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Analysis of the Implementation of Merdeka Curriculum in Mathematics Learning Based on Jean Piaget's Cognitive Development Theory in Junior High School

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Abstract- This study aims to analyze the implementation of Merdeka Curriculum in mathematics learning in junior high schools based on Jean Piaget's cognitive development theory. The Merdeka Curriculum is designed to provide freedom for educators to arrange learning relevant to student needs, especially in mathematics subjects, which are often considered challenging. This research uses a qualitative approach with a case study type. The subject is a mathematics teacher. Data were obtained through document analysis and interviews, then analyzed descriptively through data reduction, data presentation, and conclusion drawing. To ensure data validity, source triangulation was carried out. The results showed that implementing the Merdeka Curriculum in mathematics learning supports students' formal operational cognitive development stage. The project-based approach and problem-solving at the core of the Merdeka Curriculum can develop logical, abstract, and analytical thinking skills essential in mathematics. However, several obstacles were found in the implementation, such as teachers' lack of understanding of learning strategies by students' cognitive development stage, and limited interactive learning facilities. This research recommends comprehensive training for mathematics teachers to improve their ability to implement cognitive development-based learning strategies and the provision of adequate supporting facilities. With the right strategy, implementing the Merdeka Curriculum in mathematics learning in junior high schools can be more optimal in improving students' cognitive abilities.

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1. Introduction

Education is one of the important aspects in building a generation that can compete in the era of globalisation. To achieve this goal, the Indonesian government has developed the Merdeka Curriculum, which is designed to allow educators to be more flexible in designing learning according to student needs (MoECRT, 2021). One of the main objectives of this curriculum is to facilitate learning based on the potential and interests of students so that they can develop competence to the fullest (Wahyudin et al., 2024). Educators can design and implement learning that suits student characteristics, focuses on essential learning, and emphasises mastery of in-depth competencies through project-based learning. This curriculum emphasises a project-based approach to support the development of 21st-century competencies, including critical and logical thinking.

The project-based approach provides students with opportunities to learn through hands-on experience, so that they can connect theory with practice and understand the relevance of the material in everyday life as well as students who are emphasised to master critical thinking skills, communication, collaboration, and creativity (Prihantoro, 2020; Wahyudin et al., 2024; Yani & Taufik, 2020). The approach is also supported by research that shows that active learning models, such as this approach, can increase student learning motivation through independent curriculum. A study showed that students who engaged in project-based learning had better outcomes than those who used conventional methods (Fadhilah et al., 2023; Mulya, 2023; Febriana, 2017). This indicates that the learning strategies used in the Merdeka Curriculum align with the needs of students to develop high-level thinking skills that are essential in the 21st century.

Mathematics, as one of the subjects often considered complex, requires a learning approach appropriate for students' cognitive development. At the junior high school level, mathematics learning introduces students to the basic concepts that form the foundation for the next level of education. Learning approaches in junior high school generally focus more on developing logical thinking skills and conceptual understanding, while still being relevant to students' daily experiences (Cardino & Ortega-Dela Cruz, 2020; Prihantoro, 2020). For example, students are taught the concept of fractions in the context of dividing food or the concept of percentages in calculating discounts when shopping (Sagita et al., 2023). This approach enables students to apply simple mathematical concepts in everyday life while honing their problem-solving skills (Amalia et al., 2024; Wahyuni, 2024). In addition, learning mathematics in junior high school also introduces students to abstract thinking, such as algebra, which is an important basis for further learning (Ngaderi & Wahyuni, 2021). Studies show that the contextual approach in junior secondary mathematics learning helps students better understand the relevance of mathematics to the real world, thus improving their motivation and learning outcomes (Febriana, 2017; Puspita & Sugiman, 2016). Thus, the junior secondary school mathematics curriculum is designed to prepare students for more complex challenges at the next level.

