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Implementing an Observation-Based Science Process Skills Assessment Instrument in Elementary Science Learning

Wiranda Bayu Aditama[1]*, Aenullael Mukarromah[1], Defirra Alizunna[2]

[1]Department of Madrasah Ibtidaiyah, Institut Agama Islam Qamarul Huda, Central Lombok 83562, Indonesia

[2]Department of Madrasah Ibtidaiyah, Universitas PGRI Wiranegara, Pasuruan 67118, Indonesia

*Coressponding author: bayuaditamalttk@gmail.com

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Abstract: Science process skills assessment is an essential component of science learning in elementary schools because it provides information about students' development in applying scientific processes during classroom learning. This article aims to describe the implementation of a science process skills assessment instrument used in Guided Inquiry-based learning and to analyze its application among third-grade students at SDN 2 Suka Makmur. The article is based on the results of a Classroom Action Research (CAR) conducted in three cycles. Data were collected using a science process skills observation instrument administered in each learning cycle. The data were analyzed descriptively by comparing the mean scores and the percentage of classical mastery of students' science process skills across the three cycles. The findings indicate that the observation instrument effectively captured the gradual development of students' science process skills. The mean score increased from 55 in Cycle I to 73 in Cycle II and reached 83 in Cycle III, while the percentage of classical mastery improved from 30.4% to 77.3% and finally reached 100%. These results demonstrate that the observation instrument was able to document students' development in observing, classifying, interpreting, conducting investigations, and communicating learning outcomes throughout the Guided Inquiry learning process. Therefore, the science process skills assessment instrument can serve as an alternative authentic assessment tool to assist teachers in obtaining comprehensive information about students' science process skills development during science learning in elementary schools.

Keywords: *Authentic assessment, assessment instrument, elementary school, observation, science process skills*

INTRODUCTION

Science is a fundamental subject in elementary education that aims not only to develop students' conceptual understanding but also to foster scientific processes and attitudes. Science learning should provide students with meaningful learning experiences through direct interaction with natural phenomena, enabling them to construct knowledge based on scientific inquiry. Consequently, science instruction should engage students in observing, classifying, measuring, interpreting, concluding, and communicating findings as integral components of science process skills (BSNP, 2006; Bundu, 2006; Rustaman et al., 2011). Science process skills (SPS) are defined as a set of cognitive and psychomotor abilities that enable learners to acquire scientific knowledge through systematic inquiry. These skills encompass both basic process skills such as observing, classifying, measuring, predicting, and communicating and integrated process skills, including designing investigations, interpreting data, and drawing conclusions (Bundu, 2006; Rustaman et al., 2011). Mastery of SPS is considered a fundamental prerequisite for developing critical thinking, problem-solving abilities, creativity, and scientific literacy, which are recognized as essential competencies for twenty-first-century learners. Recent studies have also emphasized that strengthening science process skills remains a primary objective of science education, particularly through student-centered instructional approaches such as inquiry-based learning (Rachmadita et al., 2025).

Despite their importance, assessment practices in elementary science classrooms continue to emphasize cognitive achievement measured through written examinations. Such assessments provide limited information regarding students' ability to perform scientific processes during learning activities. Science process skills are more appropriately assessed through authentic assessment, which evaluates students' performance while they conduct investigations, experiments, discussions, and scientific communication. According to Kunandar (2013), authentic assessment enables teachers to obtain comprehensive information regarding students' competencies because it evaluates both learning processes and learning outcomes. Likewise, recent literature indicates that observation-based assessment, performance assessment, and rubric-guided evaluation provide richer evidence of students' scientific competencies than conventional paper-and-pencil tests (Martatiyana & Madani, 2024).

The effectiveness of authentic assessment largely depends on the quality of the assessment instrument employed. An assessment instrument containing clearly defined indicators of science process skills enables teachers to observe students' learning behaviors systematically and objectively (Kunandar, 2013; Purwanto, 2014). Within Guided Inquiry learning, observation instruments become particularly important because students are actively involved in identifying problems, formulating hypotheses, conducting investigations, analyzing evidence, and communicating findings. Consequently, observation instruments function not only as assessment tools but also as mechanisms for documenting students' scientific skill development throughout the learning process.

Previous studies have consistently demonstrated the effectiveness of guided inquiry in improving science process skills and science achievement among elementary school students. Agutin et al. (2024) reported that Guided Inquiry significantly enhanced students' science process skills by encouraging active engagement in scientific investigations. Similarly, Karlina et al. (2024) found that guided Inquiry improved both science process skills and conceptual understanding in elementary science learning. Furthermore, studies on authentic assessment have shown that observation-based rubrics effectively capture students' scientific performance during inquiry-based learning activities (Martatiyana & Madani, 2024).

