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Educational Robotics for Elementary Students: Teaching's Opportunity

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Abstrak

Penelitian ini mendeskripsikan robotika pendidikan untuk siswa SD/SD. Penelitian ini merupakan penelitian kepustakaan. Analisis menunjukkan bahwa robotika pendidikan (ER) dapat diperkenalkan di sekolah dasar/sekolah dasar karena kompatibel dengan mata pelajaran Sains, Teknologi, Teknik, dan Matematika (STEM). Manfaat robotika pendidikan adalah meningkatkan keterampilan berpikir tingkat tinggi, penalaran komputasi, berpikir logis, dan kemampuan memecahkan masalah. Kegiatan robotika menumbuhkan kreativitas dan imajinasi, kemampuan teknologi, kerja tim, dan keterampilan kolaboratif, minat terhadap budaya teknologi, dan pengembangan keterampilan baik pengembangan motorik maupun soft skill. Dengan menggabungkan latihan langsung, keterlibatan teknologi, dan kolaborasi, robotika dapat mengembangkan keterampilan abad ke-21. Robotika pendidikan dapat membantu siswa berkebutuhan khusus dengan mengurangi tekanan guru dan mendorong pengalaman belajar yang dipersonalisasi. Oleh karena itu, kemajuan teknologi robotik menjadikan siswa lebih mudah diakses dan dapat digunakan sebagai media pembelajaran untuk menunjang keterampilannya. Namun, robotika pendidikan menghadapi tantangan dalam pendidikan termasuk gender, guru, metode pengajaran, kurikulum, teknologi, sumber daya, masalah teknis, kurangnya pengetahuan guru, insentif pengajaran, sarana dan prasarana yang tidak memadai, langkah-langkah yang tidak memadai untuk keberhasilan integrasi, waktu, aturan/peraturan , dan biaya tinggi.

Abstract

This research describes educational robotics for elementary/primary students. This research is library research. The analysis shows that educational robotics (ER) can be introduced in elementary/primary schools, as it is compatible with subjects of Science, Technology, Engineering, and Mathematics (STEM). The benefits of educational robotics are enhancing higher-level thinking skills, computational reasoning, logical thinking, and problem-solving abilities. Robotics activities foster creativity and imagination, technological capabilities, teamwork, and collaborative skills, interest in technology culture, and skills development both motor and soft skills development. By incorporating hands-on exercises, technological engagement, and collaboration, robotics can develop 21st-century skills. Educational robotics can help students

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with special needs by reducing teacher pressure and promoting personalized learning experiences. Therefore, the advancements in robotic technology make students more accessible and can be used as learning media to support their skills. However, educational robotics faces challenges in education including gender, teachers, teaching methods, curriculum, technology, resources, technical issues, teachers' lack of knowledge, teaching incentives, inadequate facilities and infrastructure, inadequate measures for successful integration, time, rules/regulations, and high costs.

Introduction

The development of 21st-century competencies among students has emerged as a significant concern within the realm of education in recent times (Phadung et al., 2021). Computational thinking or CT is the skill that individuals need to face in the 21st century (Safrudin et al., 2021). Education that emphasizes science, technology, engineering, and mathematics (STEM) encourages children and adolescents to study these topics via hands-on experience, work, and experimentation. They are the ones who are responsible for carrying out the initiatives, which makes them the protagonists of their own educational experience.

Isnaini et al. (2019) explain that computational thinking (CT) is an essential talent for students to possess throughout the learning process, beginning with early infancy and continuing through college. Furthermore, there is a correlation between computational thinking and the Taxonomy Bloom system, because Bloom's Taxonomy serves as the foundation for education in Indonesia, there is a pressing need to further improve computational thinking because it is particularly pertinent to the educational system in Indonesia. Cognitive abilities that are associated with computational thinking include the ability to reason, analyze the process of problem-solving, and evaluate.

Aristawati et al. (2018) add that the ability to think computationally or computational thinking (CT), is a vital talent for the 21st century. It is a critical problem-solving and survival ability in this era of disruption. When universal principles are used to generate a pattern of abstraction, step-by-step troubleshooting instructions are developed to address comparable issues, recognizing similarities and differences between the patterns, and making a difficult problem solvable. By putting a focus on efficiency, precision, and the capacity to solve problems, the talent might be utilized in a variety of engineering domains. In recent times, science, technology, engineering, and mathematics (STEM) learning activities that entail tasks like "assembling, programming, and testing" have been highlighting the importance of CT skills among robot enthusiasts. The majority of ER activities take place in a formal learning environment and ER is appropriate for teaching subjects of STEM education (Kyriazopoulos et al., 2022).