However, junior high school students struggle to understand mathematics concepts, which can impact their learning outcomes. One of the main obstacles is low motivation to learn (Puspita & Sugiman, 2016), which is often influenced by the notion that mathematics is a difficult and boring subject, and some students find mathematical concepts too abstract and irrelevant to everyday life, so they have difficulty seeing the practical benefits of learning (Putri et al., 2022; Guner, 2020; Puspita & Sugiman, 2016; Murni et al., 2023). These difficulties often stem from students' weak mathematical foundations at the previous level, especially in basic skills such as counting, fraction operations, and understanding negative numbers (Geary, 2012; Walgermo et al., 2018). This lack of basic skills causes students to face major challenges when learning more complex topics such as algebra and geometry (Abdurrahman & Nofriyandi, 2022; Sugiarti & Retnawati, 2019). In addition, the lack of use of interesting and interactive learning media is also one factor affecting students' interest in learning mathematics (Widiastuti & Kurniasih, 2021). Therefore, designing a more contextualised and relevant learning approach is important to help students.

However, implementing the Merdeka Curriculum in mathematics learning in junior high schools is not free from challenges. Studies show that many teachers have difficulty understanding learning strategies based on students' cognitive development (Demetriou et al., 2022; Jee et al., 2012; Jørgensen et al., 2024). In addition, limited supporting facilities, such as interactive learning media, also hinder effective learning (Huda, 2024; Song & Cai, 2024). Therefore, according to Piaget's cognitive development theory, systematic efforts are needed to increase teachers' capacity to understand and implement learning strategies appropriate for students' cognitive development. Jean Piaget's cognitive development theory explains how human thought processes develop from childhood to adulthood (Babakr et al., 2019)—

cognitive development results from interaction between individual biological abilities and environmental experiences (Piaget, 1952). Based on Jean Piaget's cognitive development theory, junior high school students are at the concrete operational stage towards formal operations, where at this stage, students begin to think logically and abstractly, but still need concrete experiences as a basis for learning (Piaget, 1952).

To support the cognitive development of junior high school students, mathematics learning must be designed so that students understand concepts mechanically and apply them in everyday life. However, implementing the Merdeka Curriculum in mathematics learning at the junior high level still faces various challenges. Teachers often experience difficulties adjusting learning methods to students' cognitive development stage, especially in implementing project-based approaches and problem solving, which are at the core of the Merdeka Curriculum (Nurtanto et al., 2021). In addition, limited specialised training for junior secondary school teachers to understand cognitive developmental theories, such as those proposed by Jean Piaget, exacerbates the challenge (Domingo, 2023; Kilag et al., 2022). Many teachers also face obstacles in providing relevant and interactive learning media to support students' exploration in learning mathematics (Kobayashi et al., 1996; McDonald, 2012). As a result, learning mathematics in junior high school is often less than optimal in supporting students' cognitive development, especially in the ability to think abstractly, which is needed at the formal operational stage. Based on this problem, an in-depth analysis of the implementation of Merdeka Curriculum in junior high school mathematics learning is needed by considering Piaget's cognitive development theory. This research is expected to provide insight into effective and relevant learning strategies to overcome existing challenges, while supporting students' cognitive development to the fullest. Overcome these barriers. The purpose of preparing this article is to determine the implementation of Piaget's cognitive learning theory applied in learning using the independent curriculum in junior high school. Through this approach, learning is expected to support students' cognitive development according to their stages, strengthen student-centred learning, and emphasise exploration activities, concept manipulation, and collaborative discussions. So that students can get optimal learning outcomes and be able to foster their creativity.

2. Methods

(a) Research Design

This type of research is qualitative with a case study type. Case studies aim to explore a particular phenomenon in depth in real life (Yin, 2018). It is usually used when researchers want to understand how and why a phenomenon occurs (W. Creswell & Creswell, 2018). First, the researcher analysed the mathematics learning module used in the school and interviewed one of the junior high school mathematics teachers. This was followed by searching the literature and analysing how mathematics learning in junior high schools should be in the Merdeka Curriculum.

