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Teacher Agency in the Development of Integrated Science Curriculum: A Case Study in Elementary School

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A B S T R A C T

The development of a STEAM integrated science curriculum within the Merdeka Curriculum demands a high level of teacher agency because teachers play a direct role in translating curriculum policies into classroom learning practices. This study aims to analyse the agency of classroom teavhers in the development of STEAM integrated science curriculum, including their perceptions, teaching, and the challenges and supporting factors for its implementation. The research uses a qualitative approach with a case study design. The research subject is one elementary school teacher who has implemented STEAM based science learning. Data collection techniques include in-depth interviews, classroom observation, reflective questionnaires, and analysis of learning documents. Data analysis was conducted through data reduction, data presentation, and coclusion drawing, with data validity maintained through source and technique triangulation. The research findings indicate that teachers have a positive perceptions of STEAM integration and demonstrate strong agency through autonomy in adapting the curriculum, developing contextual teaching modules, and implementing project-based learning and simple experiments. However, the implementation of STEAM still faces obstacles such as limited facilities, time, and conceptual understanding of STEAM. The conclusion of this study confirms that the success of integrated STEAM science curriculum development is highly influenced by teacher agency, supported by curriculum flexibility, professional collaboration, and technological support.

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1. INTRODUCTION

Education plays an important role in creating high-quality human resources capable of competing globally. The rapid advancement of science and technology requires the education sector to face increasingly complex challenges. Education at the elementary school level plays a very important role in building students' mindsets and skills for the 21st century (Agung et al., 2024). Critical thinking skills are essential skills that should be learned from an early age. However, the reality on the ground is that many students still struggle to analyse data and information, solve problems, and develop data- and logic-based solutions (Syarief, 2025). This aligns with STEAM learning, which can encourage students to solve complex problems (Fifi & Risfaula, 2023). Therefore, teachers can play a key role in effectively implementing project-based STEAM in science learning. The interdisciplinary learning method, commonly referred to as the STEAM approach, combines five fields of knowledge: science, technology, engineering, arts, and mathematics. The goal of the STEAM approach is to create a dynamic, creative, and innovative learning environment that encourages students to think critically, solve problems, and collaborate (Kartikawati & Istianah, 2023).

STEAM learning is closely related to the Merdeka Curriculum Education policy in Indonesia. STEAM learning can significantly help students become more creative and analytical in facing 21st-century challenges, which aligns with the Merdeka Curriculum (Muftidafila et al., 2025).The Merdeka Curriculum emphasises learning flexibility, differentiation, and teacher autonomy in developing the curriculum (Mujtahid et al., 2025). The Merdeka Curriculum also provides teachers with the space to adapt teaching modules and learning strategies to the school context and student characteristics. However, this flexibility also requires teachers to be professionals ready to interpret curriculum policies into relevant learning practices (Husnul et al., 2025).

In the context of curriculum implementation that emphasises flexibility and learning autonomy, teacher agency holds a strategic position as the foundation for pedagogical decision-making. Teacher agency is understood as teachers' professional capacity to reflect on their teaching practices (Yahya & Martha, 2025) and to act autonomously and responsibly in developing and adapting the curriculum at the classroom level. The implementation of the Merdeka Curriculum demands a high level of teacher agency, considering teachers are the main actors in translating curriculum policies into contextual and meaningful learning practices (Dewi & Kuswandono, 2025).Therefore, agency can influence how teachers interpret the curriculum and teach according to learning practices that are appropriate for students and the school context (Efendi & Arijanto, 2025).

Although the STEAM approach offers great potential, various studies indicate that its implementation in elementary schools still faces challenges. One of these studies (Muftidafila et al., 2025)found that some of the challenges faced by teachers include a lack of pedagogical knowledge and difficulties in implementing STEAM content in learning (Rachmadtullah et al., 2025). Teachers experience difficulties in fully understanding the concept of STEAM integration, especially in connecting engineering and arts elements with science competencies. Additionally, limitations in professional development, planning time, and school facilities and policies also influence the practice of STEAM learning(Anindya & Suryanti, 2023). This condition indicates that the success of STEAM integration not only depends on curriculum design, but is heavily determined by the capacity and agency of classroom teachers as the primary drivers of learning.

