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Designing Learning Assessment with STEAM-Based Projects in Implementing of the *Kurikulum Merdeka*

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Abstract: This study aims to develop a learning assessment design with STEAM-based projects for implementing the *Kurikulum Merdeka* in junior high schools, focusing on the topic of environmental pollution. The Design-Based Research (DBR) approach was used, comprising three stages: analysis and exploration, design and construction, and evaluation and reflection. The assessment design was validated by three experts and tested with 35 students and a science teacher at a junior high school in Pontianak. Results from the analysis and exploration phase revealed that teachers needed a comprehensive assessment method to evaluate 21st-century skills. In the design phase, the developed assessment included project matrices and rubrics, receiving a validation score of 85.45%, indicating high validity. In the trial phase, teachers found the assessment design easy to use and effective in evaluating students' understanding of science and scientific processes. The design also identified students' problem-solving and creative thinking skills. The findings suggest that this assessment could be a useful tool for evaluating students' 21st-century skills and offers potential for further research, particularly in large-scale trials to improve its quality.

Keywords: Asesment; Project Learning; STEAM; *Kurikulum Merdeka*

Introduction

The increasing need for 21st-century skills nowadays has become a phenomenon always taken into account by education providers when delivering instruction to their students, including in science education. Science education is said by experts to be closely related to 21st-century skills because it is systematic and applicable (Oktaviani et al., 2021). In the implementation of science education, students should have the ability to apply the knowledge they have learned to address real-life problems outside of school. This is highly relevant to high-level thinking skills, such as problem-solving and critical thinking abilities (Berg et al., 2021).

Various skills in this century are highly diverse, and many experts express their opinions on this matter. The 21st-century skills include critical thinking, problem-solving, communication, collaboration, and creativity. In book titled "Literacy is not Enough: 21st Century Fluencies for The Digital Age," maps out 21st-century skills consisting of problem-solving, creativity, analytical thinking, collaboration, communication, and ethical accountability. The intersection of these three perspectives emphasizes that the demands for 21st-century skills focus on enhancing thinking skills, which students must possess to meet the demands of the times, thereby improving the quality of education as well.

In its implementation in Indonesia, efforts to meet the demand for 21st-century thinking skills are carried out through the application of the *Kurikulum Merdeka* in every level of education, including at the junior high school level (SMP) (Marisa, 2021). The main idea of this educational curriculum is the freedom and flexibility of student learning, with a focus on project activities to allow students the opportunity to construct their learning experiences directly through interaction with their contextual environment (Amalia & Alfiansyah,

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2022; Ardianti & Amalia, 2022). The relevance of implementing the *Kurikulum Merdeka* with project-based learning models lies in emphasizing collaborative activities and student empowerment to observe and develop problem-solving solutions (Alhayat et al., 2024).

Learning through project activities, also known as Project-Based Learning, is a method of learning accomplished by completing projects to produce practical solutions. This method enables students to work independently in building their knowledge. Science education through project activities offers several positive benefits. Project-based learning can strengthen students' ability to formulate solutions. Additionally, it can stimulate the development of 21st-century skills such as communication and critical thinking. It is also known that project-based learning provides a better understanding of science concepts compared to conventional learning. The project-based learning can play a role in supporting the development of soft skills needed in the workforce, such as problem-solving.

In the implementation of the *Kurikulum Merdeka* to meet 21st-century skills among students, various learning approaches suitable for this project-based learning concept are recommended. One approach widely recommended for the implementation of the *Kurikulum Merdeka* is the STEAM approach (Mabsutsah & Yushardi, 2022). STEAM stands for Science, Technology, Engineering, Art, and Mathematics, an approach that integrates these five disciplines to enhance learning effectiveness. The STEAM approach is highly suitable for learning at various levels (Fauzi & Fajrin, 2022).

The STEAM approach also has various empirically proven benefits through previous research. In learning with the STEAM approach significantly improves students' 4C skills. STEAM learning can also optimize students' learning outcomes achievement and enhance students' psychomotor abilities (Sabara et al., 2022). Student engagement in STEAM learning also increases compared to learning without STEAM implementation.

Many findings show that science subjects are highly relevant to project-based learning activities (Kusumayuni et al., 2023) and STEAM-based learning approaches (Quigley et al., 2020). Kelley & Knowles (2016) state that science education needs to support students' scientific and inquiry processes. One example is environmental pollution material (Aninda et al., 2020). This material falls within the realm of science and has many applications of knowledge, skills, and scientific attitudes. This material is highly relevant to students' daily environment, making it easier for them to analyze and think about designs and technologies related to the material.

In the implementation of the *Kurikulum Merdeka*, several studies have found that teachers have used project-based learning. Such as research by Amalia & Alfiansyah (2022) and Khasanah & Muthali'in (2023), regarding the implementation of project-based learning in the *Kurikulum Merdeka* at junior high schools. However, on the other hand, in field implementation, project activities in the implementation of the *Kurikulum Merdeka* have not yet been fully realized. Some research findings reveal this, one of which is due to teachers' inability to accommodate assessments for these project activities. The teachers did not have difficulty conducting diagnostic, formative, and summative assessments. However, the challenge arose when determining assessments appropriate for the learning objectives to be achieved, especially in project-based learning.

In formulating lesson planning for assessment development, teachers are not accustomed to developing non-test assessments, such as performance assessments, attitude assessments, and project assignments, so it is not surprising that in the field, teachers can only assess students' cognitive mastery (Nirfayanti, 2015). The findings of this problem indicate that not only regarding project assessments but also improvements are still needed in all assessments developed by teachers, including assessments for the cognitive and affective domains. The majority of teachers consider assessment as a major challenge because they find it difficult to understand (Kartowagiran & Jaedun, 2016). Many teachers admit to being less confident in designing assessment instruments and conducting the assessment process.

