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DEVELOPMENT OF MATHEMATICS CURRICULUM IN PREPARATION FOR INDONESIA'S GOLDEN AGE 2045

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ABSTRACT

The purpose of this article is to discuss the curriculum that must be developed to address challenges and seize opportunities in the era of Golden Indonesia 2045, with a focus on critical thinking skills, technology integration, and contextual approaches. The method used is library research. Data sources were obtained from relevant literature, including books, journals, and scientific articles on the selected topic. The discussion results show that technology-based learning innovations, such as software and adaptive learning systems, can be a solution for improving students' mathematical literacy. In addition, a contextual approach that integrates mathematical concepts with other fields can prepare students to address real problems in the digital era. The conclusion of this article is that developing a mathematics curriculum for Indonesia Emas 2045 must focus on improving critical thinking skills, contextualizing material, and integrating technology into learning. By overcoming challenges such as the technology gap, teaching quality, and prior curriculum implementation, mathematics education is expected to produce a generation that is superior and competitive in the era of globalization.

INTRODUCTION

Indonesia is currently preparing for the grand vision of Indonesia Emas 2045, which will mark its 100th anniversary (Rosa et al., 2024). Looking at the vision and requirements for Indonesia Emas 2045, it is clear that competent, high-quality human resources and strong education are very important for accelerating the realization of a developed country in the future (Puspa et al., 2023). An advanced nation is characterized by high-quality human resources, including spiritual values, intelligence, and skills, which can be achieved through continuous educational advancement, particularly in mathematics (Hasibuan et al., 2019). As reported on the Ministry of Education, Culture,

Research, and Technology website , the results of the Programme for International Student Assessment (PISA) show that Indonesia's mathematics literacy score in PISA 2022 increased compared to PISA 2018, with a rise of 5 positions (Kemendikbudristek, 2023). Despite this improvement, Indonesia still ranks in the lower group. The curriculum needs to be designed to maintain this momentum of improvement by incorporating critical thinking, problem-solving, and real-life applications of mathematics.

In Indonesia, the current mathematics curriculum development aims to improve students' understanding of mathematics and problem-solving skills. However, the learning methods used remain abstract, and teachers are required to emphasize the achievement of individual and classical student competencies, thereby placing greater emphasis on learning outcomes (Hamidah et al., 2021). The current curriculum, the Merdeka Curriculum, offers a great opportunity to improve the quality of education in Indonesia through an approach that is more relevant and responsive to the needs of the modern world, despite various challenges such as teacher readiness and access to technology (Rosa et al., 2024). The need for students' abilities in mathematics is not only the ability to calculate, but also the ability to reason logically and critically in problem-solving (Saputri et al., 2019). There are still many areas that need improvement in the current curriculum. Therefore, curriculum development must be carried out effectively to achieve the educational goals of the 2045 Golden Generation.

Some of the challenges arising from the lack of support from the Merdeka Curriculum include the appointment and selection process for school principals, which remains inadequate, and the allocation of resources for teacher training, which is unbalanced (Wang et al., 2023). Many teachers still find it difficult to translate curriculum objectives into practical, relevant mathematics teaching practices. In addition, unequal access to technology and learning resources across regions, especially in 3T (frontier, outermost, and disadvantaged) areas (Falah & Hadna, 2022), hinders the implementation of technology-based learning, which is also a focus of the Merdeka Curriculum. On the other hand, the curriculum's emphasis on individual student competencies often overlooks collaboration skills, creativity, and data literacy, which are crucial for addressing future challenges. This gap in curriculum implementation has the potential to hinder the achievement of Indonesia Emas 2045, which requires a generation with critical thinking, problem-solving, and innovation skills. Therefore, mathematics curriculum development must be supported by teacher training, equitable resources, and technology

integration, as well as contextual learning to create a golden generation that excels in learning outcomes and life skills in the global era.

This article will examine the principles and strategies for curriculum development that are relevant to future needs. The main focus is to answer the question, "How should the curriculum be developed to face challenges and take advantage of opportunities in the era of Indonesia Emas 2045?". Using a literature review, this research aims to provide a comprehensive perspective on the educational transformation needed. Hopefully, this study can contribute to the design of an educational model that not only equips students with knowledge but also shapes the character of the nation's future generation.

