

The Effect of Guided Inquiry–Based Student Worksheets (LKPD) on Students' Science Process Skills and Cognitive Learning Outcomes

Salma Apipah, Ismail Efendi

Biology Education, Faculty of Science, Engineering, and Applied Sciences,
Universitas Pendidikan Mandalika

*Corresponding Author: salmaapipah0501@gmail.com

Abstract

This study was motivated by students' low science process skills and cognitive learning outcomes, attributed to limited laboratory facilities and to instructional methods that did not actively engage learners. The study aimed to examine the effect of guided inquiry-based Student Worksheets (LKPD) on students' science process skills and cognitive learning outcomes. A quantitative quasi-experimental design was employed, involving two Grade X classes (experimental and control) at SMA Negeri 10 Mataram. Data were collected using an observation-sheet questionnaire to assess science process skills and a cognitive achievement test administered as a pretest and posttest. Hypothesis testing was conducted using ANOVA with the aid of SPSS. The results indicated improvement in science process skills in the experimental class, with the mean posttest score reaching 79 (compared with 77 in the control class). Cognitive learning outcomes also increased significantly, with a mean posttest score of 82 in the experimental class compared with 77 in the control class. The ANOVA results yielded a significance value of 0.00 (< 0.05), indicating that H_0 was rejected and H_a was accepted. Therefore, guided inquiry-based LKPD had a significant effect on students' science process skills and cognitive learning outcomes, and may serve as an alternative instructional medium to enhance the quality of biology learning in schools.

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INTRODUCTION

Education is widely recognized as a key driver of the development of high-quality human resources capable of competing in a globalized knowledge economy. Accordingly, quality education cannot be reduced to mere information transmission; it must prioritize information processing and higher-order thinking so that learners not only master content but also develop transferable skills and competencies (Rahmansyah, 2021). Within this perspective, teachers are required to design and implement instructional models that actively engage students in constructing knowledge rather than passively receiving it. The instructional strategies selected by teachers have been shown to substantially influence student learning outcomes (Sari & Hidayati, 2020). However, in many classrooms, lecturing remains the dominant method. Although lecturing is efficient for covering large amounts of material and addressing many students simultaneously, it often leads to low student participation and limited cognitive engagement, which, in turn, can result in a superficial understanding and unsatisfactory learning outcomes.

Student worksheets (LKPD) represent one instructional medium that can be strategically employed to increase student involvement in learning. In general, LKPD contain laboratory instructions, simple home-based experiments, discussion tasks, practice questions, and other activities that structure and scaffold students' engagement with learning materials.

Appropriately designed LKPD can support teachers in organizing learning activities, guiding students to discover concepts individually or collaboratively, developing science process skills and scientific attitudes, and enabling teachers to monitor student progress toward learning targets (Noprinda & Soleh, 2019). A growing body of research has focused on guided inquiry-based LKPD, which embeds inquiry phases such as problem identification, hypothesis formulation, experimentation, data analysis, and conclusion drawing into the worksheet structure. Islami and Khaeruddin (as cited in Aziz, 2019) reported that guided inquiry-based LKPD are more effective than conventional worksheets, and subsequent work by Islami et al. (2019) showed that guided inquiry-oriented worksheets can support the development of students' science process skills. Similarly, Hamidah and Haryani (as cited in Wardani) and Hamidah et al. (2018), in the context of chemistry education, found that guided inquiry-based LKPD not only helps students remember theoretical content but also nurtures their thinking processes through sequenced inquiry stages, facilitating independent concept discovery and improved understanding of abstract or difficult material.

Recent studies across diverse science topics and educational levels further underscore the potential of guided inquiry-based worksheets to promote both science process skills and cognitive outcomes. At the elementary level, Novan et al. (2022) developed guided-inquiry science worksheets on maintaining the health of human respiratory organs. They reported improvements in students' science process skills and learning outcomes. Sakina et al. (2024) found that guided inquiry worksheets contributed positively to science literacy and learning outcomes among fourth-grade students. Focusing on more generic aspects of scientific thinking, Faradilla and Hasan (2018) demonstrated that guided inquiry-based student worksheets can enhance students' generic science skills. At the secondary and higher-education levels, guided inquiry worksheets and related learning models have likewise been associated with gains in process skills and higher-order thinking. For example, Gustina et al. (2021) reported that a guided inquiry learning model assisted by LKPD improved students' process skills in a biochemistry course.

