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OPPORTUNITIES FOR USING ROBOTICS IN LEARNING TO SUPPORT STUDENTS' COMPUTATIONAL THINKING ABILITY IN DEVELOPING COUNTRIES

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ABSTRACT

Computational thinking or more familiarly known as Computational Thinking (CT) has been described as an important skill in learning that all students must possess. Computational thinking is a universal attitude and skill, so it can be applied to all disciplines. The basic abilities of computational thinking include algorithmic thinking, decomposition, generalization, abstraction (problem-solving), and evaluation (evaluating problem-solving solutions). This basic ability of computational thinking can be supported by applying robotics as a process of generalizing information and solving problems. In addition, robotics in education is a new innovation and engineering that can help the learning process, increase student motivation, and encourage students to think critically, creatively, and play an active role in learning. So it is necessary to have a literature review from various sources to see the extent of the opportunities for using robotics to support computational thinking in Indonesia. The purpose of this systematic literature review is to provide educators and educational researchers with an overview of the opportunities in Indonesia to apply robotics in learning as an effort to support students' ability to think computationally. The literature review was conducted using research in the last ten years and from various database sources to find the benefits of using robotics in learning and its effects on students' computational thinking. In the end, there is an opportunity for the application of robotics to education in Indonesia not only at the tertiary level, middle school, or elementary school but also for early childhood education or PAUD. In addition, the use of robotics can also motivate children's learning and can help children to take an active role in learning to count, read, and write.

INTRODUCTION

Computational thinking is an important ability that everyone must have in the learning process. Seymour (1980) Paper initiated Concretizing Computational Thinking in 1980, then became increasingly popular in 2006 after Wing conducted research at the international level and introduced it to the term Computational Thinking (computational thinking). The basic abilities of computational thinking include algorithmic thinking, decomposition, generalization (patterns), abstraction, and evaluation (Csizmadia, 2015). These basic abilities control and manage in the cognitive realm, as well as understand and solve problems in various contexts and scientific disciplines, (Lockwood, J., & Mooney, A., 2017) (Chambers, J. M. J. M., Carbonaro, M., Rex, M., & Grove, S. ,2007). Included in the ability to count, read and write in early childhood (Atmatzidou, & Demetriadis, 2016).

The education curriculum in Indonesia continues to develop, the last curriculum used was the 2013 revised curriculum. The 2013 curriculum packs several subjects with a student-centered learning system, namely student-centered learning (Sani, 2014). Student-centered learning requires students to take an active role in learning, think critically in solving problems, and be able to work together in teams. The development of technology in the 21st century explains that learning must use multimedia tools to help teachers achieve an efficient learning atmosphere. One of the renewable technologies that can be used in learning is robotics.

The application of robotics in learning has started from early childhood education to higher education (Kamal, F., & Budiyanto, C. W., 2018). Robotics is becoming a new trend and innovation in learning that can affect learning success. This success is not only in the academic field but also in the non-academic field, , . Robotics can motivate students to take part in learning, making students play an active and creative role (Toh et al., 2016). Besides, robotics in learning can also facilitate cooperation, build understanding concepts, change mindsets, and think critically. Robotics can motivate students to take part in learning, making students play an active and creative role (Toh et al., 2016). Besides, robotics in learning can also facilitate cooperation, build understanding concepts, change mindsets, and think critically.

Student-centered education indirectly requires students to take an active role and think critically in solving problems. From several previous studies that were effectively used in developed countries, further research is needed if applied in developing countries, especially Indonesia. The curriculum applied in Indonesia is in line with the basic skills of computational thinking. The basic abilities of computational thinking are logical reasoning, decomposition, pattern equalization, problem-solving, and evaluation. From some of the basic abilities of computational thinking, it can be supported by using robotics in learning. In the end, a further review is needed regarding the use of robotics in learning and its effectiveness if it is applied to support computational thinking skills.

A systematic literature review was carried out by examining the last ten years of articles from various database sources with the keywords of robotics (educational robotic), computational thinking, and the 2013 curriculum. From the literature obtained, it will show that there is a relationship between educational robotics and computational thinking skills, as well as opportunities for application in developing countries such as Indonesia.