Robotics technology is a fast-growing technology (Priandana et al., 2021). Robotics is one technology that can allow for the development of CT abilities. In the 4th iteration of the Industrial Revolution, educational robots emerged as an educational paradigm transformation. There has been rapid growth in the field of robot technology development (Zuhrie et al., 2021). When it comes to assisting human interests, robots have been utilized extensively in a variety of contexts. Robots are defined as physical agents that are capable of performing tasks by manipulating the physical world (Younis et al., 2021). There have been instances in the world of education when robots have been utilized as a learning aid to assist students in the study of subjects such as science and technology.

According to Amri et al. (2022), Educational Robotics (ER) has become well-known due to its modularity, a characteristic that may facilitate the development of abstract thought through the use of complex robotic components. These characteristics may function as instructional materials for CT, given that the domain of robotics comprises attributes of technology, intelligence, embodiment, and interaction. A better grasp of science and technology, the development of skills in computer programming, the enhancement of problem-solving capabilities, the encouragement of creativity and invention, the closing of the gap between theory

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and practice, and the practice of collaboration and social skills were the talents that were acquired. The discipline of robotics is an intersection of several scientific fields such as mechanics, electronics, computers, and control (Soebhakti & Fatekha, 2017). In general, robots can be divided into 3 categories, namely industrial robots, research robots, and educational robots (Soebhakti & Fatekha, 2017).

The integration of robotics into the field of education has garnered growing interest (Lathifah et al., 2019). Activities involving robotics can be implemented at all educational levels, from early infancy through graduate school and beyond (primary institutions). Furthermore, STEM learning remains a contemporary and significant topic within the realm of education. Science and technology education needs to advance to anticipate technological developments in response to the challenges and transformations of the 4th Industrial Revolution. To equip students with the necessary skills to adapt to these evolving challenges and changes, the field of education must implement an instructional approach referred to as Educational Robotics (ER) that incorporates robotics (Huda et al., 2021).

Recently, educators and academics in the field of education have been showing a growing interest in robotics in the classroom (Abidin et al., 2021). The development of robotics in Indonesia has been very encouraging (Zuhrie et al., 2018). Teachers can concurrently increase student learning by combining four disciplines—namely, science, technology, engineering, and mathematics (STEM)—through the utilization of robots in the classroom. Teachers can make abstract ideas in the fields of physics and mathematics more tangible in the context of the real world through the use of educational robotics, which brings together technology and engineering in one package (Abidin et al., 2021). Although it focuses mostly on the STEM fields, it is also capable of incorporating other fields, such as languages, geography, and history. These instructional robotics kits from Ebotics are intended to be utilized in the context of STEAM education. Scientists, engineers, artists, and mathematicians are the components that make up the acronym STEAM. There is a connection between these five areas in STEAM education, which results in a multidisciplinary learning process. This is accomplished through the creation of genuine projects that are based on real-life scenarios.

Over the past few years, there has been a growing interest in using robots in education (Costa et al., 2008; Saleiro et al., 2013). Along with robotic technology development, researchers and educators have employed robots to support education (Khanlari, 2013). A multitude of studies have examined the efficacy of robots in facilitating pedagogical teaching activities (Chin et al., 2014). Robotics has an important role in elementary school students' education because it can develop critical thinking and problem-solving skills from an early age. Robotics also improves collaborative and teamwork skills, introduces basic STEM concepts in an engaging way, and can be adapted for various ability levels, including students with special needs. Additionally, robotics prepares students for a future increasingly filled with technology, making them better prepared to face the challenges and opportunities of the world of work.

Benitti (2012) conducts a comprehensive examination of recently published scholarly works concerning the implementation of educational robotics. Its objective is to determine the potential educational utility of robotics in elementary, middle, and high schools, provide a summary of pertinent empirical discoveries, and suggest avenues for future research. This research reviews the studies related to the benefits of educational robotics for elementary/primary students.