In contrast, Anbiya and Khaldun (2023) showed that integrating a problem-based learning model with guided inquiry worksheets can foster science process skills and critical thinking abilities. In chemistry-related topics, guided inquiry-oriented e-worksheets have been developed to improve students' science process skills in acid–base material (Anisah & Nasrudin, 2023), and guided inquiry-based LKPD have been shown to influence learning outcomes in acid–base concepts at the senior high school level (Regita et al., 2024). In addition, guided inquiry-based worksheets integrated with a flipped classroom approach to reaction-rate material have been reported to enhance students' critical thinking skills (Khairunnisak et al., 2023).

Beyond worksheets per se, the broader literature on inquiry-based and related active learning models also supports their effectiveness for developing science process skills and cognitive achievement. Sulistyani et al. (2022) analyzed the effectiveness of guided inquiry implementation and concluded that it can significantly improve students' science process skills. Nasir et al. (2019) found that combining project-based learning with guided inquiry improved both science process skills and cognitive learning outcomes. In line with these findings, Ni'mah et al. (2018) argued that inquiry-based learning inherently requires active student involvement, as content is not merely delivered but must be constructed through experiences of discovering pre-planned concepts, while Pratiwi et al. (2021) reported that guided inquiry can increase students' enthusiasm and focus during learning activities. Collectively, these studies suggest that guided inquiry-based LKPD and related inquiry-oriented instructional designs constitute promising tools for promoting both science process skills and academic achievement across content areas and grade levels.

Despite this robust evidence base, several challenges remain in classroom practice, particularly in contexts where learning resources and laboratory facilities are limited. Preliminary observations in the present study indicate that biology learning still faces several constraints that may contribute to low learning outcomes and are closely related to the instructional models employed. The school's biology laboratory is relatively basic, offering limited support for laboratory-based learning and practicum activities. These constraints are likely to hinder the development of students' science process skills, which depend on opportunities to observe, experiment, collect and analyze data, and draw evidence-based conclusions. Furthermore, many students exhibit limited understanding of fundamental scientific concepts and difficulties in applying this knowledge to everyday contexts, abilities that are central to the science process skills and scientific literacy. In such conditions, conventional lecture-dominated instruction is unlikely to provide sufficient scaffolding for active knowledge construction, inquiry, and transfer of learning.

Guided inquiry emerges as a particularly relevant instructional alternative for biology learning in these circumstances because it systematically positions students as active participants in the learning process. By structuring inquiry phases into LKPD, teachers can create learning environments in which students are supported in exploring problems, designing or following investigations appropriate to existing facilities, interpreting empirical findings, and deriving conceptual understanding, even when laboratory resources are modest. Prior research indicates that guided inquiry-based LKPD can help learners discover concepts independently, deepen their understanding of complex material, and promote higher-order thinking, all while supporting teachers in managing classroom activities and monitoring student progress (Hamidah et al., 2018; Islami et al., 2019; Noprinda & Soleh, 2019; Pratiwi et al., 2021). However, although guided inquiry-based worksheets have been examined in various science topics such as respiratory health, acid–base reactions, reaction rates, and biochemistry, empirical studies that specifically investigate their effectiveness in biology learning under conditions of limited laboratory infrastructure, with a simultaneous focus on both science process skills and cognitive learning outcomes, remain relatively scarce.

Against this backdrop, this study seeks to address the identified gap by developing and implementing guided inquiry-based LKPD in biology learning and examining their effectiveness in improving students' science process skills and cognitive learning outcomes. By employing more innovative and engaging learning materials grounded in guided inquiry principles, the study aims to support students in achieving a deeper understanding of biology concepts and in applying these concepts in broader, real-world contexts. The findings are expected to provide empirical evidence and practical recommendations for teachers on the design and use of guided inquiry-based LKPD to foster more interactive, student-centered learning, particularly in schools with constrained laboratory resources.

