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The Use of Guided Inquiry-Based Student Worksheet on Critical Thinking and Science Process Skills of High School Students

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Abstract: Students' critical thinking and science process skills remain limited, partly because existing worksheets are not fully aligned with specific learning strategies, such as guided inquiry. This study examined differences in critical thinking and science process skills among high school students using guided inquiry-based and conventional worksheets on environmental change. A quasi-experimental method with a non-equivalent posttest-only control group design was employed. The study involved 70 tenth-grade students from a high school in Surakarta, comprising 36 students in the experimental class and 34 in the control class. The experimental class used guided inquiry worksheets, while the control class used conventional worksheets. Learning was conducted over four sessions totaling six lesson hours. Data were collected through essay tests and analyzed using Welch's t-test due to non-normality. The results showed significant differences in critical thinking (Sig. = 0.003) and science process skills (Sig. < 0.001), with higher scores in the experimental class. Cohen's d indicated medium and large effects, respectively.

Keywords: Critical Thinking Skills; Environmental Change; Guided Inquiry; Science Process Skills; Worksheet.

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Introduction

Learning in the 21st century requires students not only to mastering factual knowledge, but also to be able to analyze, evaluate, and solve problems logically through a reflective thinking process (Hastuti, 2021) Critical thinking skills are one of the main competencies that need to be developed in modern education because they help students assess information, draw rational conclusions, and make evidence-based decisions (Mardhiyah et al., 2021) Along with creativity, communication, and collaboration, critical thinking skills are an important part of the competencies needed to deal with the complexities of life in the global era (Redhana, 2019) In science learning, the development of critical thinking is inseparable from science process skills such as observing, conducting experiments, collecting, and analyzing data that shapes students' scientific thinking (Azzahra et al., 2024).

Several studies show that the critical thinking skills of high school students in Indonesia are still in the low category. Azrai et al. (2020) reported that high school students in East Jakarta still have difficulties in analyzing and evaluating science problems independently. Research by Septiany et al. (2024) also shows that students' analysis, inference, and evaluation skills in biology learning are still dominated by the low category. In addition, students' science process skills have not been developed optimally. Elvanisi et al. (2018) reported that the skills of formulating hypotheses and designing experiments were still in the low category, while Kusuma & Rusmansyah (2020) showed that most students had science process skills in the low category.

The low of critical thinking and science process skills are inseparable from the characteristics of learning that take place in the classroom. The teaching materials used are still dominated by material summaries and routine practice questions, so it does not provide space for students to explore problems and scientific investigations (Husna et al., 2020) Activities involving scientific processes such as designing experiments, analyzing data, and evaluating results are also rarely done in science learning (Purnamasari et al., 2021). Rusyady (2022) found that science textbooks only contain a limited portion related to science process skills and have not actively involved students in the scientific process. This condition is strengthened by learning practices that are still teacher-centered, so that students tend to passively receive information and are less trained to develop analysis and evaluation skills through discussion and investigation (Firmansyah & Jiwandono, 2022). The limitations of inquiry-based learning approaches also limit students' opportunities to develop high-level thinking skills that are relevant to the demands of 21st century learning (Arifin et al., 2025).

Environmental change material has characteristics that are suitable for guided inquiry-based learning because it not only requires an understanding of concepts, but also students' ability to identify environmental problems, interpret evidence, analyze the relationship between causes and impacts, and formulate alternative solutions. Problems such as water pollution and waste management can be observed through real phenomena and observational data, thus providing context for students to conduct direct investigations (Atikasari, et al., 2012). In the process, students need to carry out scientific activities such as observing, measuring, classifying, predicting, analyzing data, drawing conclusions, and communicating the results of investigations. These characteristics make environmental change material relevant for learning that provides opportunities for students to build evidence-based understanding while developing critical thinking skills and science process skills (Stevenson, 2007). This material requires teaching materials that not only present information, but also provide scaffolding systematically so that students can undergo a directed investigation process.

To address this issue, guided inquiry-based student worksheets serve as an effective alternative. The guided inquiry model provides students with the opportunity to conduct investigations through structured stages, starting from formulating problems to drawing conclusions (Maknun, 2020). Through these stages, students are encouraged to observe phenomena, collect information, analyze data, and reflect on the results obtained so that critical thinking skills can develop systematically (Wulandahri et al., 2025). Guided inquiry is also closely related to the development of science process skills because students are directly involved in scientific activities such as formulating hypotheses, determining variables, and interpreting data (Deli et al., 2017). Thus, integrating the specific syntax of guided inquiry into structured student worksheets offers potential for improving the quality of school science education, including critical thinking and science process skills

A number of studies have examined the application of guided inquiry in science learning at the high school level. Wulandari (2017) showed that the guided inquiry model was able to improve students' high-level thinking skills and science process skills, while Gusmardin et al. (2019) reported that guided inquiry combined with scaffolding prompting-questioning had a significant effect on science process skills. The findings show that guided inquiry is effective in developing scientific thinking skills through the investigation process. However, most studies still apply guided inquiry as a learning model without integrating the syntax in its entirety into the student worksheet. Most previous studies have focused on guided inquiry as a learning model, while relatively fewer studies have examined the integration of its complete syntax into student worksheets. The research context using student worksheet integrated syntax guided inquiry on these two skills in biology learning has not been widely done.