The importance of robotics for elementary school students is based on several main problems in the current education system. Traditional teaching methods are often unable to stimulate students' interest and motivation to learn. Elementary students, who are at an early stage of cognitive development, need a more interactive and fun learning approach to maintain their interest. Robotics, with its practical and applicable approach, can be an effective solution to increase student involvement in the learning process. In addition, collaborative skills and problem-solving abilities are competencies that are very necessary in the 21st century, but often do not receive sufficient portions in traditional curricula. Through robotics projects, students are encouraged to work in teams, communicate, and collaborate to achieve a common goal, thereby

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helping them develop social skills and critical thinking abilities. An early introduction to robotics can also help students develop a better understanding of technology and science. In this digital era, technological literacy has become increasingly important, and mastering the basics of robotics can provide a strong foundation for students to pursue science and technology fields in the future. Lastly, robotics also offers inclusion opportunities for students with special needs. Through the use of adaptive technology and specially designed programs, students with diverse backgrounds and abilities can enjoy equitable and meaningful learning experiences. Thus, the integration of robotics in elementary education can overcome some of the weaknesses of the traditional education system, while preparing students for more complex and dynamic future challenges.

Educational robotics bridges the mix between student learning and teacher teaching methods, stimulating curiosity, interest, and motivation and enhancing students' collaborative abilities and special educational needs. The use of robotics in education is expected to make the learning process more interesting and enjoyable, thereby stimulating students' curiosity, interest and motivation. Students are often more motivated to learn when they can interact with technology and see real results from their efforts. In many robotic activities, students work over time to design, build, and program robots, which encourages them to collaborate, communicate, and solve problems together. Additionally, robotics can also be customized to meet the specific needs of students with varying backgrounds and abilities, helping them learn in a way that best suits their learning style. Robotics helps teachers adopt more interactive and student-centered teaching methods, creating learning environments that are more dynamic and responsive to student needs. Thus, educational robotics not only develops important skills necessary for the future but also creates a more concrete and understandable teaching approach for students. Based on the explanation above, the researcher is interested to describes educational robotics for elementary/primary students.

Method

This study uses of library research. Library research encompasses a sequence of tasks involving the processing of research materials, reading and note-taking, and the collection of library data (Zed, 2008). The data utilized in this study are secondary sources. Secondary sources of information included journals, books, literature, and reports that were pertinent to the topic at hand. The researcher gathers data for this study from national journals that pertain to the subject of prophetic learning. Following the collection of numerous periodicals pertinent to the subject matter, we conducted a literature review and applied descriptive qualitative analysis to the collected data in this study. Descriptive data in the form of written sentences and behavioral outcomes observed in the findings of previous research comprised the results of the analysis.

Findings and Discussion

Findings

There are several findings found related to this research about educational robotics as follow:

A. Concept of Educational Robotic

Robotics stands as a highly auspicious domain within the realm of emergent technologies (Kerimbayev et al., 2020). Within the educational setting, students will engage in educational robotics, an amalgamation of practical application and theoretical understanding, encompassing computer science, physics, and mathematics. In the field of pedagogical robotics, the educational vector and the technological vector are integrated. Robotics, being both an academic discipline and a practical application domain, encompasses an exceptionally wide range of contemporary knowledge derived from various academic engineering specialties. Thus, the nature of robotics is interdisciplinary.

The term "robotics in education" (RiE) encompasses a wide range of robot-related applications in the realm of education (Scaradozzi et al., 2019). Globally, robotics education (RE) is an emerging and significantly expanding discipline of study (Liu et al., 2023). It has the

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potential to offer children an innovative and enjoyable educational setting in which they can actively participate in the study of Science, Technology, Engineering, and Mathematics (STEM). STEM is a support for developing technological innovation and becoming the latest trend in educational development so that education is of higher quality and of course more optimal, especially in the current era and in the 21st century. The choice of robotics to support education is because robotics can foster STEM learning. Where, STEM is a learning model that unites and combines four learning at once, including science, technology, engineering, and mathematics. Students are expected to be able to master concepts or theories and be able to hone creative, innovative thinking skills and teamwork skills through robotic media (Hanik et al., 2021).

Engaging in robotics training is a critical means of enhancing students' foundational understanding of Science, Technology, Engineering, and Mathematics (STEM). This is particularly significant as society transitions into the fourth industrial revolution and civilization advances into the fifth (Soebhakti et al., 2023). Educational robots can be categorized into distinct types based on their physical appearances and fundamental operations: intelligent assistant robots, virtual simulation robots, multi-functional suite robots, and uncommon educational robots. Educational robots are distinguished by their adaptability, digitization, consistency, humanization, and inherent interactivity (Pei & Nie, 2018).