RESEARCH METHOD

The research method used in this study is library research. The steps of library research to be carried out in this study include preparing equipment, compiling a bibliography of the literature to be used, managing time, and reading and taking notes on the literature collected. The data sources in this study were obtained from the relevant literature, including books, journals, and scientific articles on the selected topic. The data collection technique used in this literature review was to search for data related to the variable topic in the form of notes, books, papers, articles, journals, and other sources. The data analysis technique used in this literature review was content analysis.

RESULTS AND DISCUSSION

a. Challenges in Mathematics Education in Indonesia

The results of the Programme for International Student Assessment (PISA) show that Indonesia's mathematics literacy scores in PISA 2022 increased compared to PISA 2018, rising 5 positions in the rankings (Kemendikbudristek, 2023). The following is a graph of Indonesia's PISA mathematics scores from 2006 to 2022:

Source (Wijaya et al., 2024)

Figure 1. Graph of Indonesia's PISA mathematics scores from 2006 to 2022

This graph shows the development of Indonesia's PISA mathematics scores from 2006 to 2022. In 2006, the score reached 391, but it declined sharply to 371 in 2009 under the KTSP. The score began to rise again in 2015, peaking at 386 when the 2013 Curriculum (K-13) was implemented, but fell to 379 in 2018 when K-13 was discontinued. The significant decline continued in 2022 under the Merdeka Belajar policy, with the score reaching 366. This shows that there are challenges in improving the quality of mathematics learning, especially during the 2015-2022 curriculum transition period. Students who are not accustomed to solving PISA-style mathematics problems will have difficulty with them (Kholid et al., 2022). There needs to be a strengthening of problem-solving-based learning and a contextual approach to improve mathematical literacy in the development of future curricula.

The Merdeka Curriculum is designed to strengthen competency-based, contextual, and technology-based learning, but challenges in its implementation remain a major obstacle. Contextual and project-based approaches, which are more demanding in terms of depth of understanding and creativity, pose a challenge for many teachers accustomed to conventional teaching methods (Kholid et al., 2022). The rote-learning approach in mathematics education, which has long been a hallmark of previous curricula, remains evident in many schools despite the Merdeka Curriculum's efforts to change this paradigm. Teachers often teach steps that lead students to memorize without focusing on deep conceptual understanding or real-life relevance. In addition, infrastructure and resource access disparities, especially in remote areas, make it difficult to implement contextual and technology-based learning approaches evenly. This challenge is exacerbated by the lack of teacher training to support the pedagogical transformation promoted by the Merdeka Curriculum. As a result, students still find it difficult to understand how mathematics can be applied in various situations, which affects their critical and analytical thinking skills. This shows that curriculum development has not been fully realized at the implementation level.

In the context of curriculum development, the Merdeka Curriculum has introduced a new paradigm by emphasizing the integration of mathematics with other fields, such as economics, technology, and the environment. The main challenge is to ensure these curriculum principles are implemented consistently in the field. Previous curricula, which tended to focus on theory and procedural memorization, have created a gap between what students learn in school and the real needs of the workplace or everyday life. Although the Merdeka Curriculum offers flexibility, many teachers still find it difficult to

design relevant project-based or inquiry-based learning. In addition, the integration of technology into mathematics learning has not been fully realized due to limited resources across regions. To make the Merdeka Curriculum the foundation for curriculum development towards Indonesia Emas 2045, these challenges must be overcome through more focused and equitable implementation.