Although previous studies have demonstrated the effectiveness of guided inquiry in developing students' critical thinking and science process skills, most studies have focused on guided inquiry as a learning model rather than on the integration of its complete syntax into a student worksheet as a structured learning scaffold. Therefore, the novelty of this study lies in the development and empirical examination of a guided inquiry-based student worksheet that explicitly and systematically integrates the complete guided inquiry stages to scaffold students throughout the investigation process. Importantly, the present study compares this structured worksheet with a conventional worksheet within the same guided inquiry learning model. This design allows the study to examine the contribution of the worksheet structure itself in facilitating students' critical thinking and science process skills, rather than merely examining the effect of the guided inquiry model. The worksheet is further reflected in the simultaneous examination of these two skills in high school biology learning on environmental change topics, a context that requires students to interpret environmental phenomena, investigate evidence, and formulate evidence-based solutions.

Based on the results of the study and the research gaps, this study aims to determine the difference in the use of guided inquiry-based student worksheet on the critical thinking skills and science process skills of high school students on environmental change topics.

Methods

This study uses a quantitative approach with a quasi-experimental method. The independent variable of this study is the application of student worksheet based on guided inquiry. The bound variables of this study are students' critical thinking skills and science processes on environmental change topics. The research design used was a nonequivalent posttest-only control group design. The research design can be seen in Table 1.

Table 1.

Nonequivalent Research Design Posttest-Only Control Group Design.

Groups	Treatment	Posttest
Experiment	X	O
Control	C	O

(Source: Fraenkel et al., 2012)

X :Learning that applies the guided inquiry model with student worksheet based on guided inquiry.
C :Learning that applies the guided inquiry model with conventional student worksheet.
O :Posttest Critical Thinking and Science Process Skills

This research was carried out in one of the Surakarta high schools. The population in this study included all students of class X. The sample in this study was two classes X which were selected as the experimental class and the control class. Sampling was carried out by cluster random sampling by conducting normality and homogeneity tests on the odd-semester Biology score. The results of the normality test showed a significance value of > 0.05 which means that all classes have normal values. The results of the homogeneity test also showed a significance value of > 0.05 which indicates that all classes have homogeneous values. Following random class selection, Class X-3 was designated as the experimental group and Class X-2 as the control group. While both groups were taught using the guided inquiry model, the experimental group utilized student worksheets explicitly structured around guided inquiry syntax, whereas the control group used conventional worksheets. The treatment was conducted in four meetings, with a total duration of 6 lesson hours (JP) for each class. Both classes received the guided inquiry learning model, while the experimental and control classes differed in the type of student worksheet used.

In this study, the conventional student worksheet refers to the worksheet used in the control class that does not explicitly and systematically integrate the complete syntax of guided inquiry. The conventional worksheet still contains supporting information, activity instructions, questions, and observation and data collection activities; however, these activities are not explicitly organized according to the complete stages of guided inquiry. In contrast, the guided inquiry-based student worksheet systematically integrates the stages of guided inquiry as scaffolding to support students throughout the investigation process, including identifying phenomena and problems, exploring information, formulating problems, collecting and analyzing data, presenting the investigation results, drawing conclusions, and evaluating the investigation process. The distinction between the two worksheets lies in their structure in facilitating the inquiry process, while both classes receive learning through the guided inquiry model.

The data collection technique used essay tests to measure students' critical thinking and basic science process skills. The critical thinking test consisted of 12 essay items developed based on five indicators proposed by Ennis (1996), namely elementary clarification, basic support, inference, advanced clarification, and strategy and tactics. The basic science process skills test consisted of six essay items developed based on six indicators proposed by Padilla (1990), namely observing, measuring, inferring, classifying, predicting, and communicating. The items were developed by aligning the question content with the indicators of each skill and the environmental change material. Each item was accompanied by a scoring rubric to ensure consistent assessment of students' responses.

Before the instruments were administered, the test items were reviewed through expert judgment to assess their content validity. The experts evaluated the relevance of each item to the intended indicator, the suitability of the item with the environmental change material, the clarity of the question, and the appropriateness of the scoring rubric. The instruments were revised based on the experts' suggestions before being subjected to empirical validity and reliability testing. The empirical validity test was conducted using Pearson product-moment correlation, while reliability was assessed using Cronbach's alpha. The results showed that the items met the required validity criteria, with significance values < 0.05. The reliability coefficients were 0.89 for the critical thinking skills instrument and 0.81 for the basic science process skills instrument, indicating high reliability.