The same goes for the implementation of the STEAM approach to project-based learning. Although many teachers express positive perceptions of the contribution of the STEAM approach in developing students' thinking skills, it is found that there are still few teachers who apply STEAM in learning. The impact caused by the absence of STEAM-based project learning in the implementation of the *Kurikulum Merdeka* is still found passive students and relatively low problem-solving abilities among students (Lestari et al., 2019). This situation suggests that students' thinking skills have not been fully optimized in learning that provides constructive empirical experiences.

It is crucial to examine the learning assessments undergone by students. Assessment or evaluation is part of the learning process that teachers need to develop in planning learning activities. As stated in Minister of Education and Culture Regulation No. 16 of 2022 regarding process standards in the implementation of the *Kurikulum Merdeka*, one of the activities in lesson planning is formulating ways to assess the achievement of learning objectives. Within the framework of the *Kurikulum Merdeka*, although project assessment is given due urgency, it would be better to develop holistic assessments. This implies that project assessment needs to be developed simultaneously with assessments for other skill domains, namely cognitive and affective, as assessments are used to obtain evidence as a basis for consideration of the achievement of learning objectives (BSKAP, 2022). The assessment or evaluation is the activity of collecting information about students' skills, essentially aiming to determine the extent to which the learning objectives have been achieved.

Based on the findings of previous studies indicating a lack of project-based STEAM learning assessments in the implementation of the *Kurikulum Merdeka*, this research aims to develop an assessment design for STEAM-based project learning in junior high schools. The research problem formulation includes questions related to: 1) how to analyze the assessment design needs for STEAM-based project learning in the implementation of the *Kurikulum Merdeka* in junior high schools for the topic of environmental pollution; 2) what is the assessment design for STEAM-based project learning in the implementation of the *Kurikulum Merdeka* in junior high schools for the topic of environmental pollution; and 3) what are the results of testing the assessment design for STEAM-based project learning in the implementation of the *Kurikulum Merdeka* in junior high schools for the topic of environmental pollution.

Method

The research was conducted using the Design Based Research (DBR) approach (McKenney & Reeves, 2012). This research using Design Based Research (DBR) focuses on design-based research and testing interventions, so in this study, it is intended to produce effective and sustainable interventions, especially in the aspect of project assessment in the implementation of the *Kurikulum Merdeka*. The research stages include three phases: analysis and exploration, design and construction, and evaluation and reflection.

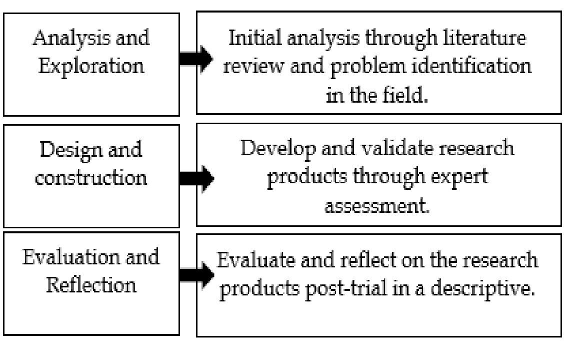


Figure 1. Steps of research method

In the first stage, needs analysis was conducted through literature studies, interviews, and document studies. Literature studies were conducted by analyzing previous findings. Interviews related to needs analysis were conducted with two junior high school science teachers in Pontianak City. The document studies were conducted on assessments developed by science teachers in the implementation of the *Kurikulum Merdeka*. Sample selection in this stage was based on subjects considered to provide the research information needs (Kumar, 2011). Thus, the data to be obtained in this stage are qualitative data.

The second stage involved the development of a prototype of STEAM-based project assessments by adopting the embedded STEAM approach (Chen, 2001) and implementing the first level of project activities, for learning meetings 2-4 meetings. The target design of these assessments is applied to junior high school students, especially for grade VII. In this stage, construct validity testing was also conducted to provide results that reflect the concepts and variables in the research to produce reliable decision-making (DeVellis & Thorpe, 2021). The validation refers to the level of intervention design built based on STEAM knowledge and the relationship of various intervention components to each other. Validation testing was conducted by three experts consisting of curriculum and learning experts, science and STEAM learning experts, and science learning practitioners in the *Kurikulum Merdeka*.

Lastly, in the evaluation and reflection stage, the prototype of the STEAM-based project assessment that has passed the validation testing stage was followed by a limited trial activity in one of the schools in Pontianak City. The trial was conducted involving 35 student participants and 1 science teacher. In this stage, research participants were selected using saturation sampling technique, meaning that all students and teachers involved in the trial directly became research participants to be considered in the analysis process. Referring to Arikunto (2010), which states, "*For rough estimates, if the subjects are less than 100, it is better to take all of them so that the research is a population study...*"

The data analysis used in this research includes quantitative data analysis and qualitative data analysis. Quantitative data analysis was conducted through descriptive statistical analysis, which involves converting numerical data obtained into percentages. The aim is to provide an overview of the distribution of scores obtained based on predetermined categories, thus explaining the situation (Hasan, 2001). Qualitative data analysis was condsucted through three steps: data reduction, data presentation, and data conclusion using descriptive analysis techniques. The goal is to present the findings in narrative form, to produce a deep understanding. The validation results of the STEAM-based project assessment prototype developed in this research were calculated through the following equation:

$$AP = \frac{\text{Actual Score}}{\text{Ideal Score}} x\ 100\% \quad (1)$$

Explanation:
AP : Percentage score
Actual Score : Score given by the validator
Ideal Score : Maximum score

The obtained percentage scores are then grouped according to the validation test categories in the Table 1.

Table 1. Validation Test Category

Interval %	Category
81-100	Very High
61-80	High
41-60	Moderate
21-40	Low
1-20	Very Low

Referring to the Table 1, the validation test results for the STEAM-based project assessment design can be considered suitable for testing if the minimum percentage reaches the high category, which is a validation test score >60% (Mawardi, 2014).

