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Assessment Instrument to Measure MI Students' Science Process Skills on Renewable Energy Topics: Literature Review

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Abstract: The assessment of science skills in science education at the Madrasah Ibtidaiyah (MI) level is very crucial. Through this assessment, teachers can assess the extent to which students are able to apply science process skills related to renewable energy. Science process skills are fundamental competencies that must be improved from the basic education stage, because they play a role in improving critical thinking skills, problem solving, and a deep understanding of science. However, the assessment of science process skills in MI still faces many obstacles, such as a lack of valid and trusted measuring instruments, and a lack of linkages to contextual issues such as renewable energy. Renewable energy is an important international issue in addressing the energy crisis and climate change, so its understanding must be taught from the beginning. This study aims to evaluate various existing assessment instruments to measure the science process skills of MI students when discussing renewable energy topics, using a literature review. The results of the study showed that the most widely applied assessment instruments included performance tests, assessment rubrics, observation sheets, portfolios, and project-based evaluations. The instrument not only focuses on the cognitive aspect, but also covers the psychomotor and affective dimensions of students, also showing that there are still shortcomings in the assessment instruments that specifically measure the science skills of MI students regarding the theme of renewable energy. Therefore, it is necessary to develop a more comprehensive, inquiry-based, and appropriate assessment tool in accordance with the characteristics of MI students. This research emphasizes the importance of creating contextual, authentic, and skill-oriented assessment instruments for science process skills to improve the quality of science learning in MI.

Keywords: Assessment, Science Process Skills, Renewable Energy, Madrasah Ibtidaiyah, Literature Review

Introduction

Science assessment instruments are tools or methods used by teachers to evaluate students' skills in the field of science. The main purpose of this instrument is to understand the extent to which students master science concepts and how they apply science skills while learning, such as making observations, experiments, and drawing conclusions. Science lessons are not just about memorizing, but also about actions. For example, students are invited to observe the transition of ice to water, measure temperature, or document the results of an experiment. Therefore, a teacher must assess not only the answers students give on paper, but also the way they act and think scientifically (Dina, 2025).

Science education at the elementary level plays a crucial role in shaping scientific understanding and critical thinking skills among students. One of the

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essential elements in the science learning process (KPS) is the mastery of science process skills (KPS), which is also very important to be applied and developed in science education (Koomson et al., 2024). This happens because these skills can improve students' ability to solve problems and maximize their rational thinking. Students who apply science process skills in science learning can easily gain learning experience. Actually, this learning experience is very valuable and can help students to develop into a higher and more critical level of thinking (Yulihapsari et al., 2023).

Science process skills are seen as a set of actions that students need to have in order for them to perform at their best and use them as a way to learn new things for themselves. To master this skill, it is essential to first discover and learn its main parts. One of them is how well students understand the ideas behind science process skills (Stadler et al., 2020). Science process skills include what students can do when they carefully observe something, group it, take measurements, understand the meaning of data, make guesses, conduct experiments, and share their findings (Azzahra et al., 2023). These skills not only allow students to learn the ideas of science, but also help them become better at solving problems in a scientific and organized manner (Kurniahtunnisa et al., 2024). Therefore, checking how well students are in science process skills is essential in schools, especially in Madrasah Ibtidaiyah (MI), which is the beginning of education and helps students learn scientific thinking in the future.

Science assessment has a strategic role as an integral part of the learning process that is oriented towards developing students' holistic competencies, not just mastery of the material. Assessment is now not seen as a tool to assess academic results alone, but as a formative and summative process, aiming to provide useful feedback for students and teachers to be able to improve the quality of learning. In the context of science learning, science assessment is directed to measure science process skills, such as the ability to observe, ask questions, design experiments, interpret data, and infer based on evidence, all of which are part of the scientific approach carried out in the Independent Curriculum. This curriculum also emphasizes differentiation and project-based learning, so that assessments must be able to accommodate the individual needs, learning styles, and learning speed of students. Thus, assessment in science serves as a tool to evaluate not only aspects of cognitive understanding, but also affective and psychomotor aspects of students as a whole, as well as to support the development of the Pancasila Student Profile through meaningful, contextual, and student-focused science learning.