RESEARCH METHOD

This study employed a quantitative, quasi-experimental design with a pretest-posttest control group. The research design is presented in Table 1.

Table 1. Research design

Class	Pretest	Treatment	Posttest
Experimental	O1	X1	O2
Control	O1	X2	O2

Table 1 indicates that the experimental class used guided inquiry-based LKPD (X1), whereas the control class received conventional instruction (X2). Pretests and posttests were administered in both classes to determine differences in students' science process skills and cognitive learning outcomes. The population comprised all Grade X students at SMA Negeri 10 Mataram. The sample consisted of Class X.C as the experimental group (n = 30) and Class X.B as the control group (n = 30). Research instruments included (1) an observation-sheet questionnaire to measure science process skills and (2) a 25-item multiple-choice test to measure cognitive learning outcomes. Before use, the cognitive test items were examined for validity and reliability.

RESULT AND DISCUSSION

Results

The study was conducted at SMA Negeri 10 Mataram with two Grade X classes serving as the experimental and control groups. The purpose was to determine the effect of guided inquiry-based LKPD on students' science process skills and cognitive learning outcomes. Before implementation, the research instruments were validated to ensure that each item aligned with the study objectives and accurately measured the intended constructs. The cognitive achievement test was also examined for reliability and item validity, as presented in Tables 2 and 3.

Table 2. Reliability test results

Cronbach's Alpha	Number of Items
0.958	30

As shown in Table 2, the Cronbach's alpha coefficient was 0.958, indicating very high internal consistency. Using $r\text{-table} = 0.3440$ (n = 30), the coefficient exceeds the reference value; therefore, the test instrument was considered reliable. Item validity was assessed by comparing the corrected item-total correlation (r-count) with the r-table. Items with $r\text{-count} > r\text{-table}$ were considered valid (Table 3).

Table 3. Item validity test results (Product–Moment correlation)

Item	r-count	Decision
Item 1	0.376	Valid
Item 2	0.964	Valid
Item 3	0.964	Valid
Item 4	0.340	Not valid
Item 5	0.964	Valid
Item 6	0.143	Not valid
Item 7	0.964	Valid
Item 8	0.964	Valid
Item 9	0.892	Valid
Item 10	0.340	Not valid
Item 11	0.340	Not valid
Item 12	0.717	Valid
Item 13	0.455	Valid
Item 14	0.892	Valid
Item 15	0.282	Not valid

Item	r-count	Decision
Item 16	0.892	Valid
Item 17	0.892	Valid
Item 18	0.396	Valid
Item 19	0.892	Valid
Item 20	0.892	Valid
Item 21	0.892	Valid
Item 22	0.454	Valid
Item 23	0.892	Valid
Item 24	0.892	Valid
Item 25	0.582	Valid
Item 26	0.892	Valid
Item 27	0.892	Valid
Item 28	0.892	Valid
Item 29	0.025	Not valid
Item 30	0.340	Not valid

Based on Table 3, the test instrument validity data comprised 30 multiple-choice items. The validity test was conducted using the Product–Moment correlation formula. The analysis results indicated that 23 items had validity coefficients exceeding the r-table value and were therefore classified as valid. Although 7 items were found to be invalid, the researchers retained 2 of them for the test, resulting in a final number of 25 items administered. This decision was made because there was insufficient time to develop and validate new replacement items. Accordingly, the researchers chose to revise the wording of the 2 invalid items by aligning them with the instructional materials, particularly by clarifying confusing phrasing, thereby making the items clearer and more consistent with the indicators being measured. The science process skills, outcomes, and cognitive learning outcomes of students in the experimental and control classes are presented below.