Result and Discussion

The result of the analysis and exploration stage

Based on the literature review in previous studies relevant to the design of assessments for STEAM-based project learning, several findings have been obtained in this study. First, research on assessments in project-based learning has been conducted and has provided positive contributions to learning, but it is still limited to the implementation of pre-*Kurikulum Merdeka*, such as the 2013 curriculum. Some of these studies who developed project assessments in science learning at elementary schools under the 2013 curriculum, and found that project assessments can improve learning effectiveness. Similarly, a study by Amri & Tharihk (2018) developed assessment tools for projects on environmental pollution and damage materials which were valid, and their implementation received positive responses from teachers. The found that the development of project assessments helped teachers assess students' critical thinking skills (Murdan and Suhadi, 2021). These literature findings indicate that in the implementation of the *Kurikulum Merdeka*, assessments for project-based learning are still underdeveloped.

Second, research on STEAM-based assessments is still limited. Previous studies have focused more on integrating STEAM into modules or teaching materials, including student worksheets (LKPDP). For example, research by Imaduddin et al. (2021) developed modules and educational game tools. Similarly, a study by Afrijhon et al. (2022) designed LKPs based on PjBL-STEM to enhance students' thinking skills. Although there have been studies developing STEM-based assessments, who created physics learning with integrated PjBL-STEM and TPACK models in the physics curriculum under the 2013 curriculum, none have integrated the art aspect (A) and adapted the implementation of the *Kurikulum Merdeka*, such as the assessment design to be developed in this study.

It can be identified that previous relevant research has not included assessments for the implementation of STEAM-based project learning in the *Kurikulum Merdeka*. This indicates that the assessment design for STEAM-based project learning in the implementation of the *Kurikulum Merdeka* has great potential for development to support the enhancement of 21st-century thinking skills in students. This conclusion is based on the understanding that project-based learning is an integral part of learning activities with the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach (Erlinawati et al., 2019). The project-based learning method implements learning by doing activities based on constructivist theory, which has been proven effective in improving higher-order thinking skills, such as problem-solving with scientific and mathematical approaches. The integration of arts (Arts) in the STEM approach is an effort to help students understand analytical concepts through the use of creativity (Pratama et al., 2022).

Based on the findings from the needs analysis conducted through interviews, it was obtained information that in the implementation of the *Kurikulum Merdeka*, science teachers have been striving to develop assessments that can measure students' science process skills, as expected by the curriculum achievement standards (CP) of the *Kurikulum Merdeka* according to the Decision of the Head of BSKAP No.009/H/KR/2022 Year 2022. This is evidenced by the finding that teachers have accustomed themselves to developing various types of assessments, including developing written tests, attitude assessments, and psychomotor assessments, as also seen through figure 1. This practice should align with Bloom's view, which classifies student behaviors into three domains: cognitive, affective, and skills.

Table 2. Learning Assesmen by Teacher

Assesments	Description
Cognitive Assessment	Conducted through a written test in the student's LKPD (Lembar Kerja Peserta Didik).
Affective Assessment	Conducted through peer assessment, graded by the group leader.
Psychomotor Assessment	Conducted through an observation sheet evaluating the presentation of discussion results in front of the class.

From the interview results, it is revealed that in the cognitive assessment used by teachers through objective tests, high-level thinking levels are not fully represented yet. Teachers are still developing questions that are explanatory in nature, which still fall within the second level, as expressed in the following interview results, "*The assessment I usually use in class is like written tests that are typically done at the end of the assessment after the learning material has been discussed. But besides tests, I also use attitude grades, which are usually done by the group leaders...*" *(Teacher 1)*

"*...The cognitive assessment through test questions is still limited because many students are not yet proficient in solving Higher Order Thinking Skills (HOTS) questions.*" *(Teacher 2)*

This finding is further reinforced by the review results of teaching module documents developed by teachers related to assessments to evaluate students' cognitive abilities.

Table 3. The questions in written assesment

Question Number	Question
1	What factors influence an object to move quickly?
2	If an object moves very fast, what are the advantages, disadvantages, or risks that may arise?

Referring to the above image, it can be inferred that the questions developed by teachers to assess students' cognitive abilities are still limited to "what" questions, indicating operational words at the first level (knowing) and the second level (understanding). Similar to several previous findings that revealed the fact that teachers in assessing students' knowledge are limited to questions focused on lower-order thinking skills (LOTS) (Jelatu et al., 2019; Safi'i & Amar, 2019). However, one effort to improve students' thinking skills is by training them to solve higher-order thinking skills (HOTS) questions (Kurniawati & Hadi, 2021).

An additional note on this finding is that teachers need to be careful in selecting operational verbs in assessments for the cognitive domain that align with the learning objectives. The importance of selecting appropriate operational verbs in assessment contexts, as they play a significant role in measuring students' achievement of basic competencies in learning.

As for assessments that evaluate the affective domain, it is known that teachers have developed assessments that can measure students' attitudes (see Figure 2). However, teachers only assess one attitude from the specified learning objectives. In other words, teachers only select certain attitudes that can be assessed. This implies that the assessment of students' attitudes should be comprehensive, in accordance with the formulation and within the scope of the Merdeka Kurriculum, and should be in line with the chosen Pancasila student profile.

Table 4. Teacher's Assesment

Developing	Meeting Expectations	Exceeding Expectations
Actively listens and takes notes on all data collected by other team members.	Listens attentively, actively shares opinions, responds to others' opinions relevant to the topic, and uses as well as provides credible information.	Actively listens, shares opinions, responds to others' opinions relevant to the topic, and uses credible sources of information. Additionally, helps teammates who are struggling and demonstrates leadership skills during discussions.

Looking at the assessment above (table 4), it can be observed that teachers only provide assessment of attitudes in the active aspect. It is important to note that assessments to evaluate students' attitudes should not only aim to achieve learning objectives and the Pancasila student profile within the context of implementing the Merdeka Curriculum, but also to understand the objects of attitude assessment. This includes not only showing attitudes towards subject matter but also towards the processes and values held during the learning process.

In measuring the success of projects in implementing the Merdeka Curriculum, teachers still face challenges, especially in developing assessments to evaluate projects. One of the reasons is that learning activities have not yet fully focused on project activities; they are still limited to classroom discussions. This statement is illustrated through the following excerpt from interview results.