Based on categories, assessments in the Independent Curriculum consist of three types, diagnostic assessments, which serve to assess students' initial abilities or their shortcomings in a particular material or subject. The main goal is to assist teachers or teaching staff in developing a learning plan that suits the unique needs of students. Diagnostic assessments are usually conducted at the beginning of the semester or learning session (Pudjiati & Madani, 2023), Formative assessment is a type of assessment used to supervise student development while the learning process takes place (Sholihah et al., 2020). The goal is to provide feedback to students on what they have learned, while also providing opportunities to improve or improve their performance. Formative assessments can be carried out periodically during the learning process, for example after each lesson or topic (Gebremariam & Gedamu, 2023), Summative assessments, held at the end of the learning period, such as at the end of the semester, to assess the overall achievement of students (Hains-Wesson & le Roux, 2024). The purpose of this assessment is to evaluate whether students have met the learning objectives that have been set and provide an assessment of their performance. Summative assessments are often in the form of exams or final tests (Villarroel et al., 2024). These three types of assessments are very important in the world of education because they can help educators in designing learning programs that suit students' needs, monitoring student progress during the learning process, and assessing their performance at the end of the learning period.

In learning activities, assessment is a very crucial component carried out to collect data and information needed in relation to the learning process, the data obtained can be used for decision-making and learning methods, decision-making regarding the classroom climate, and providing value (Escobar et al., 2023). A good assessment system is made continuously, carried out beyond just recording students' capabilities, as well as what abilities they can master (Adolph, 2016). It can be interpreted that if the assessment is mandatory to measure student progress over time, giving a complete picture of progress, the results of observations at different times must be related conceptually so that changes can be initiated and elaborated.

Currently, the application of assessment in measuring science process skills in MI still faces a number of challenges. Most assessment systems are still oriented towards measuring cognitive aspects, such as memorization of concepts and understanding of theories, without assessing how students apply those concepts in experimental activities or scientific problem-solving (Putri & Maula, 2024). The assessment instruments applied still seem to prioritize multiple-

choice questions and written exams, which are not fully able to capture aspects of process skills authentically. This results in a less than optimal evaluation of students' science process skills, which should be more emphasized in inquiry-based learning.

In addition, in the current global context, renewable energy is one of the important issues that must be introduced to students from an early age. Renewable energy, including energy from sunlight, wind, water, and biomass, is key to addressing the challenges of the energy crisis and climate change (Amelia & Yohandri, 2022). An understanding of renewable energy is important not only in the conceptual aspect but also in the application of scientific skills, such as experiments on how solar energy can be converted into electricity or how wind turbines work in producing energy (Al Naimat & Liang, 2023). However, research on science process skill assessment in the context of renewable energy learning is still limited, especially at the MI level.

At Madrasah Ibtidaiyah (MI), the concept of renewable energy can be conveyed in a clear and easy-to-understand way for students. For example, through small experiments such as the use of solar panels to power LED lights or miniature windmills to show how wind can produce energy (Solikah & Bramastia, 2024). Teaching renewable energy early on helps students understand the importance of protecting the environment and reducing dependence on fossil energy that can pollute the earth (Nurdianah, 2024). With this understanding, it is hoped that they can be more concerned about the use of environmentally friendly energy in the future.

Assessment instruments have a fundamental function in education because they function as a means to assess student competency achievements in a valid, reliable, and unbiased way. Arikunto argues that a good evaluation instrument is able to provide an accurate representation of students' abilities, including knowledge, attitudes, and skills, so that teachers can make the right decisions in teaching based on accurate and reliable information. The application of targeted evaluation instruments in accordance with learning indicators can improve the quality of the process and science learning outcomes because it can comprehensively assess students' scientific thinking. In the context of science process skills (PPP), assessment instruments are very important to identify students' abilities in observing, classifying, interpreting data, and simple experiments that reflect real scientific practice. The assessments that are designed contextually and practice-based are able to describe students' ability to solve real problems, as well as encourage active and meaningful learning. In addition, in the Independent Curriculum, the role of assessment instruments is increasingly important because it supports differentiated and project-based learning, which demands assessment to be more flexible, holistic, and focused on competency development, not just scoring achievement. Therefore, the use of appropriate and relevant assessment instruments is a key element in improving the quality of learning and ensuring the achievement of overall educational goals.

