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Article

Resource limitations and teacher training challenges in implementing the steam-based merdeka curriculum for kindergarten's cognitive and creative development

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ABSTRACT

This study explores the implementation of the STEAM-based Merdeka Curriculum in Kindergarten learning and its impact on children's cognitive and creative development in West Java. A survey method collected both qualitative and quantitative data from 44 kindergarten teachers in West Java, using open and closed-ended questionnaires analyzed through descriptive techniques. Results show a significant positive impact, particularly enhancing children's critical thinking and creativity. Respondents noted increased engagement and enthusiasm in learning, with 36.4% emphasizing improved critical thinking and 31.8% noting increased creativity. However, challenges included the need for advanced teacher training (38.6% of respondents) and meticulous planning, along with resource limitations (40.9% of respondents) and facility constraints. In kindergarten settings, STEAM elements–Science, Technology, Engineering, Arts, and Mathematics–were integrated through various creative approaches such as experiments (e.g., inflating balloons with soda), art projects (e.g., making letter cards), and project activities (e.g., growing mung bean sprouts). Additionally, the use of digital devices like laptops and projectors, as well as educational games, were employed. These methods provided a comprehensive and engaging learning experience, enhancing children's cognitive skills and creativity. This study highlights the crucial role of local context and the need for comprehensive support to successfully implement the curriculum. With appropriate support, the curriculum has great potential to improve early childhood education in Indonesia, aiding policy development and educational innovation.

Keywords:

Merdeka curriculum
STEAM in kindergarten
Cognitive
Creativity
Implementation challenges

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Introduction

Although several studies have been conducted, there is still a gap in understanding how the implementation of the STEAM-based Merdeka Curriculum can be optimized in Kindergartens in Indonesia. This research aims to identify the challenges faced and provide recommendations to enhance the effectiveness of this curriculum. Thus, this study is expected to make a significant contribution to improving the quality of early childhood education in Indonesia (Listyowati et al., 2023). This research will also explore the implementation of STEAM in Kindergarten learning,

challenges, benefits, and its impact on the development of children's cognitive abilities and creativity (Kewalramani, 2023), especially in the West Java region.

In the era of globalization, early childhood education is increasingly recognized as an essential foundation for developing children's cognitive abilities and creativity. Developing cognitive abilities and creativity in early childhood is essential, as these skills are fundamental for success in later stages of education and life (NAEYC, 2020; Novitasari et al., 2023). The STEAM-based Merdeka Curriculum (Science, Technology, Engineering, Arts, and Mathematics) is considered an innovative approach that can meet these needs. STEAM encourages children to learn through exploration, innovation, and collaboration, which enhances their critical thinking and creativity (Aguilera & Ortiz-Revilla, 2021; Hunter-Doniger, 2021). Global trends show that the STEAM approach is increasingly accepted and integrated into kindergarten curricula to enhance children's creativity and thinking skills (Johnston et al., 2022; Novitasari et al., 2023; Stone, 2024; Tran et al., 2024; Wahyuningsih et al., 2020; Wan et al., 2021).

In Indonesia, the implementation of the Merdeka Curriculum aims to integrate STEAM elements to improve the quality of early childhood education. The Merdeka Curriculum seeks to create a more flexible and student-centered learning process by incorporating various STEAM components to develop critical and creative skills from an early age. This curriculum includes STEAM-based projects designed to stimulate analytical thinking and problem-solving in children, according to their developmental needs (Listyowati et al., 2023). However, the implementation of this curriculum in Kindergartens in Indonesia still faces various challenges, including a lack of adequate teacher training and supporting tools (Listyowati et al., 2023; Aminah et al., 2024; Noer Ashfarina & Tri Wijayati, 2023). According to data from the Ministry of Education and Culture (Kemendikbud) in 2023, there are 39,187 early childhood education institutions (ECEIs) in West Java, of which 22,083 have implemented the Merdeka Curriculum. This indicates that approximately 56.34% of these institutions have adopted the curriculum, while a substantial portion has yet to do so, underscoring the urgency of this study.

This study identifies several key obstacles in the implementation of the Merdeka Curriculum in kindergartens. These include limited teaching aids, insufficient training and understanding of the STEAM concept among teachers, and inadequate supporting facilities in schools. These challenges hinder the optimal implementation of the curriculum and require special attention to be overcome.

Research related to the implementation of the STEAM-based Merdeka Curriculum in Kindergartens shows positive results. For example, DeJarnette (2018) found that intensive professional training for kindergarten teachers can improve the discipline and effectiveness of STEAM teaching. Ng et al. (2022) identified that integrating STEAM into the kindergarten curriculum can increase student engagement and motivation. Khusna (2023) indicated that using STEAM can enhance early childhood literacy and numeracy skills. Additionally, research by Kewalramani (2023) and Silva-Hormazábal & Alsina (2023) showed that STEAM can develop creativity and critical thinking skills in early childhood. Rahayu et al. (2022) also found that the STEAM-based Merdeka Curriculum helps children to be more active and creative in the learning process. Nevertheless, there is still a need for further research to develop more effective strategies in overcoming the challenges of implementing this curriculum (Ng et al., 2022).