Data were analyzed using jamovi (version 2.7.31). Normality and homogeneity of variance were assessed using the Shapiro–Wilk and Levene's tests ($\alpha = 0.05$), respectively. Because the data deviated from normality, hypothesis testing for critical thinking skills and scientific processes was conducted using Welch's t-test, with $p < 0.05$ indicating a statistically significant difference between the experimental and control groups. Welch's t-test was selected because it effectively handles unequal variances while remaining robust against non-normal data for sample sizes $N \geq 30$. The analysis was conducted using jamovi

(The jamovi project, 2021), which utilizes R to adjust the degrees of freedom appropriately for both variables.

Results & Discussion

A. The Effect of Guided Inquiry Learning with Guided Inquiry-Based Student Worksheet on Critical Thinking Skills

The results of the posttest of critical thinking skills in the control class and the experimental class were then analyzed using a prerequisite test, namely the normality and homogeneity test. This test is performed to ensure that the data is distributed normally and homogeneously, so that it can be used to proceed to the hypothesis testing stage using the t-test. After the normality test was performed, the significance value of the posttest data for the critical thinking skills of the experimental class was 0.008 and the control class was < 0.001. The results of the normality test are presented in Table 2.

Table 2.
Normality Test Results for Critical Thinking Skills Posttest.

	Data	Sig.	Conclusion
Critical Thinking Skills	Experimental class	0.008	Non-normally distributed
	Control class	< 0.001	Non-normally distributed

Since the critical thinking posttest data were non-normally distributed, hypothesis testing proceeded with Welch's t-test. This robust parametric test accommodates non-normal data (N≥30) and adjusts for unequal variances without requiring a formal homogeneity test. Based on the results of the analysis, the significance value of the critical thinking skill posttest was 0.003, which means that the significance value < 0.05. This figure shows that there is a significant difference between the experimental class and the control class. The results of the Welch's t-test for critical thinking skills are presented in Table 3.

Table 3.
Welch's t-test results for Critical Thinking Skills Posttest.

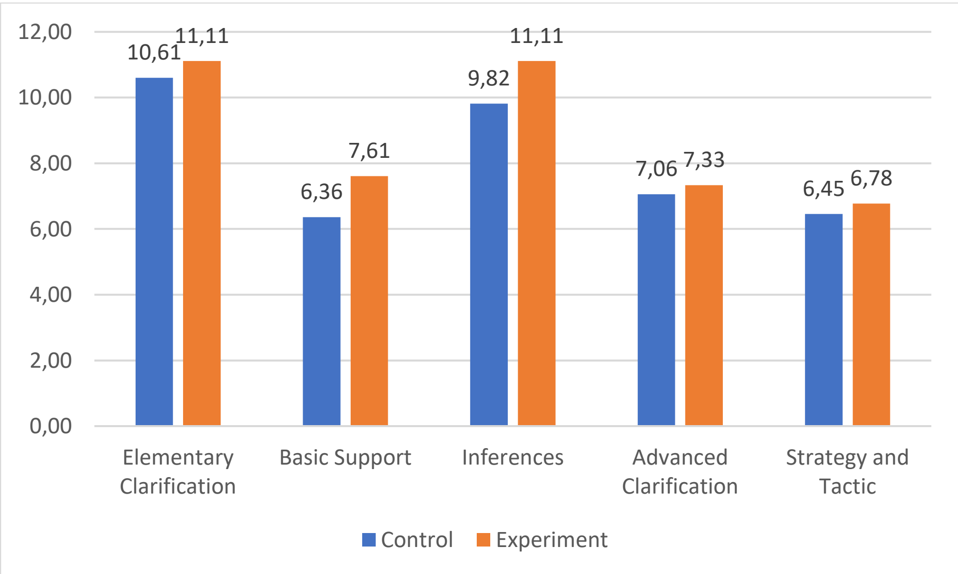
Data	Statistic	df	Sig.		Effect size
Critical Thinking Skills	3.16	55.7	0.003	Cohen's d	0.760

Table 3 shows that Welch's t-test revealed a statistically significant difference between the two groups, with a medium effect size (Cohen's d = 0.76), indicating that the guided inquiry-based worksheet meaningfully improved students' critical thinking skills compared to conventional worksheet. Aswirna et al. (2024) stated that the provision of guided inquiry-based student worksheet as scaffolding in learning is able to improve students' critical thinking skills. Student worksheet based on guided inquiry contains a series of questions and activities that encourage students to observe phenomena, collect and analyze data, and discuss results reflectively, so that the critical thinking process can be facilitated more systematically (Wulandahri et al., 2025). Thus, the average posttest score of critical thinking skills in the experimental class was higher than that of the control class.

