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STEAM-based Learning Model in Early Childhood Education

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Abstrak. Pendidikan Anak Usia Dini berperan penting dalam perkembangan anak, tetapi banyak lembaga PAUD masih menerapkan metode konvensional yang kurang mendukung eksplorasi dan kreativitas. Model pembelajaran STEAM mengintegrasikan berbagai disiplin ilmu untuk mengembangkan keterampilan berpikir kritis, kreativitas, dan kolaborasi sejak dini. Penelitian ini menganalisis efektivitas STEAM dalam meningkatkan kualitas pembelajaran di PAUD melalui studi literatur. Hasil penelitian menunjukkan bahwa STEAM berkontribusi signifikan terhadap perkembangan kognitif dan kreativitas anak, sesuai dengan teori konstruktivisme Piaget, pembelajaran berbasis pengalaman Dewey, serta teori multiple intelligences Gardner. Selain meningkatkan pemahaman konseptual melalui eksplorasi, pendekatan ini juga memperkuat teori sosial-kultural Vygotsky dengan menekankan interaksi sosial dalam pembelajaran. Dengan demikian, STEAM tidak hanya meningkatkan keterampilan akademik tetapi juga membentuk pola pikir inovatif dan adaptif bagi perkembangan anak di masa depan.
Keywords: keterampilan berpikir kritis; kreativitas; pendidikan anak usia dini; STEAM

BACKGROUND

Early childhood education (ECE) has a fundamental role in forming the basis of children's cognitive, social, emotional and motor development. However, the learning system applied in PAUD is often still oriented towards conventional methods that do not encourage exploration, creativity and active problem solving. One of the main problems in early childhood education is the limited learning models that can stimulate children to think critically and innovatively from an early age. Many PAUD institutions still use teaching methods based on memorization and repetition without providing opportunities for children to explore concepts directly through real experiences. As a result, children tend to lack problem-solving skills, analytical thinking, and creativity that should be developed early on. Therefore, a more innovative approach to ECD

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learning is needed in order to optimize children's potential and equip them with relevant skills to face future challenges.

One approach that is starting to get attention in the world of early childhood education is the STEAM-based learning model (Science, Technology, Engineering, Arts, and Mathematics). This model aims to integrate various disciplines holistically in the learning process so that children can understand the interrelationships between science, technology, engineering, arts and mathematics in everyday life. By applying the STEAM approach, children can learn more interactively, exploratively and creatively as they are given the opportunity to conduct experiments, design solutions and express their ideas in a variety of more applicable forms. This learning model not only helps improve critical thinking skills and creativity, but also trains children in collaboration, communication and innovation skills from an early age. To overcome the existing problems, this research aims to examine the effectiveness of STEAM-based learning models in improving the quality of early childhood education, as well as identifying implementation strategies that can be optimally applied in various PAUD institutions (Maharani & Zulminiati, 2021).

This research has several main objectives, including to analyze how STEAM-based learning models can contribute to improving critical thinking, creativity and problem solving skills in early childhood. In addition, this research also seeks to identify the challenges and obstacles faced in implementing this model, both in terms of the readiness of educators, infrastructure, and the curriculum used. Thus, the results of this study are expected to provide applicable recommendations for PAUD institutions in implementing STEAM-based learning models effectively to improve the quality of early childhood education in Indonesia.

Theoretically, the concept of STEAM-based learning refers to an approach that integrates various disciplines into an interrelated whole. The theory of constructivism developed by Piaget and Vygotsky is the main foundation in the application of this model, where children are considered as active individuals in building their understanding through interaction with the environment and direct experience. According to Piaget, children learn through concrete experiences that allow them to explore, try and discover new concepts independently (Rubi Babullah, 2022).

Meanwhile, Vygotsky highlights the importance of social interaction and scaffolding in the learning process, where children gain understanding through guidance from adults or more competent peers (Nabawi, 2024).