"*....As for project grades, it's still limited because project-based learning is rarely used here. It usually falls under the* *separate P5 program, which is distinct from classroom material learning."* (Teacher 1)

"....So, there are cognitive and affective grades, but only psychomotor grades are sometimes present and sometimes not, because it's used when students go through project activities, and I rarely do that. So, there are still student skills grades that cannot be identified because of this." (Teacher 2)

These findings indicate that, despite the diversity of assessments applied, the assessment of project skills is still not sufficiently emphasized. This illustrates that project-based learning has not yet been fully integrated with the Merdeka Curriculum, and there is a need for a shift in focus in the implementation of teaching. This is further supported by the results of document analysis conducted by the researcher on the implementation plans of learning, which include assessment sheets developed by science teachers in teaching module documents. It was found that the assessments developed by teachers to evaluate learning objectives have not accommodated project assessments.

Assessing students' science process skills through project activities in the implementation of the Merdeka Curriculum has not been fully conducted. The limited application of project assessments in the assessment process not only results in inaccuracies in assessing skills but also reduces opportunities for students to improve their soft skills. Especially in science learning, which not only focuses on mastering concepts but also emphasizes the discovery process (Radinsky, 2016). This approach to learning requires students to stimulate and develop science process skills (SPS). In terms of assessment, in addition to knowledge aspects, these science process skills should also be assessed more objectively, for example, by providing project assessment instruments. Without clear assessment criteria, evaluations conducted can deprive students of fairness, as indicated by the Centre for Teaching and Learning.

The result of design and construction stage

The conceptual framework of project-based STEAM learning characteristics integrated into the assessment design in this research includes: 1) Learning oriented towards higher-order thinking skills (HOTS) of the 21st century or known as the Scientific process; 2) Learning oriented towards practical problem-solving skills (engineering process); and 3) Comprehensive assessment (assessing cognitive, affective, and psychomotor domains) (Kelley & Knowles, 2016; Quigley et al., 2017; Riley, 2012).

In its development, referring to BSKAP (2022) which states that in planning assessments, it begins with assessment objectives that must align with the learning objectives and then develops assessment instruments according to the formulated objectives. Learning objectives are the main foundation in this research, therefore, before formulating assessment objectives, the formulation of expected learning objectives, especially for the topic of environmental pollution in Phase D, is carried out, followed by designing assessment grids (Mardapi, 2012). The learning objectives that accommodate project-based STEAM learning activities in this research are formulated as follows Table 5.

The formulated objectives above fall within the realm of higher-order thinking skills, specifically the levels of analyzing (C4), evaluating (C5), and creating (C6). Thus, in its design, students are expected to generate design solutions to water pollution issues through participation in collaborative project activities during the learning process. In accordance with the conceptual framework of the STEAM approach for middle school education, STEAM is applied more profoundly to explore students' potential by analyzing local/global issues in solving problems or, in other words, learning oriented towards presenting solutions (Anggraini & Huzaifah, 2017). The formulation of these objectives also serves as an effort in determining the materials used as project resources. This addresses the preparation and planning of various possibilities that may arise during the project process conducted by students (Afandi et al., 2024).

Table 5. Formulation of Learning Objectives for the Topic of Environmental Pollution

Code of Learning Objectives	Description
TP1	Elaborating the critical understanding of environmental pollution through interpretative activities on presented air quality data (C4)
TP2	Diagnosing the differences in the causes of environmental pollution due to human behavior and natural occurrences critically through observation activities on images of air pollution phenomena (C4)
TP3	Distinguishing the impacts of environmental pollution on water, soil, and air on daily life critically through identification activities in provided discourse (C4)
TP4	Evaluating environmental pollution mitigation behaviors in water critically through identification activities in provided discourse (C5)
TP5	Designing solutions to address water pollution issues by creating a creative water purification project (C6)

From Table 5, it is also found that 21st-century skills, such as critical thinking, creative thinking, problem-solving, and collaboration, are explicitly stated in the learning objectives and are also accommodated in the Pancasila student profile. The 21st-century skills involve aspects of critical thinking, creativity, collaboration, communication, and problem-solving, which can significantly contribute to students' lives (Rismi, 2021). Formulating learning objectives that lead to higher-order thinking skills at the beginning of the learning process is considered essential.

The BSNP emphasizes that teachers must integrate all assessment components into assessment grids and determine the assessment techniques to be used with the aim of clarifying and facilitating the measurement of each objective's achievement (Salamah, 2018). Thus, based on the objectives listed in Table 6, the form and objectives of the assessment to be used in learning are formulated next.

Table 6. Assesment Forms

Code of Learning Objectives	Assesment Category	Assesment Aspects	Assesment Tools
TP 1, TP 2, TP 3, TP 4	Formative	Cognitive (Science Comprehension)	Questions test in LKPD
TP 1 -5	Formative	Affective (Pancasila Student Profile)	Observation Sheet and *Peer Assesment*
TP 5	Formative	Psychomotor (Science Skills)	Project Assesment Sheet

Table 6 provides information regarding the assessment design developed in this study, aimed at assessing the three domains of student behavior in learning, namely the cognitive domain assessed with test questions, the affective domain assessed with observation sheets and peer assessment, and the psychomotor domain assessed with project assessment sheets. Evaluation of the process of student learning needs to be conducted holistically, comprehensively, and thoroughly. This evaluation involves cognitive, affective, and psychomotor aspects using in-depth techniques and procedures, considering various evidence of student learning outcomes (Reynolds et al., 2010). Holistic assessment can assist teachers in understanding the achievement of learning processes and objectives comprehensively and can also serve as feedback and reflection for future lesson planning (Naulandani et al., 2023).

Below is the assessment grid for assessing the cognitive domain in the implementation of STEAM-based project learning, which can be seen in Table 7 below.

