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Problem Analysis and Evaluation of Science Instruction in the Implementation of the Merdeka Curriculum at the Senior High School Level

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Abstract

Implementing the Independent Curriculum in science learning requires a shift towards student-centered learning, but it still faces various obstacles in the field. This study aims to analyze the implementation and problems of science learning within the Independent Curriculum at SMAN 1 Kediri, including the planning, implementation, and evaluation of learning. This study used a qualitative case study design, employing semi-structured interviews and documentation with science teachers and the Vice Principal for curriculum. The results show that learning has led to collaborative activities and discussions, but has not been optimal in developing innovative teaching modules, implementing practicums due to limited laboratory facilities, and applying authentic assessments, which remain limited to formative and summative forms. In addition, low student motivation to learn and uneven teacher competence pose challenges to curriculum implementation. The conclusion of this study indicates that the implementation of science learning within the Independent Curriculum has not been optimal and still requires improvements in various aspects. The implications of this research emphasize the importance of improving teacher competence, optimizing authentic assessments, and revitalizing laboratory facilities to create more meaningful, contextual science learning that aligns with the principles of the Independent Curriculum.

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INTRODUCTION

The rapid advancement of science and technology in the era of globalization demands that the education system continue to transform in order to produce human resources who are adaptable, creative, and competitive. In the context of secondary school education, particularly in the Natural Sciences (IPA) curriculum, these demands extend beyond the mastery of concepts to include the development of scientific process skills and higher-order thinking skills. Therefore, education no longer focuses solely on the transfer of knowledge but also on the development of 21st-century skills such as critical thinking, creativity, communication, and collaboration (Angga et al., 2022). In Indonesia, efforts to address these challenges are implemented through the Merdeka Curriculum, which is designed to provide learning flexibility, accommodate students' needs, and focus on holistic competency development (Sari et al., 2023). This curriculum also emphasizes the importance of meaningful learning experiences through contextual and activity-based approaches, so that students not only understand concepts but also apply them in daily life (Purnama, 2024).

In the context of science education, the Merdeka Curriculum plays a highly strategic role because science is not merely a collection of concepts but also a scientific process involving observation, experimentation, analysis, and drawing conclusions. This aligns with the strengthening of the Pancasila Student Profile, particularly regarding critical thinking, integrity in data processing, responsibility for experimental results, and the ability to collaborate in scientific activities (Rahmadayanti & Hartoyo, 2022). The implementation of approaches such as inquiry-based learning and project-based learning in science can be realized through concrete activities, such as simple experiments on changes in the state of matter, projects observing the surrounding environment, or analyzing natural phenomena relevant to daily life (Adriawan et al., 2025). Thus, science learning not only develops cognitive aspects but also students' process skills and scientific attitudes (Kristyowati & Purwanto, 2019).

However, the implementation of the Merdeka Curriculum in science education at the school level still faces various challenges. Based on field findings, particularly in secondary schools such as SMAN 1 Kediri, there are limitations in facilities and infrastructure,

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especially in science laboratories, which are not being utilized optimally, preventing laboratory activities from being conducted to their full potential. Additionally, teachers' competencies in designing inquiry-based and differentiated instruction vary, which impacts the suboptimal implementation of student-centered learning. The heterogeneity of student characteristics also poses a challenge in implementing the Merdeka Curriculum, which should be accommodated through differentiated instruction tailored to students' needs, interests, and readiness. On the other hand, students' motivation to learn and independence remain relatively low, thereby affecting the effectiveness of learning (Sudrajat et al., 2023). This situation indicates a gap between the ideal curriculum concept and its implementation practices in schools (Karengga et al., 2025).

An equally important issue lies in the evaluation of science learning. Evaluation under the Merdeka Curriculum should encompass diagnostic, formative, and summative assessments and integrate authentic assessments, such as projects, portfolios, and performance-based assessments (Ardiansyah et al., 2023; Utami et al., 2025). However, in practice, teachers still face difficulties designing evaluation instruments that comprehensively measure scientific process skills and scientific attitudes (Imania, 2024). Several studies indicate that teachers often face challenges in determining the appropriate form of assessment instruments and in designing assessments that are fair and aligned with learning objectives (Sumarmi, 2024; Syamsudin & Fitriani, 2024). As a result, learning evaluation still tends to focus on cognitive aspects and does not yet fully reflect the assessment principles in the Merdeka Curriculum. In fact, evaluation serves as a crucial diagnostic tool for continuously improving the learning process (Hermawansyah et al., 2024).

