacognitive skills (Pahriah et al., 2024).

Practicum usually focuses on applying module content without fully developing students' scientific performance. For this reason, supporting media such as worksheets are needed (Afriani et al., 2024). Learning should emphasize more on good practice in the laboratory, which refers to the ability of scientific performance, thus the importance of scientific performance in classroom learning activities (Pradianti et al., 2017). Therefore, it is necessary to develop guided inquiry-based LK to support student practicum with simple procedures in the laboratory so that it has the opportunity to build student knowledge (Sulaeman et al., 2021).

Howeverfew studies still integrate the guided inquiry approach with real contexts, such as the utilization of organic waste in chemistry learning, even though this approach has the potential to increase the relevance and effectiveness of learning. On the other hand, the issue of processing organic waste such as corn stover and coffee grounds as alternative energy materials is still not widely utilized in chemistry learning at school. Therefore, this study aims to investigate the effectiveness of students' scientific skills on organic waste processing integrated with a guided inquiry learning model that not only gives students practical experience in applying chemical concepts, but also develops students' scientific performance, such as critical thinking, problem-solving, and working scientifically in practicum.

METHOD

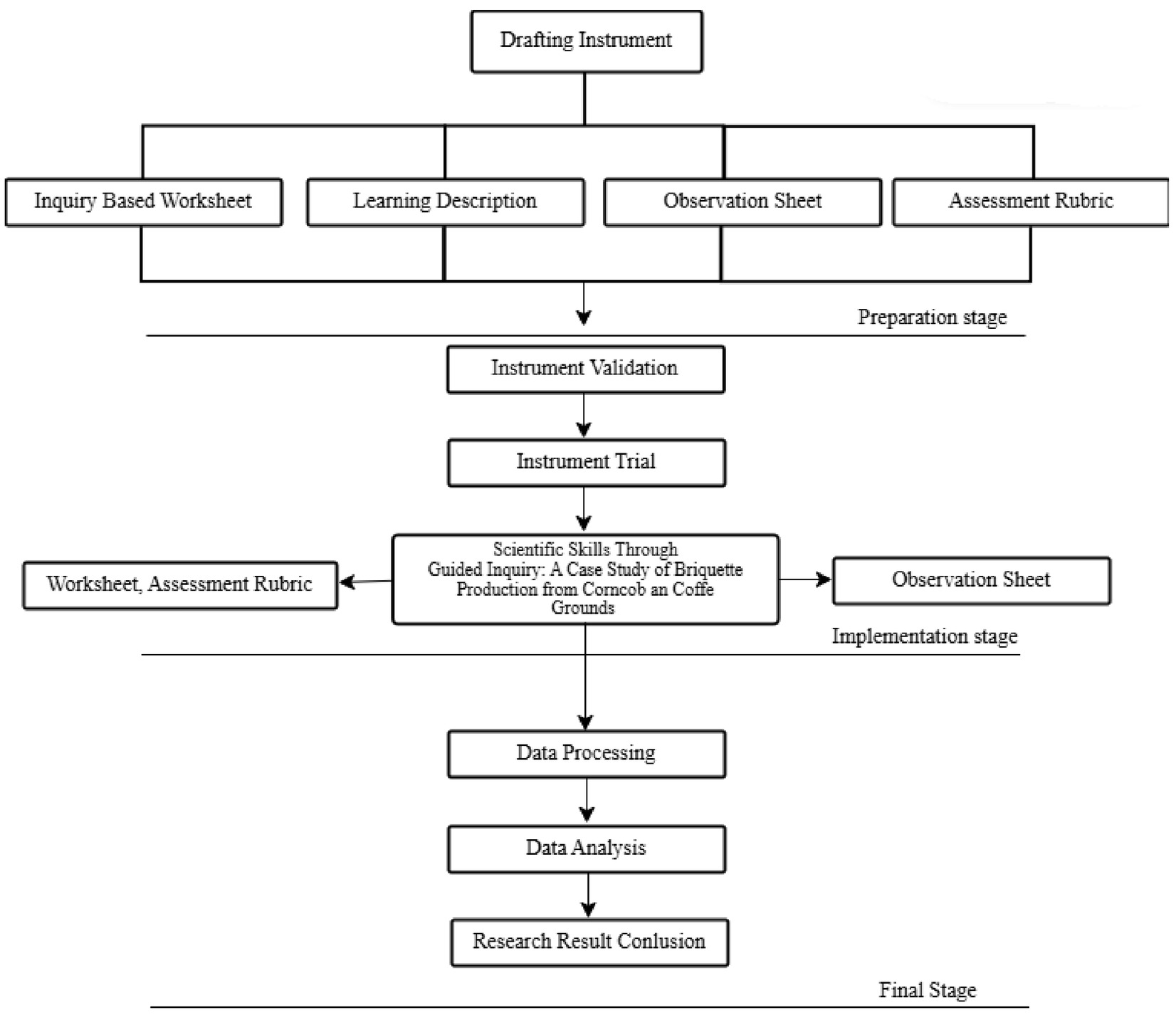

Figure 1. Research Procedure

This research uses quantitative approach, using the pre-experiment method with the One Shot Case Study design. This study used guided inquiry-based worksheets with application to students. This study involved three groups from class XI majoring in Industrial Chemical Engineering. The research focused on Waste Management subjects, subtansial waste treatment materials. The design used is a one-shot case study, which only involves one experimental class without a comparison class and an initial test. This is about applying LK using corn stovers and coffee grounds for briquette making. The research procedure as shown as Figure 1.

Research Procedure

In the preparation stage, instruments are designed as of inquiry-based worksheets, learning descriptions, observation sheets, and assessment rubrics. Experts validated the instrument and then tested to ensure its feasibility and improvement before use. In the next stage, the practicum was to make briquettes of corn stoves and coffee grounds. In the final stage, the data from the implementation were processed and analyzed to determine the effectiveness of the guided inquiry approach in improving students' scientific skills through the context of utilizing organic waste. The results of the analysis became the basis for drawing research conclusions.