Table 7. Cognitive Domain Assessment Grid (Science Comprehension)

Learning Objetives	Cognitive Level	Indicator
Elaborating the critical understanding of environmental pollution through interpretative activities on presented air quality data (T1)	C4	Presented data through a graph related to air pollution quality in Pontianak City. Students are asked to analyze the data and articulate it into an understanding of environmental pollution in general.
Diagnosing the differences in the causes of environmental pollution due to human behavior and natural occurrences critically through observation activities on images of air pollution phenomena (T2)	C4	Two images related to air pollution phenomena depicting the causes of air pollution are presented. Students are asked to diagnose the differences in the causes of air pollution leading to decreased air quality based on observations from the images.
Distinguishing the impacts of environmental pollution on water, soil, and air on daily life critically through identification activities in provided discourse (T3)	C4	A discourse about the contamination phenomenon of playgrounds and rivers is presented. Through identification activities, students are asked to differentiate the impacts that can occur due to the phenomena of soil and water pollution.
Evaluating environmental pollution mitigation behaviors in water critically through identification activities in provided discourse (T4)	C5	A discourse about the mitigation behaviors regarding the contamination of water in Pontianak City due to forest fires, which leads to the pH of water being unsuitable for consumption and everyday use, is presented. Through identification activities, students are asked to evaluate the mitigation behaviors for water pollution.

Referring to Table 7, it can be seen that the assessment design to evaluate students' understanding of science involves four practice questions with high-level thinking (from C4 to C6) consistent with Bloom's taxonomy. This is in line with the science learning outcomes in the *Kurikulum Merdeka*, which emphasize that science understanding is always associated with higher-order thinking skills (HOTS). The type of questions developed are essay questions. Essay questions are very suitable for evaluating learning achievement at a higher cognitive level than just recalling information. This is because the evaluation of learning in this test has a significant level of complexity and emphasizes the ability to generate, integrate, and present ideas.

The questions to assess science understanding in this assessment are identified to utilize various images, numerical data, and reading discourse (Table 4). Thus, providing complexity that supports students' thinking skills. The specificity of images makes them more realistic in depicting the core issues compared to the limitations of verbal media alone (Munadi, 2012). The use of images has the advantage of overcoming observation limitations and explaining various cross-disciplinary issues. Numerical data not only helps improve students' numerical skills but also supports understanding and logical thinking related to numerical concepts (Achdiyat & Utomo, 2018). The improvement in numerical skills also contributes to the development of students' critical thinking skills (Irawan & Kencanawaty, 2017).

Tables 8 and 9 present the assessment design grids to assess students' attitudes during learning, which also assess the Pancasila student profile within the framework of the *Kurikulum Merdeka*.

Table 8. Affective Domain Assesment Grid (Pancasila Student Profile)

Aspect of Student's Pancasila Profile Evaluated	Attitude Assessment Indicators
Faithful, devout to God Almighty, and noble character	The student is observed praying before the learning session.
	The student is observed checking the cleanliness around their seating area.
Critical Thinking	The student is observed asking or confirming information they have acquired.
	The student presents a reflection on the learning process.
	The student is observed expressing opinions during discussions.
Creative Thinking	Students produce interesting assignment products

Table 9. Affective Domain Assesment Grid (Attitude of Pancasila Student Profile) for Peer Assessment Sheet.

Aspects of Teamwork Assessment	Affective Attitude Assessment Indicators
Responsibility for tasks	Executes group task assignments to the maximum extent.
	Implements group task assignments within the designated time.
	Provides positive responses during the completion of group tasks.
Active in Discussions	Expresses opinions within the group.
	Poses questions within the group.
	Provides answers during group discussions.
	Communicates any issues within the group.
Use of Polite Language	Expresses opinions effectively.
	Uses appropriate expressions.
	Avoids offending the opinions of other group members.

The assessment design to evaluate students' attitudes during learning is tailored to assessment aspects that align with the formulation of learning objectives. From tables 8 and 9, it is obtained that the developed affective domain assessment design is aimed to measure four attitudes, including 1) Faithful, devout to God Almighty, and noble character; 2) Critical thinking; 3) Creative thinking; and 4) Collaboration (working together). These four assessed aspects are in line with the dimensions of the Pancasila student profile (Ministry of Education and Culture, 2021). The psychomotor domain assessment grid in the form of project assessment, it is outlined as follows.

Table 10. Rubric for Assessing the Psychomotor Domain (Science Process Skills)

Aspect STEAM	Assessment Description	21st Century Skills Identified	
		Problem Solving	Creative Thinking
S	Identifying problems and exploring knowledge	(understand problem)	(Fluency)
	Determining Project Solutions	& (devise plan)	
	Planning Project Schedule		
T	Formulating Tools and Materials		
E	Creating Framework/Scheme		
	Writing Work Procedures		
A	Producing Project Products	(carry out plan)	(flexibelity)
M	Evaluating and Reflecting on Project Activities	& (look back)	(elaboration)

Table 10 provides an overview of the assessment design developed in this research for the psychomotor domain (science process skills), which, in its development, project assessment is oriented towards 21st-century skills, with two expected skills from student project activities, namely problem-solving ability and creative thinking. The problem-solving stage refers to Polya (1994), and creative thinking refers to Maxwell (2004). The development also integrates STEAM. With each description, namely in the aspect of science, students are expected to identify problems and explore relevant scientific knowledge. In the aspect of technology, students need to formulate the tools and materials needed to complete the project. Then, in the engineering aspect, the focus is on the ability to arrange a framework or work scheme for the project to be the focus of assessment. The Art aspect emphasizes the ability to produce project products with creativity. Meanwhile, in the mathematics aspect, students are required to evaluate and reflect on project activities, involving mathematical understanding.

Table 11. Results of Expert Judgment for STEAM-Based Project Assessment

Validator	Percentage %	Validity Level
V1	80	Valid
V2	78	Valid
V3	98	Very Valid
Average	85.45	Very Valid

The assessment design is relevant to the theory that in project assessment, at least three things need to be considered as follows: (1) management skills (2) relevance and (3) authenticity. Management skills are accommodated from the project completion stages, relevance is adjusted to the problems they will solve, namely regarding water pollution (listed in the learning objectives), and authenticity is sought through their creative skills in producing interesting products. Project-based learning assessments are assessments of tasks that must be completed within a specific period. Project assessments are useful in determining the level of understanding of science, the ability to apply, and the investigative abilities of students (Majid, 2011). Research by Sener et al. (2015) shows that project assessment can help teachers measure students' skills during learning, not only measuring cognitive aspects, because in reality, not all students who perform poorly in objective tests can be considered unskilled automatically. The results of this assessment can provide teachers with insight into whether their teaching has accommodated activities that support 21st-century thinking skills. Additionally, this project assessment can also serve as a reflection for improving future learning processes (Arifin, 2009). Therefore, the improvement of students' skills can be done sustainably.