Given these issues, this study offers a novel approach by specifically examining the relationship between implementation challenges and science learning assessment practices within the Merdeka Curriculum through empirical analysis at the school level. This study employs a qualitative approach, involving science teachers and the Vice Principal for Curriculum at SMAN 1 Kediri as research participants. The research focuses not only on identifying obstacles but also on an in-depth analysis of the learning evaluation process, including the assessment methods used and their limitations. With the research scope limited to a specific educational institution, this study is expected to provide a more in-depth contextual overview. Additionally, the findings of this study offer empirical recommendations that can serve as a reference for improving the quality of evaluation and implementation of science learning within the Merdeka Curriculum.

MATERIALS AND METHODS

Time and place

This study was conducted during the odd semester of the 2024/2025 academic year, from January to March 2025, at SMAN 1 Kediri in Kediri District, West Lombok Regency, West Nusa Tenggara Province. SMAN 1 Kediri is one of the schools that have implemented the Merdeka Curriculum in their teaching and learning processes, including science classes. This school has facilities to support science learning, such as laboratories, although their use in practical activities has not been optimal. The selection of the research location was based on the school's implementation of the Merdeka Curriculum, which enabled the researcher to examine issues and practices in the evaluation of science learning in a real-world context. Additionally, the variety of learning conditions and teachers' readiness to implement the curriculum were key reasons for selecting this school as the research site.

Research design

This study employs a qualitative approach using a descriptive research design framed as a case study. The case study design was chosen because this research focuses on an in-depth examination of the implementation of science education within the Merdeka Curriculum in a specific context, namely, at SMAN 1 Kediri, thereby enabling the researcher to obtain a contextual and comprehensive understanding of the phenomenon under study. A qualitative approach was chosen because this study aims not only to identify teachers' perceptions but also to gain a comprehensive understanding of the curriculum implementation process, encompassing the planning, implementation, and evaluation of learning in real-world field conditions.

This approach enables researchers to uncover the relationship between the Merdeka Curriculum policy and ongoing science learning practices, including the various challenges and dynamics at play. Additionally, the use of a qualitative design is based on the need to explore the learning evaluation process in depth, a process that cannot be measured solely through quantitative data. Evaluation in the Merdeka Curriculum encompasses complex aspects such as process, skills, and attitude assessments, thus requiring contextual understanding through interview data and documentation. Therefore, a qualitative approach allows researchers to obtain richer, more in-depth, and meaningful data regarding the implementation of science learning evaluation (Assyakurrohim et al., 2022).

Subject and Object

The subjects of this study were science teachers at the research site, including those in physics, chemistry, and biology, as well as the Vice Principal for Curriculum. The selection of research subjects was conducted using purposive sampling, which is based on specific considerations relevant to the research objectives (Dana in Ksanjaya & Rahayu, 2022). The criteria for selecting subjects included teachers who had implemented the Merdeka Curriculum in their teaching and had experience teaching science, making them considered capable of providing in-depth information relevant to the research focus. Thus, the selected subjects consisted of science (physics) teachers and the Vice Principal for Curriculum, who play strategic roles in implementing and making decisions regarding learning policies at the school.

The subject of this study is the implementation of science education in the Merdeka Curriculum, encompassing the planning, implementation, and evaluation of instruction, as well as the challenges that arise during this process. The planning aspect involves developing instructional modules and learning objectives; the implementation aspect covers applying teaching methods and student activities; and the evaluation aspect involves using formative, summative, and authentic assessments. The issues examined relate to limitations in facilities and infrastructure, teacher competencies, and

student characteristics. Data collection was conducted through in-depth interviews and documentation, using instruments such as semi-structured interview guidelines, documentation sheets, and supporting learning documents.

Research procedure

The research procedure was conducted in several stages. The first stage was the preparation stage, which included a literature review on the Merdeka Curriculum and science education, as well as the development of research instruments. The instruments used in this study included: (1) a semi-structured interview guide, containing a list of open-ended questions regarding the planning, implementation, and evaluation of science education; (2) documentation sheets, used to collect and analyze documents such as teaching modules, learning materials, and evaluation documents; and (3) field notes to record important information during the data collection process. The second stage is data collection, conducted through direct interviews with informants and the gathering of supporting documents.

The interviews were conducted in a semi-structured format, lasting approximately 30–60 minutes per informant, and were carried out over one to two sessions as needed to gather the necessary data. During the interviews, the researcher used probing techniques to elicit more in-depth information regarding experiences and practices in science learning within the Merdeka Curriculum. The third stage was data processing, which included data reduction, data presentation, and drawing conclusions. The final stage involved interpreting the research results to obtain a comprehensive understanding of the issues and to evaluate the implementation of science learning. The interpretation process was conducted by relating the research findings to the principles of the Merdeka Curriculum, such as alignment with Learning Outcomes (CP), the sequence of learning objectives, the use of teaching modules, and the application of assessment in science learning.