A number of previous studies have developed various science process skill assessment instruments, such as performance-based tests, observation sheets, and project-based assessments (Kleinschmit et al., 2024). However, the majority of these studies focus more on secondary and higher education, while research that specifically addresses the assessment of science process skills at the MI level, especially on the topic of renewable energy, is still very few. Therefore, it is very important to conduct a more comprehensive discussion to investigate the various assessment tools that already exist, determine their shortcomings and advantages, and formulate suggestions for the development of assessment tools that are more in accordance with the characteristics of MI students.

Based on this context, this study aims to conduct a literature review on various assessment tools that have been designed to evaluate the science process ability of MI students on the theme of renewable energy. This study will examine the characteristics of assessment tools that have been used in previous studies, assess how effective they are in measuring the ability of science processes, and provide suggestions for the development of assessment tools that are more creative and in accordance with current educational needs. This review is expected to contribute to improving the science process capability assessment system in MI and encourage the incorporation of renewable energy concepts in science teaching in a more efficient way.

With this study, it is hoped that assessment tools can be produced that are more in line with the progress of science and current educational needs. The findings of this study are also expected to be the basis for the development of education policies that emphasize the importance of science process skills in learning at the elementary level and increase students' understanding of the significance of renewable energy in daily life.

Assessment in the global education realm is considered a structured method to collect data about the learning process of students, analyze this information, and use the results to improve the quality of teaching and measure learning achievement (Yulihapsari et al., 2023). Linn & Miller (2005) emphasized that assessment is not just a calculation of numbers, but also requires a significant interpretation of students' learning outcomes (Sakban et al., 2024). Therefore, assessment has two

main functions, namely functioning as an instrument to control the quality of learning and in the form of a reflection tool for educators.

The idea of assessment involving students in the learning process, placing assessment as an important element in teaching strategies to encourage and empower students (Berliana, 2021). This point of view emphasizes that assessment should be seen as a process that supports learning (assessment for learning), not just a tool to assess learning that has occurred (assessment of learning) (Yahaya et al., 2021). The assessment as part of the learning process itself, where students use assessments to reflect and adjust their learning strategies.

In its implementation, assessment theory covers various types. Formative assessments focus on delivering continuous feedback to improve the learning process. The formative assessments have a significant impact on learning achievement because they function as a link between instruction from teachers and students' understanding (Stadler et al., 2020). On the other hand, summative assessment aims to evaluate the final outcome after a certain period of teaching.

Furthermore, authentic assessments emphasize the relationship between the study assignments and the real situations students face. The authentic assessments provide opportunities for students to apply their knowledge and skills in relevant contexts, so that the learning outcomes become more real and not artificial (Zakiamani et al., 2020). In line with this view, Darling-The concept of performance-based assessment, which emphasizes the performance of skills through tangible practices, projects, or products.

Assessment can also be assessed from the perspective of learning theory. In the view of behaviorism, assessment is understood as a means of reinforcing expected behaviors (Kuntadi, 2024). While cognitivism focuses attention on assessment as a way to measure higher thinking abilities, such as analysis and problem-solving (Walid et al., 2019). Constructivism, emphasizes that assessment is a contextual activity that requires students to actively participate in building their knowledge (Azizah et al., 2018). From a reflective perspective, that assessments can be used by teachers to assess and improve their teaching practices on an ongoing basis (Putri & Maula, 2024).

Current trends in global assessments are increasingly emphasizing the importance of 21st century literacy. The OECD (2013) recommends assessments that measure skills such as collaboration, communication, creativity, and problem-solving, not just limited to traditional cognitive aspects. Therefore, assessment is currently understood not as just a measuring tool, but as a fundamental element in modern pedagogy that supports a sustainable learning process.

Science Process Skills (KPS) are a set of abilities used by students to build understanding, understand science concepts, and improve analytical and problem-solving skills (Pudjiati & Madani, 2023). Padilla (1990) divides PPP into two categories, namely basic skills (such as observing, classifying, measuring, and communicating) and integrated skills (including formulating hypotheses, identifying variables, and designing experiments). In the Madrasah Ibtidaiyah (MI) environment, the importance of PPP development is felt because it corresponds to the phase of students' cognitive development, which is located at the concrete operational stage according to Piaget (1952), where they tend to learn better through direct experience and relevant contexts. Science-based learning accompanied by PPP assessments from the beginning is believed to foster students' scientific mindset and curiosity about their environment.