Educational robotics programs are gaining popularity in the majority of developed nations and are also expanding in the developing world (Miller & Nourbakhsh, 2016). Students at all educational levels are instructed in programming, design, physics, mathematics, problem-solving, and even music and art through the use of robotics. (Socratous & Loannou, 2020) Educational robotics (ER) are programmable and constructible high-tech devices that have the potential to be utilized as an innovative educational tool in education. They operate following the principles of social constructivism and constructionism, facilitating learning and instruction through interactive exercises conducted in an inviting learning environment. Robotics is needed as education keeps up with the challenges students are facing in a technological environment (Tengler et al., 2022).

B. Benefits of Educational Robotics

In its early days, educational innovation aims to improve educational quality (Sofyan & Abdullah, 2022). In the past decade, educational robotics have garnered a growing amount of attention. At various levels of education, robots are being implemented in the teaching and learning of a variety of subjects via a variety of methodologies. Massaty et al. (2020) incorporate robotics into the learning process to promote the growth of computational thinking abilities and self-efficacy among students. Even students at all levels of their education can benefit from learning about robotics since it can be used to educate them about problem solving, programming, design, physics, mathematics, and even music and art (Younis et al., 2021).

Education incorporating robotics is particularly pertinent in the current digital society, where students are expected to be competent in technology (Gonçalves et al., 2019). Introduction to learning about robots can be done in elementary/primary school (Husni et al., 2019). At various levels of education, robots are being implemented in the teaching and learning of a variety of subjects via a variety of methodologies. Primary education is keenly interested in robotics as technological instruments for a variety of reasons, but primarily due to their compatibility with STEM subjects—science, technology, engineering, and mathematics (Bellas et al., 2019). Teaching educational robotics empowers students to resolve tangible challenges that demand expertise in STEM disciplines (Strutynska et al., 2019).

An increasing number of elementary schools incorporate this advantageous ICT aid, thereby integrating "operate robots" into the curriculum as a natural development (Galindo & Recalde, 2021). Robotics fundamentals must be incorporated into the school curriculum and

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made a fundamental component of youth education (Ospennikova et al., 2015). Several member states of the international community have already implemented the requisite decisions at the state level.

Robotics in education is an effective instrument for encouraging and promoting STEM education among students (Eguchi & Uribe, 2017). It provides students with ample opportunities to apply integration principles to various academic fields such as literacy, social studies, dance, music, and art, in addition to STEM. Moreover, it encourages students to develop collaborative skills through problem-solving, think critically and creatively, and express themselves through the use of technological tools. It is an educational instrument that enriches the learning experiences of students by incorporating hands-on and mind-on learning. Primarily, educational robotics fosters an engaging and stimulating learning atmosphere under its practical application and technological integration.

Numerous schools are incorporating robotics into the curriculum as an innovative learning environment that aids in the development of higher-order thinking skills and the resolution of complex problems by students (Blanchard et al., 2010). Educational Robotics (ER) is aiming to enhance higher-level thinking and skills (Sapounidis & Alimisis, 2021). Suwarsono & Muhid (2020) explain that participation in robotics activities fosters the development of creative thinking skills. This is not solely an exercise in generating ideas, concepts, and works; rather, it enables students to exercise and refine their motor abilities, thereby facilitating the improvement of their overall thinking abilities. Setyarsih (2020) states that robotics education impacts soft skills development for students. Even, Darmawan et al. (2023) add that robotics education improves fine motor skills for elementary students. The introduction of robotics for elementary school students will support motor development smoothly and have a positive impact on the creative thinking skills of elementary school-age students.

Robotics training has a positive effect in improving logical thinking skills, creative thinking skills, problem-solving skills, and the capacity for teamwork through integrated STEM learning of elementary students (Cholish et al., 2023). A problem-solving is regarded as one of the most important competencies for learners in the 21st century (Gratani et al., 2021). Educational Robotics (ER) has emerged as a potent instrument in recent times for fostering computational reasoning and problem-solving skills. Robotics still functions as a tool that can be used as a medium for teachers to maximize the learning they do in class. So technology is only a tool to develop students' potential (Ansari, 2020). Educational Robotics (ER) programs help provide material for challenging subjects. These programs can reestablish a balance between the learners and the technological equipment. This is because the learners can improve their computational thinking and function as programmers (Ronsivalle et al., 2019).