The quality gap in mathematics education between developed and underdeveloped regions in Indonesia is influenced by access to resources, teacher quality, and infrastructure. Developed regions tend to have more complete facilities, better-trained teachers, and adequate technological support. Based on interviews with 27 teachers, 75% stated that the lack of technology-based resources poses a significant challenge to integrating modern educational tools into mathematics learning, especially in Indonesia (Wijaya et al., 2024). Conversely, underdeveloped regions often lack textbooks, learning aids, and relevant teacher training. Winthrop states that the majority of school dropouts and out-of-school children come from low-income households, communities, and countries, indicating a pattern of educational inequality (Guo et al., 2019). Curricula in disadvantaged areas are also often outdated or unsuited to local needs, which exacerbates inequality. To reduce this gap, it is necessary to expand access to technology, provide ongoing teacher training, and improve educational infrastructure in disadvantaged areas. These steps are important for creating equality in mathematics education throughout Indonesia.

b. Principles of Mathematics Curriculum Development for Indonesia Emas 2045

The development of the curriculum is a curriculum-planning process to create a comprehensive and specific curriculum plan (Dhani, 2020). Curriculum development follows principles that aim to ensure the curriculum responds to students' and the community's needs and helps students achieve the desired results (Ayudia et al., 2023). In curriculum development, there are four stages at different levels, including the macro (national) level, institutional (school) level, subject (field of study) level, and classroom learning level (Fajri, 2019). If the macro level is not suitable, the institution can adjust it to its needs. The parties involved in curriculum development at the school level are those who contribute their thoughts, opinions, or views in evaluating, developing, implementing, and assessing the curriculum (Ayudia et al., 2023). These parties include educational personnel (teachers, education administrators), parents, school committees or council members, and other community workers. Therefore, curriculum development is

complex and must be carried out properly to achieve its objectives, especially for Indonesia Emas 2045.

The development of the mathematics curriculum for Indonesia Emas 2045 is based on principles that emphasize critical thinking, analytical, and problem-solving competencies. These principles emerged in response to challenges in Indonesian education, especially in mathematics, as reflected in PISA results, which have tended to decline in recent years. In 2015, the PISA mathematics score reached 386, but declined to 366 in 2022, indicating a lack of effectiveness in learning to improve students' abilities. One of the causes is the implementation of the previous curriculum, which still focused on memorization and did not effectively hone higher-level thinking skills. In addition, many teachers have not been able to fully integrate contextual learning that supports problem-solving. This poses a challenge in developing competent students who can compete at the global level. Therefore, the principle of competency-based curriculum development must be fully implemented in mathematics learning.

Technological advances are also a major factor influencing the dynamics of the education system (Fatimah et al., 2024). Although this principle emphasizes the use of technology, such as mathematical modeling software or digital simulations, in reality, not all schools have access to adequate infrastructure. In disadvantaged areas, limited technological resources and internet connectivity make it difficult for students to participate in digital-based learning. This exacerbates the educational quality gap between developed and underdeveloped regions. In addition, teachers' skills in using learning technology are still limited, so the implementation of this principle has not been optimal. If the technology gap is not addressed immediately, the potential of the mathematics curriculum to improve student understanding will be difficult to realize. Therefore, there needs to be equal access to technology as the foundation for curriculum development towards Indonesia Emas 2045.

In Indonesia, access to education has improved, but there are still disparities between urban and rural areas and between different socioeconomic groups (Fatimah et al., 2024). This certainly poses another challenge in the development of mathematics curricula, namely the gap in educational quality between schools in urban areas and those in disadvantaged areas. Students in disadvantaged areas often do not receive quality mathematics education due to a lack of competent teachers, infrastructure, and weak policy support. The implementation of previous curricula, such as the 2013 Curriculum, has often failed to address this problem because it focuses too much on competency

achievement targets without considering local context. An inflexible curriculum makes it difficult for teachers in disadvantaged areas to adapt their instruction to their students' needs. This hinders efforts to improve critical thinking and problem-solving skills, which are the main principles of the curriculum. Therefore, the development of a new curriculum must be more inclusive and contextual in order to reach all students in Indonesia equally.

The implementation of the previous curriculum also faced challenges because the learning orientation was still memorization-based and lacked context. The learning model often used by mathematics teachers emphasizes memorization or rote learning rather than reasoning, problem-solving, or understanding. Memorization is not the answer in mathematics, especially when students do not understand it (Mulyono & Hapizah, 2018). Mathematics instruction often focuses only on solving problems with specific steps, without encouraging students to understand the concepts in depth. As a result, students find it difficult to apply their mathematical knowledge to real-world problems that require analytical thinking. The principles of contextualization and interdisciplinarity in developing a new curriculum are key to overcoming this problem. Integrating mathematical concepts with other fields, such as economics, technology, and the environment, can help students understand the relevance of mathematics in everyday life. In this way, learning will become more interesting and meaningful, and will improve students' ability to face global challenges.