Data Analysis

Data analysis techniques used in this study include quantitative descriptive analysis to assess the results of observations of students' scientific performance in adjusting the worksheet. The data obtained in this study were calculated using the formula:

$$\%\ \text{Assesment} = \frac{\text{obtained total}}{\text{total assessment score}} \times\ 100\%$$

Then, the data is interpreted into the average learning outcome category, as seen in Table 1.

Table1 . Categories of average learning outcomes say

Average Score	Description
80-100	Very Good
66-79	Good
56-65	Sufficient
40-55	Insufficient
30-39	Fail

This research follows the stages of guided inquiry: 1. observation 2. asking questions 3. making hypotheses 4. conducting experiments 5. analyzing data 6. drawing conclusions. Instrument validity was obtained from expert lecturers to assess the suitability of the instrument content to the scientific skills indicators measured.

RESULTS AND DISCUSSION

Data analysis on the results of this study is divided into 2 parts, which include student activities on the application of guided inquiry-based worksheets and student scientific performance on LK.

The guided inquiry model can increase students' learning activity from a moderately active level to a more active one (R. M. Sari et al., 2019). The implementation of the worksheet begins with preliminary activities that aim to build apperception and increase student motivation before entering the learning process. Furthermore, the core activities were carried out, where students conducted a practicum on making briquettes from corn stover and coffee grounds, as well as completing the worksheet designed with guided inquiry stages. Learning activities encompass various actions carried out by students to achieve learning objectives. (Erzaita et

al., 2020). A recapitulation of the value of the results of observing student activity at each stage of the guided inquiry-based worksheet is given in table 2.

Table 2. Recapitulation of Student Activity Data Processing Results

Group	Student Activity (%) at Each Stage of Guided Inquiry Learning						Average	Interpretation
	1	2	3	4	5	6		
1	100	75	75	100	91,6	93,8	89,2	Very Good
2	100	100	100	100	91,6	93,8	97,6	Very Good
3	75	75	75	100	91,6	87,5	84	Very Good
Average	91,7	83,3	83,3	100	92	91,7		Very Good

Based on the data presented in the table, it can be seen that students' activities at each stage of guided inquiry-based learning show very good results. The high activity of students at each stage of learning reflects that this approach is able to encourage students' overall involvement in the learning process, both in discussion, experimentation, and reflection.