Chiazzese et al. (2019) emphasize the utilization of programming robotics artifacts could potentially enhance students' development of computational reasoning abilities. Moreover, the intervention has a greater impact on elementary students. Diago et al. (2022) also examine the impact of an educational robotic intervention on the computational thinking and mental rotation assessments administered in a classroom. Recently, educational robotics has been integrated into curricula outside the traditional STEM disciplines, where it can also facilitate the development of computational thinking (CT) abilities (Stewart et al., 2021). Jordan (2023) also investigates the impact that educational robots can have on the development of computational thinking in primary school settings, including classrooms as well as extracurricular activities.

According to Widiastuti et al. (2016), robotics extracurricular can increase the creativity of elementary school students. Suyatno & Komarina (2021) explain that extracurricular activities conducted at elementary school contributed to the development of student's abilities following their potential, as well as their creativity and confidence. Robotics extracurricular activities are activities outside of formal learning at school that focus on learning about the introduction and creation of tools that use robotic work systems. It is hoped

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that this extracurricular activity can help students develop concepts of science, technology, mathematics, and engineering. Apart from that, robotics extracurriculars can build students' skills so they can work together to solve challenges more enjoyably. This collaborative skill aims to build students' way of thinking to learn all lessons in general because all concepts for studying robotic work systems are a combination of skills to enter into the logic of the process of learning something.

Pribadi et al. (2023) explain more that by joining extracurricular robotics activities, students can develop their potential, interests, and talents in technology. The results of the research obtained by the researcher, show an increase in technological proficiency and systematic thinking of students, the sharpening of cooperation skills, creativity, and imagination. Many things can be achieved by participating in robotics activities through the facilities offered by the robotics extracurricular at school, some of which can play an important role in changing students' learning methods at school. In the robotics extracurricular, students not only learn about the theory in class but immediately put it into practice using simple robots. Robotic learning also supports the provision of integrated material between several learning subjects such as Science, Technology, Engineering, and Mathematics or STEM. The robotics extracurricular also aims to train students' motor skills and foster logical and creative thinking supported by the creation of simple projects that can make human activities easier. Robotics extracurricular activities can also aim to achieve student achievement by participating in competitions that are held by various institutions. Robotics competitions are a stepping stone for many students to open up opportunities to enter college and get contracts from big companies.

Faisal et al. (2012) demonstrate that utilizing robotics as a means to bridge the divide between how students learn and how teachers teach has been the focus of this initiative. Initially, robotics is being employed as a potent instrument to grow students' interest and pique their curiosity regarding learning. Furthermore, robotics offers students motivation to actively participate in their education, as opposed to becoming uninterested in disjointed facts, equations, and theories. Robotics activities foster an interactive learning environment that promotes student comfort, as opposed to merely requiring them to complete pre-assigned problems in the classroom.

Handayani et al. (2020) explain that using a simple robot can attract students' attention to learning. A robot that is designed to be as attractive as possible, stimulates stimulus for elementary students to have curiosity about the material taught. This curiosity will be the beginning of the growth of students' intention to learn and will continue to the stage of understanding the material. So they can increase the percentage of students' understanding of the material being taught and increase the creativity of elementary students in using robots as learning media tools and directly involving students in the practice of making robots. When students are directly involved in the practice of making robots, students will also think about designing the robot. Even though the robot is simple, students will design the robot according to their tastes and imagination. This method will indirectly hone their creativity and thinking abilities.

In recent years, Educational Robotics (ER) has emerged as a promising educational tool that holds significant promise (Costa et al., 2008). One of its notable qualities is its ability to adapt to the problem-based learning approach, in which students are encouraged to engage in critical thinking and active reasoning in response to emergent challenges. This not only stimulates their interest but also motivates them to tackle frequently intricate subjects. ER is particularly beneficial for teaching and learning natural sciences and mathematics due to these characteristics. This study provides a collection of ER sessions that can be utilized to instruct fourth-grade elementary students on problem-solving concepts associated with multiplication and division operations.

Afonso et al. (2021) examine the effects of pedagogical robotics on primary school students' motivation and learning. students were encouraged to utilize the educational robot-based learning system (Chin et al., 2014). Therefore, the implementation of educational robot-

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based learning systems in classrooms provides a substantial benefit for students, as it enhances their overall motivation and interest in learning. Liu et al. (2023) reveal that children interpreted educational robotics or Robotics in Education (RiE) activities as engaging in gameplay, which increased their interest in their studies; parents observed that their children were more attentive to activities.

