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Strengthening Computational Thinking through Innovative STEAM Activities in Early Childhood Education

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ABSTRACT

This study aims to describe the strengthening of computational thinking through innovate STEAM activities in early childhood at Joy Kids National Plus. The background of the study is the importance of building logical and systematic thinking patterns from an early age through a fun and integrated learning approach. The study used a qualitative approach with a case study method. Data collection techniques include observation, interviews, and documentation. The result showed that STEAM activities at Joy Kids Kindergarten were designed in the form of simple projects that combine elements of science, technology, engineering, art, and mathematics. The teacher's strategy in facilitating activities provides space for exploration, collaboration, and reflection. Children demonstrate computational thinking skills such as recognizing patterns, solving problems, and compiling solution steps. Teachers have a positive perception of the implementation of STEAM, despite

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technical challenges. Overall, the STEAM approach is effective in forming the basis of computational thinking in early childhood.

Introduction

The development of the era marked by the acceleration of digitalization has changed the way humans live, work, and learn. The world is currently moving towards a new order that requires every individual to have more complex, adaptive, and creative thinking abilities. The industrial revolution 4.0 has even entered a more advanced phase, namely society 5.0, where the integration between humans and technology becomes closer (Tavares et al., 2022). Consequently, education is required not only to teach basic knowledge, but also to prepare a generation that is able to think critically, solve problems, and understand technology from an early age.

This phenomenon has direct implications for the world of early childhood education. For years, education for preschoolers was seen as sufficient with free play, learning letters and numbers, and basic motor activities. Imamah & Muqowim (2020) explain that early childhood is actually a golden period for building a strong foundation for thinking. This includes the ability to recognize pattern, organize logical thinking steps, and practice solving problems independently all of which are basic elements of the ability known as computational thinking.

Globally, several countries have integrated computational thinking approaches into their early childhood education curriculum. Countries such as Finland, South Korea, and Singapore have already designed play activities that are exploratory, problem-solving, and based on simple technology, to stimulate children's thinking. Mulyati (2023) explain that activities such as compiling step by step instructions, recognizing errors in patterns, or using sensor based robotic tools have become part of children's daily lives in the classroom, without neglecting the play aspect that is the hallmark of early childhood education.

In Indonesia, although not yet a national policy several schools have begun to implement a similar approach. There is an increase in the number of institutions that integrate STEAM (Science, Technology, Engineering, Arts, and Mathematics) elements in early childhood learning. The STEAM approach is considered capable of providing a holistic, active, and contextual learning experience, which encourages children to think across disciplines while still playing (Wahyuningsih et al., 2020). In line with this, Gilano et al. (2024)) emphasized that children at the early childhood stage possess a strong intrinsic drive to investigate, observe carefully, and explore their surroundings, making exploratory STEAM-based activities particularly suitable for nurturing their curiosity and cognitive engagement. Chang et al. (2023) explain that innovatively designed STEAM activities also have a great opportunity to instill computational thinking skills naturally and enjoyably. In a similar vein, Atikah & Biru (2024) highlight that open-ended STEAM challenges designed by teachers—where answers are not directly given—encourage young children to be curious, collaborate with peers, and think creatively throughout the learning process.

Supporting this perspective, Johnston et al. (2022), through a comprehensive scoping review, concluded that STEAM holds greater relevance than pure STEM in early childhood education, as it incorporates arts and literacy to help children represent and make sense of scientific and mathematical concepts. Their findings highlight that both structured and everyday STEAM activities inherently involve inquiry, observation, and problem-solving processes that align with the core dimensions of computational thinking (CT). Furthermore, Juškevičienė et al. (2021) developed a specific learning strategy for cultivating CT abilities through physical computing within STEAM education. Their study demonstrated statistically significant improvements in 14 CT abilities across seven dimensions, such as decomposition, abstraction, algorithmic thinking, and evaluation, underscoring the effectiveness of hands-on, problem-based STEAM activities in enhancing CT. Additionally, Sun et al. (2023) emphasized the essential role of teachers in integrating CT into STEAM learning. Their research revealed that teachers' CT skills vary based on personal, professional, and institutional factors, highlighting the importance of teacher training and support systems in maximizing STEAM's potential to develop CT among learners.

While these studies primarily focus on broader educational settings, specific explorations of how STEAM-based approaches support computational thinking in early childhood education in

Indonesia remain limited. Joy Kids National Plus Kindergarten in Tasikmalaya presents an interesting local example. This institution is known for implementing STEAM-based play activities that are deliberately designed to stimulate children's thinking processes in a structured yet enjoyable manner. Children engage in simple experimental tasks, role-playing scenarios involving problem-solving, and creative projects that combine elements of technology, science, and art. Through these experiences, children implicitly develop computational thinking skills, not through direct instruction but through meaningful, context-rich play.

Considering this phenomenon and referring to previous studies that emphasize the role of STEAM in fostering children's cognitive development (Johnston et al., 2022; Juškevičienė et al., 2021; Sun et al., 2023), it is necessary to explore how the innovative STEAM-based approach applied at Joy Kids Kindergarten specifically contributes to strengthening children's computational thinking. This study is expected to provide an in-depth description of effective STEAM learning practices that can serve as a reference for other early childhood education institutions, while also contributing to the development of learning designs that align with 21st-century educational needs. Through a case study approach, this research aims to capture real classroom dynamics, teacher strategies, and children's responses to activities specifically designed to foster computational thinking patterns from an early age.

