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The Contribution of Robotics Education in Primary Schools: Teaching and Learning

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Abstract. The adoption of robotics in education has increasingly gained attention. Robotics activities can be applied in any level of education since the early childhood up to, starting in primary schools until graduate schools. Besides, the concept of STEM learning is still a trending issue in the world of education. STEM-based learning with robotics can develop knowledge and the awareness of robotics for students. Notwithstanding the vast literature on adoption of robotics into the educational context activities, there is a possibility of a limited lack of explanation on how robotics contribute in the STEM learning environment at primary school. A systematic literature review was carried out to evaluate the latest developments of robotics topics in the literature. It is prominent in the literature that robotics contribute to teaching and learning in primary schools. Teachers indicated positive responses to robotics due to the ability to attract students' attention and motivation. However, negative responses were recorded for because in the learning process robotics activities took a long time. Robotics activities ranging from assembling, programming, and testing robots can build the skills needed for students in the 21st century. Project-based learning model (PJBL) advocated as the suitable learning model for robotics facilitated education. The interaction between educators and students are collaboratively implemented rather than cooperative. Apart from a deeper literature review, the number of articles that appear in keywords is quite limited. Future research needs to be expanded into more comprehensive keywords and in a broader context.

Keyword: educational robotics, elementary schools, learning robotics, primary schools.

INTRODUCTION

Recently the development of technology has had an enormous impact on the application of education. The existence of technology in education is expected to provide the ability for students to be involved in direct exploration, learning experiences to build cognitive knowledge and social skills [1]. Relevant to Eguchi and Benitti suggestion, that robotics education creates a learning environment where students can find and develop solutions to work with real problems because of the presence of sensors and actuators [2, 3]. Robotics education can be a tool that helps students and teachers to make learning more active and students more motivated [4]. Besides, robotics education considered as one way that can be used to build the skills needed for success in the 21st century [5, 6].

Schools around the world have used robotics in their classrooms to introduce different teaching strategies. Robotic has virtual and non-virtual types. An example of a famous virtual robotic is the Robomind application that aims to provide education related to coding [7-9]. The most popular non-virtual robotics use adopted in educational activities is from LEGO robotics. Variations in the model usually used, e.g. from Evobot, NXT, RCX [3], and EV3 for general and adult users, LEGO WeDo and LEGO Duplo for early childhood users. Robotics applies to various subject's pedagogy [10], but is limited to psychology, art, or remain debatable music [11, 12].

Robotics support the expansion of STEM programs can be useful for creating future careers [13] and provides increased learning speed for students [14]. STEM education emerged as a growing trend in the world of academic education [10]. In some countries, STEM education still a new issue in recent years [10, 15]. STEM-based learning is more valuable to be applied since primary school to high school and undergraduate level [4, 16, 17]. These indicate

the introduction of STEM-based learning with robotics can develop knowledge and the awareness of robotics for students [13].

Notwithstanding the vast literature on robotics education in primary schools, there seems likely a lack of explanation on how robotics will affect the STEM learning environment in primary schools. This circumstance is likely to leave practitioners and academics without obvious guidelines as to how teaching and learning with robotics in the classroom. This review inspects works published in established learning research journals. A systematic review literature procedure was carried out on several published between 2012 and 2018.

The following paper is compiled: In the next section, the theoretical groundation of robotics in primary school literature suggested to follow. The discussions about the findings and proposed strategies in teaching and learning with robotics education suggested in the following sections. In the final section, the paper deduced.

USING ROBOTICS IN PRIMARY SCHOOL STUDENT

Activities play an important role in the acquisition and retention of knowledge. They are learning-by-doing to using objects that can lead learning to be a stronger, deeper, understanding and more durable memories. As Piaget stated, it states that students can build their own concepts, knowledge, and solutions to problems through personal experience [1, 4, 10, 18, 19]. Papert added that it would be more effective if students could gain knowledge by manipulating objects or building objects [1, 18-20]. Since Papert initiated to first applied Logo in education, the use of robotics is technology increasingly become popular in education [20-22].

Robotics facilitates learning that focuses on constructors and designers, encourage students to interact with challenges in solving problems. Learning using robotics is usually activities from designing, building, and doing programming. Learners making robots by using small robot parts, then they design the way to create a framework model. Robots will function after they can write their own code with the help of programmed software. Most robots are used in educational activities as LEGO Robots components consist of several types of control parts, sensors, motors, and visual programming systems [23].

Robotics learning activity changes the role of teachers and students. Usually, teachers transfer knowledge traditionally (lecture method) to passive audiences, while the presence of robotics gives students a more active role and teachers who will accompany them learning to use robots in primary school education is only used as an additional activity, example activities are by providing training during such as summer camps [23, 24]. Students finding interested in learning and hope learning using robotics can include in compulsory learning. In several other countries, it has begun to incorporate learning robotics into the curriculum.