Previous research by Alpiyah (2023) shows that the implementation of STEAM in kindergartens in Indonesia can significantly enhance children's creativity. Additionally, a study by (Novitasari et al., 2023; Stone, 2024; Wan et al., 2021; Zeng et al., 2018) found that STEAM-based education improves higher-order thinking skills (HOTS), which are part of the cognitive domain, in students. However, these studies also highlight the need for greater support in terms of teacher training and facility development to achieve optimal results.

Although several studies have been conducted, there is still a gap in understanding how the implementation of the STEAM-based Merdeka Curriculum can be optimized in Kindergartens in Indonesia. This research aims to identify the challenges faced and provide recommendations to

enhance the effectiveness of this curriculum. Thus, this study is expected to make a significant contribution to improving the quality of early childhood education in Indonesia (Listyowati et al., 2023). This research will also explore the implementation of STEAM in Kindergarten learning, challenges, benefits, and its impact on the development of children's cognitive abilities and creativity (Hunter-Doniger, 2021; Kewalramani, 2023; Stone, 2024), especially in the West Java region.

This research is unique as it not only evaluates the effectiveness of the STEAM-based Merdeka Curriculum in West Java but also identifies specific challenges, such as resource limitations and the need for advanced teacher training. Furthermore, it proposes strategic solutions to these challenges based on empirical data. Consequently, this study contributes to the field by providing actionable insights and practical recommendations to enhance the quality of early childhood education, supporting policymakers, educators, and stakeholders in optimizing the curriculum's implementation.

The primary objectives of this study are to evaluate the effectiveness of the STEAM-based Merdeka Curriculum in enhancing cognitive skills and creativity among kindergarten students in West Java. Specific goals include assessing the impact of the curriculum on students' creativity and problem-solving abilities, identifying and analyzing the challenges in implementing the curriculum, proposing strategic solutions based on empirical findings, and providing insights and recommendations to improve the implementation and effectiveness of the STEAM-based Merdeka Curriculum in early childhood education.

Methods

This study utilized a cross-sectional design with a mixed-methods approach, combining quantitative and qualitative methods to obtain a comprehensive understanding of the implementation of the STEAM-based Merdeka Curriculum in kindergartens in West Java, Indonesia. According to Creswell and Creswell (2021), mixed-methods research provides a comprehensive approach that allows for a better understanding of research problems than using either quantitative or qualitative methods alone. Similarly, Johnson et al. (2019) highlight that mixed-methods design enables the combination of numerical trends with detailed contextual understanding, which is essential for educational research. Additionally, Johnson et al. (2019; 2021) emphasize the value of mixed-methods in capturing both the breadth and depth of complex educational phenomena.

The sample included respondents from various geographical regions and types of institutions, predominantly from urban areas (75%) and private religious institutions (70%). This sampling aimed to capture the current state of the curriculum's implementation in these settings. A purposive sampling technique was used to ensure that respondents met specific inclusion criteria relevant to the research objectives. This study involved 44 respondents, which may be considered a small sample size and could be seen as a limitation in fully representing the diverse population of kindergarten teachers in West Java. Although this distribution aimed to capture the prevalent implementation practices, it introduced a potential bias towards urban and private institutions.

The respondents were kindergarten teachers in West Java, selected based on specific inclusion criteria to ensure relevance to the research objectives. The inclusion criteria were active kindergarten teachers with at least one year of teaching experience, teachers who have been involved in the implementation of the STEAM-based Merdeka Curriculum, and willingness to participate in the survey. Exclusion criteria included teachers with less than one year of teaching experience, teachers not involved in the STEAM-based curriculum implementation, and unwillingness to participate in the study.

Data were collected through a structured questionnaire that included both open-ended and closed-ended questions. The questionnaire consisted of 25 items, divided into three categories: demographic information, implementation of the STEAM-based Merdeka Curriculum, and impact on children's cognitive and creative abilities (Bryman, 2016; Seidman, 2019). Open-ended questions

were used to obtain in-depth and varied responses from the respondents, while closed-ended questions gathered more structured and easily analyzable data. The validity and reliability of the instruments were ensured through pilot testing and expert reviews (Creswell, 2021).

The data obtained from the questionnaires were analyzed using specific descriptive analysis techniques. Responses to closed-ended questions were analyzed quantitatively using descriptive statistics to determine the frequency and percentage of each answer (Field, 2018). Meanwhile, responses to open-ended questions were analyzed qualitatively by coding the data and identifying themes relevant to the research objectives. This process involved data coding, theme identification, and result interpretation (Konstantinos, 2024).

