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# Integration of Problem-Based Learning Model with Guided Inquiry Worksheet to Enhance Scientific Process Skills and Critical Thinking Abilities

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**Abstract:** The low ability of students to comprehend and connect information, as well as the problems they face, contributes to a low level of scientific literacy. The application of the integration of problem-based learning models with guided inquiry worksheets in this study aims to examine the improvement of students' scientific process skills (SPS) and critical thinking abilities (CTA). A non-equivalent control group design with pretest-posttest was used as the research design. The sample consisted of students from Class X MIA-1 and X MIA-2, selected through purposive sampling technique. Data obtained from the observation sheets on SPS and test questions were analyzed using the SPSS application with the analysis of covariance (ANCOVA) test. The results showed a probability sig. of 0.907 > 0.05 for SPS and a probability sig. of 0.598 < 0.05 for CTA. The research findings concluded that the application of the integration of problem-based learning models with guided inquiry worksheets can significantly enhance students' scientific process skills and critical thinking abilities.

**Keywords:** Critical thinking abilities; Guided inquiry; Scientific process skills

## Introduction

The results of PISA 2018 showed that Indonesia recorded an average score of 379 points, ranking 70th out of 78 participants. The overall average score among all PISA participants in the scientific process skills competency was 489 (OECD, 2019b). These data indicate that Indonesia's level of scientific competence has declined compared to previous PISA results. Around 51.7 percent of students were still performing at Level 2, while only 0.6 percent was at Level 5, which represents the highest level of difficulty in the PISA assessment (OECD, 2019a). It is important to note that these scores place Indonesia relatively low compared to many other participating countries in the PISA assessment. The average score reflects the need for improvement in Indonesian students' scientific process skills in a global comparative context.

The observation results at SMAN 2 Pintu Rime Gayo indicate that the reading ability of students is still low, and they lack the necessary skills to connect the information they receive to solve problems. The test results for 20 students show that the achievement of passing grades is still below 50 percent. Interviews with chemistry teachers reveal that the mastery of electrolyte solution material in the previous year was also below 80 percent. The teaching method commonly used by teachers is textbook-based instruction through discussions or lectures. The limitations in teaching media and instructional materials can contribute to the students' low motivation and interest in participating in the learning process (Deal & Peterson, 2016). Motivation is known to be one of the determining factors for success

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in the learning process (Fortus & Vedder-Weiss, 2014; Vedder-Weiss & Fortus, 2018; Fortus & Touitou, 2021).

This indicates a gap in students' abilities to perform observations, formulate hypotheses, design experiments, collect and analyze data, and draw conclusions based on the available evidence. Low scientific process skills can affect students' understanding of scientific concepts and their ability to apply scientific knowledge in everyday life (Brooks et al., 2014; Collins et al., 2018; Elisabet et al., 2019; Barnard et al., 2021; Dewi & Rukmini, 2019). Therefore, the development of scientific process skills needs to be implemented in science education.

One of the learning approaches that has gained attention is problem-based learning (PBL). PBL encourages students to learn through exploring real-world problems that are relevant to their daily lives. In the context of science education, PBL encourages students to identify problems, design and conduct experiments, and find solutions based on the scientific knowledge they have learned (Rohwer & Rice, 2015; Berland & Reiser, 2008).

Furthermore, the use of guided inquiry worksheets can enhance the problem-based learning approach in improving students' scientific process skills. Guided inquiry worksheets are designed to assist students through the inquiry process with structured steps and probing questions. This enables students to develop skills in questioning, critical thinking, data collection, and effective analysis of their findings (Putra et al., 2016; Riyadi et al., 2018).

Although problem-based learning models and guided inquiry worksheets have been separately implemented in the context of science education, research specifically explaining their combined use to enhance scientific process skills is still limited. Therefore, this study aims to explore the potential integration of problem-based learning models with guided inquiry worksheets in improving students' scientific process skills (SPS).

This study will involve students as research subjects in their science learning environment. The research method that will be used is an experiment with a control group and a treatment group. The control group will receive conventional teaching, while the treatment group will receive problem-based learning with guided inquiry worksheets. Data will be collected through classroom observations and student questionnaires.