METHODS

The research undertaken on the topic is to review literature according to the Systematic Literature Review framework [25]. Data is collected by reading peer-reviewed articles derived from the desired keywords. The literature review was conducted on journals related to the topic, especially papers that contain keyword educational robotics, learning robotic, elementary school, and primary school. Articles reviewed was conducted within the period 2012 - 2019. The search carried out under those keywords returned a total of 28 peer-reviewed articles. Those searches were mainly limited to publication outlets indexed in Scopus from 12 articles, ERIC 4 articles, Science Direct 5 articles, and the rest of the other databases to maintain credibility. The distribution of the papers depicted in the following charts FIGURE 1.

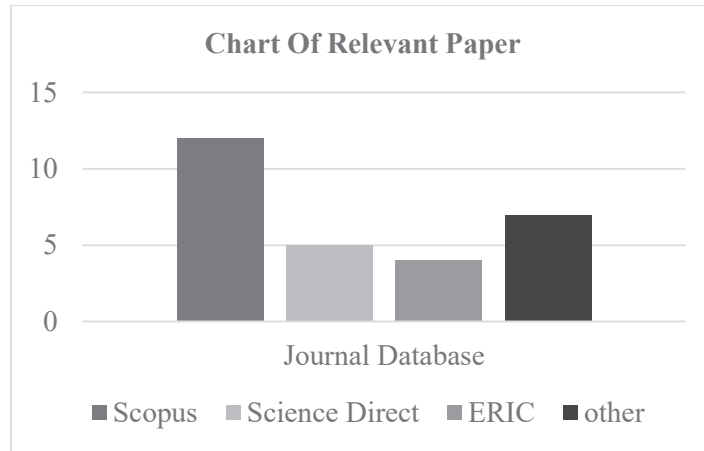


FIGURE 1. Articles Published by Journal Database

A concept matrix was developed to identify insights from each paper. There are four main categories highlighted for this literature review: teacher's attitude towards robotics, strategies for teaching robotics, students' skill, and interaction in educational robotics. Those categories will be discussed in-depth in the coming session.

RESULTS AND DISCUSSION

Upon the accumulated knowledge from a review of the literature were categorized into four areas of interest.

Teacher's Attitude Towards Robotics

TABLE 1. Teacher Attitude Toward Robotics

Author	Tool	Delivery	Content of the Article
Kay and Moss [26]	Lego NXT-G	Workshop	Teachers lack confidence in teaching programming because only a few or even none of them have any programming experience at all.
Kim, Kim [13]	MyRobotTime RoboRobo	Experiment	Using robots in lessons can help pre-service teachers in teaching. Activities that involve robots can integrate learning with STEM (Science, Technology, Engineering, Mathematics).
Savard and Highfield [22]	Lego NXT/ WeDo	Experiment	The teacher is more focused on the implementation of the robotics project with tasks that must complete. Meanwhile, the mathematical concepts that should be learned ignored.
Khanlari and Kiaie [4]	Article & Video Clip	Reviewed Website	Teachers consider robotics as a useful tool for teaching subjects pedagogy in primary schools but cannot fulfil the concepts of Mathematics.
Jaipal-Jamani and Angeli [27]	Lego WeDo	Experiment	Teachers become more self-efficacy and can develop their knowledge and computational thinking skills using robotics.
Reich-Stiebert and Eyszel [11]	Robot Nao	Simulation	Primary school teachers feel that using robots to primary school students is not suitable.

The teacher has different attitudes in learning robotics presented in Table 1. Almost teachers and pre-service teachers primary school has positive attitudes towards new technologies like robotics [13, 26, 27]. The use of robotics is a strategy that is expected to expand teacher knowledge about science content. Primary school teachers usually do

not have science degrees or have not taken university courses in particular disciplines. Not only science, integrating several subject areas is not impossible if using robotics [27]. All teachers and pre-service teachers initially had difficulties in learning robotics, but they can overcome them through trial and error. The experience and knowledge of how to survive through difficulties will help teachers to reach effective teaching goals [13].

Negative attitudes were also found for teaching and learning with educational robots [4, 11, 22]. The teacher is concerned that a robot will replace his role. They assumed that primary school children considered not suitable for applied robotics learning. Overall, the teacher reported a little previous experience with the robots. Teachers lack confidence in teaching programming because only a few or even none of them have any programming experience at all [11]. After attending the workshop, the teacher acknowledged that they became more confident to use robotic learning [26]. However, there may be many difficulties in applying the robotics lesson in the classroom. Not all teachers can apply what they should do based on training or workshop [13].

Strategies for Teaching Robotics

TABLE 2. Strategies for Teaching Robotics

Author	Learning Approaches
Altin and Pedaste [21]	Many learning approaches can be applied to robotics learning such as discovery learning, collaborative learning, problem-solving learning, project-based learning, competition-based learning, compulsory learning, and inquiry learning.
Park, Kim [28]	Gradual learning that starts from the basic, advanced, and application stages is carried out in introducing educational robot.
Khanlari [29]	Robotics learning will succeed if students work as small groups.
Camilleri [30]	Project-based learning has a suitable approach to be applied in learning robotics because it fits the characteristics of constructivism.
Rodríguez, Martín-Pulido [31]	Combining educational robotics with a project-based learning environment creates tools that can motivate and train students in various activities.