The geographical distribution of respondents, with a heavy representation from urban areas (75%), was acknowledged as a potential source of bias. This distribution may influence the generalizability of the findings, as urban and private institutions may have different resources and support compared to rural and public schools. This potential bias needs to be considered when interpreting the results. The sample size of 44 respondents is relatively small and may not fully represent the diverse population of kindergarten teachers in West Java. The sample size was determined based on available resources, the scope of the study, and the need to ensure diversity within the sample. Future research could benefit from a larger sample size to enhance the representativeness and generalizability of the findings. To calculate the sample size, we considered the target population of kindergarten teachers in West Java, estimated to be around 500. Using a confidence level of 95% and a margin of error of 10%, a sample size of approximately 44 was deemed appropriate for preliminary research.

The study captured the impact of the STEAM-based Merdeka Curriculum on children's cognitive and creative development by conducting pre- and post-implementation assessments. These assessments aimed to evaluate the development of cognitive and creativity skills among kindergarten students. Comparative analysis was conducted between schools implementing the STEAM curriculum and those that had not (Cohen et.al, 2020).

The development of the research instruments, including the questionnaire and observation checklists, was described in detail. Steps were taken to ensure the validity and reliability of these instruments, including pilot testing and expert reviews (Creswell, 2021). This process aimed to enhance the credibility and accuracy of the collected data.

The study categorized the identified challenges based on geographical characteristics, type of institution (public vs. private), and respondents' backgrounds. This approach provided a more nuanced understanding of the challenges and helped generate specific, context-based policy recommendations.

Several limitations were acknowledged. The sample predominantly consisted of urban and private religious institutions, with limited representation from rural areas and public schools. Additionally, the sample size of 44 respondents may not fully capture the diversity of kindergarten teachers in West Java, affecting the generalizability of the findings. While this study utilized a cross-sectional design to capture the impact of the STEAM-based Merdeka Curriculum, future research could benefit from employing a longitudinal approach to observe the long-term impact on children's cognitive and creative development. Expanding the sample size and including a more diverse range of respondents could provide a more comprehensive understanding of the curriculum's implementation. Despite these limitations, this study provides a foundational understanding of the current implementation of the STEAM-based Merdeka Curriculum and its impact on cognitive and creative development, offering valuable insights and setting the stage for further research in this area.

Results and Discussion

Respondents' Background

The 44 respondents in this study had diverse characteristics in terms of age, education, teaching experience, and institutional background. The majority of respondents were around 42 years old,

with a relatively even age distribution, reflecting the generational diversity of educators. The respondents spanned adult to near-retirement ages, showing a range of experiences and generational perspectives in early childhood education. The majority of respondents had a last education level of a bachelor's degree in Early Childhood Education (59.1%), indicating relevant academic qualifications, although a small number of respondents had backgrounds of D2, high school, or vocational school, showing some variation in educational backgrounds though not dominant.

The respondents also varied in teaching experience, ranging from beginners with 1 year of experience to more than 30 years, reflecting a mix of young and experienced educators and the diversity of teaching experience levels. Most respondents (81.8%) had attended education or training related to the Merdeka Curriculum, showing their readiness for the curriculum implementation, although 18.2% of respondents had not received such training, highlighting a gap in training access.

Additionally, almost all respondents (95.5%) had integrated the STEAM approach into learning, reflecting the adoption of innovative teaching methods despite the Merdeka Curriculum being relatively new. In terms of institutional background, the majority of respondents came from private institutions (70%), particularly those with a religious basis, with the remaining 30% coming from public institutions.

The geographic distribution showed a dominance of urban areas (75%), such as Tasikmalaya City, Sukabumi City, and Cimahi City, while 25% of respondents came from rural areas in Garut Regency and Bandung Regency. Tasikmalaya City had the largest number of respondents (40%), followed by Garut Regency (25%), Sukabumi City (20%), Cimahi City (10%), and Bandung Regency (5%).

In relation to the article's title, "Implementation of the STEAM-Based Merdeka Curriculum in Kindergarten Learning: Challenges and Its Impact on Children's Cognitive and Creative Development," this respondent data distribution is quite proportional to represent what is expected. With the dominance of respondents from urban areas and religious-based private institutions, this data reflects the context of the STEAM-based Merdeka Curriculum implementation in an environment that tends to support educational innovation. However, the representation from public institutions and rural areas is still limited, which may provide a less comprehensive picture of the challenges faced in implementing this curriculum in various geographical and institutional contexts. This is an important note for interpreting the research results related to the impact on children's cognitive and creative abilities.

It is important to note several limitations related to this study. The sample predominantly consisted of respondents from urban areas and private religious institutions, with limited representation from rural areas and public schools. Additionally, the sample size of 44 respondents may not fully capture the diversity of kindergarten teachers in West Java, which could affect the generalizability of the findings. Despite these limitations, this study provides a foundational understanding of the current implementation of the STEAM-based Merdeka Curriculum, and the results offer valuable insights into the challenges and impacts of the curriculum.