Research data analysis

Data analysis in this study employed qualitative descriptive analysis techniques. The data collected were analyzed in three main stages: data reduction, data presentation, and drawing conclusions (Miles & Huberman, as cited in Zulfirman, 2022). Data reduction was conducted by selecting, focusing, and grouping data based on a priori categories aligned with the Merdeka Curriculum concept, encompassing instructional planning, implementation, and evaluation, as well as formative, summative, and authentic assessments (Darwin et al., 2023). Additionally, the categories also encompass the implementation of differentiated instruction and the reinforcement of the Pancasila Student Profile in science education. Data presentation was conducted as systematic narrative descriptions to facilitate understanding and to identify patterns and relationships among findings.

Next, conclusions were drawn from the patterns, relationships, and findings in the research data by relating them to the principles of the Merdeka Curriculum. To ensure the credibility of the data, this study employed triangulation techniques, specifically source triangulation and methodological triangulation. Source triangulation was achieved by comparing data from science teachers and the Vice Principal for Curriculum, while methodological triangulation was achieved by comparing interview results with supporting learning documents. This analysis aims to provide an accurate, in-depth picture of the implementation of the Merdeka Curriculum in science learning, as well as the problems encountered in the field.

RESULTS AND DISCUSSION

Result

Results of Interviews with Science Teachers at SMAN 1 Kediri

Table 1. Summary of Interview Results with Science Teachers at SMAN 1 Kediri

Indicators	Key Findings
Understanding & Implementation	Teachers perceive the Merdeka Curriculum as a learning approach that promotes student autonomy. Instruction is conducted through discussions, presentations, and collaborative activities; however, the development of the teaching module follows an "observe, imitate, modify" approach. The integration of content with real-world phenomena has been applied to simple topics but remains suboptimal for more complex materials.
Facilities & Support	Laboratory facilities are not optimal, as much of the equipment is outdated. The school has provided digital media; however, its utilization remains limited. Support from the school and fellow teachers is generally strong.
Problems & Constraints	The main challenges include limited laboratory facilities, low student motivation to learn, and uneven student readiness for independent learning.
Learning Evaluation	Assessment is still dominated by formative and summative approaches. While evaluation emphasizes the learning process, authentic assessments, such as projects and portfolios, have not been implemented optimally. Feedback tends to be general in nature (e.g., rewards and motivational remarks).
Solutions & Expectations	Teachers expect improvements in laboratory facilities and increased student motivation to support more active, practice-based science learning.

Results of the Interview with the Deputy Head of Curriculum at SMAN 1 Kediri

Table 2. Summary of the Interview with the Deputy Head of Curriculum at SMAN 1 Kediri

Indicators	Key Findings
Understanding & Policy	The school has integrated the Merdeka Curriculum into the School-Based Curriculum (KSP) and promotes the implementation of flexible learning approaches.
Facilities & Support	The school provides training (through teacher professional forums/MGMP and both online and offline programs) as well as supervision; however, these supports have not been evenly distributed among all teachers.
Problems & Constraints	The main challenges include uneven teacher understanding of the Merdeka Curriculum and limited access to intensive training programs.

Learning Evaluation	The school implements various forms of assessment; however, their execution depends on teachers' readiness. Evaluation is used to monitor learning outcomes and inform curriculum improvement.
Solutions & Expectations	There is a need to enhance teacher competencies, improve learning facilities, and align the curriculum with future demands.

Research findings indicate that implementing science education under the Merdeka Curriculum has fostered student-centered learning through discussion and collaborative activities. However, its effectiveness is still influenced by limited facilities, variations in teacher competencies, and the suboptimal application of authentic assessment. Additionally, there is a gap between school policies and classroom teaching practices, particularly regarding learning assessment.

Discussion

Challenges in Implementing Science Education in the Merdeka Curriculum

The research findings indicate that the implementation of the Merdeka Curriculum in science education at SMAN 1 Kediri has proceeded through three main stages: planning, implementation, and learning evaluation, all of which are mutually integrated (Fadlilah et al., 2024). However, in practice, a gap remains between the ideal curriculum concept and its implementation in the field. During the planning stage, findings indicate that teachers have understood the basic concept of Merdeka Belajar as a form of learning that grants students the freedom to be active and independent. This understanding is reflected in teachers' efforts to design enjoyable, student-centered learning experiences. However, substantively, instructional planning remains suboptimal. This is evident in the tendency for teachers to use an "observe, imitate, and modify" approach when developing instructional modules, indicating that innovation and creativity in designing instructional materials remain limited.