Methods

This study uses a qualitative approach with a case study design. The rationale for using this approach is to explore and understand the phenomenon in its natural context, rather than under controlled or experimental settings. Sugiyono (2019) explains that qualitative research is a method used to deeply understand phenomena experienced by research subjects, with emphasis on meaning, experiences, and perspectives of individuals or groups within specific contexts. In line with this, Creswell defines a case study as a research design in which the researcher explores a phenomenon within a bounded time and context, collecting detailed and in-depth information to gain a more comprehensive understanding (Assyakurrohim et al, 2023). In this study, the subjects were kindergarten teachers and B-level students at Joy Kids National Plus Kindergarten, Tasikmalaya. Data were gathered through participatory observation, in-depth interviews, and documentation of learning activities. The researcher acted as the main instrument, supported by observation and interview guides. Data were analyzed using the interactive model by Miles and Huberman, which consists of data reduction, data display, and conclusion drawing or verification (Qomaruddin & Sa'diyah, 2024).

Results and Discussions

Innovative STEAM activities at Joy Kids Kindergarten are not merely thematic, but are meaningfully integrated across disciplines—science, technology, engineering, art, and mathematics—through children's natural play. Each activity is structured as a simple project, such as building a bridge using ice cream sticks, assembling a toy car from recycled materials, or conducting basic water and color experiments. These learning experiences embed exploratory and investigative components, allowing children to play an active role, pose questions, experiment, and draw conclusions. This approach aligns with early childhood developmental characteristics, where children are intrinsically motivated to explore their surroundings and construct understanding through hands-on experiences. As Gilano et al. (2024) emphasize, young children possess a strong investigative drive, are keen observers, and naturally engage in exploratory behavior to seek new information from their environment.

The prominent characteristic of STEAM activities at Joy Kids Kindergarten is an approach that prioritizes the process, not just the end result. Teachers provide open challenges, do not provide direct answers, and provide space for children to experiment and work in teams. According to Atikah & Biru (2024) this creates a learning environment that stimulates children's curiosity, collaboration, and creativity.

Teachers have an important role in creating a comfortable, safe, conducive learning through designing activities that are appropriate to the context and needs of children (Karokaro et al., 2024). Teachers at Joy Kids Kindergarten integrate STEAM activities into daily activity plans, taking into account children's interests and developmental stages. Strategies implemented include starting activities with trigger questions, providing flexible manipulative materials, and encouraging children to find their own solutions.

In implementation, teachers act as facilitators and companions. They guide children to observe, analyze, and convey ideas verbally and through visual works. Teachers also actively reflect either children on the process and result of activities, as an effort to build children's thinking awareness. According to Hendrianto & Afrianingsih (2024) that when teachers act as facilitators and companions this allow children to think independently and receive direction when needs.

Children's computational thinking skills develop through challenging and logically stimulating STEAM activities. The activity can be in the form of constructive play. Constructive play is a play activity where children form something, create a certain building with the available play equipment (Fitria & Rahmawati, 2021). Children begin to demonstrate the ability to break down large tasks into smaller steps, recognize pattern from repeated experiments, make predictions, and sequence problem solving steps. Nurjanah et al. (2021) emphasized that these skills are recognized as important components for every early age child in determining components for every early age child in determining their fate in the future.

Activities that have been carried out to hone these skills in TK Joy Kids are a project to build a bridge from straws and plasticine, children work together to create a design plan, try out different structures, and repair them if they fall over. They learn from failure, try new strategies and become accustomed to evaluating their processes. This activity shows how children naturally develop systematic and reflective thinking skills. In addition to these skills, this project can also develop other skills. Such as the result of research from Sa'ida (2021) which revealed that with STEAM learning using plasticine can also develop spatial abilities and can also stimulate active learning children.

Based on observations and interviews, it can be seen that STEAM activities have a significant impact on improving children's computational thinking, especially in terms of problem solving, logical thinking, and the preparation of simple algorithms. Children become more confident in making decisions, more systematic in conveying ideas, and are accustomed to facing challenges with a trial and error approach. Teachers noted an increase in children's ability to design solutions and explain their thinking processes in a coherent manner. Children also seemed more interested in project-based activities and had higher perseverance in completing tasks. This shoes that STEAM activities not only enrich the learning experience, but also form analytical thinking patterns from an early age. Kumala et al. (2021) explain the achievement of computational thinking abilities of children aged 5-6 years, including being able to follow instruction given by teachers, being able to understand mistakes and correct them independently or through discussions with friends, being able to express ideas in various works, being able to divide task into small parts, being able to translate codes given by the teacher through a series of actions.

Teachers at Joy Kids Kindergarten gave positive responses to the STEAM approach. They considered this approach relevant and effective in developing children's potential from an early age. STEAM is considered to be able to form critical and creative thinking habits, as well as enrich children's learning experiences. However, teachers also noted challenges such as limited materials, preparation time, and training needs. However, the benefits felt were greater, especially in forming children who we more reflective, independent, and accustomed to facing problems in a fun constructive way. This is in line with the findings of Jannah & Dheasari (2025) which revealed that obstacles in implementing STEAM can be overcome through teacher training and resource adaptation, with learning outcomes remaining optimal.

Conclusion

The implementation of innovative STEAM activities at Joy Kids Kindergarten has been proven to strengthen the computational thinking skills of early childhood. Children show development in terms of solving problems, recognizing patterns, formulating steps to solve them, and reflecting on the process they have gone through. All of this grows through fun and meaningful project activities, which combine elements of science, technology, engineering, art, and math. Teachers play an important role as facilitators who accompany children's thinking processes with an open and reflective approach. Despite challenges such as limited materials and time, STEAM activities still have a positive impact on children's thinking that is more logical, creative, and systematic from an early age.

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