The validation results of the assessment design for STEAM-based project learning oriented towards 21st-century thinking skills in this development research are presented in Table 11.

The validity results obtained for the assessment design in STEAM-based project learning in this research found varying validation scores (Table 11). However, on average, the overall validation scores provided by the three validators fell into the "highly valid" category with a percentage score of 85.45%. Table 11 shows that the score given by validator 3 (V3) is the highest with a percentage of 98% (highly valid category), while validator 1 (V1) and validator 2 (V2) gave almost the same scores, respectively 80% and 78% (valid category). These findings suggest that the developed STEAM-based project assessment design is of acceptable quality to be piloted.

To comprehensively examine the validation results due to the approximately 10-point difference between one validator and the other two validators, an analysis was conducted on each aspect. The validation results for each aspect are outlined as follows.

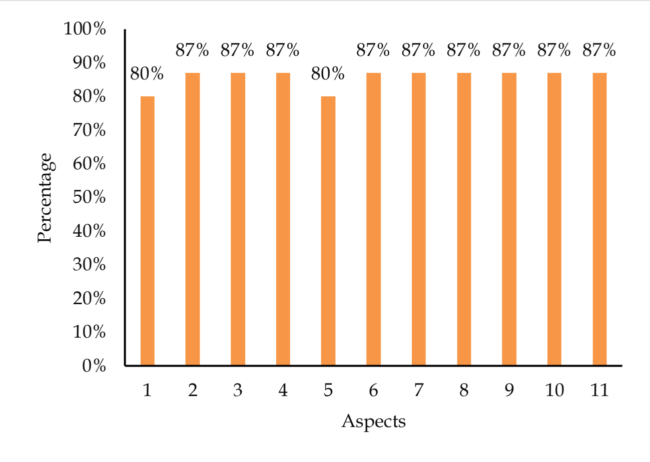


Figure 2. The Results of Validation for Each Aspect of Assessment

Referring to Figure 2 above, it is gathered that each aspect of the developed project assessment falls into the highly valid category. With a dominance of a percentage score of 87%, there are 9 aspects that achieve this score. Meanwhile, there are 2 other aspects that obtain an 80% score, but still belong to the highly valid category (Mawardi, 2014). In other words, through the review of each aspect in this assessment design, all aspects are in line with the characteristics of the STEAM approach and the context of the *Kurikulum Merdeka*. This is supported by several previous research findings, which state that assessments developed for evaluating learning fall into the acceptable category and can be used to evaluate the implementation of learning (Dharmawati et al., 2016; Putriadi, 2020).

Validation tests regarding the feasibility of this developed assessment design found notes for improvement, especially in the construction aspect, such as. The assessment that has been developed needs to be further aligned with the learning outcomes (LO) and learning objectives (LO) formulated earlier. This means that in science comprehension questions, the measurement results of 21st-century skills need to be apparent. If the purpose of the question is to measure problem-solving abilities, then the keywords of this skill need to be included in the question.

Referring to those improvement notes not only enhances the quality of assessment instruments but also makes assessments clearer and more effective as tools for measuring learning objectives. Findings from studies by (Arsad et al., 2011) indicate that 21st-century skills require careful integration into the assessment process. Therefore, the results of this research highlight the need for meticulous integration of 21st-century skills into assessment instruments, including both knowledge tests and non-test assessments, to evaluate skills effectively.

The result of evaluation and reflection stage

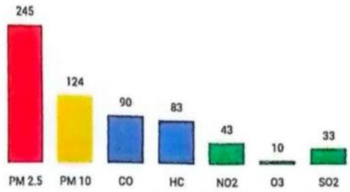
The evaluation and reflection stage in this research were conducted through limited trials at one school in Pontianak City, namely SMP Mujahidin Pontianak, where the assessment design was used to assess two learning sessions undertaken by the students. Based on these results, it was found that science teachers using the assessment design for STEAM-based project learning in the implementation of the *Kurikulum Merdeka* at the junior high school level, particularly on the topic of environmental pollution, provided positive feedback. Teachers expressed that the assessment design facilitated their ability to assess the achievement of learning objectives, although it was considered extensive, it aligned with the formulated learning objectives set according to the achievement of science learning in phase D. Here's a quote from the interview:
"*.....The assessment, although extensive, is easy to understand and very comprehensive, especially for project assessment.*" (Science Teacher)

The teacher also stated that the assessment she used helped students better in answering essay questions. This provides an overview of the contribution of the developed assessment design, especially in providing stimulus for students. Revealed through the following interview quote:
"*It is also evident from the assessment results that students have improved in answering the questions.*" - (Science Teacher)

This indicates that the assessment design developed in this research not only provides convenience for teachers to assess the overall learning objectives but also supports students' thinking abilities. Then, when examined from the analysis of participants' work on the learning process assessed with the assessment design in this research, several findings are obtained as follows:

Firstly, in working on practice questions to measure science comprehension, participants are identified in four categories: very good (VG), good (G), fairly good (FG), and needing guidance (NG). The classification of these categories refers to (BSKAP, 2022). Overall, most participants are classified as very good (4 groups), while each of the other categories has 1 group. This finding indicates that the assessment developed in the research to measure science comprehension can classify students' abilities. An example of the developed essay question and how participants' answers to the question are related are presented below (Table 12).