In practice, teachers have carried out planning steps such as analyzing Learning Outcomes, developing Learning Objective Sequences, selecting instructional models, and preparing teaching materials and assignments. These findings align with Yusra (2021), who states that planning is a systematic process for determining instructional actions. However, issues arise when such planning is not fully grounded in students' needs and characteristics. Student heterogeneity is a key factor influencing implementation success (Pramunita et al., 2026). As a concrete example, in abstract science topics such as organ systems or energy concepts, teachers struggle to connect the material to students' daily life contexts. This results in learning that is not yet fully contextualized as intended in the Merdeka Curriculum. In fact, the use of media and real-world contexts has been proven to increase student interest and engagement (Isjayanti et al., 2023; Nurluthfiana et al., 2023). Thus, the main problem at the planning stage lies not only in the technical aspects of developing instructional materials but also in teachers' ability to contextualize science content in alignment with students' characteristics.

During the implementation phase of the learning process, the research findings indicate that instruction has adopted a student-centered approach through group discussions, presentations, and collaborative work. These activities demonstrate that students have been actively engaged in the learning process, particularly in developing collaboration and communication skills. These findings align with those of Purbasari et al. (2022), who state that collaborative learning is effective in developing social problem-solving skills. Additionally, critical thinking skills were beginning to develop through discussion and problem-solving activities. Students were trained to exchange ideas, express opinions, and complete tasks together, as highlighted by Aufa et al. (2020) in their discussion of the importance of communication skills in learning.

However, upon closer examination, the instructional implementation still does not fully reflect the characteristics of science education in the Merdeka Curriculum. Experimental and practical activities—which should form the core of science education—have not been carried out optimally due to limited laboratory facilities. Consequently, instruction is dominated by conceptual discussions rather than direct scientific exploration. For example, in topics that should involve practical work, such as measurements or observations of physical/chemical phenomena, teachers rely solely on verbal explanations or discussions without actual experiments. Alternatives like digital simulations also remain underutilized (Handayani, 2023). This indicates that facility limitations are not being offset by innovative teaching methods. This finding reinforces the results of studies by Anjani & Lestari (2023) and Amelia et al. (2025), which emphasize the importance of enhancing teachers' capacity to develop adaptive learning. Thus, the challenges at the implementation stage are not merely technical (facilities) but also pedagogical (learning strategies) (Husain et al., 2023).

During the learning evaluation phase, the research findings indicate that teachers have conducted ongoing evaluations through assessments both during and at the end of the learning process. Evaluations were carried out through observations of student activities, presentations, and learning reflections (Fatkhurrohman et al., 2024). This indicates that, in principle, evaluation is already moving toward a formative approach that emphasizes the student learning process, in line with the principles of the Merdeka Curriculum (Fadlilah et al., 2024). However, upon more critical analysis, evaluation practices remain limited and do not yet fully reflect authentic assessment. Teachers tend to rely solely on formative and summative assessments, while diagnostic assessments, projects, and portfolios have not been utilized optimally (Firmanzah & Sudibyo, 2021). Additionally, the feedback provided to students remains general in nature—such as motivation and rewards—rather than specific feedback that could enhance students' understanding (Dianti et al., 2025). This situation indicates that evaluation has not yet fully functioned as a tool to improve learning but remains limited to measuring learning outcomes (Ramadhani et al., 2021). Consequently, there is a gap between the concept of evaluation in the Merdeka Curriculum and actual practice in the field.

Evaluation of Science Education in the Merdeka Curriculum

Conceptually, evaluation is a systematic process for measuring the achievement of learning objectives (Karegga et al., 2025). In the context of this study, the

evaluation of science learning encompasses three main aspects: knowledge, skills, and attitudes.

Regarding knowledge assessment, the research findings indicate that teachers have routinely implemented formative and summative assessments. Assessment is not only used to measure final outcomes but also to monitor students' progress in understanding. Additionally, schools have implemented various forms of evaluation, such as written tests, projects, and portfolios. However, upon closer analysis, these practices are not yet fully consistent. Teachers predominantly use written tests rather than project- or portfolio-based assessments. This indicates that although the policy framework is comprehensive, its implementation is not yet optimal. This situation aligns with the findings of Aziza et al. (2024) and Andriani et al. (2022), who state that assessment is still dominated by cognitive aspects.