Elementary school classroom teachers play a strategic and complex role in the development of integrated STEAM science curriculum (Qomariyah et al., 2025), because in addition to teaching various subjects, teachers are also responsible for integrating learning holistically according to the characteristics of the students. In the implementation of the Merdeka Curriculum, teachers are given broader autonomy to design and adapt learning at the classroom level, thus demanding strong professional capacity and agency in pedagogical decision-making (Rahmawati & Astuti, 2024). Research (Hafizhah et al., 2024)has described the implementation of STEAM in science learning in the classroom, teachers' understanding of STEAM concepts, limitations, and the lack of professional training for teachers. However, research has not yet specifically examined how teacher agency adapts the curriculum and modifies teaching modules for STEAM-integrated science learning.

This study aims to analyse how classroom teachers' agency contributes to the development of STEAM-integrated science within the Merdeka Curriculum, classroom teachers' practices in implementing and designing STEAM-based science learning, and to identify the challenges and supporting factors faced by classroom teachers in developing STEAM-based science curriculum in the classroom.

2. RESEARCH METHODOLOGY

This research uses a qualitative methodological approach and employs a case study as its design (Alimun, 2025). Researchers chose this qualitative approach because the study aims to deeply understand the agency of classroom teachers, including their perceptions, practices, and the challenges they face in developing an integrated STEAM science curriculum within the real-world context of elementary school learning. The case study allows researchers to explore the phenomenon holistically and contextually, aligning with the characteristics of STEAM implementation, which is highly influenced by school policies, teacher competence, and learning culture.

The research subjects are one classroom teacher who has implemented science learning with the STEAM approach. The classroom teacher who is the research subject has experience designing science learning by integrating STEAM, is active in implementing the independent curriculum, and is directly involved in developing STEAM-based science learning materials. The research instrument is an interview focused on the teacher's cognitive foundation, the teacher's involvement in science curriculum planning, and the teacher's initiative and creativity in integrating STEAM, and it reveals the teacher's structural limitations.

Data collection techniques in this study include in-depth interviews with classroom teachers, questionnaires, and documentation. In-depth interviews were conducted using an interview guide containing questions about (1) classroom teachers' understanding and perceptions of STEAM learning, (2) teachers' decision-making when designing STEAM-integrated science learning, (3) classroom teachers' initiatives and creativity in developing STEAM-integrated science teaching modules, and (4) the obstacles and support experienced by classroom teachers in implementing STEAM in learning. Classroom observations were then conducted to record the implementation of STEAM learning in the classroom, as well as the role of classroom teachers as facilitators and student participation in STEAM learning. Questionnaires were given to classroom teachers as a written reflection on their experiences in implementing STEAM-based science learning; the questionnaire instruments contained questions that elicited in-depth narrative responses. The documentation uses an analysis of teacher documents, including teaching modules, learning tools, and STEAM-based science learning assessment instruments created by the teachers.

Next, the collected data was compiled into a narrative describing the roles and institutions of teachers in designing and implementing the STEAM-integrated science curriculum. The final stage was drawing conclusions, which included the final data analysis stage where documentation, interviews, and questionnaires were integrated. Data validity through source triangulation and research techniques by comparing data from interviews, classroom observations, questionnaires, and documents to determine the consistency of information obtained from teachers. This can provide a comprehensive overview of how teachers can contribute to the development of STEAM-based curricula.

3. RESEARCH AND DISCUSSION

This study aims to examine how classroom teachers perceive the development of a STEAM-integrated science curriculum, their teaching practices, and the implementation challenges they face when implementing STEAM-integrated science lessons. Based on the results of a questionnaire survey conducted with classroom teachers, along with additional documentation related to classroom teachers' agency towards the STEAM-integrated science curriculum. In this study, classroom teachers were asked several questions to guide the interview, allowing the researcher to understand their agency in answering questions about the STEAM-integrated science curriculum.

3.1. The Central Role of the Classroom Teacher in the Development of STEAM-Based Sciene Learning

First, the role of teachers in the research results shows that strict teachers play a very central role in the development and implementation of STEAM-based science. Classroom teachers design learning activities based on students' needs and characteristics by developing flexible teaching modules.