A general description of the robotics teaching strategy is presented in Table 2. The background of educational robotics is constructivist learning. Constructivist learning provides direct exploration and design experience using tools that provide opportunities for students to understand concepts. Khanlari said robotics learning would succeed if students work as small groups [29]. Forming groups means requiring individuals to communicate with each other so that the issues discussed can resolve. However, sometimes, communication problems occur among groups member which make some students choose better at working personally [32].

Basically, constructivist learning creates various approaches that can be used to study robotics such as discovery learning, collaborative learning, problem solving learning, project-based learning, competition-based learning, compulsory learning, compulsory learning, and inquiry learning [21]. The most widely used approach is project-based learning [30, 31]. Providing task in the form of projects creates an environment of active learning activities to find solutions and can be integrated with other fields [33]. Construction activities and programming of robots are formed in a variety of challenging tasks helping them to solve problems [34], especially if the assignment of tasks is given phases from low level to expert [28].

Students' Skill

Primary school children are still considered too fast in knowing programming. Usually, students will initially find it challenging to learn, but over time students get learning experiences [20]. The robotics environment can make primary school students use physical programming tools to make robot programming activities. The tool helps them learn quickly without the need to learn the complicated syntax and then can validate the results of programming that have been made [35]. Experience directly using robotic tools can improve thinking skills and through programming introduces students to linguistic skills [5]. This ability develops into computational thinking, which is an activity to abstract problems and finds solutions that can be automated [36]. Computational thinking is a general skill for students will form when learning robotics [37]. It is a problem-solving skill that has been widely mentioned a lot [3, 5, 38]. Also, learning with robotics trains students in teamwork skills [5, 14, 18, 38]. The ability of teamwork is closely

related to communication skills. The occurrence of good communication in groups will have an impact on high learning outcomes [24]. Other abilities possessed by students when learning robotics can see in Table 3.

TABLE 3. Students' Skill

Author	Skills Built on Robotics
Benitti [3]	Skills that can improve through robotics, i.e. problem solving, scientific inquiry, and logic.
Scaradozzi, Sorbi [5]	Using LEGO WeDo teaches programming to primary school students, also developing their creative thinking, teamwork, problem-solving skills, linguistic skills, and logic
Smyrnova-Trybulska, Morze [14]	Robotics learning activities make students have ability to learn independently, work in groups, effective collaboration, and skills in communication
Korkmaz [39]	The Lego Mindstorms Ev3 activities enhance students' algorithmic thinking and programming skills.
Zygouris, Striftou [18]	During participating in robotics activities students gain social skills (teamwork) and become productively competitive.
Chalmers [38]	Opportunities in developing computational skills, problem-solving, and group work can be done by educational robotics such as using LEGO WeDo.

Interaction in Educational Robotics

TABLE 4. Interaction in ER

Author	Content of the Article
Somyürek [19]	Robotics as a tool for constructivist learning has four components: active, authentic, various perspectives, and collaborative.
Yuen, Boecking [40]	Cooperation and collaboration have different understandings, and robotics leads more to collaboration that will help students to have creative thinking and problem solve.
Kucuk and Sisman [20]	The existence of collaborative activities in robotics education influences positive teacher-student interactions.
Kim, Kim [13]	Participants ask questions to the teacher and answer the teacher's questions as a group is collaborative activities found in learning robotics using small groups.

Learning activities with games provide a pleasant environment. The behaviour of playing with robots provides entertainment for students. The robotics activity process introduces learning with game scenarios through designing and building robots together [38]. Students usually need a long time to construct robots so they need guidance from the teacher. Initially, participants will be guided during the learning process but gradually students will try to learn independently so that they are able to ask questions as needed [20]. Participants can ask questions to the teacher and be able to answer teacher questions is one form of positive interaction found between teacher and student. This is one of the collaborative forms that have been carried out [13]. Cooperative and collaboration have different meanings (see Table 4). Robotics is more specific for collaboration. Collaborative activities go beyond cooperative because collaboration is more a process of creating students as creative thinkers and problem solvers, different from cooperative activities that are only to achieve goals [40]. Collaborative leads students to be able to think through various sides [19].

CONCLUSION

The purpose of this article is to find out the contribution of educational robotics in primary schools to produce the correct guidelines for implementing robotics activities in the teaching and learning process. The results of this research indicate that the use of robotics in primary schools can contribute well to the learning environment. Teachers in accepting new technologies have various attitudes, and there are positive and negative. Hence, teachers feel that they can apply robotics learning if they already have a basic knowledge about robots. From various learning approaches, project-based learning is a suitable approach for applying robotics learning. The results of learning robotics indicate that students can build computational thinking skills, teamwork, communication skills and collaborative interaction between students and teachers. However, the number of journals reviewed in this article is considered limited. Further empirical research must be conducted to examine related matters.

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