However, most previous studies have primarily focused on evaluating the effectiveness of instructional models in improving learning outcomes or science process skills, whereas limited attention has been given to the implementation of the assessment instruments themselves. In many studies, observation instruments merely serve as data collection tools without detailed discussion regarding their characteristics, implementation procedures, or their capacity to document students' development of science process skills. Considering that the quality of assessment instruments substantially influences the accuracy of assessment results, examining their implementation constitutes an important area for educational research.

This article is derived from a Classroom Action Research (CAR) conducted in a third-grade classroom at SDN 2 Suka Makmur. Unlike the original study, which focused on improving students' science process skills and learning outcomes through Guided Inquiry, the present article specifically examines the implementation of the science process skills assessment instrument employed throughout the learning process. The analysis emphasizes the characteristics of the observation instrument, its implementation procedures, and its ability to document students' science process skills development based on empirical evidence collected during the three action research cycles. Therefore, this study aims to describe the implementation of a science process skills assessment instrument within Guided Inquiry-based science learning and to analyze its effectiveness in documenting the development of elementary students' science process skills. The findings are expected to contribute to the advancement of authentic assessment practices by providing practical insights into the use of observation-based assessment instruments for evaluating science process skills in elementary science education.

METHOD

Research Design

This article was developed from a Classroom Action Research (CAR) study that originally aimed to improve elementary students' science process skills and science learning outcomes through the implementation of the Guided Inquiry learning model. Unlike the original study, which emphasized the improvement of students' achievement, the present article focuses on the implementation of the science process skills assessment instrument employed throughout the learning process. Therefore, this study aims to describe the characteristics of the assessment instrument, the science process skills indicators measured, the implementation of the instrument during classroom instruction, and the outcomes of its implementation in documenting students' science process skills development.

The classroom action research followed the model proposed by Arikunto et al. (2010), consisting of four stages: planning, action, observation, and reflection. The study was conducted in three instructional cycles. Reflection at the end of each cycle was used to refine both the instructional process and the implementation of the assessment instrument in the subsequent cycle. This reflective approach enabled teachers to continuously monitor students' science process skills through authentic assessment (Kunandar, 2013).

Research Site and Participants

The study was conducted at SDN 2 Suka Makmur and involved 23 third-grade elementary school students as research participants. All students participated in science learning activities using the Guided Inquiry model throughout the three research cycles. The classroom teacher implemented the instructional activities, while the researcher acted as an observer responsible for assessing students' science process skills using an observation-based assessment instrument. The selection of third-grade students was based on their cognitive developmental stage, which enables them to engage in simple scientific investigations with appropriate teacher guidance. Guided Inquiry was selected because it provides students with opportunities to actively participate in scientific inquiry, beginning with problem identification and ending with communicating experimental findings (Bundu, 2006; Rustaman et al., 2011).

Science Process Skills Assessment Instrument

The primary instrument analyzed in this study was an observation sheet designed to assess students' science process skills during classroom learning activities. The instrument was developed based on the science process skills framework proposed by Bundu (2006) and Rustaman et al. (2011) and subsequently aligned with the instructional phases of the Guided Inquiry learning model. The instrument was constructed as an analytic rubric to evaluate students' performance throughout the learning process.

The assessment instrument comprised ten indicators of science process skills: (1) formulating problems, (2) formulating hypotheses, (3) planning experiments, (4) preparing experimental equipment and materials, (5) assembling experimental apparatus, (6) conducting observations and measurements, (7) analyzing data, (8) drawing conclusions, (9) collaborating within groups, and (10) presenting experimental findings.

Each indicator was assessed using a three-level analytic rubric. A score of 3 (Good) was assigned when students independently performed the expected activity correctly and appropriately. A score of 2 (Fair) was assigned when students completed the activity with teacher assistance, while a score of 1 (Poor) indicated that students did not participate or were unable to perform the expected activity. The use of an analytic rubric was intended to improve the consistency and objectivity of performance assessment during science learning activities (Srirahayu & Arty, 2018).

Characteristics of the Assessment Instrument

The primary instrument analyzed in this study was an observation-based assessment rubric designed to evaluate students' science process skills during Guided Inquiry learning activities. The instrument was adapted from the science process skills framework proposed by Bundu (2006) and Rustaman et al. (2011) and contextualized to match the learning activities implemented in the classroom. Rather than measuring conceptual understanding through written tests, the instrument focused on assessing students' performance throughout the scientific inquiry process.

The assessment instrument consisted of ten observable indicators representing the sequence of scientific inquiry activities, as presented in Table 1. Each indicator was assessed through direct classroom observation using an analytic rubric. Students' performance was evaluated on a three-point rating scale, where 3 = Good (independently performs the activity), 2 = Fair (performs the activity with teacher assistance), and 1 = Poor (does not participate or is unable to perform the activity).