The difference in critical thinking skills between the two classes can be explained based on the differences in the structure of the student worksheet used during the learning process. Student worksheet based on guided inquiry not only assigns tasks to students, but also provides gradual scaffolding to guide students in facing problems, collecting evidence, analyzing information, evaluating investigation results, and drawing conclusions based on evidence. The series of activities provides students with the opportunity to be directly involved in the thinking process that is part of critical thinking skills (Maknun, 2020). In contrast, conventional student worksheet that do not fully integrate the guided inquiry syntax provide more limited direction in connecting each investigation activity with the thought process. The advantages of guided inquiry-based student worksheet in this study are not solely due to the existence of practicum activities, but also by the structure of student worksheet which systematically guides students to use evidence in solving problems and making decisions. For more detailed posttest average data for each critical thinking skill indicator, it is presented in Figure 1.

Figure 1.

Comparison of Posttest Average by Critical Thinking Skill Indikator.



Based on Figure 1, overall each indicator of critical thinking skills of the experimental class was higher than that of the control class. This shows that guided inquiry learning assisted by guided inquiry-based student worksheet affects students' critical thinking skills.

In the elementary clarification indicator, the experimental class showed better results than the control class with an average posttest score of 11.11 and 10.61. The high scores in both classes show that this skill is the most basic critical thinking skill so that it is relatively easier to practice than other indicators. However, the experimental class still obtained higher results because the guided inquiry-based student worksheet directed students from the orientation stage to identify and focus on the problems to be investigated. These results are in line with the research of Ridzal et al. (2023) which showed that the application of guided inquiry had a strong influence on the critical thinking skills of biology students with an average effect size of 1.866 (strong effect). Annisa et al. (2021) also reported that the guided inquiry model was able to improve students' critical thinking skills as seen from the increase in pretest to posttest scores.

The difference in results was also seen in the basic support indicator, where the experimental class obtained an average posttest score of 7.61, while the control class was 6.36. The experimental class demonstrates that guided inquiry-based worksheets enable active investigation, better training students to collect and evaluate evidence-based information. On the other hand, conventional student worksheet is more oriented to the information that is already available, so that students' opportunities to develop these skills become more limited. These findings are in line with the research Firdaus & Wilujeng (2018) which shows that the use of guided inquiry-based student worksheet produces better critical thinking skills compared to the use of conventional student worksheet.

The inference skills also showed superiority in the experimental class with an average posttest score of 11.11, while the control class obtained a score of 9.82. These results show that the stages of data analysis and conclusion drawing in guided inquiry-based student worksheet are able to train students to build logical conclusions based on empirical data. In contrast, in the control class, the process of drawing conclusions is more directed by the teacher, so that students' opportunities to develop inference skills independently are more limited. The results of this study are supported by Irwanto et al. (2024) who found that guided inquiry learning combined with problem solving is able to significantly improve critical thinking skills. Ningsih (2025) also shows that the inquiry approach has a huge influence on students' inference skills.

The advanced clarification indicator showed a relatively small difference between the experimental and control classes, with mean scores of 7.33 and 7.06, respectively. This finding may indicate that although the guided inquiry-based worksheet provided opportunities for students to investigate environmental problems and develop explanations based on evidence, students still required more explicit practice in elaborating and clarifying the reasoning underlying their conclusions. This is important because advanced clarification requires students not only to identify or provide an explanation but also to examine and clarify the basis of an explanation. Nugroho et al. (2021) reported that advanced clarification was less frequently represented in the questions analyzed in a high school chemistry textbook than other critical thinking indicators, suggesting that students may receive fewer opportunities to practice this aspect of critical thinking during learning. Therefore, the relatively small difference observed in the present study may be related to the limited opportunity for students to repeatedly engage with tasks that specifically require further clarification and examination of their reasoning. This interpretation is also supported by Isra et al. (2025), who demonstrated that learning activities supported by an e-worksheet specifically designed to target the advanced clarification indicator can enhance students' critical thinking skills. Accordingly, future implementation of guided inquiry-based worksheets on environmental change should provide more explicit scaffolding for advanced clarification, particularly through follow-up questions that require students to elaborate the reasons for their conclusions, examine alternative explanations, and justify their interpretations based on the evidence obtained. Such targeted activities may provide students with more opportunities to develop advanced clarification alongside the inquiry process.

The advantage of the experimental class was also seen in the strategy and tactics indicators, with an average posttest score of 6.78, while the control class obtained a score of 6.45. These results show that guided inquiry-based student worksheet provides opportunities for students to formulate solutions to environmental problems based on the evidence that has been obtained during the investigation. In contrast, in conventional learning, student involvement in the decision-making process is still relatively limited. These findings are supported by research by Nurliana et al. (2023) which states that learning that is still teacher-centered causes strategies and decision-making skills to develop less than optimal because students do not get enough opportunities to think and determine solutions independently.