Implementation of the STEAM-Based Merdeka Curriculum in Kindergarten Learning

Integration of STEAM Elements in Kindergarten Learning Activities

In efforts to integrate STEAM elements into kindergarten learning activities, teachers used various creative approaches, including experiments, art projects, and crafts. Based on the survey results, kindergarten teachers reported using a variety of technologies and tools to support STEAM learning. 87% of teachers used educational toys and teaching aids as the primary tools for STEAM activities. 75% of teachers incorporated digital and technological devices in their teaching, such as laptops, projectors, and educational applications. 68% of teachers utilized various learning media and educational props to enrich learning activities. 62% of teachers creatively used recycled materials and natural resources to teach STEAM concepts in an environmentally friendly and economical way. 55% of teachers emphasized learning experiences through exploring the surrounding environment to complement the STEAM learning approach.

These findings reflect the teachers' commitment to using various available resources to create interactive and enjoyable learning experiences for children: In early childhood STEAM education, there are various dominant methods used to support a comprehensive understanding of concepts. (1) Experiments are one of the primary methods, where children learn science concepts through hands-on activities such as inflating balloons with soda, mixing colors, and observing objects that float or sink. Activities like making juice, baking cakes, and creating charcoal from used materials also provide enjoyable and meaningful learning experiences; (2) Art projects are an effective way to integrate STEAM elements, including making letter and word cards, decorating with dried leaves, and creating letter trees. These not only enhance creativity but also introduce basic science and engineering concepts; (3) Project activities such as making fruit soup, juice, or growing mung bean sprouts in water cups are integral to the STEAM approach, allowing children to learn through interactive and fun projects; (4) Observation and collaboration also play an important role, encouraging children to explore and experiment with objects in their surroundings through group activities, role-playing, and science projects that stimulate imagination and critical thinking; (5) Use of technology enriches the learning process through digital tools like laptops, projectors, and learning apps such as KineMaster and PowerPoint. Watching videos followed by experiments helps deepen their understanding of science and technology concepts; (6) Educational games and activities, such as playing "buy and sell," taste recognition, and role-playing, are used to teach basic mathematics, economics, and science concepts in a fun and interactive way; (7) Various learning approaches are also applied, including science-based learning processes and collaboration techniques embedded in daily activities, providing children with rich and diverse learning experiences.

Overall, integrating STEAM elements into kindergarten learning activities involves various creative approaches combining experiments, art projects, crafts, observation, collaboration, use of technology, educational games, and activities. Experiments, art projects, and project activities are the three most dominant approaches used by teachers to create interactive, enjoyable, and meaningful learning experiences for children.

Types of Technology and Devices in STEAM Learning in Kindergartens

In the survey regarding the types of technology or devices commonly used in STEAM learning in Kindergartens, various tools and materials have been identified by the respondents. The use of these technologies and tools is divided into several main categories based on their functions in learning activities.

The survey data indicate that kindergarten teachers use a variety of technologies and tools to support STEAM learning. The use of educational toys and teaching aids is highly dominant, followed by digital devices and technology. Learning media and educational aids are also frequently used to enrich learning activities. In addition, recycled materials and natural resources are creatively used to teach STEAM concepts in an environmentally friendly and economical way. Equally important, learning experiences through exploring the surrounding environment complement the STEAM learning approach in kindergarten. This reflects the teachers' commitment to using various resources to create interactive and enjoyable learning experiences for children.

After reviewing the respondent data, it can be identified that educational toys and teaching aids are the dominant categories frequently used in STEAM learning in kindergartens. This includes various types of toys such as LEGO, blocks, plasticine, and teaching aids for numbers, letters, and mathematics. These educational toys are widely used because they help children understand basic concepts in an interactive and enjoyable way. Furthermore, digital devices and technology such as laptops, screens, projectors, and various learning applications are also frequently used to support STEAM learning. The use of these digital devices provides access to a wider range of learning resources and facilitates a more dynamic learning process. Recycled materials and natural resources are also popular choices among teachers. The use of these items not only supports creativity but also teaches children about the importance of recycling and utilizing available resources around them. Overall, educational toys, digital devices, and recycled materials and natural resources are the three main categories dominantly used in STEAM learning in kindergartens.