Thus, the STEAM approach is in accordance with the principles of early childhood learning because it provides learning experiences based on exploration, experimentation and collaboration. In addition, the STEAM approach is also supported by the theory of multiple intelligences developed by Howard Gardner. Gardner identified that every child has diverse intelligences, including logical-mathematical, spatial, kinesthetic, musical, interpersonal, and naturalist intelligences (Berliana & Atikah, 2023). The STEAM model allows children to develop these different types of intelligence simultaneously through various experimentation, art and technology-based activities. For example, in science exploration activities, children not only learn about physics and biology concepts but also develop logical thinking, analytical skills and creativity through direct observation and experimentation. Meanwhile, in the art and engineering aspect, children are given the opportunity to design, create and modify their own works, which trains their imagination as well as fine motor skills.

In addition, according to (Motimona & Maryatun, 2023) revealed that children who engage in STEAM-based learning have higher levels of interest in science and technology, and show improvements in communication and collaboration skills. Another study according to (Herro & Quigley, 2016) also emphasizes that STEAM-based learning can provide a more meaningful and enjoyable learning experience for children because they can learn through hands on exploration and problem-based projects. Although the STEAM-based learning model has many advantages, the challenges in its application cannot be ignored. One of the main obstacles often faced is the limited resources and facilities in many PAUD institutions, especially in less developed areas. The application of this model requires adequate equipment, teaching materials and infrastructure so that the learning process can run optimally. In addition, the readiness of educators is also an important factor in the successful implementation of STEAM in PAUD. Many educators still have limited understanding and skills to teach science, technology and engineering concepts to early childhood. Therefore, training and developing teacher competence is a very crucial aspect so that STEAM-based learning models can be applied effectively.

Taking these aspects into account, this research will explore how the implementation of STEAM-based learning models can improve the quality of early childhood education and identify strategies that can be applied to overcome existing obstacles. It is hoped that the results of this study can contribute to the development of ECD education that is more innovative, holistic, and based on the needs of children in the modern era. The application of STEAM in early childhood education not only aims to improve academic skills, but also shapes children's character to be more creative, independent, and able to think critically in facing future challenges.

KAJIAN TEORI

Bagian ini menguraikan teori-teori relevan yang mendasari topik penelitian dan memberikan ulasan tentang beberapa penelitian sebelumnya yang relevan dan memberikan acuan serta landasan bagi penelitian ini dilakukan. Jika ada hipotesis, bisa dinyatakan tidak tersurat dan tidak harus dalam kalimat tanya.

METHODOLOGY

This research uses a qualitative approach with a descriptive method that aims to analyze the application of STEAM-based learning models in early childhood education. The data in this study were obtained through a literature study that included various academic sources, such as scientific journals, books, and education policy documents related to the application of STEAM in PAUD. Analysis is carried out by reviewing various previous studies that discuss the concept, implementation, and benefits and challenges of STEAM-based learning models.

The data analysis process is carried out using data reduction techniques, data presentation, and conclusion drawing based on theoretical mapping and findings from various relevant literature. Data validity is maintained by using source triangulation techniques, which compares various references from credible academic literature to obtain objective and comprehensive conclusions. With this method, the research is expected to provide in-depth insight into the effectiveness of STEAM based learning models in early childhood education and provide recommendations for more innovative curriculum development in the future.

RESULT AND DISCUSSION

1. Application of STEAM-based Learning Model in Early Childhood Education

The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach in early childhood education (ECE) is becoming one of the more widely applied strategies to enhance children's critical thinking skills, creativity, and exploration. This concept integrates various disciplines in a fun and interactive way, so that children can learn holistically. Based on various studies, the application of the STEAM learning model in ECD not only enriches children's learning experience, but also contributes significantly to the development of their cognitive, social and motor skills. The model emphasizes hands- on experience in learning, where children are encouraged to explore, observe and solve problems independently or in groups. In relation to the theory of constructivism, the STEAM approach provides opportunities for children to build their own understanding based on concrete experiences.