(b) Participants

This study involved one junior high school mathematics teacher in West Sumatra Province. The subject was selected by purposive sampling based on consideration of willingness to be interviewed. This technique is commonly used in qualitative research when researchers want to explore in-depth data from sources considered the most representative or have direct experience of the phenomenon under study (W. Creswell & Creswell, 2018). This allows the researcher to obtain a sample relevant and contextual to the research question (Palinkas et al., 2015).

(c) Instruments

Case studies usually combine multiple data sources to provide a comprehensive picture of the phenomenon under study (W. Creswell & Creswell, 2018; Yin, 2018). In this study, data were collected through document analysis and interviews. The documents referred to here are Merdeka Curriculum documents and mathematics learning modules that the concerned schools use. Meanwhile, the interview guideline focuses on the learning process, learning challenges, solutions, and teacher expectations.

(d) Data Analysis

Descriptive techniques describe data obtained from document analysis, observation, and interviews.

The documents analyzed included the Mathematics Teacher's Handbook, the Learning Outcomes of Mathematics Subjects in the Merdeka Curriculum, and the Student Worksheets used in learning the system of linear equations of two variables (SPLDV) at the school. After analyzing the documents, the researcher reduced the data by selecting relevant information, such as the learning objectives written in the documents, the material presented, and the recommended learning methods in the teacher's guidebook. Data was also collected through semi-structured interviews with teachers. In addition, data were obtained through direct observation of the SPLDV learning process. After the data is collected, the next step is to present the data in descriptive narratives that describe the learning process chronologically and contextually. This data presentation includes direct quotes from interviews, descriptions of classroom activities, and fragments of relevant documents to show how the Merdeka Curriculum is applied in SPLDV learning. Key findings are formulated by finding patterns, themes, or relationships between data from document analysis, observations, and interviews. This process is not carried out separately, but simultaneously by triangulating sources, namely comparing data from documents, observations, and interviews to ensure data consistency and validity. To strengthen the findings, the results of this analysis are also verified by comparing the patterns or approaches found in the field with relevant literature regarding Jean Piaget's cognitive development theory, the concept of project-based learning in Merdeka Curriculum, and the results of previous research related to the application of Merdeka Curriculum in mathematics learning at the junior high school level.

3. Results and Discussion

(a) Results

The school we analysed is geographically located in the Air Tawar Barat area and is an educational destination, especially for elementary school graduates and the equivalent from the West Padang City area. The school is one of the oldest vocational schools in Agam Regency. Established in 1995, it was originally known as SMP Pembangunan KORPRI IKIP Padang. Education at the junior high school level focuses more on developing basic competencies and student character as a foundation for continuing education to the next level. Junior high school is not directly related to the world of work, but it plays an important role in building students' cognitive, social, and emotional abilities. This is an important foundation before students continue their education to a more specific level, such as vocational or high school.

Mathematics is one of the subjects that all junior high school students must study. The document analysis found that mathematics learning outcomes were consistent with the learning objectives and criteria for achieving learning objectives designed by the teacher. For example, students can understand the concept of two-variable linear equations at the end of learning linear systems. They can use appropriate methods (graph, substitution, elimination, and mixture) to determine the solution of two-variable linear equations to model real-world situations. Then the teacher formulates some learning objectives on this element, including understanding a system of linear equations of two variables and solving linear equations of two variables. After studying this chapter, the teacher formulates two criteria to achieve the learning objective of understanding the concept of linear equations of two variables, three criteria to achieve the learning objective of determining the solution of a system of linear equations of two variables by graphing, substitution, elimination, and mixed methods, and two criteria to achieve the learning objective of solving linear equations of two variables modelling and solving contextual problems related to the system of linear equations of two variables.