Table 1. Types of Technology and Devices in STEAM Learning in Kindergartens

Educational Toys and Teaching Aids	Digital Devices and Technology	Learning Media and Educational Teaching Aids	Recycled Materials and Natural Resources	Learning Experiences and Environment
▪ LEGO ▪ Drawing board ▪ Number, letter, Hijaiyah teaching aids ▪ Mathematics teaching aids ▪ Educational toys, posters, flashcards ▪ Toys for choosing pictures, sticking, etc. ▪ Blocks, plasticine ▪ Dice blocks ▪ Beads, loose parts materials, paints, etc. ▪ Traditional toys or recycle handmade toys ▪ Puzzle ▪ Number blocks and picture cards as well as imitation toys	▪ Laptop, screen, and projector ▪ Smart TV, ▪ Social media ▪ Using TAB with enuma program ▪ Mobile Phones ▪ Interactive media ▪ Videos on Youtube ▪ Power point ▪ Learning media using projectors ▪ Devices used: Kinemaster ▪ Canva	▪ Learning media and educational teaching aids ▪ Learning models ▪ Colour mixing experiments ▪ Playing with blocks ▪ Learning media using projectors ▪ Learning media using Power Point ▪ Natural materials, projector, TV, etc.	▪ Recycle unused materials ▪ Educational toys, recycled materials, natural resources, electronics, etc. ▪ Recycled materials, natural resources, electronics, etc. ▪ Recycled materials ▪ Loose part ▪ Simple technology around children, e.g., scales, coconut grater, used bottles, blocks ▪ Used materials, natural resources, loose part ▪ Natural materials and loose part ▪ Toys from recycled materials like aqua bottles	▪ Exploring the school environment ▪ Introducing the surrounding environment

Source: Processed from research survey data

Strategies for Integrating the Merdeka Curriculum with STEAM Elements in Kindergarten Learning

The respondents identified various strategies for integrating STEAM elements into kindergarten learning. These strategies can be classified into several main categories: (1) Child-Centered Learning Approach is one of the main strategies emphasized by many respondents. This approach includes learning through play, being oriented towards the development and needs of children, and giving children the freedom to choose activities they enjoy. It aims to create enjoyable and meaningful learning experiences tailored to children's interests and needs, in line with Sujana (2019), who stated that the Independent Curriculum emphasizes a Child-Centered Learning approach. (2) Use of Media and Educational Teaching Aids is also a key strategy to enhance children's engagement. Respondents highlighted the importance of using attractive media, educational tools, and materials available around the school–such as recycled items or simple materials–to encourage creativity and interactive

participation in learning. (3) Planning and Creating a Comfortable Learning Environment is another important strategy. This includes thorough planning and providing a safe, enjoyable atmosphere where children feel happy and not pressured. Such an environment stimulates curiosity, critical thinking, and problem-solving. (4) Enhancing Teacher Competence is considered essential to ensure the successful implementation of STEAM learning. Respondents mentioned attending training, webinars, and participating in learning communities, as well as collaborating with colleagues to share experiences and strengthen teaching practices. (5) Integrating STEAM Elements into Learning is also viewed as a critical strategy. This involves designing learning approaches that incorporate science, technology, engineering, arts, and mathematics to develop the essential skills and abilities children need for the future.

Overall, the respondents' responses indicate that integrating STEAM elements into kindergarten learning can be achieved through a holistic and collaborative approach, focusing on the needs and interests of children and enhancing teacher competence. The benefits of these strategies include improving critical thinking, creativity, problem-solving, and active participation of children in learning.

Key Benefits of the STEAM-Based Merdeka Curriculum in Kindergarten Learning

Based on the survey results on the benefits of using the STEAM-based Merdeka Curriculum in early childhood education in kindergarten, respondents' views can be grouped into several main themes. Overall, the responses indicate that this curriculum has significant benefits in supporting children's development: Enhancement of critical thinking skills is one of the most frequently mentioned advantages. Many respondents emphasized that the curriculum encourages children to think critically, break down barriers of ideas, and develop their observational abilities from their surroundings. As many as 16 respondents (36.4%) stated that this approach makes children more active in problem-solving and analytical thinking, as reflected in responses like "Teaching children to think critically" and "Making children think critically." (2) Increase in creativity is another important benefit. A total of 14 respondents (31.8%) mentioned that STEAM activities give children the freedom to express their imagination and enhance their creativity. Responses such as "Enhancing children's creativity" and "Children are free to express their imagination" indicate that this curriculum supports a creative and exploratory learning environment. This aligns with the findings of Alpiyah (2023), who noted that creativity can flourish through project-based independent learning, particularly during the golden age of child development. (3) Enjoyable and meaningful learning is also a prominent feature of the STEAM curriculum. Ten respondents (22.7%) stated that children show more enthusiasm and interest during STEAM-based activities, making the learning experience both fun and effective. Comments like "Learning activities become more enjoyable, interesting, and increase children's curiosity" illustrate this point. (4) Utilization of available resources is another strength of the curriculum, as it encourages the use of materials found in the surrounding environment. Five respondents (11.4%) pointed out that learning can be enriched by making use of everyday items, as seen in remarks such as "We can utilize the learning resources available around us." (5) Learning according to interests and talents is also facilitated by the STEAM approach. Six respondents (13.6%) noted that the curriculum allows children to explore their own interests and talents, helping them reach their full potential. Statements like "Students can learn according to their own interests and talents" reflect how this flexible and personalized approach supports holistic child development.

Challenges in Implementing the STEAM-Based Merdeka Curriculum in Early Childhood Education

In the effort to improve education quality, kindergartens are trying to implement the Merdeka Curriculum using the STEAM (Science, Technology, Engineering, Arts, and Mathematics) method. However, this journey is not easy. From the conducted survey, it was found that the biggest challenge is the limitation of resources and facilities, with 40.9% of respondents identifying this as the main obstacle. Many kindergartens still lack adequate equipment and facilities to support STEAM-based learning.