Several studies support the effectiveness of this model Uzezi & Zainab (2017) found that with an approach centered on student activity, guided inquiry improved students' critical thinking and scientific performance. In addition, research by Öztürk et al, (2022) stated that the guided inquiry model requires students to actively conduct research and analysis, thus triggering the interaction of their involvement in each stage of learning. Thus, guided inquiry can produce a marked increase in student engagement, motivation and academic achievement as well as long-term retention (Belo, 2021). This shows that with the right guidance, it can facilitate the learning process and help students better prepare for materials related to environmental issues in academia. Learning outcomes are changes in behavior obtained by students after experiencing learning activities. Learning that enables students to take a more active role in their learning process compared to traditional teaching methods (Thorndahl & Stentoft, 2020). According to Murnihati & Darmawan (2022) learning outcomes are changes in behavior obtained by learners after experiencing learning activities. Overall, the results of student activity through the guided inquiry approach have important implications for chemistry teaching. Teachers provide opportunities for students to investigate phenomena and solve existing problems in groups, the learning process becomes more effective and interesting.

Carried Out The Observations

In the early stages of learning, students carried out observations of the waste materials that will be used and observe the problems from the discourse presented. With guidance, students show a more systematic way of observation, and are more thorough in recording data and phenomena (Jong et al., 2023). Student activities in making observations can be seen in Figure 2.

Figure 2. Activity in Carried Out The Obsevation

After students' observation activities take place, the observation data are presented in more detail in Table 3.

Table 3. Average results at the observation stage

Group	Score obtained (Maximum 4)	Score	Interpretation
1	4	100	Very Good
2	4	100	Very Good
3	3	75	Good
Average		91,7	Very Good

The results obtained regarding the achievement of students' scientific performance in guided inquiry-based learning activities at the stage of making observations show that groups 1 and 2 can carry out all stages of learning optimally, both in aspects of understanding concepts, involvement in group discussions, and in conveying the results of thinking logically and scientifically. This is by the findings of Naini et al., (2024), which state that learning using guided inquiry-based worksheets at the stage of making observations can improve scientific performance skills because the guided inquiry model reflects the scientific method. Showing that guided inquiry, as in the observation phase, consistently improves students' understanding and scientific skills (Chengere et al., 2025). Research Setiwati et al., (2015) added that students are more confident and enthusiastic about participating in learning.

In contrast, group 3, obtained a score of 3 equivalent to a 75 and is in the good category. This states that it is an obstacle per the statement of Fransiska et al., (2018) that students who are accustomed to conventional learning methods experience obstacles in applying the stages of making observations. Furthermore, striking differences also appear in the aspects of mastery of practical procedures and skills in conducting practicum. With experiments in finding and sorting information from various sources so that they have broader knowledge and high accuracy. This makes experimental class students more careful and skillful in carrying out each step in practicum activities (Oktaviana et al., 2020).

Formulating the Problem

At the stage of formulating the problem, the researcher guided the participants of class XI in identifying problems through discussion. Findings by Suseno et al., (2023) stated that the stage of formulating problems will increase student curiosity, which is the foundation of motivation in the learning process. Giving students an understanding of the problem of the large amount of corn stover waste and coffee grounds that have not been managed optimally can encourage their interest in understanding the issue and formulating the right solution. Students' activities in formulating the problem can be seen in Figure 3.

Figure 3. Activity in Formulating Problem

Next, the researcher directed the participants to formulate questions related to the topic of the experiment. In this second stage, students were asked to formulate two problem questions related to the discourse that had been delivered. This is in line with research conducted by Mulyani et al., (2015) which states that guided inquiry emphasizes scientific problem-solving through a process of in-depth investigation in order to find answers to problems that have been formulated. In addition, Erawarni & Yulianti (2021) highlighted that students' skills in formulating problems and their relation to scientific processes include pattern observation and scientific reasoning.