RESEARCH METHODS

This research is a systematic research methodology literature review. A systematic literature review is a preliminary study by reviewing previous studies. This article adopts the systematic methodology of the literature review from Okoli (2010). The steps are taken in making a systematic literature review include 8 steps. These steps are determining the objectives of the literature review, the provisions for conducting a review, searching for literature, grouping literature, assessing quality, extracting data, formulating findings, and writing review results. The results of each step are as follows:

Determine the purpose of the literature review

The first step in literature is to define goals and assess what is needed. Identifying goals and objectives that will be carried out by the researcher. This article examines the existence of opportunities

2. Make provisions for reviewing (protocol of the review)

The provisions in conducting literature before searching are determining the database that will be used to look for references and determining the keywords to be used before the search begins. Here we use a database with a background in information technology and use the keywords "educational robotic", "computational thinking" and "curriculum 2013".

3. Looking for literature (searching for the literature)

In this study, we used different databases and digital libraries. including ScienceDirect, Springer Link, ACM Digital Library, and other digital libraries.

4. Grouping literature (practical screen)

Table 1. Database data used

Bibliographic Database	**Database URL**	**Total**
ScienceDirect	http://www.sciencedirect.com	14
ACM Digital Library	http://dl.acm.org	4
Springer Link	http://link.springer.com	4
Other	...	13
Total		**35**

A practical screen is also commonly called a filter for inclusion, at this stage, the researcher examines explicitly and considers which one is included in the realm of review. This can be seen from the appropriate keywords, then reading the skimming in the abstract and conclusions. We reviewed 35 papers from three databases with appropriate keywords.

5. quality appraisal

In this step, we need to explicitly outline the criteria for judging which articles are of insufficient quality to be included in the review synthesis. The criteria for the papers we review are computational thinking in education, robotics in education, and implementation of the 2013 curriculum. Figure 1, depicts the education level of the reviewed literature, and Figure 2, illustrates the number of papers reviewed based on the search topic.

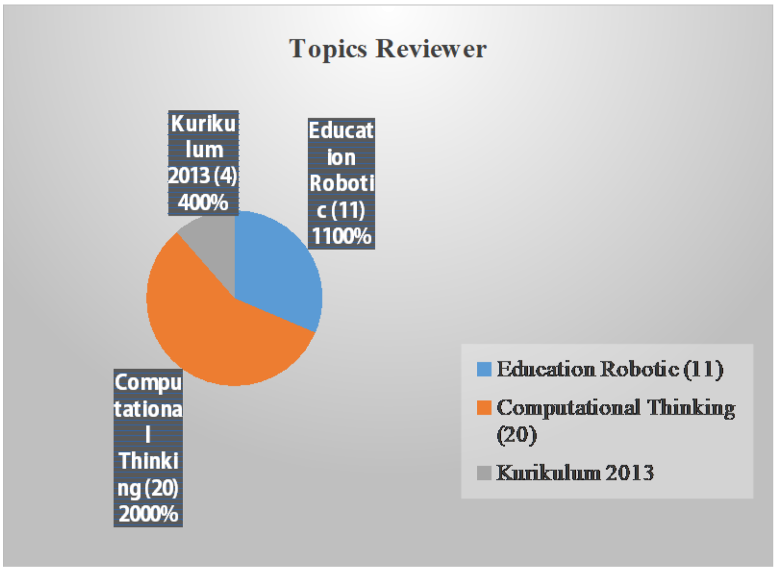

Figure 1. Education Level Data reviewed

6. data extraction

Once all literature has been identified, we need to systematically extract applicable information from each study. As a means of building a comprehensive understanding of the subject, a concept matrix is constructed focusing on computational thinking and educational robots. The concept matrix includes the title and name of the paper, year of publication, participation, level, delivery, subject, keywords, insights, and themes (Watson and Webster, 2002). In this study, we extracted from each selected literature. This matrix concept provides information to verify quality criteria and to perform synthesis. Next, the items were grouped into findings. These findings are the result of systematic literature discussion.

7. synthesis of studies

This step involves combining the facts drawn from the research, then grouping the findings based on common themes. Formulate the findings of the effects of computational thinking and robotics education on learning. This is also related to the 2013 curriculum education system prevailing in Indonesia.

8. writing the review

The final stage of this literature review is to write the results of the discussion and findings in the previous stage into an article.