The mathematics subject team divided the eight learning objectives in the System of Linear Equations of Two Variables (SPLDV) chapter into two semester allocations. The first six learning objectives, such as understanding the concept of linear equations of two variables to determining the solution of SPLDV with various methods, are set for the odd semester (semester five) with a total time allocation of 72 lesson hours. Meanwhile, the next two learning objectives, modelling and solving contextual problems related to SPLDV, are allocated for the even semester (semester six) with 72 lesson hours. Henceforth, we will discuss the mathematics teaching module for grade IX students. This teaching module contains elements, Pancasila Junior High School Student Profile, facilities and infrastructure, student objectives, learning models and modes, learning objectives and achievement indicators, learning activities, student worksheets, learning assessment, learning materials, and bibliography. Learning the system of linear equations of two variables (SPLDV) consists of eight meetings. The activity begins with understanding the meaning of SPLDV, followed by learning the methods of solving SPLDV, namely graphs, substitution, elimination, and mixed methods. The learning ends with modelling and solving contextual

problems related to SPLDV.

In the first meeting, the teacher greeted the students and asked one of them to lead the prayer together. Then, the teacher continued by checking students' attendance, providing perceptions related to learning materials and linking them to everyday life, conveying learning objectives and material about presenting data in matrix form, and describing the scenario of learning activities and assessments that will be carried out.

The core activities began with implementing differentiated learning based on the results of the initial formative assessment. This assessment is in the form of a checklist. It is done orally to determine the extent of students' understanding of a system of linear equations of two variables. If more than 50% of the students scored more than or equal to 50, then the students were ready to follow the learning. However, if not, students can read the prerequisite material independently or with teacher guidance. The teacher and students ask and answer questions about the meaning and basic concepts of SPLDV. The teacher guides students in discussing the meaning of a system of linear equations, graphical, substitution, and elimination methods in solving SPLDV, and how to determine the solution set. Furthermore, students are assigned to compile three examples of two-variable linear equation systems with different solutions, then solve them using the graphing, substitution, and elimination methods. Students pay attention to the teacher's explanation about the advantages, disadvantages, and applications of each method of solving SPLDV.

Then, students work on student worksheets in groups to formatively evaluate the process. The teacher checks students' understanding and provides guidance to students who need it as a form of positive differentiation. Student representatives present the results of their group discussions while other students respond. Students are allowed to ask questions about material that has not been understood.

We only saw a brief snapshot of the student worksheets in the SPLDV teaching module, so little information was obtained. The student worksheets contain a title, instructions for use, learning objectives, criteria for achieving learning objectives, description, tools and materials, work steps, and formative assessment. Each student worksheet does not have the discovery learning model syntax in the implementation section. The teacher used the contextual problem on the fourth student worksheet as an introduction to present the data in the system of equations.

Problem 1. Lina was asked to record the number of books borrowed from the school library by class IX students for one week with the following data. On Monday, there were 5 students who borrowed maths books and 3 students who borrowed science books. On Tuesday, 4 students borrowed maths books and 2 students borrowed science books. On Wednesday, 6 students borrowed maths books and 5 students borrowed science books. On Thursday, 3 students borrowed maths books and 4 students borrowed science books. Finally, on Friday, 7 students borrowed maths books and 6 students borrowed science books. Based on the data, organise the numbers into a system of two-variable linear equations, then determine the solution to find the average number of books borrowed

Figure 1. Snapshot of One of the Contextual Problems on the Fourth Student Worksheet

Figure 1 shows that the problems presented in the student worksheets are related to daily activities at school. The teacher confirmed this in the interview by giving examples of problems relevant to the context of students' lives. The aim is to relate mathematical material, such as data presentation or systems of equations, to students' real experiences so that learning becomes more meaningful and interesting. Contextual problems in junior high school mathematics learning help students understand mathematical concepts, such as tables, graphs, or simple mathematical models, while training them to apply them in everyday situations. It also prepares students to deal with complex situations at the next level of education or in real life.

The following is a snippet of the interview with the teacher concerned.