The growing popularity of robotics technologies in education has the potential to affect students' learning (Kucuk & Sisman, 2017). According to Mufarola & Murbowo (2019), the benefits of learning robotics are: 1) stimulate systematic thinking and structure in solving a problem. 2) improve motor skills gently in children. 3) improve imagination skills in designing a robot, because in designing robots it is necessary creativity. 4) train cooperation in groups and increase self-confidence, accept and respect the opinions of other people, and dare to say or display creative ideas. 5) practice patience and perseverance in creating a project.

Latip et al. (2020) assess the impact of incorporating educational robotics into STEM education on the development of students' collaborative abilities. The cultivation of collaborative abilities among students can be achieved through the implementation of pedagogical approaches that incorporate hands-on exercises, technological engagement, and collaboration. The incorporation of educational robotics into STEM education can encompass these learning activities. Stem-robotic learning is an alternative learning strategy that can be implemented to foster the development of 21st-century skills, particularly collaborative skills. Participation in robotics activities fosters the development of creative thinking skills. This is not solely an exercise in generating ideas, concepts, and works; rather, it enables students to exercise and refine their motor abilities, thereby facilitating the improvement of their overall thinking abilities (Miselina & Muhid, 2020).

Di Battista et al. (2020) reveal that robotics can be a valuable tool for school students with special needs (SNs). The findings indicated that the majority of educators considered ER to be an effective intervention for children who have multiple special needs, especially those with disorders. However, it is difficult for a teacher to focus on every student in a class, especially when each student has unique needs. Robots can help students with special needs, reduce pressure on teachers, and allow students to develop their own personalized learning experiences. Robots can be programmed to work with individual students who need extra help and tailor the work to them. This can help students focus, motivate themselves, and get more enjoyment from their learning.

Safrudin et al. (2021) reveal that robotics has the potential to enhance the abstraction capabilities of students. Moreover, robotics education increases students' engagement with the learning process. Educators have initiated the development of robotics to integrate it into numerous subjects. STEM, or the integration of the fields of science, technology, engineering, and mathematics. It requires educators with the ability to pursue careers in STEM. Moreover, STEM education incorporating robotics necessitates that teachers investigate a range of skills, including students' abstraction abilities. It is anticipated that students possess this skill to simplify intricate problems, thereby rendering them more manageable to resolve.

Some subjects have abstract concepts and are difficult to understand, such as science and mathematics (Handayani et al., 2020). Not all students can accept the abstract concepts that have been explained by the teacher in a very short time. Robots designed in the education sector can make things easier for teachers to explain this abstract concept. The robot can be programmed so that teachers can create visual learning. Students can see directly the application of functions or formulas in the real world which is unique and interesting. That way, robots can be used as creative tools that are useful in the field of education. This is a challenge for teachers to prepare a robot education mechanism that is appropriate while still considering student competence in understanding robotics concepts well, to encourage creativity and innovation of students.

The last, Virnes et al. (2008) reveal that with a singular concentration on the unique requirements of children, educational robotics may be able to eliminate obstacles to learning

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and enhance special needs education. The implementation of educational robotics ought to be tailored to the specific requirements of each child while also acquainting them with the potential of diverse modes of self-expression and investigation. It ought to enhance the quality of instruction and intervention, promote two-way communication between the child and robot, and facilitate advanced hands-on programming. The research findings provided us with the conviction that educational robotics when appropriately modified, can accommodate a diverse range of users with unique requirements.

C. Curriculum about Implementation of Educational Robotics

Implementing a robotics curriculum for elementary school students in Indonesia is an important step in preparing the younger generation to face an increasingly advanced technological era. The steps start with research and curriculum development that suits the needs of students in Indonesia, as well as teacher training to understand basic robotics concepts and effective teaching strategies. Procuring the necessary equipment and infrastructure is also an important aspect, including integrating the robotics curriculum with the existing school curriculum. Next, teachers need to develop appropriate teaching materials and carry out learning using appropriate methods. Evaluation of student achievement and subsequent adjustments to the curriculum are an important part of this process. By implementing these steps, it is hoped that elementary school students can develop skills and knowledge in the field of technology that is relevant to current developments.