Research by Jong et al., (2023) concluded that the problem formulation phase can increase students' cognitive engagement and scientific thinking skills. The process requires students to connect prior knowledge with new contexts, practicing scientific performance skills. Thus, students' cognitive engagement increases because they do not just receive information but form the direction of the guided inquiry process. The research Saekawati & Nasrudin (2021) conducted means that students' active involvement increases, especially in formulating problems and critical thinking. The results of the guided inquiry-based worksheet in stage 2 formulating the problem are shown in Table 4.

Table 4. Average results at the stage of formulating the problem

Group	Score obtained (Maximum 4)	Score	Interpretation
1	3	75	Good
2	4	100	Very Good
3	3	75	Good
Average		83,3	Very Good

The level of participant involvement in the problem formulation stage reached 83.3, which is classified as very good based on Table 4. However, only one group had all its members actively participating in the process of identifying problems and formulating questions, while in the other two groups, only two to three members from each group were involved in the discussion. The ability to formulate problems is one of the important aspects of developing scientific performance. This result is in accordance with what was stated by Widodo et al., (2023) who stated that the learning approach used was quite effective in encouraging students to identify and formulate problems appropriately and could encourage participate in the process of problem identification and formulation actively. The more relevant the problem presented in the waste management issue, the greater the opportunity for students to identify and solve problems effectively.

Creating a Hypothesis

Students' activities in formulating problems can be seen in Figure 4.

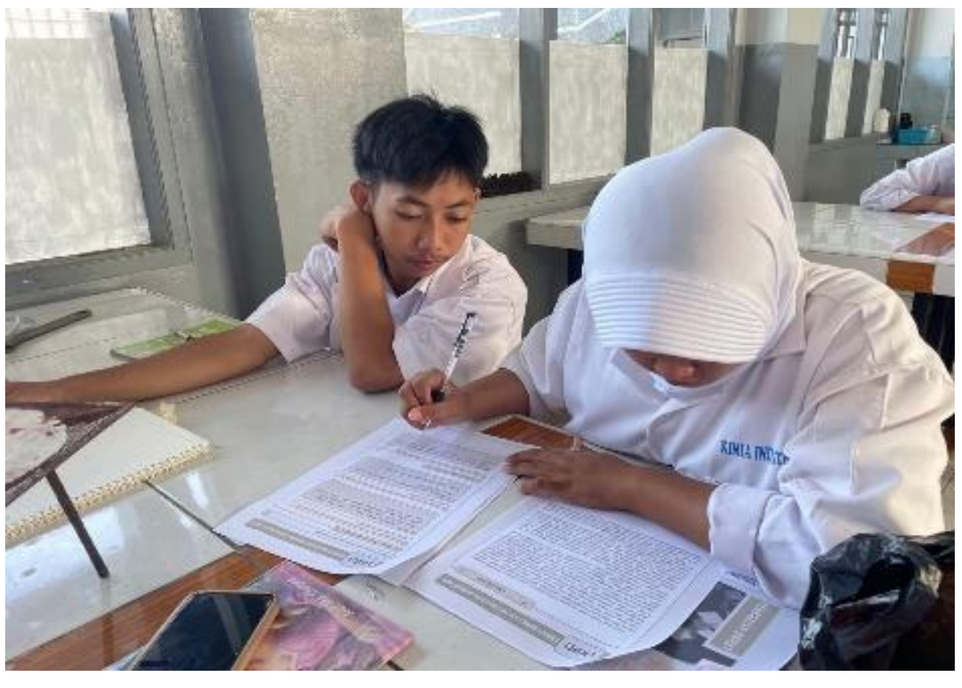

Figure 4. Hypothesis Making Activity

Practitioners are directed to search for appropriate literature to formulate temporary answers to research questions. Hypothesis formulation is one of the stages in the scientific method that serves as a guidepost in the research process. Without a hypothesis, research can lose focus and the goals to be achieved (Halim et al., 2022). The results of the guided inquiry-based worksheet in stage 3 of hypothesis generation are shown in Table 5.