Moreover, another significant challenge is the lack of training and understanding for teachers. A total of 38.6% of respondents mentioned that they need more training and support in integrating STEAM concepts into daily learning activities. Without adequate understanding, the implementation of this method becomes less effective and does not achieve the expected goals.

Additionally, 34.1% of respondents stated that they find it difficult to integrate STEAM concepts into learning. Integrating various disciplines into a cohesive learning method requires deep skills and understanding, which often poses a challenge for teachers. Support from the school or institution is also highlighted, although only 4.5% of respondents consider it the main obstacle. This support is crucial to provide the motivation and assistance needed by teachers in implementing the STEAM method.

Although constraints such as limitations of devices and software, funding, and time for preparing STEAM learning were mentioned by a small number of respondents (each 2.3%), they still represent factors that cannot be overlooked in the effort to implement this curriculum.

In terms of geographical and institutional diversity, the majority of respondents were from urban areas and private institutions, which may influence the challenges identified. Urban areas often have better access to resources and training opportunities compared to rural areas. Similarly, private institutions may have different support structures compared to public schools.

To address these challenges, appropriate policies, continuous training, and support from various parties are essential. For instance, providing targeted training programs and increasing resource allocation can help bridge the gaps in implementation. Additionally, fostering collaboration among educators through learning communities can enhance the sharing of best practices and innovative solutions.

Overall, the survey results indicate that the implementation of the Merdeka Curriculum with the STEAM method in kindergartens faces various challenges that need to be addressed with appropriate policies, continuous training, and support from various parties to achieve optimal results. This can be seen in the diagram below:

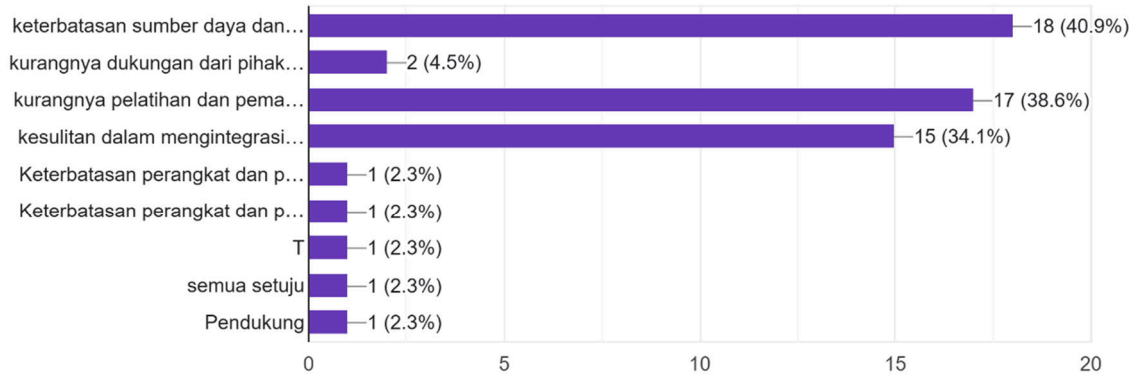

Figure 1. Challenges in Implementing the STEAM-Based Merdeka Curriculum in Kindergarten Learning

Based on the survey results regarding the main obstacles or challenges in implementing the Merdeka Curriculum using the STEAM method in Kindergartens, it is evident that one of the major challenges faced is the limitation of resources and facilities, with 18 respondents (40.9%) mentioning this as a significant issue. Additionally, 17 respondents (38.6%) felt that the lack of training and understanding for teachers also poses a major barrier in the implementation of the STEAM method. Other notable challenges include difficulties in integrating STEAM concepts into learning, with 15 respondents (34.1%) stating this as a challenge. Support from the school or institution is also considered insufficient by some respondents (4.5%). Furthermore, a few respondents pointed out the

limitations of devices and software, funding constraints, as well as limited time for preparing STEAM learning as obstacles, although the number of respondents mentioning these issues is relatively small, with each being cited by 1 respondent (2.3%). These results show that the biggest challenges in implementing the Merdeka Curriculum using the STEAM method are related to resources, facilities, and teacher training.

Impact on the Development of Children's Cognitive Abilities and Creativity in Kindergarten

This section discusses the results of the data analysis from respondents, focusing on the impact of the STEAM-based Merdeka Curriculum on the development of children's cognitive abilities and creativity in kindergarten. The findings highlight significant positive impacts as observed and reported by kindergarten teachers. The implementation of the STEAM-based Merdeka Curriculum in Kindergartens has a significant positive impact on the development of students' cognitive abilities and creativity. This curriculum provides opportunities for students to explore and express their learning interests, aiming to shape students with good competence and character. Respondents identified that this approach teaches children to think critically and solve problems. This is reflected in responses such as "Children can think critically and solve problems" and "Fostering critical thinking in children, enthusiastic about learning because the learning is fun."