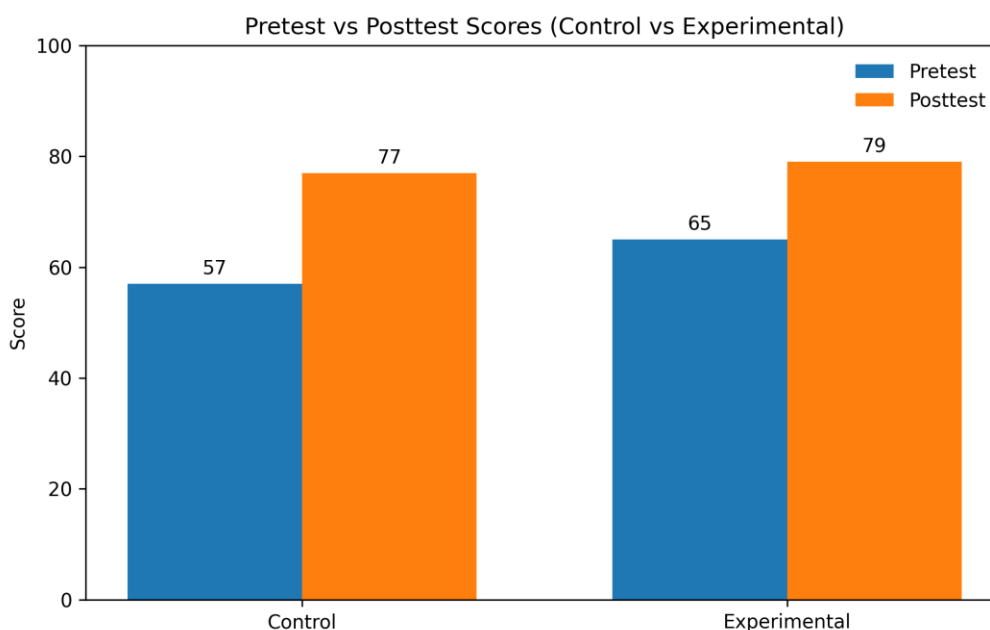


Figure 1. Mean science process skills scores

Based on Figure 1, the average score for students' science process skills in the experimental class increased from a pretest score of 65 to 79 on the posttest. Meanwhile, in the control class, the average pretest score of 57 increased to 77 on the posttest. Before conducting an ANOVA test to determine the effect of the treatment, normality and homogeneity tests were conducted. The normality test results are shown in Table 4, and the homogeneity test results are shown in Table 5.

Table 4. Normality test for science process skills (Shapiro–Wilk)

Group	Statistic	df	Sig.
Pretest-Experimental	0.942	30	0.106
Posttest-Experimental	0.931	30	0.051
Pretest-Control	0.967	30	0.463
Posttest-Control	0.950	30	0.167

Based on Table 4, the Shapiro-Wilk column shows that the pretest and posttest data for science process skills in both classes, and that the pretest-posttest difference between the experimental and control classes has a p-value > 0.05, indicating the data are normally distributed. The next prerequisite test is the data homogeneity test. The results of the homogeneity test are shown in Table 5.

Table 5. Homogeneity test for science process skills (Levene's test)

Based on	Levene Statistic	df1	df2	Sig.
Based on Mean	0.859	3	116	0.464
Based on Median	0.715	3	116	0.545
Based on Median and with adjusted df	0.715	3	112.299	0.545
Based on trimmed mean	0.864	3	116	0.462

Based on Table 5, the pretest and posttest data show that the science process skills of students in both classes are homogeneous (p-value > 0.05). The results of the analysis of students' science process skills are shown in the average scores for the experimental and control classes in Table 6, comparing pretest and posttest averages.

Table 6. ANOVA results for science process skills

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9329.500	3	3109.833	20.396	0.00
Within Groups	17686.467	116	152.470		
Total	27015.967	119			

Table 6 shows a p-value of 0.00 (< 0.05), indicating that H_0 was rejected and H_1 accepted at the 95% confidence level. Thus, guided inquiry-based LKPD had a significant effect on students' science process skills. After the ANOVA showed significant differences among groups, a Tukey post hoc test was conducted to identify which groups differed significantly. The results of the Tukey post hoc test are presented in Table 7.