Table 12. The answer of student's work

<table>
<tr><td>Question</td><td>

Write down the information you have obtained and explain what is meant by environmental pollution. (Additional information: Air quality categories based on particulate matter (PM 2.5) levels are as follows: 0–15.5 (Good), 15.6–55.4 (Moderate), 55.6–150.4 (Unhealthy), 150.4–250.4 (Very Unhealthy), and >250.4 (Hazardous). Source: BMKG).</td></tr>
<tr><td>Answer</td><td>According to the air quality graph in Pontianak City, the air condition for PM 2.5 is very unhealthy because the particulate levels exceed 250.4. Therefore, based on this understanding, environmental pollution is a condition where the environment is not maintained or has already been contaminated.</td></tr>
</table>

Based on the Table 12, it is known that the questions in the cognitive domain assessment in this research demand students' critical thinking skills. The question asks students to explain the meaning of environmental pollution from the interpretation of data related to air quality in Pontianak City. The question also provides factual information related to the real conditions around the students, meaning the question is contextual.

The answers provided by the students will be classified according to how they critically solve the problem. In this case, the indicator is that students can provide explanations from the analysis results (elementary clarification) (Ennis, 2011). In the very good category, it means that students successfully explain the data and relate it to the definition of environmental pollution (Table 12). On the other hand, for students classified as needing guidance, they fail to provide explanations from the interpretation of the given data.

In the affective domain assessment, which aims to measure students' attitudes within the framework of the Pancasila student profile, as outlined in the assessment criteria (Table 8), the four attitudes to be assessed are grouped based on guidelines referring to the assessment indicators. For example, in this study, for the assessment aspect of faith and piety towards God Almighty and noble character, through teacher observation sheets, the teacher observes students in their learning activities and assesses "YES" or "NO" to the behaviors that emerge. In the pilot test, attitude assessment for this aspect is identified when students are asked to pray and check the cleanliness of the classroom. The teacher can observe students praying and checking the trash around their desks and chairs. As for other aspects, such as critical thinking and creative thinking, they accumulate during the core learning activities. Attitude assessment conducted through teacher observation is essential because a decrease or increase in cognitive test scores does not always reflect the level of student achievement in affective and psychomotor aspects (Astuti, 2012). Similarly, for peer assessment, but the difference is that the student leader acting as the group leader provides the assessment.

The attitude assessment is conducted by assigning scores adjusted to the number of indicators that appear (responsibility, activeness, and politeness). Thus, through this assessment design, teachers can involve students in the assessment process. Student involvement in the assessment process is necessary to ensure a clear understanding of the steps needed to complete tasks and achieve optimal quality standards (Tumilty et al., 2022). Although attitude assessment through peer assessment has the potential for bias (Safaroh & Dewi, 2017), this assessment is still needed to evaluate students' social skills. Given the importance of measuring social abilities through rubrics lies in students' ability to assess both themselves and others when interacting in groups.

Lastly, the psychomotor domain assessment to assess students' science process skills refers to the implementation of projects conducted by students during the learning process, where assessment is given after students complete the project in the second meeting. In the assessment design to evaluate students' skills, they are grouped into two, according to the main characteristics of the STEAM approach, namely students' scientific process skills and students' engineering process skills, but still within the framework of problem-solving skills and creative thinking determined in the assessment criteria. The findings from this trial phase obtained information that the assessment results of students in carrying out projects to design water purification tools were classified into three categories: below standard (BS), approaching standard (MS), and meeting standard (SS), with overall each stage of project design skills from start to finish students classified as approaching standard (MS).

In practice, the provision of assessment is adjusted to the aspects of process skills aligned with problem-solving indicators (Polya, 1994), which are also grouped based on the integration of each of the STEAM elements. The following are detailed aspects of the science process skills assessed.

First, writing the problem and determining the solution to be implemented, in this assessment aspect, it includes indicators of problem understanding (understand problem) and fluency. Additionally, this aspect is also aimed at assessing students' scientific process skills (known as the scientific process in the STEAM approach), in line with the concept of science learning that should provide investigative activities for students (Learning Outcomes according to the decision of the head of the education standards, curriculum, and assessment agency of the Ministry of Education and Culture number 008/H/KR/2022). At least in science learning in the implementation of the *Kurikulum Merdeka*, students need to be given activities; 1) Observing; 2) Questioning predicting; 3) Planning and conducting investigations; 4) Processing, analyzing data, and information; 5) Evaluating and reflecting; and 6) Communicating.

Table 13. Observation Results

Observed item	Findings
Water Colour	Brown
Water pH	pH 4
Water aroma	Odorless

Table 14. Formulation of problems and determination of solutions by students

Question Number	Question	Answer
1b	Find information about the characteristics of polluted water from various sources. After that, observe the water being tested. Do you think this water is polluted?	Yes, the water is polluted.
1c	What issue did you find from the previous observation, and what solution would you propose to address the problem? Provide a reason for choosing that solution.	The water is polluted. The solution is to avoid littering so that the water does not get polluted. Another solution could be to implement water filtration.

The figure above provides insights to assess students' scientific process skills starting with observation. At this stage, an interesting result was found, namely all students classified in the meeting standard (SS) category. This can be information about students' strengths in investigative activities, indicating that these activities produce empirical evidence rooted in observation and experimentation (Leicester & Taylor, 2010).

Second, writing a schedule plan accompanied by time from start to finish, including indicators of devising a plan (devise plan) and fluency. With Figure 9 showing an example of students' work in scheduling the project. Based on the findings, in this aspect, students' skills were predominantly categorized as approaching standard (MS).

Table 15. The result of project schedule

Time	Aktivity
25 -01-2024	Designing the tool
26-01-2024	Dividing the tools to be used
27-01-2024	Purchasing materials
28-01-2024	Making the tool
29–01-2024	Implementing the project

Building on the information provided in the table 16, it is understood that this aspect can assess students' skills in planning project schedules from start to finish. Teachers can use this activity design as a monitoring tool for the success of the learning process.

Table 16. Formulation of tools and materials for students' project plan

Tool	Material
Scissors 1500 ml Mineral Water Bottle	Sponge Cotton Charcoal Palm Fiber Coconut Husk Gravel

Third, constructing the design of tools and materials, including indicators for devising a plan and fluency. This aspect integrates the element of technology (T), requiring students to determine the technology in the form of tools and materials used to complete the project. The results of the students' work are depicted in the Table 16.