In terms of skill assessment, the main challenge encountered was the limited availability of laboratory facilities. As a result, the assessment of science process skills could not be conducted optimally. Teachers used only alternative methods, such as discussions, simple observations, and presentations. For example, skills such as measuring, observing, and analyzing data could not be assessed directly through laboratory experiments but only through discussion activities. This resulted in students' science process skills not being comprehensively assessed. Nevertheless, the school's efforts to improve laboratory facilities indicate an awareness of the importance of this aspect.

Regarding attitude assessment, the research findings indicate that it is conducted through observation during instruction, particularly during discussions and presentations. This assessment reflects efforts to foster scientific attitudes such as cooperation, responsibility, and curiosity. However, attitude assessment remains largely general and is not yet supported by structured instruments. This results in assessment outcomes that are less objective and difficult to measure consistently. Thus, although all three aspects of evaluation have been implemented, the quality of their implementation still needs improvement.

Implications and Contributions of the Research

Based on the research findings, several important implications can be identified. First, improving teachers' competence in designing instruction and assessment is a top priority. Teachers must not only understand the concepts of the Merdeka Curriculum but also implement them in a contextual and innovative manner. Second, the limitations of laboratory facilities impact not only the delivery of instruction but also the quality of assessment. Therefore, revitalizing laboratory resources is a critical priority. Third, learning evaluation needs to be directed toward authentic assessments that comprehensively measure knowledge, skills, and attitudes. This requires the development of more systematic and standardized instruments. Fourth, low student motivation and independence indicate that implementing the Merdeka Curriculum depends not only on teachers but also on students' readiness. Therefore, more engaging and contextual learning strategies need to be developed.

These implications suggest that improving the quality of science education requires more than just curriculum changes; it also necessitates systemic support, including enhanced teacher competencies, adequate facilities, and strengthened academic supervision in schools. Furthermore, the use of digital media can serve as an alternative solution to address limitations in laboratory facilities, although it cannot fully replace hands-on experimental experiences. In terms of its contribution, this study provides an empirical overview of the gap between the Merdeka Curriculum policy and science teaching practices in the field, particularly regarding learning assessment. This study also underscores that curriculum implementation depends not only on policy but also on the readiness of human resources and the learning environment.

This study has limitations: it was conducted at only one school with a limited number of informants; therefore, the findings cannot yet be widely generalized. Additionally, the data were primarily obtained through interviews, so they do not fully reflect teaching practices as observed directly in the classroom.

CONCLUSION

Based on the research findings, it can be concluded that the implementation of science education under the Merdeka Curriculum at SMAN 1 Kediri has been carried out through three main stages: planning, implementation, and evaluation. During the planning stage, teachers developed instructional materials in accordance with regulations; however, they were still limited in their ability to create innovative, context-specific teaching modules. During the implementation stage, instruction has shifted toward student-centered learning through discussion and collaboration activities, but has not been optimal in experimental activities due to limited laboratory facilities. During the evaluation stage, teachers have applied formative and summative assessments and emphasized the student learning process, but have not fully implemented authentic assessments in a diverse and comprehensive manner. Assessment of knowledge and attitude aspects has been carried out fairly well, while skill assessment remains limited. In addition, several major obstacles exist, including low student motivation, limited infrastructure, and uneven teacher competence in implementing the Merdeka Curriculum (Nadhifah et al., 2023).

The implications of this study highlight the importance of enhancing teachers' competencies in designing authentic learning and assessment, as well as the need to optimize laboratory facilities to support experiment-based learning. However, this study has scope limitations: it was conducted at only one school with a small number of informants, so the generalizability of the results remains limited. Therefore, future research is recommended to involve more schools and informants and to combine qualitative and quantitative methods to obtain more comprehensive results. In addition, further research needs to examine, in greater depth, the implementation of authentic assessment and strategies to increase students' motivation to learn science in line with the Merdeka Curriculum.

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AUTHOR'S CONTRIBUTION

Table 3. Author Contributions

Contribution Indicator	Author			
	1	2	3	4
Conceptualization	✓	✓		✓
Literature Review			✓	
Research Design / Methodology		✓	✓	✓
Instrument Development	✓	✓		✓
Data Collection	✓		✓	✓
Data Curation		✓	✓	
Formal Analysis	✓	✓		✓
Data Interpretation	✓		✓	
Writing – Original Draft	✓			
Writing – Review & Editing		✓	✓	✓
Visualization / Tables	✓		✓	
Supervision	✓	✓	✓	✓

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