For example, in kindergarten science experiments, children are encouraged to mix various colours of water using pipettes, observe the changes, and ask questions about the results. Similarly, they might build towers from blocks, thinking critically about how to construct a stable structure. Such activities help foster critical thinking skills, enabling children to be more active in problem-solving and analytical thinking. Quantitatively, 36.4% of respondents highlighted the enhancement of critical thinking skills as a significant impact. The observed attitudes included curiosity, analytical thinking, and questioning behaviour.

Many respondents noted that through STEAM-based learning, children in kindergarten become more creative and free to express their imagination. For instance, in art projects, children use recycled materials such as plastic bottles and cardboard to create artistic works like robots or hats decorated with dried leaves they collect from the school yard. Responses like "Children can be more creative" and "Enhancing creativity through STEAM Learning in Children Aged 5-6" indicate that this curriculum provides a supportive environment for children to innovate and create. Quantitatively, 31.8% of respondents observed an increase in children's creativity. The observed attitudes included innovation, imagination, and artistic expression.

Enjoyable and meaningful learning becomes one of the positive impacts of this curriculum implementation in kindergarten. Children feel happy and joyful during the learning process, making them more enthusiastic about learning. Activities such as using educational toys like LEGO or building blocks to understand basic mathematical concepts or making fruit juice together, where children learn scientific processes and life skills while enjoying the activity, affirm this. Responses such as "Children enjoy learning" and "Very good, because children feel happy and joyful during learning" support this observation. Quantitatively, 22.7% of respondents noted that learning becomes more enjoyable and meaningful. The observed attitudes included enthusiasm, joy, and active participation.

Some respondents mentioned that this curriculum leverages available learning resources around the kindergarten, such as everyday materials. For example, teachers might take children on a walk around the school to identify different types of plants and insects or use simple materials like plastic bottles and straws to create windmills, fostering a sense of creativity and resourcefulness. Responses include "We can utilize the learning resources available around us," with 11.4% of respondents highlighting this aspect. The observed attitudes included resourcefulness, environmental awareness, and practical application of concepts.

The curriculum also allows kindergarten students to learn according to their own interests and talents, enabling them to develop their potential optimally. This flexibility is evident in activities where children are free to choose between drawing, playing music, or reading books, receiving guidance and support from teachers based on their individual interests and talents. Responses like

"Students can learn according to their own interests and talents" illustrate this benefit, with 13.6% of respondents mentioning it. The observed attitudes included motivation, self-direction, and personalized learning.

To strengthen the findings, both quantitative and qualitative data were collected and analysed. The survey data indicates that kindergarten teachers see significant benefits from implementing the STEAM-based Merdeka Curriculum.

Table 2. Impact of the STEAM-Based Merdeka Curriculum on Kindergarten Children's Cognitive Abilities and Creativity

Impact	Percentage of Respondents (%)	Kindergarten s students Observed Attitudes
Enhancement of Critical Thinking Skills	36.4	Curiosity, analytical thinking, questioning behavior
Increase in Creativity	31.8	Innovation, imagination, artistic expression
Enjoyable and Meaningful Learning	22.7	Enthusiasm, joy, active participation
Utilization of Available Resources	11.4	Resourcefulness, environmental awareness, practical application
Learning According to Interests and Talents	13.6	Motivation, self-direction, personalized learning

Source: Processed from research survey data

In addition to quantitative data, qualitative responses were analysed to understand the specific ways in which the STEAM-based Merdeka Curriculum impacts children's cognitive abilities and creativity in kindergarten. The following quotes illustrate the positive effects observed by teachers: "Children can think critically and solve problems," "Fostering critical thinking in children, enthusiastic about learning because the learning is fun," "Children can be more creative and freer to express their imagination," and "Very good, because children feel happy and joyful during learning."

Research by Zeng et al. (2018) found that STEM education is conducive to improving students' higher-order thinking and cognitive ability levels with an effect size of (d = 0.798). This meta-analysis synthesizes data from several STEM studies worldwide, indicating that teaching methods and student experiences in STEM education have a positive effect on student learning. Alpiyah (2023) showed that creativity grows through project-based learning, especially in young children. This aligns with our findings that STEAM-based learning allows children to express their imagination and develop creativity (Filipe et al., 2024). Macalalag (2022) highlighted that engaging learning activities increase students' enthusiasm and interest in learning. The positive responses from our study indicate that the STEAM approach makes learning more enjoyable and meaningful for children. A study by brahim Ya ar KAZU (2021) emphasized the importance of utilizing everyday materials and resources in STEAM education to foster creativity and problem-solving skills. Our findings also support this approach, as teachers highlighted the use of available resources. According to Heni et al. (2021), allowing students to learn according to their interests and talents can significantly enhance their motivation and engagement. This is consistent with our findings that the STEAM curriculum provides flexibility and freedom in the learning process. Moreover, a recent study by Atikah & Biru (2024) indicates that integrated STEAM activities can enhance children's collaborative skills and emotional development, which align with the observed positive attitudes in this study. Another study by Hrynevych et al. (2021) found that the use of digital tools in STEAM education enhances technological literacy and problem-solving skills, supporting the findings related to resource utilization and practical applications. Additionally, that research suggests that STEAM-based projects improve children's resilience and adaptability, which are crucial for their overall development. Atikah & Biru (2024), ibrahim Yaşar KAZU (2021), and Stone (2024) highlighted the role of play in enhancing

cognitive and creative development in early childhood education, which aligns with our findings on enjoyable and meaningful learning.

