Jurnal Smart Paud

p-ISSN 2599-0144, e-ISSN 2614-1248
Vol. 6, No.1, January 2023, Pages:1-11, Doi: http://dx.doi.org/10.36709/jspaud.v6i1.18
Available Online at, https://smartpaud.uho.ac.id/

Robotics For The Development of Preschool Children's Creativity

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Abstract

The use of technology in 21st century education is not unfamiliar. One form of technological innovation in the field of education is robotics. The use of robots in learning is in line with STEM learning, because children are invited to build their own desired robots, design their own robots, and enter coding according to their wishes so that this activity can stimulate children's creativity. This study aims to determine the application of robotics in the development of early childhood creativity. The research method used is systematic literature review. Literature sources come from international articles relevant to the topic of study from 2011 to 2021. The results show that robotics applied in early childhood learning can develop creativity. Educational robots can be used as a place for children to develop, apply, and channel ideas, thoughts, ideas, and creativity in a work. Robotic activities can introduce children to STEM or STEAM concepts as well as computational thingking so that in addition to creativity, children are trained in logical, creative, and structured thinking skills.

Keywords: early childhood; creativity; robotics.

INTRODUCTION

Technology has penetrated the field of education. Technology integration in early childhood education is currently done following the STEAM (science, technology, engineering, art, mathematics) learning concept. technology-STEAM learning integration begins to be implemented in the early childhood education context as a step to develop children's competitiveness and prepare them to meet future demands. The STEAM concept has been reported to stimulate creativity, digital literacy, and critical thinking skills (Hussain et al., 2020), which are highly important to cope with time development. Creativity is one of the developmental aspects that should be stimulated as early as possible since children with high creativity are better at solving problems using original ideas, making it important for the children's future (Bers, 2018).

Children's creativity becomes increasingly important because it may also facilitate their idea changes and skill development (Daud et al., 2012). Children's creative thinking skills may be affected by a range of factors, including the curriculum and teachers' teaching methods. Children's creativity may also be developed through STEM, STEAM, or scientific learning process (Zahra et al., 2013), during which teachers may facilitate children's exploration, opportunities to express new ideas, and help children make new discoveries in the surroundings (Daud et al., 2012).

Our observation in a kindergarten shows that the children's creativity development was still limited, as they were engaged in monotonous activities that limit their exploration. There have been many innovations made for developing children's creativity, including the

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integration of technology to learning activities. Many countries worldwide have implemented the technology in learning. More than 50% of children in the US and UK have familiar with mobile devices for playing and developing creativity (Marsh et al., 2018).

Technology is considered suitable for enhancing children's creativity because it is in line with the STEAM concept. One of the technological innovations in the field of education is the educational robot. Educational robot is deemed a correct stage to attract children to constructive learn-through play activities (Dorouka et al., 2020). The educational robot is a robot used as a learning media that allows children to design, build, and program their own robot. Robotic learning could be categorized into project-based learning method that combines science, technology, engineering, and mathematics (Aristawati & Budiyanto, 2018).

Educational robotics is considered to better stimulate individuals' creativity development through learning activities, which is in line with the constructivism theory stating that students would be able to understand the meaning of learning when they are directly engaged in creative and innovative activities (Aristawati & Budiyanto, 2018). Educational robotics is designed by taking learning-through-play concept into account, making it more interesting, easier, and more efficient for students. The learning activities are student-centered, providing them with opportunities to explore through robotic activities such as manipulation, coding, and object construction. These opportunities are believed to improve their creativity.

Considering the importance of developing preschool children's creativity and the technological dynamics in the field of education, educational robotics emerges as a suitable learning medium for developing children's creativity. Educational robotics allows children to design and develop their own robots and programs. Educational robotics is designed by taking learning-through-play concept into account, making it more interesting, easier, and more efficient for students (Jdeed et al., 2020).

It is important to implement educational robotics based on appropriate pedagogical curriculum and practices, and in this regard, teachers play an important role in this learning model. However, studies on educational robotics in the early childhood education context is still scarce, making it difficult for teachers to understand the application and benefits of educational robotics in the learning context. This article is expected to motivate teachers to make learning innovations by introducing the STEAM concept through educational robotics to stimulate preschool children's creativity. They are also expected to find out suitable methods and educational robotics for the early childhood education context.