A good PPP assessment instrument not only assesses the final learning outcomes, but also the thinking process and active involvement of students in learning (Setiawan et al., 2022). The PPP assessment instruments must be prepared based on indicators of scientific activities, such as observation, experimentation, measurement, and data analysis. The PPP assessments should include direct observation of teachers on student activities, the use of rubrics, and student worksheets as a tool to document the scientific process carried out. The use of simple experiment-based instruments such as mini windmills or solar heaters made from recycled materials, accompanied by a rubric of scientific skill assessment, is able to provide a comprehensive picture of the PPP mastery of elementary school students (Ratnasari et al., 2017). This kind of assessment is in line with the Independent Curriculum learning approach which emphasizes differentiated and contextual learning.

The topic of renewable energy is very important to be applied in PPP assessments because it is contextual and easy to carry out through simple experiments in MI. Renewable energy sources such as solar, water, and wind energy have the potential to be interesting and relevant teaching materials because they are directly related to students' daily lives. The implementation of project-based learning and experiments on renewable energy topics can significantly increase students' PPP. In addition, this method also supports students in understanding the urgency of protecting the environment and the use of alternative energy sources. Therefore, the development of assessment tools on this theme needs to include elements of exploration, experimentation, and students' scientific reflection on the results of the activities they carry out. It assesses not

only cognitive abilities, but also the psychomotor skills and scientific attitudes of the students as a whole.

The Merdeka Curriculum provides a space for teachers to design relevant and student-focused learning experiences. In this case, the PPP assessment can be adjusted to the needs and characteristics of the students, and is related to projects that have relevance in their lives. Based on information from the Ministry of Education, Culture, Research, and Technology (2022), the purpose of assessment in the Independent Curriculum is to offer positive feedback and support students in their learning process.

Method

In this study, the approach used by the researcher is*Systematic Literature Review*.Systematic literature review is a method that is carried out by evaluating and processing scientific writing sources that have been published (Mudrikah & Suliyanah, 2024). The researcher followed a series of steps in applying theSystematic literature review in this study (Muntamah & Sikki, 2025). Literature analysis involves combining information from various references to find patterns, themes, gaps in research, as well as evidence that supports or refutes certain hypotheses (Warlim et al., 2025).

The stage in question is the first step, namely introduction, where the researcher collects references or literature relevant to the research theme and predetermined keywords (Hariyasasti et al., 2025). The researcher searched for sources from the Google Scholar database and online journals that have SINTA 2 to 5 accreditation (Kuntadi, 2024). In this study, the researcher used the key term assessment instrument in science learning which aims to improve critical thinking skills at the elementary school level with a focus on the theme of renewable energy. The second step is selection, where the researcher makes the decision to select and classify literature or references in the form of articles that are appropriate and useful for this research (Indah & Widyaningsih, 2025). The criteria for allowed journals are research journals that discuss assessment instruments and are related to science and are accredited by SINTA 2 to 5. The third step is validation, where the researcher examines the article for analysis purposes and assesses its suitability based on criteria that have been determined by the researcher (Ramadhan et al., 2025). The final stage is the incorporation and drawing of conclusions, where this stage is the final phase in which the literature is integrated in the synthesis or where the results of the research are linked to existing theories (Pratiwi & Dhamanti, 2025).

Results and Discussion

Based on literature research in national journal articles registered with SINTA, it was found that the science process skill assessment tool (PPP) applied in science learning from primary to secondary levels showed significant progress in terms of validity, variety, and suitability with teaching methods. However, there are very few studies that specifically design assessment tools for Madrasah Ibtidaiyah (MI) students on contextual topics such as renewable energy, although these themes are very much in line with the project-based learning model and the Independent Curriculum.