It is expected that this research will provide empirical evidence on the effectiveness of using problem-based learning models with guided inquiry worksheets in improving students' SPS. The results of this study can contribute significantly to the development of more innovative and effective science learning strategies that can be implemented in an educational context. This research can also enhance students' understanding and skills in science, thus contributing to their overall scientific literacy.

## Method

*Materials and Equipment*

Prior to conducting the experiment in both classes, an introduction to the tools, materials, and equipment that will be used is provided. This introduction is necessary as students need to be given preliminary knowledge about the experiment that will be conducted. For the electrolyte solution experiment, a simple apparatus consisting of a light bulb, battery, and iron rod connected using cables is used. The materials used include common household items such as salt, sugar, urea fertilizer, detergent solution, and water

*Population and Sample*

The population in this study consists of 38 students from Class X MIA at SMA N 2 Pintu Rime Gayo in Bener Meriah Regency. The sample used in this study consists of two classes, one as the experimental group and one as the control group, with a total sample size of 38 students. The instruments used to collect data on critical thinking skills and process skills are a critical thinking ability test and process skills observation. The data obtained will be analyzed using statistical and descriptive methods.

*Geographical Conditions of Schools and Students*

This research is conducted at SMA Negeri 2 Pintu Rime Gayo, located in Jl. Bireuen-Takengon, Negeri Antara Village, Gajah Putih District, and Bener Meriah Regency. The surrounding community predominantly works as farmers.

*Data Processing*

The data processing for this study involved a quasi-experimental method with a pretest-posttest non-equivalent control group design. The research was conducted in three stages: administering a pretest before the instruction using guided inquiry-based worksheets, implementing the problem-based learning model with guided inquiry worksheets, and conducting a posttest after the instruction using guided inquiry-based worksheets. The data obtained from the research were processed using IBM SPSS 2.5 software, and the analysis employed the ANCOVA (Analysis of Covariance) test.

## Result and Discussion

*Students' Scientific Process Skills*

The analysis of the data on students' Scientific Process Skills (SPS) between the experimental and control groups is presented in Figure 1.

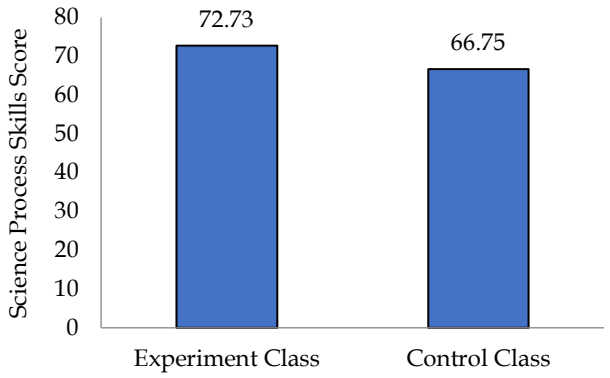


**Figure 1.** Average scores of scientific process skills (SPS) in the experimental and control groups

The average SPS scores in the experimental group are higher compared to the control group. The use of guided inquiry worksheets in the experimental group has a positive impact on improving students' acquisition of scientific process skills.

The statistical test using analysis of covariance (ANCOVA) yielded a significance probability (p-value) of 0.907, which is greater than 0.05. Therefore, it can be concluded that there is a significant difference in students' SPS between the experimental and control groups. This means that there is an improvement in students' SPS when using guided inquiry-based worksheets.

Guided inquiry can enhance students' SPS because its structure supports the development of necessary skills. In contrast, conventional teaching often relies on student textbooks, which may provide practical instructions but limit students to following prescribed steps. As a result, students may have less active participation during practical activities.