RESULTS AND DISCUSSION

The Importance of Computational Thinking Ability in learning

Computational thinking is a cognitive or thinking process that involves logical reasoning by which problems are solved and represented, procedures and systems are better understood. This includes:

1. Ability to think algorithmically;
2. Ability to think concerning decomposition;
3. Ability to think in generalizations, identify and make use of patterns;
4. Ability to think in abstraction, choosing good representations;
5. Ability to think in terms of evaluation.

While the approach used in computational thinking skills is to play and experiment, create and create, analyze, and find solutions to problems, and collaborate. An overview of the concepts and approaches to computational thinking is shown in Figure 3 below.

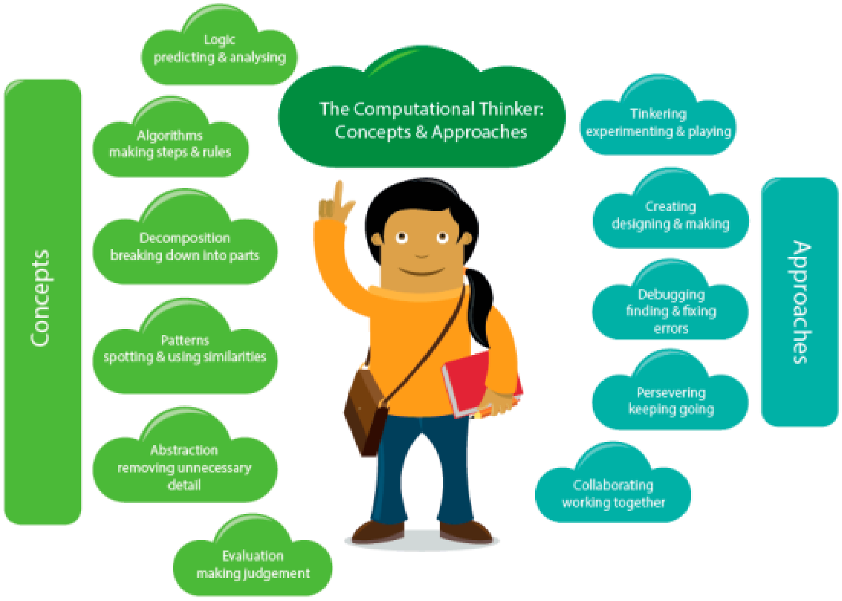

Figure 2. Computational Thinking Concepts
(Source: Csizmadia, 2015)

Computational thinking skills are important for various levels of education, especially for children aged 1-13 (Mohaghegh & Mccauley, 2016). Computational thinking can be applied in various subjects to increase the effectiveness of learning and equalize the understanding of various students, one of which is in Science (Marina Umaschi Bers, Flannery, Kazakoff, & Sullivan, 2014). Apart from science, computational thinking skills can also be applied in mathematics (Orton et al., 2013). Especially for children in elementary school, thinking about computing is an important thing that can increase the level of creativity in solving problems (D. J. Portelance, Strawhacker, & Bers, 2016). Computational thinking can also be applied at various ages and levels of education, one of which is at the university level (Chen et al., 2017). Then, computational thinking has also been shown to increase in male and female students (Atmatzidou & Demetriadis, 2016).

The benefits of robotics education to improve students' thinking skills

Using robotics in learning can make students more logical and creative in solving a problem, than those who do not use robotics media (Hutamarn et al., 2017). Another point of interest is that robotics can be used to improve CT. Robo Cup Junior (RCJ) has a positive impact on STEM (Science, Technology, Engineering, Mathematics) learning. Not only that, robotics has an impact on the skills required in the STEM field including collaboration and communication skills, computational thinking, and engineering skills (Eguchi, 2016) (Özturan *, Bozanta, Basarir-Ozel, Akar, & Coşkun, 2015). And then, Lego Education Wedo is also effective at enhancing Computational Thinking. The potential of Lego wedo Education software in the subject of natural sciences to promote computational thinking, and to engage primary education students in programming, and problem-solving is proven (Pinto-Llorente, Martín, González, & García-Peñalvo, 2016). Apart from that, there are also software applications capable of enhancing CT. An example is Scratch, this has been proven. Significant improvements are related to the concept of learning, logic, and computational practice with an active approach and, also, show improvements related to computational thinking and computational practice (Sáez-López, Román-González, & Vázquez-Cano, 2016). Using strokes shows that students enjoy playing with scratches and shows that this programming environment is efficient for learning some programming constructs in childhood and lower levels of education (Papadakis, Kalogiannakis, & Zaranis, 2016).