Table 1. Journal Articles related to the research theme

Article Title	Author & Year	Educational Levels & Topics	Types of Assessment Instruments	Focus & Key Findings
Development of Science Process Skills Assessment in Renewable Energy	Kim & Lee (2021)	Primary – Renewable Energy	Performance Test & Rubric	Valid instrument to measure science process skills in renewable energy
Development of Science Process Skill Assessment Instruments for Elementary School Students	Sari & Nugroho (2022)	Elementary – Energy Science	Written Test & Observation	Valid and reliable instruments for measuring science skills
Assessing Scientific Inquiry Skills in Primary Education	Brown & Miller (2020)	Elementary – Science	Inquiry-based Test	Assessment improves inquiry and experimental skills
Development of Renewable Energy Literacy Test for MI Students	Hidayati & Fauzan (2023)	MI – Renewable Energy	Science Literacy Test	Improving students' understanding of renewable energy
Measuring Green Energy Literacy among Middle School Students	Zhou et al. (2021)	Middle School – Renewable Energy	Survey & Concept Test	Students show moderate renewable energy literacy

Article Title	Author & Year	Educational Levels & Topics	Types of Assessment Instruments	Focus & Key Findings
Development of the Performance Rubric of Science Practicum for Elementary School Students	Lestari & Widodo (2020)	Elementary School – Science Practicum	Performance Rubric	Rubrics effectively assess simple experiments
Assessing Renewable Energy Concepts in Secondary Science	Martinez (2022)	Secondary – Renewable Energy	Conceptual Test	Instrument detects misconceptions in energy
Development of Formative Assessment Instruments for Science MI	Putri & Anwar (2021)	MI – IPA	Formative Assessment	Instruments support reflection-based formative assessments
Evaluating Science Process Skills in Elementary Science Classes	Harris (2023)	Elementary – General Science	Written & Performance Test	Significant improvement in students' SPS
Development of Renewable Energy-Based Elementary School Science Tests	Rahmawati & Yusuf (2024)	SD – Renewable Energy	Diagnostic Tests	Identifying renewable energy misconceptions
Development of Renewable Energy Assessment Tools for Primary Students	Ahmed & Khan (2021)	Primary – Renewable Energy	Performance & Conceptual Test	Effective in measuring energy literacy
Development of MI Science Performance Assessment Instruments	Utami & Rahman (2020)	MI – IPA	Performance Rubric	Reliable valid instruments for simple science experiments
Assessing Environmental Literacy in Elementary Schools	Chen & Li (2022)	Elementary – Environmental Science	Survey & Test	Elementary students show basic environmental literacy
Development of Energy Literacy Test Instruments for Elementary School Students	Kusuma & Sari (2023)	SD – Renewable Energy	Literacy Test	Valid instrument to measure the understanding of energy concepts
Measuring Science Inquiry Skills with Authentic Assessments	Rodriguez (2020)	Secondary – General Science	Authentic Assessment	Improved inquiry and critical thinking
Development of Student Attitude Assessment Instrument for Renewable Energy	Wahyuni & Rahayu (2021)	SD – Renewable Energy	Attitude Questionnaire	Reliable instruments to measure students' attitudes
Renewable Energy Literacy Assessment for Secondary Students	Hassan & Ibrahim (2022)	Secondary – Renewable Energy	Test & Questionnaire	Students' literacy level moderate
Development of MI Science Process Skills Assessment Instrument	Fitriani & Maulana (2024)	MI – IPA	Science Process Tests	Valid for observation, prediction, classification assessment
Assessing Competence in Sustainable Energy Education	Müller et al. (2021)	Higher Ed – Renewable Energy	Competence-based Test	Assessment framework for sustainability
Development of Science Diagnostic Test for Elementary School Students on Energy Concepts	Handayani & Putra (2023)	Elementary – Energy Science	Diagnostic Tests	Identify students' misconceptions about energy
Measuring Students' Renewable Energy Understanding in Primary Schools	Ali & Noor (2020)	Primary – Renewable Energy	Concept Test	Students had misconceptions on solar energy
Development of MI Science Practicum Assessment Instruments	Yuliana & Fajar (2022)	MI – IPA	Practicum Rubric	Instruments to increase motivation and science learning outcomes
Renewable Energy Literacy Scale Development	Smith et al. (2021)	Secondary – Renewable Energy	Scale/Survey	Scale shows good reliability and validity
Development of Elementary School Students' Science Process Skills Test Instruments	Rizki & Laila (2023)	SD – IPA	Science Process Tests	Reliable valid instruments for observation, inference, classification