**Table 1.** Results of Scientific Process Skills Analysis

| Source | Type I Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 342.483a | 3 | 114.161 | 9.505 | .000 |
| Intercept | 184.245.158 | 1 | 184.245.158 | 15.340.256 | .000 |
| Class | 342.000 | 1 | 342.000 | 28.475 | .000 |
| Pretest | .316 | 1 | .316 | .026 | .872 |
| Pretest Class* | .166 | 1 | .166 | .014 | .907 |
| Error | 408.359 | 34 | 12.011 | | |
| Total | 184.996.000 | 38 | | | |
| Corrected Total | 750.842 | 37 | | | |

a. R Squared = .456 (Adjusted R Squared = .408)

Therefore, the integration of guided inquiry-based worksheets can be an effective approach to promote active learning and enhance students' SPS. The difference in the results of SPS between the experimental and control groups can be attributed to the active role of students during practical activities. Guided inquiry-based worksheets require students to search, analyze, and prove their findings without the assistance of a teacher. An inquiry-based laboratory also enables students to actively participate in problem-solving, connect acquired knowledge with everyday experiences, and develop skills to generalize knowledge (Yakar & Baykara, 2014).

Laboratory learning aims to help students understand abstract scientific concepts by making them more tangible and concrete. Activities in the laboratory can also enhance students' understanding of the subject matter and skills. SPS are expected to have a positive influence on students' laboratory skills and conceptual understanding (Merdekawati, 2017). The laboratory serves as a means to engage in various activities oriented towards SPS. The purpose of using the laboratory in education is to develop skills in observation, data recording, instrument use, measurement, and reporting experiment results (Samani & Iskandar, 1999). Practical learning plays a role in the development of SPS.

Laboratory learning can be effectively implemented when students possess the skills necessary to perform each required process. SPS are among the many skills that students need to enhance their potential (Handayani et al., 2017). The rapid development of scientific knowledge, which is not absolute, necessitates the use of scientific process skills to explore and continually update knowledge based on existing experiences (Puspita et al., 2017).

SPS can be developed through appropriate learning models that align with the components of SPS. The inquiry-based learning model is one such model that has a syntax aligned with the components of scientific process skills. The syntax of the inquiry-based learning model shares common goals and components with the approach to scientific process skills (Mutrovina &

Syarief, 2015). Inquiry-based learning can enhance SPS because its syntax allows for the honing of these skills in students.

Guided inquiry learning is implemented with guidance from the teacher who acts as a facilitator. It is used for students who are not yet accustomed to inquiry-based learning. Learning through inquiry-based models can enhance students' SPS (Siska et al., 2013). Guided inquiry learning is used to discover a concept through a scientific process that involves investigative activities as part of SPS.

*Students' Critical Thinking Skills*

The analysis of the data on students' critical thinking skills (CTS) between the experimental and control groups is presented in Figure 2.

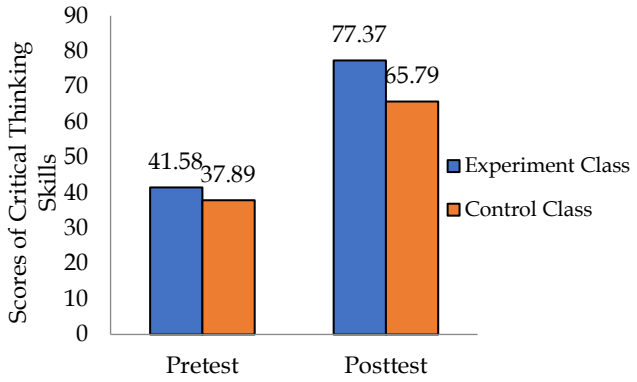


**Figure 2.** Average scores of critical thinking skills in the experimental and control groups

Based on Figure 2, it shows the difference in pretest scores between the experimental and control groups, with scores of 41.58 and 37.89, respectively. These results indicate that both groups have relatively similar levels of knowledge. However, a notable difference is observed in the posttest results, with the experimental group achieving an average score of 77.37, while the control group obtained a lower average score of 65.79. This difference can be attributed to the different treatments applied to the two groups, with the experimental group using a problem-based learning model with guided inquiry-based worksheets, while the control group only used a conventional learning model with the aid of textbooks. This implies that the implementation of the experimental treatment has a positive influence on improving students' CTS.

The improvement in students' critical thinking skills after learning using a problem-based learning model integrated with guided inquiry-based worksheets can be analyzed using the statistical method of ANCOVA. The dependent variable used in this study is the posttest score, while the covariate is the pretest score. A covariate is another factor that is expected to influence the dependent variable, apart from the treatment given (Culpepper & Aguinis, 2011). The covariate needs to be considered because it has a relationship with the posttest score, which is the research objective. The identified covariate that can influence the posttest score is the pretest score, as the same set of questions is used in both tests. The results of the analysis indicate a correlation between the pretest and posttest scores, indicating that the pretest fulfills the criteria to be used as a covariate.