The indicators were organized according to the sequence of activities typically performed during Guided Inquiry learning, beginning with problem identification and ending with scientific communication. This structure enabled the instrument to capture students' procedural and collaborative skills throughout the inquiry process rather than merely evaluating learning outcomes. The use of an analytic rubric provided explicit performance criteria for each indicator, thereby improving scoring consistency and minimizing observer subjectivity. Consequently, the instrument functioned not only as an assessment tool but also as an authentic assessment framework capable of documenting students' science process skills development continuously throughout the instructional cycles.

Table 1. Characteristics of the science process skills assessment instrument.

No	Dimension	Indicator	Assessment Technique	Scale
1	Problem Identification	Formulates scientific problems	Classroom observation	1-3
2	Hypothesis Formulation	Develops hypotheses based on identified problems	Classroom observation	1-3
3	Experimental Planning	Plans experimental procedures	Classroom observation	1-3
4	Preparation	Prepares experimental equipment and materials	Classroom observation	1-3
5	Experimentation	Assembles experimental apparatus correctly	Classroom observation	1-3
6	Observation	Conducts observations and measurements systematically	Classroom observation	1-3
7	Data Analysis	Analyzes and interprets observational data	Classroom observation	1-3
8	Conclusion	Draws conclusions based on experimental evidence	Classroom observation	1-3
9	Collaboration	Works cooperatively within the group	Classroom observation	1-3
10	Scientific Communication	Presents experimental findings	Classroom observation	1-3

Data Collection

Data were collected through classroom observations using the science process skills assessment instrument during each instructional cycle. Observations were conducted throughout all stages of Guided Inquiry learning, including problem orientation, hypothesis formulation, experiment planning, experimental implementation, data analysis, conclusion drawing, and presentation of experimental findings. Students' performance at each stage was observed and scored according to the established assessment rubric. In addition to observation data, learning achievement tests, field notes, and classroom documentation were collected as supporting data. However, this article focuses exclusively on observation data because the primary objective was to evaluate the implementation of the assessment instrument as a form of authentic assessment in elementary science learning.

Data Analysis

The collected data were analyzed using both qualitative descriptive and quantitative descriptive approaches. Qualitative descriptive analysis was employed to describe the characteristics of the assessment instrument, the science process skills indicators measured, and the implementation of the instrument during Guided Inquiry instruction. This analysis examined the alignment between the instrument indicators, the Guided Inquiry learning phases, and the theoretical framework of science process skills proposed by Bundu (2006) and Rustaman et al. (2011).

Quantitative descriptive analysis was conducted by calculating the mean science process skills score and the percentage of classical learning mastery for each instructional cycle. Students' science process skills scores were obtained from the accumulated scores across the ten assessment indicators and subsequently converted into percentage scores according to the assessment guidelines adopted in the original study. The results were presented in tabular form and interpreted to describe the instrument's ability to document students' science process skills development throughout the three instructional cycles. The interpretation of the findings was not intended to determine the effectiveness of the Guided Inquiry learning model. Instead, the analysis focused on explaining how the observation-based analytic rubric functioned as an authentic assessment instrument for documenting students' science process skills in elementary science classrooms. The findings were further discussed in relation to previous studies on authentic assessment and science process skills assessment to strengthen the interpretation and educational implications of the study.

RESULTS

Characteristics of the Science Process Skills Assessment Instrument

The assessment instrument employed in this study was an observation sheet designed to evaluate students' science process skills throughout Guided Inquiry-based science learning. Unlike written tests that primarily assess conceptual understanding, the observation instrument enabled teachers to evaluate students' ability to perform scientific processes directly during classroom activities. The use of observation as an assessment technique is consistent with the principles of authentic assessment, which emphasize evaluating students' performance and learning processes in real instructional contexts rather than relying solely on learning outcomes (Kunandar, 2013; Martatiyana & Madani, 2024).

The instrument was developed based on the science process skills framework proposed by Bundu (2006) and Rustaman et al. (2011). The assessment indicators were subsequently aligned with the instructional phases of the Guided Inquiry learning model to ensure that each stage of scientific inquiry could be systematically observed and assessed. In contrast to conventional achievement tests that focus on correct or incorrect answers, the observation instrument emphasized students' participation and performance throughout the inquiry process. Overall, the instrument comprised ten performance indicators representing the sequence of scientific inquiry activities: (1) formulating problems, (2) formulating hypotheses, (3) planning experiments, (4) preparing experimental equipment and materials, (5) assembling experimental apparatus, (6) conducting observations or measurements, (7) analyzing data, (8) drawing conclusions, (9) collaborating within groups, and (10) presenting experimental findings. Collectively, these indicators assessed not only students' cognitive abilities but also their procedural, psychomotor, and collaborative competencies demonstrated during science learning.