In addition, project-based and experiential learning theories also reinforce the idea that children will more easily understand new concepts if they are directly involved in activities relevant to their daily lives. Furthermore, the application of STEAM in ECD also opens up opportunities to develop more adaptive and flexible learning theories. For example, modifications to Howard Gardner's multiple intelligences theory can be made by adjusting STEAM learning strategies to suit different types of children's intelligence. In this case, STEAM integration not only targets academic aspects, but also supports interpersonal, intrapersonal and kinesthetic intelligence through art and technology-based activities. Thus, the STEAM model not only maintains established educational principles but also gives rise to new variations in teaching methods that are more inclusive and adaptive.

The following is how to apply the STEAM model in PAUD that refers to research findings and theories that have been developed:

a. Project-based Learning

A project-based approach allows children to combine various STEAM disciplines in one meaningful activity. Well-designed projects help children develop critical thinking, problem- solving and creativity skills (Alifah

Andhianto et al., 2024). For example, building a classroom garden not only introduces children to the concept of plant growth in science, but also teaches

basic construction techniques, utilization of simple technology, and

calculation of area using mathematical principles. This is in line with experiential learning theory which emphasizes the importance of direct involvement in the learning process.

b. Exploration-based Learning

Exploration is at the core of the STEAM model and allows children to develop their curiosity and analytical skills (Fauziah et al., 2022). Explorative activities such as simple scientific experiments can provide a more in-depth learning experience and help children understand science concepts in real life. For example, experiments on floating and sinking objects not only introduce basic physics principles, but also encourage children to think logically and make predictions based on observations. This approach is in line with the discovery learning theory developed by Jerome Bruner, where children gain understanding through active exploration of their environment.

c. Supportive Learning Environment

An optimally designed learning environment is essential in the implementation of STEAM in ECD. Classrooms that are inclusive and equipped with props that support exploration can increase children's engagement in learning. In addition, the provision of various art materials and simple technology allows children to better express their creativity. This is in line with Bronfenbrenner's ecological theory, which emphasizes that the environment has a significant influence on children's development.

d. Collaboration and Communication

According to (Hadzami & Maknun, 2022) STEAM-based learning also encourages children to work in small groups, so they can learn to

communicate, collaborate and share ideas with peers. Through activities that involve discussion and joint problem solving, children can develop social skills that are important for their future lives. In addition, reflection after the

activity can help them evaluate the learning process and understand concepts better. This strategy supports Vygotsky's social theory, which emphasizes that social interaction plays an important role in children's cognitive development (Wondal et al., 2020).

e. Application of Technology in Learning

The use of technology in STEAM learning can increase children's engagement and make learning more interesting. Educational apps designed specifically for early childhood education can be a helpful tool in introducing science, technology and math concepts in a more interactive way. In addition, technology also allows children to experiment with design and engineering concepts virtually before they apply them in the real world (Noviyanti et al., 2023). This supports the theory of connectivism which emphasizes that learning in the digital era should integrate technology as part of the learning process.

By optimally implementing the STEAM model in ECD, children not only acquire academic skills, but also develop an innovative mindset that will benefit their future. This approach also contributes to development of educational theory by tailoring more flexible and experiential teaching methods.

2. Benefits of STEAM-based Learning on Early Childhood Cognitive Development, Creativity, and Problem Solving Skills

STEAM-based learning models in early childhood education have been proven to provide significant benefits in academic, social and emotional aspects. According to (Prameswari & Anik Lestariningrum, 2020) who said that this approach plays an important role in developing 21st century skills that include critical thinking, creativity, innovation, collaboration and communication. In an increasingly complex digital age, these skills are fundamental for children to be able to adapt and compete in a dynamic world. According to (Whildan, 2021) In line with the theory of constructivism proposed by Piaget, the STEAM approach allows children to build their understanding through active interaction with the environment and direct experience, which is in line with the principle that learning will be more meaningful when individuals are actively involved in the process of exploration and discovery. In addition, the STEAM model also

contributes to improving concept understanding through explorative and project-based activities (Neneng Nur & Mulyawan Safwandy Nugraha, 2023). Children are given opportunities to experiment, test hypotheses and solve problems creatively, which strengthens their understanding of science, technology, engineering, art and math concepts. In this regard, the STEAM approach not only supports the theory of constructivism but also extends the concept of experiential learning developed by John Dewey, where learning should be linked to real life and not limited to the memorization of information. As such, it emphasizes the importance of active engagement and reflection in learning, allowing children to gain a deeper and more meaningful understanding.