Robotics education is an important thing to include in the curriculum for elementary school students. The main reasons are as follows: 1) future preparation. Technology is increasingly becoming an integral part of everyday life, and understanding robotics is becoming increasingly important. introducing robotics concepts from an early age will help students prepare for a future that is increasingly dependent on technology. 2) skills development. Robotics learning can help students develop a variety of skills, including problem solving, creativity, programming, logic, and computational thinking. these skills are invaluable in facing future challenges in the digital era. 3) Stimulation of interest and motivation: robotics learning tends to be interesting for students because it involves interesting elements such as building and operating robots. this can stimulate students' interest and motivation to learn, thereby improving the overall quality of learning. 4) Collaboration and creativity: robotics often involves collaborative projects where students work together to design, build, and program robots. This not only develops collaborative skills, but also promotes creativity and innovation. 5) inclusive education: robotic learning can be designed to accommodate a variety of learning styles and student needs, thereby enabling inclusive education that engages all students without exception. By including robotics education in the elementary school curriculum, we can provide a strong foundation for student development in facing increasingly complex future challenges in a world dominated by technology.

D. Challenges of Educational Robotics in the Teaching-Learning Process

There are several challenges in the implementation of educational robotics. Primarily, educational robots are utilized in the domains of special education, language acquisition, STEM education, and others. Despite this, the implementation of educational robotics in education is related to issues about gender, teachers, technology, and resources (Pei & Nie, 2018).

Tzagkaraki et al. (2021) found that challenges of educational robotics at the technical level or owing to teachers' lack of relevant knowledge or the lack of suitable measures for their successful integration into the primary school curriculum. Both of these factors are responsible for the difficulties that arise. Besides, obstacles that emerge during its implementation, and its position within academic curricula.

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The money and time required to prepare the activities, as well as the pervasiveness of technology in our daily lives—a reason why some educators are hesitant to incorporate robotics into the classroom—are some of the factors that impede its implementation (Negrini, 2020). Alsoliman (2018) states that some obstacles that are associated with the utilization of educational robots include a lack of information, skills, teaching methodologies, incentives, suitable infrastructure, and rules and regulations.

Karypi (2018) has the same statement that the implementation of educational robotics is caused by several problems, including a lack of financing and physical infrastructure, inadequate training for teachers, and curriculum scheduling that is not flexible enough to accommodate students' needs. It is thus necessary to adopt several structural and procedural changes to further incorporate ER in educational institutions. Although the benefits of integrating new technologies into educational institutions are evident, their implementation is slowed by the absence of a well-established set of best practices, evaluation of experiences, and tools (Screpanti et al., 2021).

Based on the findings above, shows that challenges associated with the use of robotics in education include the high costs of providing robots to students, repairing and modifying robots, as well as the need for adequate school facilities and infrastructure to support robotics education. Another challenge is the lack of teaching methods that cover the full range of knowledge in soft robotics, as most existing approaches focus on robots with fixed morphologies and rigid structures. Additionally, there are obstacles to incorporating robotics into the classroom, such as the need for teacher training and the potential for cultural norms and web-mediated educational regulations/policies to hinder virtual learning. Students with visual impairments face special challenges in accessing mathematics content, and although educational robotics can improve accessibility and interaction, there is a need for human-robot interaction (HRI) to drive the design and functionality of educational robots.

Discussion

Incredible advancements have been made in the field of robotic technology. Products that are equipped with robotic technology are becoming more readily available, and they range from the most basic robots to the most complex robots. It is designed to accommodate a wide range of specialized requirements. Several robotic goods are already completed, so all that is required of students is to play with them. In addition, some robots need to be assembled and adjusted, and there are even robot components that can be chosen according to the design that is intended for the robot. In this way, robots have a great degree of versatility, which allows them to meet the demands of the curriculum and the level of interest of students according to their educational level.

A teacher may employ learning media that is intentionally created for learning purposes (by design) or that is not explicitly intended for learning but can be utilized as such (by utilization) within the Learning Technology discipline. Therefore, in addition to serving as educational resources, robots can also be an engaging learning medium that piques students' interest. The potential of robotic technology lies in its ability to foster the development of diverse competencies that align with the requirements of the curriculum.

Robots are used as a learning medium by teachers, where robots are used to support increased competence, such as; critical thinking, computing (logical, systematic), and creativity. Even though it is not designed as a learning medium, robots can be used as a learning medium. Teachers can utilize robotics as a medium of instruction, employing them to facilitate the development of skills such as critical thinking, systematic and logical computation, and creativity. Although they are not intended for educational purposes, robots can serve as learning mediums. Robotics currently has a significant role in changing learning methods in schools. Students can not only absorb lessons through the theory taught in class but can also directly practice them through robot media. Apart from that, overall robotics learning also supports students to obtain material that is integrated between the subjects of Science, Technology, Engineering, and Mathematics (STEM).