Each indicator was assessed using an analytic rubric consisting of three performance levels: Good (3), Fair (2), and Poor (1). Scores were assigned according to the level of students' independence in performing each scientific activity. Students received the highest score when they completed an activity independently and correctly, an intermediate score when teacher assistance was required, and the lowest score when they did not participate or were unable to perform the expected activity. The analytic rubric provided explicit scoring criteria, thereby improving scoring consistency and minimizing observer subjectivity during classroom observations, as presented in Table 2. A similar approach was recommended by Srirahayu and Arty (2018), who reported that observation-based analytic rubrics enhance the reliability and consistency of science process skills assessment.

Another important characteristic of the instrument is its close alignment with the Guided Inquiry instructional sequence. During the orientation and problem-identification phases, the observer assessed students' abilities to formulate scientific problems and develop hypotheses. During the exploration and experimentation phases, assessment focused on students' abilities to plan experiments, prepare experimental equipment and materials, assemble the apparatus, and conduct systematic observations. Finally, during the data analysis and conclusion phases, the instrument was used to evaluate students' abilities to analyze experimental data, draw evidence-based conclusions, collaborate effectively with group members, and communicate the results of their investigations.

The alignment between the assessment indicators and the Guided Inquiry learning phases demonstrates that the instrument functions not merely as an evaluation tool but also as an authentic assessment framework capable of documenting students' science process skills development throughout the learning process. This finding is consistent with the study conducted by Martatiyana and Madani (2024), which concluded that observation-based assessment instruments supported by analytic rubrics provide more comprehensive information about students' competency development than conventional paper-and-pencil assessments. Therefore, the assessment instrument employed in this study possesses characteristics that make it suitable for evaluating science process skills in Guided Inquiry-based science learning at the elementary school level.

Table 2. General characteristics of the assessment instrument.

No	Component	Description
1	Instrument Type	Observation
2	Instrument Format	Analytic Rubric
3	Rating Scale	1-3
4	Observer	Researcher
5	Observation Period	During Guided Inquiry learning activities

Science Process Skills Indicators Measured by the Assessment Instrument

The science process skills assessment instrument employed in this study was designed to evaluate students' scientific skills throughout Guided Inquiry-based learning activities. Unlike conventional achievement tests that primarily measure conceptual understanding, this observation-based instrument assessed students' engagement and performance during each stage of the scientific inquiry process. The assessment indicators were developed based on the science process skills framework proposed by Bundu (2006) and Rustaman et al. (2011), and subsequently adapted to the characteristics of elementary school students as well as the instructional phases of the Guided Inquiry learning model.

The instrument consisted of ten indicators representing the sequence of scientific inquiry activities performed by students throughout the learning process. Each indicator was assessed using an analytic rubric with three levels of performance: Good (score = 3), Fair (score = 2), and Poor (score = 1), as presented in Table 3. Scores were assigned based on students' level of independence and the quality of their performance in carrying out each scientific activity.

Table 3. Framework of the science process skills assessment instrument.

Guided Inquiry Phase	Science Process Skill Domain	Performance Indicator	Observable Aspect	Good (3)	Fair (2)	Poor (1)
Problem Orientation	Scientific Reasoning	Problem Formulation	Ability to identify and formulate scientific problems based on observed phenomena	Independently formulates scientific problems	Formulates scientific problems with teacher assistance	Does not participate in formulating scientific problems
Hypothesis Formulation	Scientific Reasoning	Hypothesis Formulation	Ability to develop logical hypotheses or tentative explanations	Independently formulates logical hypotheses	Formulates hypotheses with teacher assistance	Does not participate in formulating hypotheses
Experimental Planning	Investigation Skills	Experimental Planning	Ability to design appropriate experimental procedures	Independently plans experimental procedures	Plans experimental procedures with teacher assistance	Does not participate in planning experiments
Experimental Preparation	Procedural Skills	Preparation of Equipment and Materials	Ability to prepare experimental equipment and materials according to the procedures	Independently prepares equipment and materials correctly	Prepares equipment and materials with teacher assistance	Does not participate in preparing equipment and materials
Experimental Implementation	Procedural Skills	Assembly of Experimental Apparatus	Accuracy and organization in assembling experimental apparatus	Independently assembles the apparatus correctly and systematically	Assembles the apparatus with teacher assistance	Does not participate in assembling the apparatus
Observation	Observation Skills	Observation and Measurement	Accuracy in conducting observations and measurements and recording the results	Conducts careful observations independently and accurately records the results	Conducts observations but still requires teacher assistance	Does not participate in observation activities
Data Analysis	Analytical Skills	Data Analysis	Ability to process and interpret observational data	Independently analyzes and interprets observational data	Analyzes data with teacher assistance	Does not participate in data analysis
Verification	Critical Thinking	Drawing Conclusions	Ability to formulate conclusions based on experimental evidence	Independently draws conclusions supported by experimental evidence	Draws conclusions with teacher assistance	Does not participate in drawing conclusions
Collaboration	Collaborative Skills	Group Collaboration	Participation and cooperation during group activities	Actively collaborates and contributes within the group	Demonstrates adequate collaboration with group members	Demonstrates limited collaboration during group activities
Communication	Scientific Communication	Presentation of Experimental Findings	Ability to communicate investigation results orally	Clearly presents and demonstrates mastery of the experimental findings	Adequately presents the experimental findings	Demonstrates limited understanding when presenting the experimental findings