In addition, research also shows that the application of STEAM can increase children's interest in learning. Through methods that are active, fun and relevant to everyday life, children become more motivated to explore new things. This supports the intrinsic motivation theory described by Deci and Ryan in their self-determination theory, where individuals are more driven to learn when they feel they have control over their own learning and see it as meaningful. The STEAM approach, which allows children to choose their own projects and work in a collaborative environment, reflects this principle by giving them the freedom to explore and learn according to their interests and curiosities. Furthermore, the STEAM model also plays a role in the development of creativity and innovation. By encouraging children to think outside the box and find unique solutions to problems, this approach supports the multiple intelligences theory developed by Howard Gardner. While the theory initially categorizes intelligences into specific categories, such as logical-mathematical, linguistic and kinesthetic intelligences, the STEAM context shows that children can develop multiple intelligences simultaneously in one activity. For example, when children build a structure using simple materials, they use not only spatial intelligence to design the shape, but also interpersonal intelligence when working with friends, as well as kinesthetic intelligence when they assemble the parts. Thus, this learning model expands the concept of intelligence as something dynamic and integrated, which is not limited to separate categories as proposed in Gardner's initial theory.

In addition to creativity, children's social and emotional skills are also developed through collaborative activities that are an integral part of STEAM. Children learn to

work in teams, share ideas, appreciate other people's perspectives, and manage their emotions when facing challenges or difficulties in completing projects. This is in line with the socio-cultural theory proposed by Vygotsky, which emphasizes that learning occurs in a social context and that interactions with others, both peers and adults, play an important role in children's cognitive and social development. However, in its application in STEAM, this theory can be further modified by highlighting the role of technology as a mediator in social interaction. The use of digital tools in STEAM learning allows children to collaborate not only with friends in the neighborhood but also with other individuals from different backgrounds through online platforms. As such, socio cultural theory can be expanded to include the concept of "digital-social interaction", which recognizes the importance of technology in shaping children's learning experiences in the modern era.

Furthermore, the application of STEAM also prepares children for further education, particularly in the fields of science, technology, engineering and math (STEM). By providing early experience in the exploration of these concepts, children become better prepared to face academic challenges at higher levels of education. In this regard, the STEAM approach can be linked to readiness theory, which states that meaningful early experiences can build a strong foundation for further learning. However, recent findings also suggest that the STEAM approach can modify this theory by emphasizing the importance of integration between various disciplines from an early age, so that children are not only prepared in one particular field, but have a holistic and cross-disciplinary mindset.

Not only that, the STEAM model also strengthens problem-solving skills, which is an essential aspect of learning. Children are not only taught to find the right answer, but also to think critically, evaluate various possibilities, and seek innovative solutions based on experiments and observations

CONCLUSION

The application of the STEAM model in early childhood education has been proven effective in improving children's critical thinking skills, creativity and exploration through interactive and experiential learning. This model is based on constructivism, project-based learning, and cognitive and social development theories

that emphasize the importance of hands on exploration and collaboration. Through activities that integrate various disciplines, STEAM not only strengthens children's conceptual understanding but also encourages intrinsic motivation and the development of multiple intelligences. In addition, social interactions in STEAM learning contribute to children's social and emotional skills, supporting the socio-cultural theory of cognitive development. Thus, the STEAM approach not only provides academic benefits but also shapes innovative and adaptive mindsets that are important for children's readiness to face future challenges.

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