**Table 2.** Results of Critical Thinking Skills Analysis

| Source | Type I Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 1712.278a | 3 | 570.759 | 6.078 | .002 |
| Intercept | 194.694.737 | 1 | 194.694.737 | 2.073.176 | .000 |
| Kelas | 1.273.684 | 1 | 1.273.684 | 13.563 | .001 |
| Pretest | 412.022 | 1 | 412.022 | 4.387 | .044 |
| Kelas * Pretest | 26.572 | 1 | 26.572 | .283 | .598 |
| Error | 3.192.985 | 34 | 93.911 | | |
| Total | 199.600.000 | 38 | | | |
| Corrected Total | 4.905.263 | 37 | | | |

a. R Squared = .349 (Adjusted R Squared = .292)

The statistical test using analysis of covariance (ANCOVA) yielded a significance probability (p-value) of 0.001, which is less than 0.05. This indicates a significant difference in students' CTS between the experimental and control groups. Furthermore, the p-value for the interaction term "Class*Pretest" is 0.598, which is greater than 0.05. This implies that there is no significant difference in pretest scores between the experimental and control groups. Therefore, the difference in students' CTS using guided inquiry-based worksheets is not influenced by the pretest results.

The differing results obtained are likely due to the different treatments applied, both in terms of the learning models used and the implementation of guided inquiry-based worksheets. The control group implemented conventional teaching, where the teacher provided detailed explanations and gave practice questions at the end of the lesson. On the other hand, the experimental group implemented problem-based

learning integrated with guided inquiry-based worksheets. The integration of the learning model and guided inquiry-based worksheets directed students to engage in each stage of the learning process based on the provided syntax. The inclusion of problem-solving activities in the learning process allowed students to have an active role in their learning experience.

The improvement in CTS can be observed from the number of correctly answered questions in the posttest compared to the pretest. The initial ability of the students is relatively low, as indicated by the predominance of incorrect answers in the pretest phase. This can be analyzed by investigating each item of the test that was correctly answered based on the given indicators. The test items were developed based on the desired achievement indicators. The test items in this study encompassed five indicators. The questions given varied in cognitive levels from understanding to evaluating, aiming to enhance students' critical thinking skills. High-level cognitive questions were used for evaluation purposes to improve students' higher-order thinking skills (Ghani et al., 2017; Khaldun et al., 2019; Janssen et al., 2019; Martens et al., 2019). The implementation of high-order thinking skills (HOTS) is also a focus of the 2013 curriculum implementation aimed at enhancing the quality of Indonesian students to compete in the job market (Sarah et al., 2021).

Contemporary learning should not be limited to textbooks alone; it can be complemented with various other learning media, such as guided inquiry-based worksheets. This allows the learning process to maximize students' understanding and knowledge of a subject. The use of guided inquiry-based worksheets in learning is crucial as it provides opportunities for students to actively engage in the learning process. The steps involved in guided inquiry-based worksheets guide students in understanding the concepts being taught (Sya'idah et al., 2020). These steps foster creativity, innovation, and problem-solving skills among students (Curtis et al., 2020).

## Conclusion

Engaging and enjoyable learning experiences can enhance students' interest and motivation. When learning activities are enjoyable, students find it easier to absorb the taught material. The development of Guided Inquiry-based Worksheets in conjunction with specific learning models provides different learning approaches, preventing monotony and boredom among students. Integrating Problem-Based Learning (PBM) with guided inquiry-based worksheets offers a diverse learning experience that can enhance students' scientific process skills (SPS) and critical thinking skills (CTS).

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**Author Contributions**
Khairil Anbiya and Muhibbudin conceptualized the research idea, designed of methodology, management and coordination responsibility, analyzed data, conducted a research and investigation process; Ibnu Khaldun and Yusrizal conducted literature review and provided critical feedback on the manuscript.

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**Conflicts of Interest**
The authors declare no conflict of interest.

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