Second, the classroom teacher here positions themselves not only as a material presenter in the classroom, but also as a facilitator, designer of student learning experiences, and motivator in learning. The role of this classroom teacher is realised through planning real-world problem-based learning, and for assessment in developing 21st-century skills, one of which is students' critical thinking (Khoiriya et al., 2023).

Picture 1. Interview with the classroom teacher

Third, the classroom teacher also plays the role of evaluator in STEAM-based science learning. The evaluation activities carried out by the teacher are not only focused on the students' final results but rather emphasise the learning activities that are taking place. The teacher assesses the effectiveness of learning by observing students' attitudes, responses, and participation during the learning process.

3.2. Classroom Teacher Autonomy in Adapting the Science Curriculum

From the results of the class teacher interviews, it was shown that teachers have flexibility in adapting the science curriculum to the needs and characteristics of their students. This autonomy can be seen in the development of teaching modules, the selection of learning methods, and the adjustment of learning evaluations. Teachers view the curriculum as a flexible framework that can be developed contextually to make learning more meaningful. This aligns with the independent curriculum, which takes a more flexible approach and focuses on student needs. This allows teachers to adjust the material to students' abilities and local context during the learning planning process (Maria et al., 2025).

3.3. Teacher Initiatives Based on Students Needs and Characteristics

Given the students' condition, teachers need flexibility and pedagogical sensitivity. This reinforces the idea that the success of STEAM-based science learning is highly dependent on the teacher's ability to understand and respond to the diversity of their students.

3.4. Contextual and Simple STEAM Implementation Practices

The STEAM approach is applied by teachers in contextual and simple learning practices. Project-based learning and hands-on experiments are used, utilising available tools such as simple technology and recycled materials. This method shows that the implementation of STEAM depends more on teacher creativity than on sophisticated facilities.

3.5. Challenges and Support in STEAM Development

The interview results revealed that one of the main challenges in developing STEAM-based science learning lies in the limited availability of facilities and infrastructure, particularly technology-based learning aids. This limitation affects how teachers can effectively integrate technological elements into science learning, forcing them to modify their teaching strategies to still achieve learning objectives. Besides resource limitations, teachers also face the challenge of adapting STEAM learning to different student conditions and characteristics. Teachers must ensure that the designed learning remains relevant, meaningful, and accessible to all students, even if supporting facilities are not yet adequate.

On the other hand, the interview results indicate that there are important supporting factors in the development of STEAM-based science. The teacher stated that technological support such as the use of AI helps teachers in lesson planning, finding references, and addressing shortcomings in the learning process (Amelia et al., 2024). Technology is used for teaching and assisting with planning. Besides technological support, collaboration with peers is also very important. Teachers see collaboration as a way to share ideas, get advice, and reflect on lessons learned. Discussions with other teachers help broaden perspectives and improve the quality of STEAM-based science development.

Next, a study was conducted on learning materials, teaching modules, assessments, and science learning implementation notes in the classroom. The results of this study are used to show how teachers design and implement STEAM-based science in student learning. The lesson planning documents indicate that the teacher has created teaching modules and learning tools that incorporate art, mathematics, science, technology, and engineering.

Students are not only expected to master science concepts, but also to enhance their creativity, problem-solving skills, and critical thinking. Learning activities in the teaching module are adapted to student characteristics and the learning environment context. Students can connect science concepts with everyday life phenomena through learning activities designed by the teacher that are contextual and problem-based. This shows that the STEAM-based science program is flexible and adaptable.

STEAM-based science learning is conducted through simple experimental activities, group discussions, and project-based assignments. Students were actively engaged in the learning process by observing, experimenting, speaking, and presenting the results of their activities. This is demonstrated by observation notes and photos of classroom activities.

Picture 2,3 students are actively involved in learning and the teacher acts as a facilitator

During the learning process, the teacher functions as a facilitator who provides direction, guidance, and feedback. Although teachers don't dominate the lessons, they encourage students to participate actively and work together. This research shows that STEAM-based science learning is implemented in a student-centered and participatory manner. The documentation results show that STEAM-based science learning has been planned, implemented, and evaluated systematically. The documentation also shows consistency between the planning, implementation, and assessment of learning. This result provides an empirical picture of how teachers develop STEAM-based science in the classroom.