B. The Effect of Guided Inquiry Learning with Guided Inquiry-Based Student Worksheet on Science Process Skills

Prior to hypothesis testing, posttest data for science process skills were evaluated for normality. Results showed that scores for both the experimental and control classes were non-normally distributed ($p < 0.001$; Table 4). Because the assumption of normality was violated, the homogeneity test was omitted, and hypothesis testing proceeded directly using Welch's t-test.

Table 4.

Normality Results for Science Process Skills Posttest.

	Data	Sig.	Conclusion
Critical Thinking Skills	Experimental Clas	< 0.001	Non-normally distributed
	Control Class	< 0.001	Non-normally distributed

Due to non-normality in the science process skills posttest data, hypothesis testing was carried out using Welch's t-test. As a robust parametric approach, it accommodates non-normal data while effectively handling potential variance differences for sample sizes N≥30. Based on the results of the analysis, the significance value of the critical thinking skills posttest was < 0.001, which means the significance value < 0.05. It shows that there is a significant difference between the experimental class and the control class. The results of the Welch's t-test test for science process skills are presented in Table 5.

Table 5.

Welch's t-test results for Critical Thinking Skills Posttest.

Data	Statistic	df	Sig.		Effect size
Critical Thinking Skills	318	38.0	< 0.001	Cohen's d	0.836

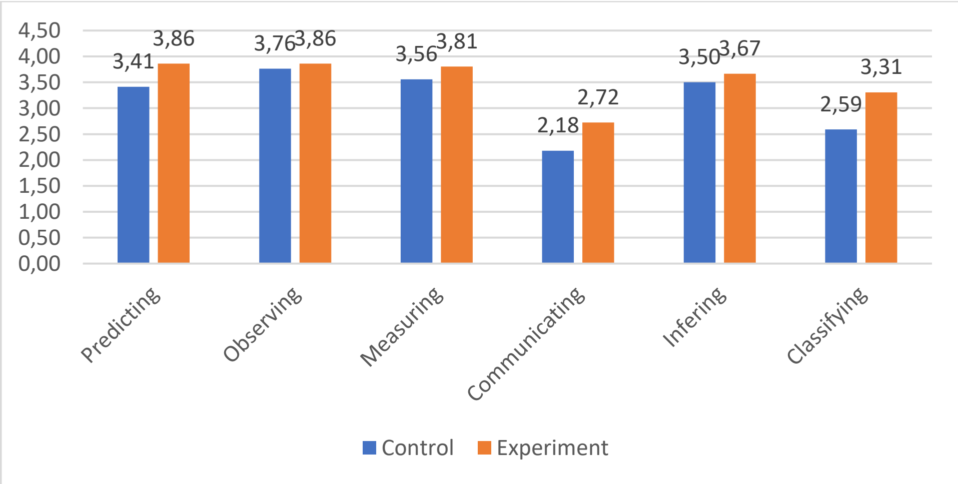
Table 5 shows that Welch's t-test revealed a statistically significant difference between the two groups for science process skills, with a large effect size (Cohen's d = 0.836), indicating that the guided inquiry-based worksheet substantially enhanced students' science process skills compared to conventional worksheet. The findings are in line with the research of Budiyono & Hartini (2016) which reported that students who learn through guided inquiry have higher science process skills than students who follow conventional learning.

The difference in science process skills between the experimental class and the control class is related to the difference in the level of direction of scientific activity in the two student worksheets. Student worksheet based on guided inquiry presents a gradual investigation process so that students are consistently directed to make observations, make predictions, make measurements, group information, analyze observation results, and communicate the results of the investigation (Deli et al., 2017). Each of these stages provides an opportunity for students to practice science process skills directly in the context of environmental problems. Meanwhile, conventional student worksheet still allows students to carry out observation and data collection activities, but does not provide a complete structure of guided inquiry stages to connect these activities as a systematic investigation process. The advantages of guided inquiry-based student worksheet in improving science process skills can be attributed to the consistency and regularity of students' opportunities to practice scientific skills during the learning process (Deli et al., 2017). For more details, the average posttest data for each science process skill indicator is presented in Figure 2.

The results showed that the predictive skills of students in the experimental class were better than those in the control class, with an average score of 3.86 and 3.41, respectively. These findings indicate that guided inquiry worksheets provide students greater opportunities to formulate hypotheses and predict events using gathered information. According to Fitriyani et al. (2017), predictive skills often do not develop optimally because students are still rarely involved in formulating conjectures before investigations are carried out. In contrast, the developed worksheet explicitly guides students to make early predictions, better training this skill. This result is also strengthened by research by Syarif et al. (2025) which shows that the application of guided inquiry effectively improves science process skills, including predictive skills.