Table 7. Post hoc Tukey test for science process skills

Group	N	Mean
Pretest-Control	30	57
Pretest-Experimental	30	65
Posttest-Control	30	77
Posttest-Experimental	30	79

Based on Table 7 of Tukey's Post Hoc Test, there was a significant difference between the pretest and posttest scores in the experimental and control classes. The average pretest score for the experimental class was 65, while the control class's average pretest score was 57. After learning, the control class's posttest score increased to 77, and the experimental class's posttest score reached 79, the highest. Each group was in a different subset, indicating that the differences between the groups were statistically significant at the 0.05 level. This shows that the learning method applied in the experimental class was more effective in improving students' science process skills than the control class. Furthermore, the data on students' cognitive learning outcomes are shown in the average scores for each class in Figure 2.

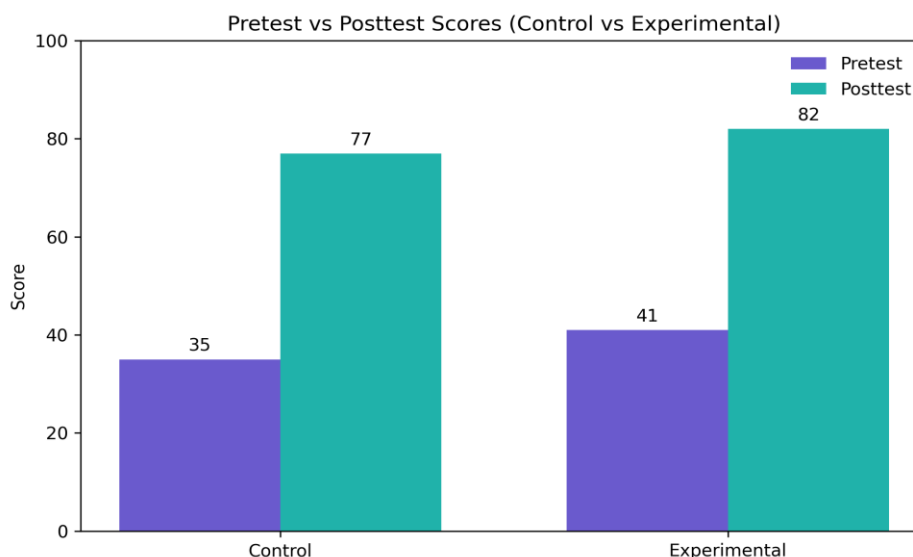


Figure 2. Mean cognitive learning outcomes scores

Based on Figure 2, the average value of students' science process skills in the experimental class increased from a pretest score of 41 to a posttest score of 82. Meanwhile, in the control class, the average pretest score of 35 increased to 77 in the posttest. Before conducting an ANOVA test to determine the effect of the treatment, normality and homogeneity tests were conducted. The normality test results are shown in Table 8, and the homogeneity test results are shown in Table 9.

Table 8. Normality test for cognitive learning outcomes (Shapiro–Wilk)

Group	Statistic	df	Sig.
Pretest-Experimental	0.973	30	0.613
Posttest-Experimental	0.941	30	0.100
Pretest-Control	0.950	30	0.169
Posttest-Control	0.947	30	0.140

Based on Table 8, the Shapiro-Wilk column shows that the pretest and posttest data for cognitive learning outcomes in both classes, with p -values > 0.05 for the experimental and control classes, indicate that the data are normally distributed. The next prerequisite test is the data homogeneity test. The results of the homogeneity test are shown in Table 9.

Table 9. Homogeneity test for cognitive learning outcomes (Levene's test)

Based on	Levene Statistic	df1	df2	Sig.
Based on Mean	1.416	21	97	0.130
Based on Median	0.326	21	97	0.998
Based on Median and with adjusted df	0.326	21	64.164	0.997
Based on trimmed mean	1.312	21	97	0.187

Based on Table 9, the pretest and posttest data show that students' science process skills in both classes are homogeneous (p -value > 0.05). The results of the analysis of students' cognitive learning outcomes are shown in the average scores for the experimental and control classes, as well as in the pretest and posttest averages, in Tables 10 and 11.