METHOD

This systematic literature review scrutinized studies on the application of robotics in early childhood education and its effect on children's creativity. The findings were analyzed and presented descriptively. Teachers could use the result of this review as a reference related to the robotic technology for preschool children's creativity development.

Articles were obtained from online databases, including Science Direct, Scopus, SpringerLink, ACM Digital Library, and IEEE Access. Several keywords were used, including 'robotic', 'creativity', and 'early childhood'.

Table 1 Literature Study limitation

Year of publication	Source	Document Type	Subjects	Keywords
2012-2021	Science Direct, Scopus, SpringerLink, ACM Digital Library, IEEE Access	Article	Preschool Children	Robotics, creativity, early childhood

RESULT AND DISCUSSION

The findings of studies on robotics for preschool children's creativity development is presented in Table 2.

Table 2 Study findings

Category	Article	Finding
The effect of robotic activity on preschool children's creativity development	(Heider & Jalongo, 2015)	- The use of tech-based equipment and media could improve children's creativity. - Integrating technology and interactive media into curriculum allows children to have creative experience that supports higher-order learning activities while promoting art-oriented learning.
	(González & Muñoz-Repiso, 2018)	- Programming- and robotic-based learning provide students with opportunities to develop computational thinking at the elementary education level.
	(Dorouka et al., 2020)	- The technology was found to be effective in the thematic areas of robotics, STEM, and digital literacy. - Interactive technology could also improve children's technological and engineering skills, in addition to their mathematical, reading, and scientific skills.
	(Peter et al., 2021)	- Applying social robots into the learning process may also improve children's prosocial attitude.
	(Alves-Oliveira et al., 2020)	- Social robots play important roles in developing children's creativity. - Using YOLO robot is reported to improve children's creativity through

Category	Article	Finding
		programming activities.
	(Alves-Oliveira et al., 2019)	- Introducing robotic activities could be done using YOLO robot that suits STEAM learning concept. - YOLO is one of the technological novelties and innovation in learning capable of improving children's creativity. YOLO robot may facilitate children to make their own storyline.
	(Marina U. Bers et al., 2019)	- Robotics involves children in an enjoyable learning activities that suit their developmental stage, which include problem-solving, abstract thinking, and logical thinking skills. - KIBO robotics is one of the educational robotics that could be used for children's learning activities. - It involves children to learn through robot programming by integrating simple coding activities that is in line with STEAM concept.
The effect of robotic activity on preschool children's creativity development	(Di Lieto et al., 2017)	- Executive function in early childhood education could be intensively improved through robotic training programs.
	(Eguchi, 2016)	- Educational robot is proven to improve children's STEM interests. - The combination of educational robot and project-based and goal-oriented learnings may develop children's long-term motivation to explore the STEAM-based learning activities.
	(Angeli & Valanides, 2020)	- Bee-Bot was found to be effective in improving children's computational thinking. - Using robot in children's learning activities could effectively improve their spatial relations. - Robots could be used for reforming and improving the old curriculum by

Category	Article	Finding
		stimulating children's computational thinking skills, preparing them to face the 21st century development.
	(Behnamnia et al., 2020)	- Digital game-based learning could improve children's creative thinking and problem-solving skills, in addition to their curiosity and children's exploration skills.
	(Marina Umaschi Bers et al., 2014)	- tangibleK robotic program is reported to be able to integrate technological education into early childhood education. - This program allows children to develop their problem-solving skills and computational thinking.
The effect of robotic activity on preschool children's creativity development	(Nacher et al., 2016)	- Technology in early childhood education may develop children's motor, socio-affective, and cognitive aspects.
	(Strawhacker et al., 2020)	- CRISPEE robot used for 10 minutes in the classroom helps children recognize symbols effectively.
	(de Paula et al., 2018)	- The robot's interesting elements facilitate the development of children's narrative knowledge and computational thinking skills.
	(Jdeed et al., 2020)	- Swarm Robotics was found to play crucial roles in children's education. - It could stimulate children's cognitive and STEM-related skills.
The effect of robotic activity on preschool children's creativity development	(Marina Umaschi Bers, 2018)	- KIBO robotics could be used for improving complex skills, such as repeat, loops, and conditional statement. - Applying KIBO to learning activities was found to improve children's socioemotional skills, such as communication and collaboration.