Figure 2.

Comparison of Posttest Averages by Science Process Skill Indikator.



Observing skills were one of the indicators that obtained high scores in both classes, although the experimental class still showed better results (3.86) than the control class (3.76). This condition shows that the skill of making observations is relatively easy to develop when students are directly involved in investigative activities. Guided inquiry-based worksheets direct students to systematically observe environmental changes, ensuring they learn from their own observations rather than relying solely on teacher explanations. These results are in line with the research of Fatmi & Sahyar (2014) which found that observation skills obtained the highest improvement in inquiry learning. The findings are also supported by Fitriyani et al. (2017) who stated that students' direct involvement in the observation process is an important factor in improving observation skills.

In the measuring indicator, the experimental class obtained a higher score (3.81) than the control class (3.56). This difference indicates that student worksheet based on guided inquiry is able to guide students in measuring more accurately during investigation activities. This is inseparable from the work instructions in the student worksheet which are compiled in stages so that students are more directed when taking measurements. The results of this study are in line with Fitriyani et al. (2017) who reported that guided inquiry learning is able to improve skills using tools and materials because students gain direct experience through practicum activities. In addition, measuring skills are also supported by observation skills that have developed well during the learning process.

Compared to other indicators of science process skills, communication skills still showed the lowest achievements, although the experimental class still scored higher (2.72) than the control class (2.18). These results show that the skill of conveying observations and conclusions requires more intensive training than other process skills. While these worksheets provide opportunities to discuss and present investigation results, time constraints may prevent the optimization of students' communication skills. This finding is in accordance with the research of Fatmi & Sahyar (2014) which states that communication skills are the lowest improvement indicator because they are influenced by interaction and cooperation between students. This interpretation is consistent with the findings of Muslikah et al. (2025), who reported that science process skills, particularly communicating results, improved significantly when students received progressive scaffolding through explaining, prompting, cueing, and questioning, with questioning showing the greatest effectiveness for communication skills. Therefore, the relatively low communicating score in the present study suggests the need to provide more explicit and continuous scaffolding for scientific communication within the worksheet. Practically, teachers can incorporate guiding questions that require students to organize investigation results, explain the meaning of the data, formulate evidence-based conclusions, and present their findings orally or in writing. Providing repeated opportunities for presentation and feedback throughout the inquiry process, rather than limiting communication to the final stage of the activity, may help students develop their ability to communicate scientific findings more effectively.

The students' inferring skills also showed a better tendency in the experimental class with an average score of 3.67, while the control class obtained 3.50. These differences show that the stages of data analysis in guided inquiry-based student worksheet help students relate the results of observations with conclusions based on evidence. According to Fatmi & Sahyar (2014), the process of drawing conclusions is the final stage in inquiry learning that functions to integrate all research results. In line with that, Fitriyani et al. (2017) explained that inference skills develop through data analysis and discussion activities, so that the more actively students are involved in these two activities, the better their skills in drawing conclusions.

The most striking score difference was seen in the classifying indicator, where the experimental class obtained an average score of 3.31, while the control class obtained only 2.59. These findings show that guided inquiry-based student worksheet is more effective in training students to group various environmental change phenomena based on their characteristics. During the investigation process, students not only gather information, but also organize it into specific categories so that the classification process takes place more systematically. These results are in line with the research of Fitriyani et al. (2017) which states that classification skills develop through data collection and discussion activities. In addition, Syarif et al. (2025) also reported that guided inquiry learning provides a better improvement in science process skills than conventional learning.

Conclusion & Recommendation

This study demonstrates that supporting guided inquiry instruction with systematically structured student worksheets leads to significantly greater learning gains. Analysis using Welch's t-test confirmed statistically significant differences in the experimental group in both critical thinking skills ($p = 0.003$) and science process skills ($p <$

0.001). These findings show that integrating explicit inquiry syntax directly into learning materials is crucial for optimizing student skill development, rather than relying on guided inquiry instruction paired with conventional worksheets. Consequently, future research should extend these findings by incorporating targeted scientific communication activities and advanced concept elaboration into worksheet designs, while expanding testing across broader sample sizes and science topics to enhance generalizability.

References

Annisa, S. N., Setiono, & Juhanda, A. (2021). Kemampuan Berpikir Kritis Peserta Didik Melalui Model Pembelajaran Guided Inquiry Berbasis Riset Berbantuan Media WhatsApp. *Jurnal Pendidikan Mipa*, *11*(1), 18–26. https://doi.org/10.37630/jpm.v11i1.431

Arifin, Z., Sukarmin, Saputro, S., & Kamari, A. (2025). The effect of inquiry-based learning on students' critical thinking skills in science education: A systematic review and meta-analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(3), 1–24. https://doi.org/10.29333/ejmste/15988

Atikasari, S., Wiwi, I., & Andreas, P. B. P. (2012). Pengaruh pendekatan problem based learning dalam materi perubahan lingkungan terhadap kemampuan analitis. *Unnes journal of Biology Education,* 18-25.