By integrating previous research and supporting literature, we strengthen our findings and align them with the title of the article, "Implementation of the STEAM-Based Merdeka Curriculum in Kindergarten Learning: Challenges and Its Impact on Children's Cognitive and Creative Development." The results of this study provide a comprehensive understanding of how the STEAM-based Merdeka Curriculum positively impacts children's cognitive abilities and creativity, creating a conducive learning environment for their holistic development. This is in line with the goals of early childhood education to foster well-rounded individuals with strong cognitive, creative, and social-emotional skills.

Addressing the reviewer's comments, the study includes quantitative data to support the qualitative findings, analyses the potential biases due to the sample's geographical and institutional diversity, and compares the results with previous research. The strategies for implementation have been detailed, and the impact on non-academic aspects, such as social-emotional development, has been acknowledged. With these considerations, the study provides a robust analysis of the benefits and challenges of implementing the STEAM-based Merdeka Curriculum in kindergartens.

Conclusion

The implementation of the STEAM-based Merdeka Curriculum in Kindergarten learning shows various significant positive impacts, especially on the development of children's cognitive abilities and creativity. Based on the survey results and respondents' feedback, the application of this curriculum allows students to be more active in exploring and expressing their learning interests. This is reflected in the enhancement of critical thinking and problem-solving skills in children, as well as the development of their creativity. For example, students participate in science experiments, build towers from blocks, and engage in art projects using recycled materials, all of which foster critical thinking and creativity.

Students become more enthusiastic and motivated to learn, creating an enjoyable and meaningful learning environment. The use of various media and educational teaching aids, along with a child-centered approach, further enriches their learning experience. This curriculum also leverages available resources around the kindergarten, such as everyday materials, to support learning activities and foster resourcefulness and environmental awareness among students.

However, the implementation of this curriculum is not without challenges. Some teachers identified the need for advanced training and thorough preparation to optimize the application of the STEAM curriculum. Teacher involvement in learning communities, webinars, and training is crucial for enhancing their competence in implementing this curriculum. Additionally, accurate evaluation through summative and formative assessments helps in precisely measuring learning outcomes and children's development.

To address these challenges and enhance the effectiveness of the STEAM-based Merdeka Curriculum, several recommendations are proposed. It is essential to provide intensive and continuous training for teachers to enhance their understanding and implementation of the STEAM-based curriculum. This can be achieved through workshops, webinars, and professional development programs. The government and educational institutions should allocate sufficient budget for the development and maintenance of STEAM-related infrastructure, including laboratories, educational tools, and digital resources. Developing implementation guidelines that are tailored to local contexts can help schools adapt the curriculum effectively. These guidelines should consider the unique needs and resources of each school and community. Schools should collaborate with educational experts and researchers to continuously improve the curriculum and address any emerging challenges. This collaboration can also provide valuable insights into best practices and innovative teaching methods. Encouraging community and parental involvement in the learning process can enhance the

effectiveness of the curriculum. Workshops and information sessions for parents can help them support their children's learning at home. Implementing regular monitoring and evaluation processes to assess the effectiveness of the curriculum and make necessary adjustments. This can include feedback from teachers, students, and parents, as well as standardized assessments.

This study has several limitations that should be acknowledged. The sample size of 44 respondents is relatively small and may not fully represent the diverse population of kindergarten teachers in West Java. The predominance of respondents from urban areas and private religious institutions introduces a potential bias, as these settings may have different resources and support compared to rural and public schools. Additionally, the cross-sectional design of the study limits the ability to observe long-term impacts of the STEAM-based curriculum.

There are numerous opportunities for future research to build on the findings of this study. Longitudinal studies could provide insights into the long-term impact of the STEAM-based Merdeka Curriculum on children's cognitive and creative development. Exploring the implementation of the STEAM curriculum in rural areas and public schools could offer a more comprehensive understanding of its effectiveness across different contexts. Further research could also investigate the impact of specific training programs and resources on teachers' ability to effectively implement the curriculum.

Overall, the STEAM-based Merdeka Curriculum in Kindergarten provides great benefits in supporting the holistic development of children, both in terms of cognitive abilities and creativity. The dominant support from respondents indicates that this curriculum has great potential to improve the quality of early childhood education in Indonesia. With a collaborative approach that focuses on children's needs and continuous support for teachers, the existing challenges can be overcome, and the maximum benefits of this curriculum can be achieved.

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