The scoring rubric was developed based on students' level of independence in performing each indicator. A score of 3 (Good) was assigned to students who independently completed the expected activity accurately and according to the prescribed procedures. A score of 2 (Fair) was assigned when students completed the activity with assistance from the teacher or peers, whereas a score of 1 (Poor) was assigned when students did not participate or were unable to demonstrate the expected performance. The characteristics of the analytic rubric indicate that the instrument assessed not only students' learning outcomes but also the scientific processes demonstrated throughout classroom activities. For example, in the problem formulation indicator, the observer evaluated not only the accuracy of students' responses but also their active participation in identifying scientific phenomena and formulating researchable problems. Similarly, the data analysis and drawing conclusions indicators focused on students' ability to transform observational evidence into meaningful scientific interpretations supported by empirical data obtained during the experiment.

In addition to assessing scientific inquiry skills, the instrument also incorporated collaborative competencies through the indicators of group collaboration and presentation of experimental findings. These indicators reflect the view that science education aims not only to develop scientific reasoning but also to foster communication and teamwork skills, which are considered essential twenty-first-century competencies. The inclusion of these indicators is consistent with Rustaman et al. (2011), who argued that science process skills encompass an integration of intellectual abilities, practical skills, and scientific attitudes developed simultaneously during science learning. The ten indicators constitute a comprehensive framework representing the complete sequence of scientific inquiry activities implemented in Guided Inquiry learning. Consequently, the observation-based assessment instrument functioned not merely as a scoring tool but also as an authentic assessment framework capable of systematically documenting students' science process skills development throughout the instructional process.

Implementation of the Science Process Skills Assessment Instrument

The implementation of the science process skills assessment instrument in this study was fully integrated into the Guided Inquiry learning process. Rather than being administered solely at the end of instruction as a summative evaluation tool, the instrument was continuously applied throughout each stage of classroom learning. This approach enabled the observer to obtain comprehensive information regarding the development of students' science process skills during the learning process, rather than merely evaluating final learning outcomes. According to Kunandar (2013), authentic assessment should capture students' competencies throughout the learning process, allowing teachers to obtain meaningful information for improving instructional practices.

The assessment process began during the problem orientation phase, when the teacher introduced a scientific problem related to the lesson topic. At this stage, the observer assessed students' abilities to identify scientific phenomena and formulate investigable problems. These activities represented the initial indicators of science process skills because they reflected students' abilities to recognize scientific phenomena and relate them to their prior knowledge and learning experiences. Students were subsequently encouraged to formulate hypotheses as tentative explanations for the identified problems. The observer assigned scores according to students' level of participation and independence in performing these activities based on the predefined analytic rubric. The next stage involved experimental planning and preparation. During this phase, the assessment instrument was used to evaluate students' abilities to design experimental procedures, prepare the required equipment and materials, and assemble the experimental apparatus correctly. These three indicators represented students' procedural competencies in planning scientific investigations before conducting observations. The analytic rubric enabled the observer to assign objective scores according to students' levels of independence, distinguishing between students who completed the activities independently, those who required teacher assistance, and those who did not actively participate. The use of detailed performance indicators facilitated consistent assessment across all instructional cycles.

During the experimental implementation stage, the assessment focused primarily on students' abilities to conduct observations, perform measurements, and record experimental data systematically. These activities constitute the core components of science process skills because they provide students with direct experiences in interacting with scientific objects and phenomena. Assessment considered not only the accuracy of students' observations but also their participation in following appropriate scientific procedures throughout the investigation. Consequently, the instrument provided evidence of students' scientific inquiry processes rather than merely documenting the final outcomes of learning. This finding is consistent with Martatiyana and Madani (2024), who reported that observation-based assessment supported by analytic rubrics provides a more comprehensive representation of students' performance than conventional paper-and-pencil tests.