A. Robotics for Preschool Children.

Robot could be applied to early childhood education by combining play, creative, and constructive activities (Alves-Oliveira et al., 2019) It encourages children to play with the

robot materials separately, during which they are allowed to freely build their robot following their imagination and develop the codes to insert their command.

Using robot in early childhood education is a concrete realization of introducing the STEM concept to them (Marina Umaschi Bers et al., 2013). To date, early childhood education is focused on literacy skills, numeracy, and few scientific concepts. It is safe to say that robotic program is an innovative means to introduce the concepts of technology and engineering to children. Regarding Technological development in early childhood education, scholars have added the element of art to the STEM concept, turning it into STEAM concept (Jamil et al., 2018)

The STEAM learning concept encourages students to explore and be creative using objects in their surroundings. The use of technology in early childhood STEM concept may develop children's motor, socio-affective, and cognitive aspects (Nacher et al., 2016). Technology in early childhood education could be categorized into two types: screen technology, which consists of passive and interactive technologies, and digital technology (Lindeman et al., 2013). However, not all technologies are applicable to early childhood education, and those suit the early childhood education is the interactive ones. Interactive technology could improve children's technological and engineering skills, in addition to their mathematical, reading, and scientific skills (Dorouka et al., 2020). The findings show that some robots are applicable to early childhood education.

Table 3 Types of Robotics

YOLO Robotics	KIBO Robotics	Swarm robotic	Bee-bot	CRISPEE	TangibleK Robotics
A social robot that utilize sensors, designed for enhancing children's creativity.	Screen-free robotics that allows children to make, design, and decorate their own robots. The robot use is consistent with the STEAM concept.	This is a robot that stimulates children's cognitive and STEM-related skills.	An easy-to-use robot for children capable of developing their computational thinking skills	Classroom use of this robot is effective for introducing symbols to children	This robot is helpful for stimulating children's problem solving and computational thinking skills.

As shown in the table above, robot has been increasingly used in the educational context. Educational robot in early childhood education allows children to explore their creativity. The robot's interesting elements facilitate the development of children's narrative knowledge and computational thinking skills (de Paula et al., 2018). The application of robotic in early childhood education could take its first step by including robotic learning in the curriculum. Integrating technology and interactive media into the curriculum allow children to have creative experiences that support higher-order learning and promote art-oriented learning (Heider & Jalongo, 2015).

The application of educational robot to early childhood education is reported to bring various positive impacts, such as improved concentration, logical thinking skills, creativity,

and imagination (Dorouka et al., 2020). In addition, social robot is known to affect children's autonomy and socialization with their peers. STEAM and scientific concepts introduced through robot use may introduce children to the work order, teaching them to solve and be responsible for their action.

The use of educational robot should be supported by the availability of robotic materials. The most substantial hindrance lies in the cost needed to provide robotic materials. Furthermore, the implementation of robotic learning should be balanced with teachers' understanding of children's skills to ensure that the learning suits their developmental stages. It is also important to socialize the importance of educational robotics to parents, in addition to conducting training for teachers.

Teachers play important roles in robotic learning activities as an optimal teacher-robot collaboration will prevent students from being robot-dependent (González & Muñoz-Repiso, 2018). One of the concerns with robot use in early childhood context is children's addiction. In this regard, teachers need to communicate with children and encourage them to discuss about their work. Robot for the learning process should also be adjusted to the children's developmental stage. Educational robot could be classified based on children's age as follows (Jdeed et al., 2020): (1) Unwritten programming language robot, such as BeeBot, which uses buttons or symbols for its programming. This robot could be used for early childhood, yet it lacks ability to stimulate children's reading skills; (2) Block-based programming language robot, which involves children learning about a certain concept; (3) Text-based programming language robot, which is programmable using a limited number of text commands. Educational robots that suit children's characteristics and development could support the attainment of children's robotic learning.