Aswirna, P., Roza, M., & Aldania, R. (2024). Application of Lkpd Based on Guided Inquiry Model Assisted By Phet Simulation To Learners' Critical Thinking Skills. *Journal of Learning and Technology in Physics*, *2*(2), 46. https://doi.org/10.24114/jltp.v2i2.56676

Azrai, E. P., Suryanda, A.-, Wulaningsih, R. D., & Sumiyati, U. K. (2020). Kemampuan berpikir kritis dan literasi sains siswa sma di jakarta timur. *EDUSAINS*, *12*(1), 89–97. https://doi.org/10.15408/es.v12i1.13671

Azzahra, M. Z., Nawahdani, A. M., & Falani, I. (2024). The relationship between science process skills and 21st century skills in science learning: Systematic literature review. *EduFisika: Jurnal Pendidikan Fisika*, *9*(3), 297–305. https://doi.org/10.59052/edufisika.v9i3.38451

Budiyono, A., & Hartini, H. (2016). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Siswa SMA. *Wacana Didaktika*, *4*(2), 141–149. https://doi.org/10.31102/wacanadidaktika.4.2.141-149

Deli, H. R., Purwanto, A., & Darwis, D. (2017). Pengaruh Model Pembelajaran Guided Inquiry Dipadu Two Stay Two Stray (TSTS) Terhadap Keterampilan Proses Sains Siswa Pada Materi Larutan Asam Basa Terintegrasi Pendidikan Lingkungan Hidup Hadits. *Jurnal Riset Pendidikan Kimia*, *7*(2), 153–159. http://journal.unj.ac.id/unj/index.php/jrpk/article/view/3067

Elvanisi, A., Hidayat, S., & Fadillah, E. N. (2018). Analisis keterampilan proses sains siswa sekolah menengah atas. *Jurnal Inovasi Pendidikan IPA*, *4*(2), 245–252. https://doi.org/10.21831/jipi.v4i2.21426

Ennis, R. H. (1996). *Critical thinking*. NJ: Prentice-Hall.

Fatmi, N., & Sahyar. (2014). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Siswa Pada Materi Laju Reaksi. *Jurnal Pendidikan Fisika*, *3*(1), 47–52. https://jurnal.unimed.ac.id/2012/index.php/jpf/article/view/3277/2945

Firdaus, M., & Wilujeng, I. (2018). Pengembangan LKPD inkuiri terbimbing untuk meningkatkan keterampilan berpikir kritis dan hasil belajar peserta didik. *Jurnal Inovasi Pendidikan IPA*, *4*(1), 26–40. https://doi.org/10.21831/jipi.v4i1.5574

Firmansyah, A., & Jiwandono, N. R. (2022). Tendency of Teachers in Applying Student Center Learning and Teacher Center Learning Approaches in Learning. *Jurnal Guru Indonesia*, *2*(1), 33–39. https://doi.org/10.51817/jgi.v2i1.229

Fitriyani, R., Haryani, S., & Susatyo Eko, B. (2017). Pengaruh Model Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Pada Materi Kelarutan Dan Hasil Kali Kelarutan. *Jurnal Inovasi Pendidikan Kimia*, *11*(2), 1957–1970.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to Design and Evaluate Research in Education (8th ed.)*. McGraw-Hill.

Gusmardin, Y., Bektiarso, S., & Wicaksono, I. (2019). Pengaruh model pembelajaran guided inquiry disertai scaffolding prompting questioning terhadap keterampilan proses sains siswa pada materi gerak lurus di SMA. *Jurnal Pembelajaran Fisika*, *8*(2), 93–100.

Hastuti, D. (2021). 21st Century Skills In Primary School Learning. *SHEs: Conference Series*, *4*(5), 932–936.

Husna, N., Arief, S., & Mochamad, Z. (2020). Keefektivan bahan ajar tumbuhan mangrof untuk melatihkan keterampilan berpikir kritis siswa. In *QUANTUM: Jurnal Inovasi Pendidikan Sains* (Vol. 11, Issue 2).

Irwanto, I., Suryani, E., & Cahyani, T. S. (2024). Improving Students' Critical Thinking Skills Using Guided Inquiry with Problem-Solving Process. *International Journal of Religion*, *5*(6), 243–251. https://doi.org/10.61707/917r2021

Kusuma, A. E., & Rusmansyah. (2020). Analysis of Science Process Skills for Senior High School Students in Banjarmasin. *Universal Journal of Educational Research*, *619*, 11–16. https://doi.org/10.13189/ujer.2020.081803

Maknun, J. (2020). Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts and Critical Thinking Skill of Vocational High School Students. *International Education Studies*, *13*(6), 117. https://doi.org/10.5539/ies.v13n6p117

Mardhiyah, R. H., Aldriani, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). Pentingnya Keterampilan Belajar di Abad 21 sebagai Tuntutan dalam Pengembangan Sumber Daya Manusia. *Lectura: Jurnal Pendidikan*, *12*(1), 29–40.