In this assessment aspect, overall, students are classified as approaching the standard (MS) category because almost all students have not taken into account the quantity of materials they use in the project. Fourth, formulating the project workflow scheme, which also includes indicators for devising a plan and fluency. At this stage, students' engineering process skills can already be assessed, ideally involving skills in design thinking and hands-on execution.

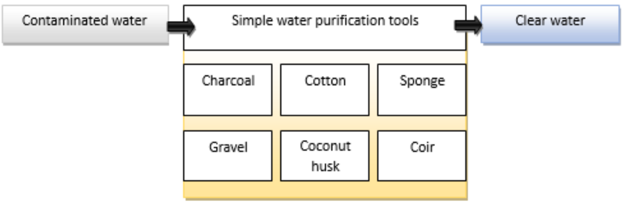


Figure 3. Project workflow scheme devised by students

With the formulation of the workflow scheme in Figure 3, teachers can measure students' processes in determining their framework. The assessment results for this aspect of process skills are similar to the previous assessment findings, with students' skills in formulating the workflow scheme dominated by the approaching standard (MS) category. This is crucial in project-based learning with the STEAM approach as it constitutes part of students' autonomy (Quigley & Herro, 2017). Moreover, according to Nurasiah et al. (2022), during project-based learning, several characteristics are identified, including students' responsibility for setting the predetermined framework and students experiencing situations where they must solve a problem or challenge without definite answers beforehand (such as cases that can be addressed through a project-based approach).

Fifth, writing procedures for project steps, including indicators for carrying out the plan and fluency. In this aspect of project assessment.

Table 17. Procedure developed by students

No	Activity
1	Take the 1500 ml bottle, use scissors to cut the bottom and make a hole in the center of the bottle cap.
2	After making the hole at the bottom, insert the sponge and cotton, then arrange them neatly.
3	Add a layer of charcoal and ensure it is evenly distributed inside the bottle.
4	Insert the palm fiber (ijuk) followed by the coconut husk, then arrange them neatly.
5	Lastly, insert the gravel into the bottle, ensuring it is evenly distributed inside.
6	Make sure all materials, such as sponge, cotton, charcoal, palm fiber, coconut husk, and gravel, are washed and dried before use to ensure cleanliness and the effectiveness of the filtration.
7	After preparing the filter layers, make sure the bottle is placed at a higher position. Then, pour the water to be filtered into the bottle through the open part slowly and carefully.
8	The filtered water will flow out. Collect the filtered water using the container that has been prepared.

Sixth, producing products from project activities, including indicators for carrying out the plan and flexibility, and providing attachments on the worksheet including indicators for carrying out the plan and originality, with findings shown in Figure 4.

Figure 4. Project product in the form of a simple water purification tool produced by students

In this assessment aspect, not only students' skills in carrying out the project are assessed, but also the demand for aesthetic value (art elements) in the project product produced. Although the majority of students are classified as approaching the standard, there are groups of students who are below the standard in this assessment aspect. This finding indicates the need for improvement in students' creativity. Because the art element (A) is an effort to help students understand analytical concepts through the use of creativity. In practice, teachers assess from the products attached and also those presented in front of the class.

Seventh, providing evaluation and reflection on the product, including indicators for looking back and elaboration. In this aspect of skill, overall, students are classified as approaching the standard.

Table 18. Results of evaluation and reflection on students' project

Question	Answer
Discuss the project budget results with your group. Evaluate whether the benefits of the project product are in line with the budget and its potential to prevent water pollution. Include reasons.	It is balanced because with a simple water purification tool, at an affordable price, the project product can provide benefits.
Write the conclusion, suggestions, and recommendations for the project activity you have completed.	The water purification tool from the project can be used to filter water, turning it from dirty to cleaner.

The last aspect assessed in the process skill using the assessment design in this research is evaluation and reflection. As seen in the Table 18, during the evaluation and reflection on the water purification tool designed by students, mathematical abilities are used. Students are asked to evaluate the effectiveness of the product with the budget spent. Through this process, teachers can assess students' ability to apply mathematical thinking in evaluating the performance and efficiency of the projects they have designed.

From the discussions provided above, it can be understood that the designed assessment in the psychomotor domain developed in this research can assess both scientific and engineering process skills. By providing assessment guidelines tailored to each stage, the results of this pilot study suggest that with the developed assessment design, teachers can classify students' skills effectively, identify strengths and weaknesses in students' scientific process skills thoroughly, and determine the achievement of goals and the appropriateness of project-based learning methods. In line with Rasyid & Mansur (2007), assessment is not only used to achieve learning objectives but also to assess the effectiveness of the learning process, and helps teachers identify students' abilities comprehensively, both weaknesses and strengths.

Conclusion

Based on the research results obtained, it can be concluded that in the implementation of the *Kurikulum Merdeka*, science teachers express the need for assessment designs to assess the implementation of learning comprehensively, including for STEAM-based project learning. The research findings have implications for teachers, encouraging them to create holistic assessment designs. This research highlights the necessity for science teachers to have effective assessment tools that evaluate 21st-century skills across cognitive, affective, and psychomotor domains. The assessment design, which includes project matrices and rubrics, was validated by experts and received a high validity score of 85.45% The assessment design for STEAM-based project learning developed in this research has passed the feasibility test, obtaining results classified as very valid and suitable for testing. Moreover, the pilot study findings from the assessment provide information that teachers feel assisted and facilitated in measuring the overall achievement of learning objectives. The developed assessment design is also revealed to be able to assess the entire learning process of students, for cognitive, affective, and psychomotor domains.

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Author Contributions
Each author contibuted significantly to the development of this article. A.A., conducted the research, collected and analyzed data, and drafted the manuscipt. R.C., supervised the research process, provided guidance, and reviewed and refined the manuscript. Both authors approved the final version of the article.

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Conflicts of Interest
The authors declare no conflict of interest.

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