B. Robotics for preschool children's creativity

Creativity is a holy grail in education because it may significantly affect individuals' education, mental health, and success. According to (Alves-Oliveira et al., 2020), educational robot is more attractive for children. Furthermore, children interacting with educational robot tend to exhibit new ideas, be more interested in exploring new objects, and exhibit more original thinking, which serves as a part of creativity. According to (Zahra et al., 2013), creativity represents the interaction between personality and the environment.

The use of robotics in learning is in line with STEM (Dorouka et al., 2020) and STEAM (Eguchi, 2016) concepts. The applications of STEM or STEAM to learning may enhance children's creativity through a learning process. Robotics in early childhood education is implemented based on STEM or STEAM concepts, in which children's creativity is stimulated through technology and engineering aspects. The use of tech-based equipment and media could improve children's creativity (Heider & Jalongo, 2015). Applying YOLO robots, children may improve their creativity through programming, while KIBO Robots could improve the children's creativity through robotic elements that allow children to build their own robots.

Educational robot for developing children's creativity comprises elements that allow children to design their own robot. In other words, it could facilitate children's imagination and stimulate their cognitive, physical, motor, socio-emotional, and creative skills (Bers et al., 2019) by combining the elements of play, create, and develop to a student-centered learning process (Alves-Oliveira et al., 2019). In addition to developing children's creativity through thinking process, educational robot could develop their computational thinking skills, which eventually enhance their creative thinking skills.

Programming- and robotic-based learning provide students with opportunities to develop computational thinking at the elementary education level (González & Muñoz-Repiso, 2018). Some robots reported to be able to develop computational thinking skills include Bee-Bot, TangibleK Robotics, and CRISPEE Robotics. Children's computational thinking could be enhanced through coding that uses easily understood symbols for children. Coding used in the robot may enhance children's complex conceptual skills such as repeat, loops, and conditional statement (Bers, 2018).

The use of simple coding helps children to understand abstract objects. Thus, when children reach five years of age, they will be familiar with the concept of order, cause-and-effect, and pattern (Strawhacker et al., 2020). Robot application in computational thinking could stimulate the children's problem-solving skills. When engaged in coding activities, children may encounter errors that cause their robot to move not in accordance with their intention, hence training children to solve the problems logically (Di Lieto et al., 2017). In other words, using robot may train the children's logical, creative, and structured thinking skills.

Based on the description above, robot in early childhood education may improve children's creativity through the thinking process. Children's creative and computational thinking skills may be stimulated through STEM and STEAM concepts in robotic learning. In addition to improving creativity, the executive function in early childhood education could be intensively improved through robotic training programs (Di Lieto et al., 2017). The use of robotics could also enhance children's social skills. For instance, YOLO social robot could improve children's prosocial attitudes and KIBO Robotics could develop children's socioemotional skills, such as communication and collaboration.

CONCLUSION AND RECOMMENDATION

Educational robots facilitate children to develop, implement, and channel their ideas and creativity. Educational robot in early childhood education should also be adjusted to the children's developmental stages. There are currently many educational robots available, such as KIBO Robotic, YOLO, Bee-Bot, Swarm Robotics, TangibleK Robotics, CRISPEE. Educational robot that suits children's developmental stage will likely facilitate children express their creativity and ideas by playing, creating, building, and coding their robots. Such robotic activities will introduce children to STEM, STEAM, and computational thinking. STEM or STEAM concepts may help develop children's creativity through its technologies and elements. Regarding computational thinking concepts, children's creativity is stimulated by coding, allowing them to train their logical, creative, and structured thinking skills.

To address hindrances in application of robotics in early childhood education, schools need to facilitate robotic learning using easy-to-find materials to maintain affordability. It is also important to prepare teachers' ability to implement robotics learning through workshops involving robotic experts and by adjusting the learning to children's characteristics. This review is expected to serve as a reference for teachers and schools to understand the importance of creativity development through integration of robotic technology into early childhood education. Future studies are recommended to discuss the steps of robotic learning to provide teachers and schools with more detailed information.

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