Table 5. Average results at the stage of making a hypothesis

Group	Score obtained (Maximum 20)	Score	Interpretation
1	18	90	Very Good
2	17	85	Very Good
3	19	95	Very Good
Average		90	Very Good

Based on Intan (2020) research findings, creating hypotheses as the third stage in guided inquiry significantly improves students' metacognitive abilities. The average score of the three groups is 90, which overall indicates that the majority of students have demonstrated excellent mastery of the material or skills assessed. This indicates that the learning process was successful in improving students' scientific understanding and performance consistently among the groups. These results are in line with research conducted by Liandari et al., (2017) which shows that the science process skills approach through the practicum method can develop students' scientific performance in formulating and testing hypotheses. The stages of making hypotheses can help students think scientifically and solve problems using the scientific method. This is in line with Rahmatika et al., (2022) statement that formulating problems can help students generate more accurate and meaningful hypotheses and increase their confidence in the inquiry process.

Conducting an Experiments

At this stage, students begin to carry out practicum activities that have been previously designed. Laboratory experiments involve students in the inquiry process, where they play an active role by asking questions, making conjectures, making observations, organizing data, and explaining the patterns found (Adrianus Nasar, 2019). Student activities in conducting experiments can be seen in Figure 5.

Figure 5. Activity Conduct an Experiment

As a crucial part of the scientific working process, this stage provides an opportunity for students to apply their theoretical understanding in the form of real experiments. Thus, this stage reflects the extent to which students understand the concepts that have been learned and their readiness to carry out practicum activities in groups. Based on the results at the stage of conducting experiments, it is shown in Table 6.

Table 6. Average results at the stage of conducting experiments

Group	Stages (Scores earned)					Total Score (Maximum 20)	Score	Interpretation
	1	2	3	4	5			
1	4	4	3	3	3	17	85	Very Good
2	4	3	3	3	4	17	85	Very Good
3	4	4	4	3	3	18	90	Very Good
Average							87	Very Good

The implementation of experimental activities at the guided inquiry stage is proven to make a significant contribution to improving science process skills, scientific performance, and student learning outcomes (Fitriyani, 2017). Research theory shows that laboratory learning with a guided inquiry approach encourages active student involvement through direct interaction with materials so as to develop critical thinking skills and improve scientific skills (Gupta et al., 2015).

This score reflects a good understanding of the instructions and responsibilities of each member of the group. These results are in line with the views of Chintya et al., (2023) who state that the score obtained through the implementation of the practicum illustrates the level of understanding of students in carrying out experiments. This is in accordance with what is stated by Simbolon et al., (2015) practicum is a learning pattern that provides direct experience to students in learning because they do it themselves and also pay attention to every variable during laboratory practice.

Analyzing Data

In this process, students not only receive lessons from the researcher's explanation but also discover for themselves the essence of the material they are learning. One of the important activities in this process is analyzing the data that has been obtained. The stage of analyzing data can support student involvement in learning (Suseno et al., 2023). The average results at the stage of analyzing data can be seen in Table 7.

Table 7. Average results at the stage of analyzing data.

Group	Score obtained (Maximum 4)	Score	Interpretation
1	3	75	Good
2	Good	75	Good
3	Good	100	Good
Average		83	Very Good

Based on Table 7, two groups scored 75 in the good category, while one group achieved a perfect score of 100 with an excellent interpretation. The overall average is 83, which falls into the excellent category. These results reflect that most students were able to process and interpret the experimental data correctly, although there are still some groups that need improvement in understanding the meaning of the data in depth. This shows that the stage of analyzing data in the guided inquiry learning model can improve students' science process skills, which are part of scientific skills (Sufriyah, 2024). In addition, research by Sulistyani et al., (2022) indicated that students' involvement in data analysis activities contributed to the improvement of critical, logical, and structured thinking skills, especially in developing scientific skills.

However, there are a number of limitations that must be taken into account in interpreting the findings of differences in student understanding in analyzing data Kaliisa et al., (2024). The suggestion for improvement for future research at the data analysis stage is to explain to

students how to make observations and skills that must be mastered before collecting data (Dagnew et al., 2020).

Making Conclusions

From the researcher's observations, each group representative was able to present the results of the experiment well. The conclusion making stage in this model helps improve students' science process skills, which is an important component of scientific performance in science learning (Pradianti et al., 2017). The activities of students during presenting the results can be seen in Figure 6.