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There are several reasons why educational robotics should be taught. The following social skills are fostered in children and adolescents through the utilization of educational robotics: 1) teamwork: when children progress through the process of working in groups, they come to realize that the outcomes they desire are far more likely to be achieved if they collaborate. 2) discipline and ability to compromise: they comprehend and internalize the significance of committing to the project that they are working on, as well as the need to be patient and diligent. 3) making an experiment. Through the process of trial and error, the outcomes of their labor become visible very fast, and they can determine on their own whether or not they are correct. They learn that making errors is a necessary part of the learning process through the process of experimentation. 4) ability for resilience and conquer the fear of making errors, which contributes to an increase in their self-esteem. This occurs as they are learning that failure is an essential part of any learning process. 5) empowering via do-it-yourself: students achieve autonomy by building their robots and finding solutions to a variety of challenges on their own, all while having fun and furthering their education.

On the other hand, it fosters the scientific and technological capabilities that are: 1) In the field of programming language, they learn these concepts. They acquire their initial concepts of programming and comprehend that it must have order, structure, and technique. 2) In the field of computational thinking, students learn how to abstract concepts, break down a large problem into smaller components, and offer solutions that may be expressed as a series of instructions and algorithms through the process of developing and manufacturing robots. 3) In the field of science, students acquire and put into practice a variety of attitudes, including curiosity, wonder, analysis, and research. It is taught to them how to look for, retrieve, and manage information. 4) Interest in the culture of technology, students begin their introduction to the culture of technology by gaining access to information technology, the internet, and materials that are multimedia in nature. While, in creativity and innovation, students can confirm that there is no one option that is genuine and unique. Because of this, they can unleash all of their creative potential, in addition to gaining knowledge from their peers and searching for unique solutions that go beyond the initial alternative.

While Alimisis (2013) explains the statement differently that the introduction of robotics into the classroom does not guarantee that students will benefit academically; numerous variables can influence the outcome, and technology cannot change minds on its own. While robots can certainly contribute to the improvement of learning, the underlying fundamental problem lies in the curriculum rather than the robots themselves. The curriculum, not robots, will determine the learning outcome and the degree to which technology is aligned with sound learning theories. Educational robotics should be viewed as a tool that supports the development of fundamental life skills, such as cognitive and personal growth, as well as teamwork. These abilities allow individuals to develop their ability to utilize their creativity, to express themselves, and to make decisions in their lives that are both creative and valuable. The benefits of robotics apply to all students; the target groups in robotics projects and courses should include the entire class, and not only the children who are particularly gifted in science and technology.

Conclusion

Robots are used as a learning medium by teachers, where robots are used to support increased competence, such as; critical thinking, computing (logical, systematic), and creativity. Even though it is not designed as a learning medium, robots can be used as a learning medium. Teachers can utilize robotics as a medium of instruction, employing them to facilitate the development of skills such as critical thinking, systematic and logical computation, and creativity. Although they are not intended for educational purposes, robots can serve as learning mediums. Robotics currently has a significant role in changing learning methods in schools. Students can not only absorb lessons through the theory taught in class but can also directly practice them through robot media. Apart from that, overall robotics learning also supports students to obtain material that is integrated between the subjects of Science, Technology, Engineering, and Mathematics (STEM).

Educational robotics is gaining popularity as a learning tool for students, particularly in elementary and primary schools. It is compatible with STEM subjects and can enhance higher-level thinking skills and problem-solving abilities. Robotics activities foster creative thinking, motor skills development, and soft skills development. It can also enhance computational reasoning abilities, particularly for elementary students. Educational robotics bridges the gap between students' learning and teachers' teaching methods, stimulating curiosity and motivation. It can improve students' collaborative abilities, creative thinking, and special needs education. By incorporating hands-on exercises, technological engagement, and collaboration, robotics can develop 21st-century skills and improve overall thinking abilities. It can also help students with special needs by reducing teacher pressure and promoting personalized learning experiences. Educational robotics faces challenges in special education, language acquisition, and STEM education due to factors like gender, teachers, technology, and resources. Technical issues, teachers' lack of knowledge, and inadequate measures for successful integration are also obstacles. High costs, inadequate facilities, and teaching methods in soft robotics also hinder its integration. However, advancements in robotic technology make them more accessible and can be used as learning media to support critical thinking, computing, and creativity. Robotics can foster social skills, and scientific and technological capabilities, and foster interest in technology culture.

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