Researcher:	*Good morning, Mum. Thank you for taking the time to attend today's interview. I want to ask about the SPLDV learning process you teach in class IX, especially about the use of contextual problems related to students' daily activities.*
Teacher :	*Good morning. You are welcome, I am happy to share. Yes, I deliberately use contextual problems that are close to students' daily lives so they feel that mathematics is not far from their lives.*
Researcher:	*If I look at the student worksheets, for example, in Figure 1, the problem is related to borrowing books in the school library. Why did you choose that context?*
Teacher :	*Well, in my opinion, when the problem is directly related to what students experience*

	daily, it is easier for students to understand the meaning of the problem. For example, borrowing books is a routine activity at school, so they can immediately imagine the situation. Also, I wanted to show that the SPLDV concept can be used to analyze simple data, not just abstract numbers in a textbook.
Researcher:	*Very interesting, Mum. Does this mean that students learn to organize data into tables, create equations, and solve systems of equations in a more contextualized way?*
Teacher :	*That is right. They are not just counting numbers but also learning how to process real data into simple mathematical models. That skill will be useful for them later, either in further school or their daily lives.*
Researcher:	*After the students solve the problem, do you hold a reflection or evaluation together?*
Teacher :	*Yes, of course. At the end of the lesson, I invite them to discuss the difficulties they have experienced, and then we evaluate whether the concept has been understood. I also distribute an assessment sheet to record their results. After that, I will explain the next lesson plan and take the time to show appreciation to those who have actively participated.*
Researcher:	*After the whole SPLDV meeting is over, how do you evaluate the students' learning outcomes?*
Teacher :	*I conduct a written test as a form of summative evaluation. The standard of learning completeness is 71. If their score is below that, they have to take remedial classes. For those who have completed it, I give enrichment through challenging questions to deepen their understanding.*
Researcher:	*Okay, Mum. Thank you very much for your explanation. This context-based approach is very interesting and in the spirit of the Merdeka Curriculum. Hopefully, it can inspire other teachers, too.*
Teacher :	*Thank you again. I would also be happy if this experience could be useful.*

As stated during the interview, at the end of the lesson, the teacher and students reflect on the activities that have been carried out to evaluate students' understanding of SPLDV material. The teacher also distributes an assessment sheet to record the final learning outcomes. After that, the teacher conveys the learning plan for the next meeting and gives appreciation and motivation to students for their participation. The learning activity ends with praying together.

After completing eight meetings covering all SPLDV learning objectives, the teacher conducted a written test as a form of summative evaluation of the material coverage. Students who scored less than 71 were declared not to have achieved learning completeness and were given a remedial programme. Conversely, students who scored 71 or above were declared complete and received enrichment activities to deepen their understanding.

(b) Discussion

Their stage of cognitive development strongly influences the mathematical thinking process of junior high school students. In general, they are at the concrete operational stage towards formal operational, where students begin to think logically and abstractly, but still need concrete experiences as a basis for learning (Piaget, 1952; Santrock & Roehrig, 2023). Logical and analytical thinking skills develop, allowing students to solve simple problems systematically (Piaget, 1952). For example, in learning the system of linear equations of two variables (SPLDV), students are asked to determine the relationship between two variables, such as the price of an item and the number of items purchased. Students can visualise the data through graphs, construct simple linear equations, and find solutions using graphing or substitution methods. This process reflects their ability to connect concrete representations with abstract concepts, thus supporting the development of their logical and analytical thinking skills (Santrock & Roehrig, 2023).

When studying the system of linear equations of two variables (SPLDV), junior high school students can determine the intersection point of two lines based on the given equations. With the help of graphs or tables, they can understand the relationship between two variables and use substitution, elimination, or graphing to find the solution. Students can also check the correctness of their solution by resubstituting it into the initial equation. This process reflects the development of logical thinking skills that dominate at the concrete operational stage towards formal operations (Piaget, 1952; Santrock & Roehrig, 2023). Junior high school students need guidance from teachers to help them move from concrete to abstract understanding. Teachers provide systematic exercises, such as constructing simple mathematical models from contextual problems, to

gradually develop their analytical and abstract thinking skills. According to Piaget's theory, this aims to enable students to apply the SPLDV concept in various real situations and optimally support their cognitive development.