Following the observation stage, the assessment continued with data analysis and conclusion drawing. These indicators were designed to evaluate students' abilities to process observational data, interpret experimental findings, and formulate conclusions based on empirical evidence obtained during the investigation. Students who independently analyzed data and drew evidence-based conclusions received the highest scores, whereas those who required teacher guidance received lower scores. This scoring mechanism demonstrates that the assessment instrument evaluated not only students' final products but also their level of independence in scientific reasoning and inquiry. The assessment instrument also incorporated the evaluation of collaborative and communication skills through the indicators of group collaboration and presentation of experimental findings. These indicators played an essential role in Guided Inquiry learning because scientific investigations were conducted collaboratively. The observer assessed students' participation in group discussions, their ability to share responsibilities with group members, and their competence in communicating investigation results to the class. The inclusion of these indicators reflects the understanding that science process skills encompass not only experimental abilities but also collaboration and scientific communication, which are integral components of inquiry-based science learning. This perspective is consistent with Bundu (2006), who emphasized that science process skills should be developed through the integrated cultivation of cognitive, psychomotor, and affective competencies.

The assessment instrument was implemented consistently throughout the three instructional cycles, enabling the observer to collect comparable data on students' science process skills development over time. The observation results indicated a continuous improvement in students' mean science process skills scores, increasing from 55 in Cycle I to 73 in Cycle II and reaching 83 in Cycle III. Similarly, the percentage of students achieving the mastery criterion improved substantially from 30.4% in Cycle I to 77.3% in Cycle II and ultimately reached 100% in Cycle III. These findings demonstrate that the observation-based assessment instrument effectively documented students' progressive development of science process skills across successive learning cycles. Although these improvements were influenced by the implementation of Guided Inquiry instruction, the observation data indicate that the instrument consistently captured changes in students' scientific performance throughout the study.

The implementation of the science process skills assessment instrument demonstrates that an observation-based analytic rubric can be effectively integrated into elementary science instruction. The instrument functioned not only as a scoring tool but also as an authentic assessment framework that enabled teachers to continuously monitor students' science process skills development throughout the learning process. These findings support the study by Srirahayu and Arty (2018), which reported that observation rubrics improve the objectivity and consistency of science process skills assessment. Likewise, the findings are consistent with Munjiah and Utari (2025), who concluded that performance-based authentic assessment provides more comprehensive information about students' competency development than conventional assessment approaches. Therefore, the implementation of the assessment instrument in this study suggests that observation-based assessment represents a practical and effective alternative for supporting science learning that emphasizes the development of science process skills in elementary education.

Results of the Assessment Instrument Implementation

The implementation of the science process skills assessment instrument generated data describing students' performance development throughout the Guided Inquiry learning process. The data were collected through continuous classroom observations conducted during each instructional cycle using the established analytic rubric. The observation scores were subsequently converted into achievement scores to facilitate the interpretation of students' levels of science process skills. A summary of the implementation results is presented in Table 3.

Table 3. Summary of the implementation results of the science process skills assessment instrument

Cycle	Mean Observation Score	Mean Achievement Score	Classical Mastery (%)
I	16.5	55	30.4
II	21.9	73	77.3
III	24.9	83	100.0

As shown in Table 3, the observation results demonstrated a consistent improvement across the three instructional cycles. During Cycle I, students achieved a mean science process skills score of 55, with a classical mastery level of 30.4%. These findings indicate that most students were still classified within the poor to fair performance categories when carrying out the scientific activities assessed through the observation instrument. At this initial stage, students generally required substantial guidance from the teacher to participate effectively in Guided Inquiry learning, particularly when engaging in inquiry activities that demanded active participation and independent scientific reasoning. The assessment instrument successfully documented these initial conditions through the systematic application of the observation rubric to all participants. Rather than recording only the final learning outcomes, the observer evaluated students' participation and performance throughout each scientific activity according to the established performance indicators. Consequently, the results obtained in Cycle I provided a baseline profile of students' science process skills before instructional improvements were introduced in the subsequent cycles.

A considerable improvement was observed during Cycle II. The mean achievement score increased to 73, while the percentage of classical mastery reached 77.3%. This improvement suggests that the observation instrument effectively captured changes in students' performance following the reflection and refinement of Guided Inquiry instruction. The observation data revealed that an increasing number of students achieved higher scores across the assessment rubric, reflecting greater participation and independence in scientific inquiry activities. This development was further evidenced by the increase in the mean observation score from 16.5 in Cycle I to 21.9 in Cycle II, demonstrating the instrument's sensitivity in detecting students' progressive development of science process skills during classroom learning.

Despite this improvement, the Cycle II results also indicated that several students had not yet achieved the predetermined mastery criterion. These findings demonstrate that the assessment instrument served not only to identify improvements in students' competencies but also to diagnose learners who continued to require additional instructional support. Such a diagnostic function represents one of the essential characteristics of authentic assessment, as observation data can be utilized by teachers to design appropriate instructional interventions for subsequent learning cycles (Kunandar, 2013). The implementation of the assessment instrument during Cycle III produced the most favorable outcomes. Students' mean achievement score increased to 83, accompanied by a mean observation score of 24.9, while the percentage of classical mastery reached 100%. All students participating in the third instructional cycle successfully met the predetermined mastery criterion. These results indicate that the observation-based assessment instrument consistently documented the progressive development of students' science process skills throughout the three instructional cycles.