Table 10. ANOVA results for cognitive learning outcomes

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52401.067	3	17467.022	72.546	0.00
Within Groups	27929.600	116	240.772		
Total	80330.667	119			

Table 11. Post hoc Tukey test for cognitive learning outcomes

Group	N	Mean
Pretest-Control	30	35
Pretest-Experimental	30	41
Posttest-Control	30	77
Posttest-Experimental	30	82

Based on Table 11 of the Tukey Post-hoc Test, there was a significant difference between the pretest and posttest scores in the experimental and control classes. The average pretest score for the experimental class was 41, while the control class's average pretest score was 35. After learning, the control class's posttest score increased to 77, and the experimental class's posttest score reached 82, the highest. Each group was in a different subset, indicating that the differences between the groups were statistically significant at the 0.05 level. This shows that the learning method applied in the experimental class was more effective in improving students' science process skills than the control class.

Discussion

Based on the ANOVA results for students' science process skills, the significance value was 0.00, which is below the 0.05 significance level. This indicates a statistically significant difference between the experimental group, which used Guided Inquiry-based LKPD, and the control group, which used conventional instructional methods. Accordingly, it can be concluded that the implementation of Guided Inquiry-based LKPD had a significant effect on students' science process skills. This finding is further supported by an F value of 20.396, suggesting a substantial between-group difference. Post-hoc analysis using Tukey's

method showed that the greatest improvement in science process skills occurred in the experimental posttest group, which achieved a mean score of 79, considerably higher than those of the pretest and control groups. Learning activities facilitated through Guided Inquiry-based LKPD provided more meaningful learning experiences because students were directly engaged in scientific processes such as observation, experimentation, discussion, and conclusion. These activities not only strengthened practical skills but also fostered students' critical and analytical thinking. These results are consistent with the findings of Aisyah (2020) and Wijayanti and Saputra (2021), who reported that Guided Inquiry approaches are effective in significantly improving students' science process skills.

For students' cognitive learning outcomes, normality and homogeneity tests were first conducted as prerequisites for ANOVA. The results indicated that the data were normally distributed and homogeneous, thereby meeting the assumptions for ANOVA. The ANOVA results for cognitive learning outcomes yielded a significance value of 0.00, indicating that the use of Guided Inquiry-based LKPD had a statistically significant effect on improving students' cognitive achievement. The experimental group's posttest mean was 82, exceeding the control group's posttest mean of 77, while both groups' pretest means were substantially lower. This pattern demonstrates that Guided Inquiry-based LKPD effectively enhanced students' conceptual understanding. Through this approach, students did not passively receive information; instead, they constructed understanding through exploration, investigation, and discussion. This is aligned with studies by Zubaidah et al. (2018), Damayanti et al. (2020), and Maulidina and Afriani (2021), which similarly found that Guided Inquiry-based instruction significantly improves cognitive learning outcomes by promoting more active and meaningful learning processes.

CONCLUSION

Based on the findings, it can be concluded that guided inquiry-based LKPD had a significant effect on both students' science process skills and cognitive learning outcomes, as indicated by significance values of 0.00 for both variables, which are below the 0.05 threshold. This result reflects a meaningful difference between the experimental and control groups. Students who learned using guided inquiry-based LKPD demonstrated greater improvement in science process skills and conceptual understanding than those who learned through conventional instruction.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that biology teachers implement guided inquiry-based Student Worksheets (LKPD) as an effective instructional strategy to enhance students' science process skills and cognitive learning outcomes. Schools should also support the application of inquiry-based learning by providing adequate facilities and professional development opportunities for teachers to optimize its implementation. In addition, future researchers are encouraged to conduct similar studies with larger samples, different subject topics, or extended observation periods to further examine the effectiveness and long-term impact of guided inquiry-based LKPD on students' higher-order thinking skills and overall academic achievement.

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