The purpose of this study is to interpret the results of interviews conducted by teachers in the classroom and documentation of STEAM-based science learning. By integrating these two data sources, this study provides a broad overview of the role of teachers, pedagogical decision-making processes, and the challenges and support related to the development of STEAM-based science learning.

The Role of the Teacher as the Main Actor in the Development of STEAM Based Science Learning

The interview results indicate that the role of the teacher is very important in the design, implementation, and evaluation of STEAM-based science learning. Teachers are not only responsible for creating the curriculum. Nevertheless, as teachers, they also adjust learning experiences to meet the needs and characteristics of students. The documentation results show the process of developing teaching modules, contextual learning planning, and adapting project-based and experimental learning activities.

The integrase results indicate that the implementation of STEAM in science learning is highly dependent on the role of the teacher. The teacher plays an active role in transforming

STEAM ideas into relevant and meaningful learning practices for students. This aligns with the idea that the success of learning innovation is not only determined by policy or curriculum, but also by the teacher's ability to develop and adapt learning.

Pedagogical Decision Making Based on Student Needs and Characteristics

The interview results indicate that teachers conduct cognitive and non-cognitive assessments before designing STEAM-based science learning. This practice demonstrates that pedagogical decisions are made carefully and focus on the learners. In determining learning strategies, teachers consider students' initial abilities, readiness to learn, and characteristics. Additionally, they consider how complex the STEAM learning activities are. To support documentation results, lesson plans and teaching modules are adapted to meet the needs of the students. This data integration shows that STEAM-based learning designed with science in mind is inclusive and adaptable, considering student diversity.

Implementation of STEAM-Based Science Learning and Student Engagement

The results of interviews and learning documentation show that the STEAM-based science learning approach utilises learning activities that emphasise active student engagement. Teachers integrate Science, Technology, Engineering, Arts, and Mathematics elements into simple experiments, group discussions, and project-based learning relevant to the students' life context.

Teacher agencies assist and guide students during learning. Students have the opportunity to actively participate in learning activities such as observing, experimenting, and problem-solving. The documentation results of the learning implementation show that students not only receive knowledge but are also directly involved in the learning process, which requires cooperation and critical thinking. STEAM-integrated science learning relies on student engagement. By observing the students' responses, enthusiasm, and attitudes during the learning process, teachers can evaluate the effectiveness of the learning. This result indicates that students' emotional and social engagement is considered important for the success of STEAM learning.

Thus, student engagement in STEAM-based science learning is not only an outcome of the teaching strategies implemented, but also becomes the learning objective itself. The implementation of STEAM, which places students as active subjects of learning, demonstrates that science learning can be designed to be more meaningful, contextual, and responsive to students' needs.

Challenges and Support in Developing STEAM-Based Science Learning

The results of the interviews and discussions showed that the main obstacle to developing STEAM-based science learning is the limited availability of facilities and infrastructure, especially technological aids. However, teachers can overcome this problem by utilising their learning resources and adapting their teaching to field conditions.

However, collaboration with peers and digital technology support are important factors in supporting the development of STEAM-based science learning. This finding indicates that the successful implementation of STEAM is not only determined by the availability of facilities, but also by how teachers can optimally utilise professional support and technology.

4. CONCLUSION

This research shows that classroom teachers play a central role in the development and implementation of STEAM-based science learning. Teachers are not only curriculum implementers, but also learning designers, facilitators, evaluators, and innovators who actively adapt learning to students' needs and characteristics.

The research findings reveal that teachers' initiative in integrating STEAM is driven by their understanding of students' initial abilities, potential, and readiness to learn. STEAM-based science learning is designed contextually and adaptively because mapping student conditions facilitates reflective pedagogical decision-making. This method allows students to actively participate in the learning process. This also supports the development of their ability to think critically, creatively, and collaboratively.

This study also shows that STEAM-based science learning has a dynamic between challenges and support. Teachers face many challenges because they lack sufficient advice and infrastructure, particularly regarding technology. However, digital technology support and collaboration with peers are crucial to helping teachers develop creative and sustainable learning approaches. Overall, STEAM-based science learning can be successful if teachers have room for initiative, adequate professional support, and the reflective ability to assess and improve their teaching. This finding confirms that the success of STEAM-based science learning is highly influenced by the agency and professionalism of classroom teachers.

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