Compared with the previous cycles, the results obtained in Cycle III reveal a stable pattern of improvement across the assessment data. This progression was reflected not only in the increase in the class mean score but also in the growing number of students who achieved the Good and Excellent performance categories. Accordingly, the assessment instrument generated information that extended beyond quantitative achievement scores by providing meaningful evidence of students' gradual performance development throughout Guided Inquiry-based science instruction. The repeated implementation of the assessment instrument across successive instructional cycles also demonstrated that the observation rubric contributed to improving the consistency of the assessment process. The predefined scoring criteria provided clear guidelines for the observer when evaluating each science process skills indicator. As a result, the possibility of subjective judgment was minimized because every score was assigned according to explicit descriptions of students' observable performance. This finding supports the study conducted by Srirahayu and Arty (2018), who concluded that analytic rubrics enhance the objectivity and consistency of science process skills assessment during laboratory and practical learning activities.

Beyond documenting students' learning progress, the implementation results also demonstrate that classroom observation constitutes an appropriate assessment technique for evaluating science process skills. Unlike written examinations that primarily measure conceptual knowledge, observation enables teachers to assess how students conduct scientific investigations, collaborate with peers, analyze experimental data, and communicate investigation results throughout the learning process. Consequently, the data generated by the observation instrument provide a more authentic representation of students' actual scientific performance than conventional paper-and-pencil assessments. The findings of this study reinforce those reported by Martatiyana and Madani (2024), who argued that observation-based authentic assessment provides a more comprehensive evaluation of students' competencies than conventional assessment approaches. Similarly, the results are consistent with the findings of Munjiah and Utari (2025), who demonstrated that observation instruments supported by analytic rubrics generate more meaningful information for teachers in monitoring the development of students' science process skills. Therefore, the implementation of the science process skills assessment instrument in this study not only produced evidence of students' learning achievement but also generated valuable diagnostic information that can assist teachers in continuously evaluating and improving science instruction.

DISCUSSION

The findings of this study demonstrate that the observation-based science process skills assessment instrument effectively documented students' progressive development of science process skills throughout the implementation of Guided Inquiry learning. This was evidenced by the continuous increase in the mean science process skills scores from Cycle I to Cycle III, indicating that the instrument was sufficiently sensitive to capture changes in students' performance during the instructional process. In the context of this study, the improvement in students' scores reflects not only the development of their scientific competencies but also the instrument's ability to record variations in students' engagement and participation throughout each stage of scientific inquiry.

A major strength of the assessment instrument lies in its use of an analytic rubric comprising performance indicators that directly represent the sequence of scientific inquiry activities, including problem formulation, hypothesis development, experimental planning, preparation of equipment and materials, assembly of experimental apparatus, observation and measurement, data analysis, drawing conclusions, group collaboration, and presentation of experimental findings. Such a structure enabled teachers to evaluate students' scientific performance comprehensively rather than focusing solely on their final learning outcomes. Consequently, the instrument satisfies the essential characteristics of authentic assessment, which emphasizes evaluating students' ability to apply knowledge and skills within meaningful learning contexts (Kunandar, 2013).

These findings are consistent with Bundu (2006), who argued that science process skills should be assessed through students' actual engagement in scientific activities rather than exclusively through written examinations. According to Bundu, mastery of scientific concepts alone cannot adequately represent students' competence in scientific inquiry unless it is accompanied by direct observation of activities such as identifying problems, conducting experiments, making observations, and communicating investigation results. Therefore, the observation-based instrument employed in this study provided teachers with more comprehensive information regarding students' science process skills than would have been obtained through conventional paper-and-pencil assessments.

The results also support the theoretical framework proposed by Rustaman et al. (2011), who emphasized that science learning should provide students with direct opportunities to engage in scientific inquiry in order to develop scientific thinking, practical skills, and scientific attitudes simultaneously. The observation instrument accommodated these dimensions by incorporating indicators that assessed intellectual competencies, practical laboratory skills, collaborative learning, and scientific communication. Consequently, the instrument functioned not merely as an assessment tool but also as a mechanism for continuously monitoring students' competency development throughout the learning process.

Another notable strength of the instrument is the use of an analytic rubric containing explicit performance descriptors for each achievement level. These descriptors provided clear scoring guidelines for the observer, thereby reducing subjectivity during classroom assessment. Students who independently completed scientific activities received the highest scores, whereas those requiring teacher assistance received proportionally lower scores according to their level of independence. Such a scoring procedure is consistent with Purwanto (2014), who emphasized that educational assessment instruments should employ explicit and objective scoring criteria to ensure the credibility and accountability of assessment results.