Figure 6. The Activity of Making Conclusions

In a case study conducted by Suardana et al., (2019) it was found that guided inquiry models include important phases such as making inferences from data and comparing them with research questions or hypotheses which confirms that familiarizing students with making inferences can strengthen their understanding. The results of student assessment of guided inquiry-based learning at stage 6, namely making conclusions, are shown in Table 8.

Table 8. Average results at the stage of making conclusions

Group	Stages (Scores earned)			Total score (Maximum 12	Score	Interpretation
	1	2	3			
1	4	3	3	10	83,3	Very Good
2	4	3	3	11	83,3	Very Good
3	4	4	3	10	91,6	Very Good
Average					88,3	Very Good

The ability to draw conclusions is one of the important indicators in developing scientific skills because it involves the process of analysis and evaluation. Based on research findings Cai et al., (2021) shows that making conclusions will increase students' learning experience and science process. This achievement shows that the learning strategy applied is able to encourage students to think reflectively and critically about the information they get. Then the presentation was done using posters. The results of students' posters can be seen in Figure 7.

The poster-based scientific presentation method can improve students' activities and speaking skills. This skill is part of scientific performance that is important in science learning (D. P. Sari, 2017). This is supported by Eker (2016) who states that the use of posters as an alternative learning tool significantly improves academic achievement and student attitudes towards the subject. The results of research by Ross et al., (2019) show that presentations using posters facilitate scientific performance skills and create a positive learning environment and problem-solving.

Figure 7. Student Poster Results

The average score obtained by each group in each stage showed a positive consistency, with an outstanding interpretation category. The results indicate that the guided inquiry model allows students to explore diverse strategies for solving-problems and improving of their critical thinking skills and scientific skills. Through activities such as formulating hypotheses, designing experiments, and drawing conclusions, students show improvement in their scientific skills (Chengere et al., 2025). In addition, the opinion of Putri & Novita (2024) the results of his research stated that LK with guided inquiry model of chemistry representation needs to be developed to train students' process skills in chemistry learning. Strengthened by research from Prasetya et al., (2021) states that guided inquiry-based LK can strengthen scientific performance in laboratory practicum.

Novita (2015) states that the use of guided inquiry significantly supports students to find concepts independently in chemistry by involving students in learning in the laboratory and effectively improving student learning abilities on chemistry topics (Zammiluni et al., 2018). Also supported by research from Ginting et al., (2023) reported positive response results and high activity during learning with guided inquiry learning models. The challenges in implementing LK with guided inquiry models are balancing guided inquiry with curriculum coverage and doubts about its benefits in the traditional evaluation system (Qiftiyah, 2025). This is supported by Fitzgerald et al., (2019) who revealed several of significant barriers lack of teacher confidence in its application, insufficient time and strict curriculum adjustments.

Worksheets designed with guided inquiry stages show that core activities are implemented quite well. This can be seen from the results of students' scientific performance at each stage of LK, which is by the predetermined time. In addition, students were seen actively discussing during learning with their group members, and the practicum implementation went smoothly. Therefore, guided inquiry-based learning is highly recommended to be widely applied in science education to encourage the achievement of 21st-century competencies (Alake-Tuenter et al., 2015).

CONCLUSION

The study's result successfully identified the effectiveness of the guided inquiry-based learning model in making briquettes from corn stover and coffee grounds waste. They proved to increase student activity, conceptual understanding, and scientific performance at all stages of learning. The results showed that student activity reached 90.3%, while scientific skills showed very good results, with scores between 83-91.7 at each inquiry stage. This research makes an important contribution to developing contextualized chemistry learning media by applying guided inquiry-based LK that integrates the utilization of organic waste as teaching material. The results showed that this approach can to encourage the active involvement of students in the learning process, improve understanding of concepts meaningfully, and foster concern for environmental issues.

RECOMMENDATIONS

1. Curriculum Integration : Incorporate guided inquiry-based modules into regular chemistry curricula.
2. Teacher Training : Educators should receive structured training on inquiry-based instruction.
3. Real Contextualization : Encourage practicum themes the address environmental and community issues.
4. Expanded Research : Further studies should explore broader implementations across different contexts and variables.

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