In the Merdeka Curriculum, mathematics learning in junior high schools is designed to be relevant to students' daily needs and experiences (Dwi Pamungkas et al., 2023; Muhaimin & Juandi, 2023; Yulianti, 2023). Project-based and problem-solving approaches are well-suited to support students' cognitive development based on Piaget's theory (Piaget, 1952). Mathematical thinking processes, such as understanding the problem, formulating solutions, and evaluating results, are developed gradually through this approach. For example, students are tasked with determining the total price of goods in a transaction using a system of linear equations of two variables (SPLDV). This scenario could involve calculating the price of several kilograms of fruit with different prices per kilogram. Such activities help students connect mathematical concepts to real-life situations while developing logical and analytical thinking skills that support their transition to the formal operational stage.

Contextualised approaches relevant to everyday life are helpful for junior high school students to understand the relevance of mathematics in various real situations (Beigie, 2008; Surya et al., 2017). Teachers can use project-based learning, such as calculating total expenditure when shopping or analysing simple data in tables or graphs. The aim is to give students hands-on experience to connect them more to the material learnt. Teachers also try to relate the problems in students' worksheets to their surrounding environment, such as school or household activities. However, the implementation of this approach has not been optimal. Teachers revealed that most students have low basic mathematics skills, making it difficult to understand more complex concepts. Some students consider maths difficult and irrelevant, but when teachers provide examples close to their lives, students' enthusiasm increases. Integrating technology in mathematics learning, such as GeoGebra applications to visualise graphs or other software to present data, helps students learn more interestingly and interactively (Farrajallah, 2016; Weinhandl et al., 2020). This technology also allows students to learn independently outside the classroom according to the principle of Merdeka Belajar. Teachers are important in implementing adaptive and innovative learning strategies to support students' learning. However, some teachers face challenges integrating elements of the Pancasila Learner Profile into mathematics learning, such as gotong-royong and critical thinking. Therefore, additional strategies and training for teachers are needed to create more effective and meaningful student learning experiences.

Teachers expect more training to make learning mathematics in junior secondary schools more relevant, interesting, and aligned with students' needs. This training includes the development of project-based learning modules, the use of interactive technology, and the implementation of diverse learning strategies. Providing multimedia devices and digital learning aids, such as graphic calculators or mathematical visualisation applications, strongly supports innovative learning. Engaging students in group activities enables effective discussion and collaboration, helping them to understand difficult mathematical concepts. For example, collaborative maths game activities or group projects involving simple data analysis can help students learn from peers (DiNapoli, 2018; Siller & Ahmad, 2024; Zhang, 2024).

The Merdeka curriculum encourages learning approaches tailored to students' abilities, interests, and needs (Putri et al., 2022). Teachers can assign tasks with different difficulty levels or guide students individually based on their learning styles. This approach ensures that all high and low-ability students achieve the learning objectives. In addition, some students have negative perceptions of maths due to previous learning experiences. Therefore, providing psychological support through character strengthening and counselling is important. Students are taught that mistakes are part of the learning process and that every individual has the potential to improve. This aims to increase students' motivation and confidence in learning mathematics.

4. Conclusion

Implementing the Merdeka Curriculum in junior high school mathematics learning based on Jean Piaget's cognitive development theory provides a more relevant educational approach for students' developmental stages. Through this approach, mathematics learning is designed to support students' cognitive development, especially transitioning from the concrete operational stage to formal operations. Learning emphasises exploration, manipulation of concepts, collaborative discussion, and project-based or problem-solving methods relevant to students' daily experiences.

The Merdeka Curriculum also offers flexibility in teaching methods, such as technology integration, interactive learning media, and contextual approaches to help students understand the relevance of mathematics in real life. However, implementing the Merdeka Curriculum in junior high schools still faces challenges, such as low basic abilities, limited facilities, and a lack of teacher training in integrating

elements of the Pancasila Student Profile in mathematics learning.

Therefore, greater support is needed by developing contextualised learning resources, intensive teacher training, and closer collaboration between teachers, students, and the surrounding environment. According to Piaget's theory, with the right approach, the Merdeka Curriculum can be a strong foundation for improving students' understanding of mathematics while supporting their cognitive development.

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