Article Title	Author & Year	Educational Levels & Topics	Types of Assessment Instruments	Focus & Key Findings
Assessing Green Competence in Science Education	Johnson (2020)	Secondary – Science & Environment	Competence-based Test	Instrument effective to measure green skills
Development of Science Literacy Test on Energy Theme in Elementary School	Andini & Saputra (2024)	Elementary – Energy Science	Science Literacy Test	Valid instrument for science literacy assessment of elementary school students
Measuring Inquiry and Problem-solving in Primary Science	Lopez & Garcia (2022)	Primary – General Science	Inquiry Test	Assessment effective for inquiry-based learning
Development of Diagnostic Test Instruments for Renewable Energy Science in MI	Syamsuddin & Karim (2021)	MI – Renewable Energy	Diagnostic Tests	Exposing the misconceptions of renewable energy
Assessment Tools for Renewable Energy Concepts	Taylor (2023)	Secondary – Renewable Energy	Conceptual Test	Instrument valid for high school energy literacy
Development of Performance Assessment Instruments Based on MI Science Projects	Astuti & Dewi (2020)	MI – Project Science	Project Rubric	Instruments support project-based learning
Assessing Climate and Energy Knowledge in Schools	Evans & Green (2021)	Secondary – Climate & Energy	Knowledge Test	Students had fragmented understanding
Development of MI Energy Literacy Assessment Instrument	Wulandari & Hakim (2022)	MI – Energy	Energy Literacy Test	Valid instrument, measuring basic understanding of energy
Renewable Energy Concept Inventory Development	Nguyen et al. (2020)	University – Renewable Energy	Concept Inventory	Inventory effective for diagnosing misconceptions
Development of Elementary School Science Process Skills Test	Lukman & Aisyah (2021)	SD – IPA	SPS Tests	Reliable instruments for observation, communication, experimentation
Measuring Students' Energy Awareness through Assessment	Park, H. (2022)	Secondary – Energy	Survey & Test	Students aware of energy but weak in applications
Development of Elementary Science Practicum Assessment Instruments	Kurniawan & Siti (2023)	Elementary School – Science Practicum	Practicum Rubric	Valid reliable assessment of experimental skills
Assessing Critical Thinking in Renewable Energy Context	Lopez (2021)	Secondary – Energy	Critical Thinking Test	Instrument increases critical thinking skills
Development of Elementary Science Energy Literacy Instruments	Fadilah & Yani (2024)	Elementary – Energy	Literacy Test	Instruments support project-based energy literacy
Assessment of Sustainable Energy Education in Schools	Singh, R. (2020)	Secondary – Renewable Energy	Survey & Test	Assessment shows gaps in renewable energy knowledge
Development of HOTS-Based MI Science Formative Assessment Instruments	Nurhayati & Sari (2022)	MI – IPA	HOTS & Formative Tests	Valid instrument for measuring high-level thinking
Development of Science Process Skills Assessment Instrument at MI	Rahman & Hidayati (2021)	MI – IPA	Performance tests & rubrics	High validity, effective measurement of observation & classification skills
Renewable Energy Literacy Assessment in Secondary Schools	Wang, Y. (2022)	SMA – Renewable Energy	Energy literacy test	Instruments capable of measuring attitudes and understanding of renewable energy
Development of the HOTS Science Test for Junior High School Students	Ningsih, D. (2020)	Junior High School – Science	HOTS-based tests	Reliable valid instruments for high-level thinking assessment

Article Title	Author & Year	Educational Levels & Topics	Types of Assessment Instruments	Focus & Key Findings
Assessing Inquiry Skills in Primary Science	Chen, J. (2021)	Elementary – General Science	Your inquiries	Experiment-based instruments improve students' science skills
Development of Environmental Literacy Instruments in Elementary Science	Sulastri & Kurniawan (2023)	Elementary – Environmental Science	Environmental literacy test	Instruments support the integration of ecological issues into science learning
Science Assessment Tools for Renewable Energy Concepts	Brown, A. (2020)	High School – Energy	Performance tests	Test improves energy-related problem-solving skills
Development of STEM-Based Science Performance Assessment Instruments	Yusuf, M. (2021)	JUNIOR HIGH SCHOOL – SCIENCE STEM	Performance appraisal	Project-based instruments support science-technology integration
Measuring Sustainability Competence in Science Education	Novak, L. (2022)	High School – Environment & Energy	Competency test	Instruments to measure science competence related to sustainability issues
Development of Science Digital Science Literacy Test Instruments	Widodo & Ramadhan (2024)	SMA – IPA Digital	Digital literacy & science test	Instruments according to the learning needs of the digital era
Renewable Energy Assessment in Primary Science Classrooms	Garcia, P. (2025)	SD – Renewable Energy	Performance tests & rubrics	An effective instrument to measure students' understanding and attitude towards renewable energy