Muslikah, S., Hsb, M. H. E., & Romundza, F. (2025). Pengaruh Bimbingan Scaffolding Terhadap Keterampilan Proses Sains Dalam Pembelajaran Kimia Hijau. *AL-MUADDIB: Jurnal Kajian Ilmu Kependidikan, 7*(4), 426-435.

Ningsih, D. A. (2025). Implementation Approach Inquiry in Science learning for Increase Ability Think Critical. *Scientica Education Journal*, *2*(5), 21–29. https://doi.org/10.62872/adgf3c71

Nugroho, I. S., Mulyani, S., & Susanti, E. (2021). Analisis soal dalam buku ajar kimia kelas xi ditinjau dari indikator berpikir kritis. J*urnal Penelitian Pendidikan*, 24(2), 116-125.

Nurliana, M., Khairuna, & Adlini, M. N. (2023). Analisis Kemampuan Berpikir Kritis Siswa Kelas X IPA Di SMA Harapan Bangsa Tanjung Morawa Pada Mata Pelajaran Biologi. *Pendekar: Jurnal Pendidikan Berkarakter*, *1*(5), 33–43.

Padilla, M. J. (1990). The Science Process Skills. *NARST*.

Purnamasari, J., Wardhani, S., & Nawawi, S. (2021). Analisis soal keterampilan proses sains (KPS) pada materi biologi di SMA Kota Palembang. *Bioilmi: Jurnal Pendidikan*, *VII*(I), 9–17.

Putri, O. D., Nevrita,. & Hindrasti, N. E. K. (2019). Analisis Kemampuan Berpikir Kritis Siswa pada Aspek Advanced Clarification dan Inference pada Konsep Sistem Pencernaan di Kelas XI MIPA SMA Negeri 2 Tanjungpinang. *Pedagogi Hayati, 3*(2), 32-35.

Rahmi, Y. L., Alberida, H., & Astuti, M. Y. (2019). Enhancing students' critical thinking skills through inquiry-based learning model. *Journal of Physics: Conference Series*, *1317*(1). https://doi.org/10.1088/1742-6596/1317/1/012193

Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, *13*(1), 2239–2253.

Ridzal, D. A., Hatuala, M., Haswan, H., & Farnia, F. (2023). Meta-analysis: The effect of guided inquiry on students' critical thinking skills in biology learning. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *5*(2), 171–178. https://doi.org/10.20527/bino.v5i2.16030

Rusyady, I. H. (2022). Analysis Of Science Process Skills Developedby Prospective Biology Teacher College Students. *BioEdu: Berkala Ilmiah Pendidikan Biologimiah Pendidikan Biologi*, *11*(2), 321–329.

Septiany, L. D., Puspitawati, R. P., Susantini, E., Budiyanto, M., Purnomo, T., & Hariyono, E. (2024). Analysis of High School Students' Critical Thinking Skills Profile According to Ennis Indicators. *IJORER : International Journal of Recent Educational Research*, *5*(1), 157–167. https://doi.org/10.46245/ijorer.v5i1.544.

Stevenson, R. B. (2007). Schooling and Environmental Education: Contradiction in Purpose and Practice. *Environmental Education Research, 13,* 139-143.

Syarif, N. C., Haikal, M., & Antika, T. L. (2025). Efektivitas model inkuiri terbimbing dalam memberdayakan keterampilan proses sains dan motivasi belajar siswa di MA Miftahul Ulum Better Pamekasan. *Biology and Education Journal*, *5*(2), 112–122.

The jamovi project (2021). jamovi. (Version 2.2) [Computer Software]. Retrieved from https://www.jamovi.org

Wulandahri, W., Hidayati, H., Darvina, Y., & Novitra, F. (2025). Validity Analysis of Electronic Student Worksheets Based on Guided Inquiry to Improve Students' Critical Thinking Skills. *Jurnal Penelitian Pembelajaran Fisika*, *11*(1), 35–51. https://doi.org/10.24036/jppf.v11i1.12

Wulandari, D. (2017). *Efektivitas Model Pembelajaran Guided Inquiry Terhadap Kemampuan Berpikir Kritis Dan Keterampilan Proses Sains Siswa Kelas XI IPA SMA Materi Sistem Respirasi* [Universitas Negeri Yogyakarta]. http://eprints.uny.ac.id/id/eprint/53594