The present findings are further supported by the study conducted by Srirahayu and Arty (2018), who developed an experiment performance assessment instrument to evaluate science process skills during laboratory activities. Their study demonstrated that observation-based analytic rubrics improved scoring consistency while providing a more accurate representation of students' scientific performance. Similar to the present study, performance indicators served as the basis for assigning scores, ensuring that assessment focused not only on the final product but also on students' scientific inquiry processes throughout experimental activities.

Furthermore, the findings are consistent with the work of Martatiyana and Madani (2024), who concluded that observation-based authentic assessment represents an effective approach for evaluating science process skills in science education. They argued that classroom observation enables teachers to assess students' abilities to identify problems, conduct investigations, analyze data, and communicate scientific findings directly during learning activities. These characteristics closely correspond to the implementation of the assessment instrument in the present study, where observations were conducted continuously throughout every phase of Guided Inquiry instruction. Consequently, the assessment data provided evidence not only of students' learning achievement but also of their progressive learning processes and scientific performance.

The repeated implementation of the assessment instrument across the three instructional cycles also demonstrated its diagnostic value. Observation data enabled teachers to identify students who continued to experience difficulties in performing scientific inquiry activities, thereby providing evidence for refining instructional strategies in subsequent learning cycles. This diagnostic function represents one of the major advantages of authentic assessment because assessment results are used to support instructional improvement rather than merely to determine students' final grades. Accordingly, the observation-based instrument fulfilled an important formative assessment function by providing continuous feedback throughout the instructional process.

Despite these promising findings, several limitations should be acknowledged. First, the analysis focused primarily on students' total science process skills scores rather than examining the development of individual performance indicators separately. A more detailed indicator-level analysis would provide richer information regarding which specific science process skills developed most substantially and which aspects still require instructional improvement. Second, the study was conducted in a single elementary classroom involving a relatively small number of participants. Consequently, the findings should be interpreted with caution and cannot be generalized to broader educational contexts without further empirical validation. Future research is therefore recommended to develop observation-based science process skills assessment instruments that include comprehensive psychometric evaluation, such as content validity, construct validity, reliability testing, and indicator-level performance analysis, to provide stronger empirical evidence regarding the effectiveness of the instrument.

The findings indicate that the observation-based science process skills assessment instrument has considerable potential for application as an authentic assessment tool in elementary science education.

The instrument systematically documented students' science process skills development, generated meaningful information to support teachers' instructional decision-making, and contributed to science learning that emphasizes the development of twenty-first-century competencies. Therefore, observation-based analytic rubrics may serve as an effective alternative assessment approach for elementary science instruction, particularly in inquiry-oriented learning environments that emphasize active scientific investigation.

CONCLUSION

This study demonstrates that the observation-based science process skills assessment instrument can be effectively implemented as an authentic assessment tool in Guided Inquiry-based science learning at the elementary school level. The instrument, which consists of ten performance indicators representing the stages of scientific inquiry, enabled systematic observation and evaluation of students' engagement throughout the learning process. The use of an analytic rubric with clearly defined performance criteria contributed to more objective and consistent assessment of students' science process skills.

The implementation results showed that the instrument successfully documented the progressive development of students' science process skills across the three instructional cycles. Students' mean achievement scores increased from 55 in Cycle I to 73 in Cycle II and reached 83 in Cycle III, while classical mastery improved from 30.4% to 100%. These findings indicate that the instrument was sufficiently sensitive to capture changes in students' scientific performance and participation during Guided Inquiry activities. Beyond measuring learning outcomes, the instrument also provided meaningful diagnostic information that supported continuous monitoring of students' inquiry skills and informed instructional improvement.

The findings suggest that observation-based assessment supported by analytic rubrics offers a comprehensive alternative to conventional paper-and-pencil assessments for evaluating science process skills. By assessing students' performance during authentic scientific activities, the instrument provides richer evidence of scientific inquiry competencies, including critical thinking, experimental skills, collaboration, and scientific communication. Consequently, the instrument has considerable potential for supporting competency-based science learning and the development of twenty-first-century skills in elementary education.

Despite these promising results, this study was limited to a single classroom context and focused primarily on overall science process skills scores. Future research is recommended to investigate the psychometric properties of the instrument, including its validity and reliability, and to analyze the development of individual science process skills indicators across diverse educational settings. Such studies would provide stronger empirical evidence regarding the effectiveness and broader applicability of observation-based science process skills assessment instruments in elementary science education.

Data Availability The data supporting the findings of this study are available from the corresponding author upon reasonable request.
Ethical approval All procedures performed in the study followed the ethical standards.
Consent for publication All authors have read and agreed to the published version of the manuscript.

Consent to participate Consent to participate was obtained from all individual participants included in the study.

Informed consent Informed consent was obtained from all individual participants included in the study. Data were reported anonymously in the study.

Conflict of interest The authors declare no competing interests.

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