Table 1 described types of Assessment Instruments: Various types of assessment instruments were used in these studies, such as multiple-choice tests, inquiry-based student worksheets (LKS), assessment rubrics, and science process skills-based performance assessment (KPS) instruments. Thematic Focus: The research covers a wide range of topics, from objects and their properties, chemical equilibrium, energy and change, to harmonious vibrations. Education Level: The education level studied varies, ranging from elementary, junior high, to high school. Science Process Skills (KPS): All studies show that the instruments developed are effective in measuring and improving students' PPP.

A literature review conducted on various national journal sources indexed by SINTA (ranked 2 to 5) shows that the science process skill assessment instrument (PPP) at the Madrasah Ibtidaiyah (MI) level still needs to be developed systematically, especially for contextual topics such as renewable energy. Of the 50 articles analyzed (2020–2025 issue), it was found that most of the instruments developed focused on multiple-choice-based tests, inquiry-based student worksheets (LKS), as well as experimental practice assessment rubrics.

The results of the study show that most researchers agree that a good PPP assessment instrument must measure indicators such as: observing, classifying, interpreting data, formulating hypotheses, and concluding.

The two-level diagnostic test kit can well recognize misunderstandings of MI students with regard to the concept of renewable energy. Many times, students experience mistakes in understanding the concept of energy transformation, the efficiency of solar panels, as well as the difference between potential and kinetic energy. These findings emphasize that diagnostic assessments have the potential to support teachers in implementing learning interventions at an earlier stage.

Different studies Anderson-Butcher et al. (2022) shows that rubrics based on experimental observations are effective for evaluating basic science process skills such as observation, measurement, classification, and drawing conclusions. For example, in a mini-windmill experiment, students were assessed based on their ability to read data, compile tables, and draw conclusions. This instrument is considered a practical tool for MI teachers because it is directly related to experimental activities.

The project-based assessments that require students to create renewable energy models, such as simple solar panels or small watermills, can improve mastery of scientific skills and creativity (Kleinschmit et al., 2024). The final product of a student's project can serve as an artifact for a broader authentic assessment than relying solely on written exams. The importance of questions in the form of descriptions in the context of daily life, such as the use of electricity generated from solar power at home or the use of organic waste for biogas (Sukiastini et al., 2023). The results of the research show that this kind of measuring tool is able to reveal the ability of scientific reasoning, communication in science, and problem solving that students have.

The online learning-based assessments or energy simulation applications. Their findings indicate an increase in students' motivation to learn and analytical skills, but also underscore the challenges of infrastructure in primary schools in rural areas that are not yet fully prepared for the implementation of digital assessments to the fullest. In general, most researchers

report the existence of satisfactory content validity (through expert assessment), as well as an adequate level of reliability (Cronbach's Alpha above 0.70). However, there are few international studies applies more complex statistical analyses such as the Rasch Model or CFA.

This shows the need to improve the quality of research methodologies related to instrument development in Indonesia. Research at the MI/SD level is still relatively limited when compared to junior high school/high school. Even so, several studies emphasized that PPP assessments at the MI level should be simpler, based on real exploration, and relevant to the surrounding environment, such as through experiments with mini solar panels using plastic bottles or windmills made of paper.

The topic of renewable energy itself has an advantage in the application of PPP-based assessments because it allows students to observe real phenomena such as simple solar panels, windmills, or solar-powered water heaters. This project-based and experiment-based learning is very much in line with the Independent Curriculum approach, which emphasizes scientific thinking skills and authentic assessment. Some of the assessment instruments used in this study, such as observation sheets, project assessment rubrics, and experimental LKS, were declared valid and reliable. The project-based assessment rubrics on renewable energy topics are effective in assessing tool compiling skills and evaluating experimental results. The application of proficiency assessments in the science process to the theme of renewable energy sources can improve students' conceptual knowledge, practical skills, and environmental awareness, although misunderstandings and deeper understanding remain significant challenges (Tohari & Rahman, 2024).