Finally, the principle of technology-oriented mathematics curriculum development needs to be adapted to the actual educational conditions in Indonesia. Low PISA results indicate that students' understanding of mathematical concepts is not yet optimal, so the use of technology must be directed towards effectively improving mathematical literacy. The use of technology such as GeoGebra, digital simulations, or adaptive learning platforms can help students understand abstract concepts visually and interactively. The success of this principle requires support from various parties, including teacher training, infrastructure provision, and government policies that favor educational equity. By implementing sound curriculum development principles, the challenges of mathematics education in Indonesia can be overcome, enabling the goal of Indonesia Emas 2045 to produce a superior, competitive generation to be achieved.

c. Mathematics Curriculum Strategy and Implementation

The mathematics curriculum aims to develop students' logical, analytical, and problem-solving skills through a relevant approach. Curriculum design must be in line with its implementation strategy, based on key principles such as simplicity, ease of understanding and implementation, orientation towards the comprehensive development of students' competencies and character, flexibility, harmony, collaboration, and consideration of the results of studies and input obtained (Hattarina et al., 2022). For example, mathematics learning in the Merdeka Curriculum is designed to be more enjoyable, and students are not required to master mathematics in depth because each student has different interests and potential (Septiani et al., 2022). Learning strategies relevant to 21st-century skills include project-based learning, problem-based learning, and inquiry-based learning (Atmaja & Noviantari, 2024), in which students are encouraged to connect mathematical concepts to real life through assignments or projects. In addition, strengthening data and statistical literacy is a priority in preparing students for the era of big data. The use of digital technology, such as mathematical software and online learning platforms, is also an important element in implementing this curriculum. Teacher competence must be continuously improved through ongoing training so that they can adopt innovative teaching strategies. Overall, a mathematics curriculum that focuses on real-world applications and technology-based learning can increase the relevance and effectiveness of learning for students.

Project-based and inquiry-based approaches in mathematics learning aim to connect mathematical concepts with real-life situations. In a project-based approach, students work on real tasks such as designing a family budget, calculating travel costs, or analyzing student data at their school, so they can understand the application of mathematics directly. During the inquiry process, teachers act as facilitators and mentors by providing guidance, asking leading questions, and offering relevant resources (Haryanti & Muryaningsih, 2024). Both approaches help students develop critical, creative, and collaborative thinking skills, while also increasing their motivation to learn. The integration of these two approaches enables students not only to understand mathematical theory but also to apply it in real-world contexts. Thus, mathematics learning becomes more relevant, engaging, and meaningful for students.

Strengthening data and statistics literacy is very important in the era of big data, where students need to understand, analyze, and use data in their daily lives. Teaching begins with basic concepts such as data types, descriptive statistics, and frequency

distributions. Students are also taught to use software such as Excel and Python for in-depth data analysis. Data visualization is an important part where students learn to present data through graphs or diagrams to facilitate interpretation. Data-based projects, such as analyzing economic trends or the impact of weather on agricultural yields, can reinforce students' understanding of statistical concepts. Data literacy instruction also emphasizes the ethics of data use, including privacy and personal data protection. With strong data literacy, students are better prepared for the world of work and a life increasingly dependent on information management.

The development of mathematics teachers' competencies is a key factor in improving classroom learning quality. The inability of teachers and school staff to use technology is a major obstacle to implementing the digital curriculum (Zuhriyah et al., 2024). To overcome this problem, educators are given additional classes and exams to train teachers and school staff to use software and computer hardware. The training also covers the development of pedagogical skills, such as designing project-based or inquiry-based learning that is relevant to students' real lives. Teachers' digital literacy is very important so they can use online resources and digital tools in their teaching. In addition, teachers need ongoing training to adopt innovative and creative teaching methods. Mentorship programs or workshops can be effective ways to improve teacher capacity. With competent teachers, an innovative mathematics curriculum can be implemented more effectively, with a positive impact on students.

d. Innovation in Mathematics Learning in the Digital Age

The use of technology in mathematics learning is one of the important innovations to support curriculum development towards Indonesia Emas 2045. Research shows that the use of technology and innovation plays an important role in improving the effectiveness of mathematics learning (Saputra & Subekti, 2024). Interactive mathematics software, such as GeoGebra or Wolfram Alpha, can help students visualize mathematical concepts more clearly, improve their understanding, and enhance their problem-solving skills, providing an interactive and in-depth learning experience (Chandrasegaran & Maat, 2023). With software, students can understand difficult concepts, especially in real-world contexts. Additionally, online learning platforms that provide adaptive exercises and automated assessments, such as Khan Academy or Ruangguru, can help students learn independently at their own pace. Access to technology and the internet is still limited in many places, especially in remote areas, hindering the equitable use of

technology in the learning process (Khumaidi et al., 2024). For teachers to master educational technology and apply it effectively in the classroom, they need intensive, ongoing training (Mekalungi et al., 2024). With optimal technological support, mathematics learning can become more relevant and effective in facing global challenges.

Game-based learning (GBL) is one innovative approach that can be applied to increase student motivation in mathematics learning. GBL can be used to simulate real-life situations, where students can apply their learning and deepen their understanding of the subject matter (Jääskä & Aaltonen, 2022). This approach integrates game elements, such as challenges, levels, and rewards, to create a learning experience that is both fun and challenging. Educational games such as Prodigy Math Game allow students to solve math problems in the context of a specific story or mission, thereby engaging them more emotionally and cognitively. Implementing GBL requires curriculum adjustments to remain aligned with learning targets. With this approach, mathematics learning can become more inclusive, especially for students who are usually less interested in traditional learning methods.

A more creative, adaptive, and responsive future for education can be wisely shaped by leveraging technology (Hasanbasri et al., 2023). By using the insights provided by AI, teachers can optimize teaching strategies, choose the best learning methods, and tailor methods to student needs (Mambu et al., 2023). For example, platforms such as DreamBox Learning provide a personalized learning experience, where questions or materials are automatically adjusted to students' abilities based on their performance. The AI system's ability to provide instant, adaptive feedback enables it to identify errors or misconceptions and offer additional exercises or explanations as needed, an important component of AI's ability to personalize learning (Arnadi et al., 2024). In the context of the curriculum, this approach can reduce learning gaps in heterogeneous classrooms by allowing students to learn at their own pace. Despite its great potential, adaptive learning adoption in Indonesia remains limited due to infrastructure and cost constraints. By developing a curriculum that integrates adaptive systems, mathematics education can become more inclusive and efficient, aligning with each student's needs.

Insights and significant results from big data analysis are used in technology-based processes to support decision-making strategies across sectors, including educational institutions, the business world, and government (Djunaidi et al., 2025). In education, the Indonesian government has developed new information technology applications to revise the elementary school curriculum and prepare students for the challenges of the fourth

industrial revolution, such as big data, the internet of things, and artificial intelligence (Setyaningsih, 2020). Big data also enables students to understand how mathematics plays a role in evidence-based decision-making, but integrating it into the curriculum requires adequate technological support and teacher training to ensure effective data use. Additionally, it is important to teach students the ethics of data use, such as privacy and data accuracy, so that they become responsible data users. Big data literacy in mathematics education will be an important asset for Indonesia's golden generation to compete in the global era.

CONCLUSION AND RECOMMENDATIONS

The mathematics curriculum must be developed with competencies, contextuality, and technology integration to address challenges and seize opportunities in the era of Indonesia Emas 2045. Curriculum development must also address challenges in previous curricula, such as the technology access gap, teaching quality in disadvantaged areas, lack of ongoing teacher training, and equitable educational infrastructure. Adaptive, innovative, and inclusive curriculum development, along with the use of technology in mathematics learning, is one of the key innovations supporting curriculum development towards Indonesia Emas 2045.

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