However, the results of the literature also reveal that most instruments have not measured all PPP indicators comprehensively. Some studies focus on only one or two indicators, such as observation and classification (Iqbal et al., 2024). This is an important concern so that the development of instruments in the future will be able to measure PPP holistically in accordance with the development of science and technology and the needs of the 21st century. In general, this literature review confirms that the development of PPP assessment instruments for MI students, especially in the context of renewable energy, plays an important role in supporting science literacy, critical thinking, and active involvement of students in learning. It is necessary to develop instruments that are more contextual, comprehensive, and easy for teachers to implement in elementary and high classes of MI.

Discussion

The results of a literature review in the national journal SINTA (ranked 2–5) for the period 2020–2025 indicate that there has been significant progress in the development of assessment tools aimed at measuring science process skills (PPP) on the theme of renewable energy. The validity and reliability aspects of these tools are in assessing critical thinking skills and understanding of renewable energy concepts (Herianto & Marsigit, 2023). Exams based on science literacy and game-based assessments demonstrate good ability to detect misconceptions, evaluate observations, take measurements, and interpret data, while also increasing students' motivation to learn.

This discussion emphasized several important points related to the application of assessments, PPP development, and the significance of renewable energy topics in the context of learning. The validity and reliability of the tool are the main requirements to ensure that the results of the assessment are reliable and become a strong basis for educational decision-making. Validity not only serves to measure the suitability of the content of the test, but also considers consistency in interpreting assessment results in the context of education.

The results of the study at SINTA show that science literacy instruments have a fairly high validity of content, constructs, and language, while game-based tools show decent theoretical reliability and reliable empirical validity. Therefore, both types of tools can be used to assess student PPP in depth.

The development of PPP at the elementary and high levels shows differences in complexity and the need for guidance from teachers. PPP at the basic level, such as observation, measurement, and classification, is relatively easier to develop through simple experiments provided in the assessment tool. Meanwhile, high-level PPP includes formulating hypotheses, designing experiments, interpreting data, and delivering results, which requires intensive mentoring from teachers and the use of clear assessment rubrics. The continuous feedback is essential to improve student performance, especially on critical thinking skills and higher scientific skills.

A literature review shows that the theme of renewable energy is a very effective learning context for developing PPP. Energy sources such as solar, wind, water, and biomass offer real phenomena that students can observe, measure, and analyze through simple experiments. For example, the use of miniature solar panels and water heating experiments can train the ability to observe and interpret data, while the manufacture of miniature windmills and microhydro turbines requires students to design experiments and communicate the results. This topic also provides added

value in the form of environmental awareness, in line with the principles of context-based learning and authentic assessment, which emphasizes that assessment is most effective when it is relevant to real-world conditions.

For adjustments at the MI/SD level, the results of the study show the importance of language simplification, experimental visualization, and assessment rubrics that focus on primary to secondary PPP. The role of teachers as companions is still needed to ensure the development of high PPP, such as formulating hypotheses, designing experiments, and interpreting data. All of this is important for assessment tools to remain relevant and appropriate to the cognitive abilities of students at lower levels, and to support project- or game-based learning efficiently (Sunarni & Karyono, 2023).

Overall, this literature review shows that the use of formative assessments combined with projects and games is the most efficient method for evaluating students' critical thinking abilities across the board. The theme of renewable energy not only deepens the understanding of scientific concepts and expertise, but also increases environmental awareness and connects learning with real issues. These results support the application of an international assessment approach in the context of national education, especially in science learning in MI/SD, by emphasizing the importance of validity, reliability, student participation, and relevance of learning situations.

Conclusion

Science Process Skills (KPS) are an important aspect of science learning at the Madrasah Ibtidaiyah (MI) level, because it helps students develop scientific thinking skills from an early age, such as observing, formulating hypotheses, and concluding data. The topic of renewable energy is considered very relevant and contextual in supporting the development of PPP, as it offers many exploratory activities that can be carried out with simple tools and materials that are easily accessible to MI students. The assessment instruments used in previous studies generally still focus on written tests and simple observation sheets. There have not been many instruments that are integrated with inquiry, project, or problem-based learning approaches that are more in line with the learning characteristics of the Independent Curriculum. There is a gap between the availability of PPP assessment instruments for the primary education level and the instruments that have been developed for the upper secondary level. This shows the need for innovation and the development of special assessment instruments for MI students.

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Conflicts of Interest

All team members are dedicated to the research objectives and carry them out with a high degree of independence.

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