Opportunities for Using Robotics for Computational Thinking Skills with the 2013 Curriculum in Indonesia

The following study demonstrates the use of robots at different levels of schools. Robots can increase student confidence in programming classes. Many responses from students in the first-year experiment showed a project using robots to be useful in programming classes (Lee & Lovvorn, 2016). In a different study, using LEGO Mindstorms NXT is significant for teaching in data acquisition, control systems engineering, and Real-Time Systems undergraduate programs (Cruz-Martín et al., 2012). Furthermore, LEGO Mindstorms NXT fulfills the basic education and professional orientation demands of high school students who focus on automation, control systems, and robotics (S. A. Filippov, Fradkov, & Andrievsky, 2011). Using robots as a teaching tool, learning theory based on foundation can support lessons that are not directly related to robotics in higher education (Spolaôr & Benitti, 2017). In addition, ER also uses efficiently in the classroom about science subjects and the math cycle (Ospennikova et al., 2015). Not only that, robots have significant effects on three subscales (mathematics and scientific investigation, teamwork, social skills) as well as for two main categories (technical skills and soft skills / social aspects) (Kandlhofer & Steinbauer, 2016).

The use of robots in courses for children and adults, makes the perspective of children becoming scientists and engineers (S. Filippov, Ten, Shirokolobov, & Fradkov, 2017). Then, Robotic Education (ER) in early childhood is suitable for increasing ability planning and controlling complex tasks and is suitable for fostering several important life skills (cognitive, personal development, and teamwork) (Di Lieto et al., 2017). Robotics can be used as a tool to engage children in developing computational thinking, robotics, programming, problem-solving, and learning about the engineering design process. Not only the cognitive dimension but also extends to the social and moral dimensions of children's experiences through and with technology, towards the goal of helping children develop in an integrated and holistic manner (Marina U. Bers, 2010). It is also supported that using robotics to attract kindergarten children in science and technology (Marina U. Bers & Portsmore, 2005) (Özturan * et al., 2015)

Then, the influence of robots on children's skill development can be grouped into four main categories: cognitive, conceptual, linguistic, and social (collaborative) skills (Toh et al., 2016). Recent research and theory based on new programming environments support the argument that children's animation programming, graphic models, games, and robots (with age-appropriate material) enable them to learn and apply concepts such as abstraction, automation, analysis, decomposition, and design. recurring (Sullivan & Kazakoff, 2013). Interestingly, in pre-kindergarten, children can master the basic concepts of programming and robots. Robotics is not only an interesting activity, but it can also be integrated into other curricular units that occur in the classroom (Sullivan & Bers, 2016).

Using robotic technology in education is increasingly common and has the potential to influence student learning. Educational robotics is a valuable tool for developing students' cognitive and social skills, and it is of great interest to teachers and researchers, from pre-schools to universities. For example, elementary school students and teachers in Turkey use robots for one-to-one robotic instruction (Kucuk & Sisman, 2017). Then finally, the Robotics curriculum is also effectively used in Montessori classrooms. The effectiveness of curriculum robotics in a Montessori classroom should include material that mimics traditional Montessori tangibles, a teacher who is comfortable and confident with teaching robotics, and a collaborative student environment (Elkin, Sullivan, & Bers, 2014).

Atmatzidou and Demetriadis have investigated the CT adopted by Wing, this focused on basic CT skills: abstraction, generalization, algorithms, modularity, decomposition and problem solving (Atmatzidou & Demetriadis, 2016) (Atmatzidou & Demetriadis, 2014) (Wing, 2008). The proposed model encompasses skills that can easily emerge when students engage in educational robotics activities. In detail, the proposed model for CT skills presented in Table 2.

Table 2. The CT skills model applied in study

CT skills	Description	Student skills
Abstraction	Abstraction is the process of creating something simple from something complicated by leaving out the irrelevant	1 Separate the important from the excessive information. 2 Analysis and determine general behavior or programming structure

CT skills	Description	Student skills
	details, by finding the relevant patterns, and by separating ideas from tangible details.	between different scripts. 3 Recognize abstractions between different programming environments.
Generalization	Generalization is transferring a problem-solving process to a wide variety of problems.	Expand the solution to the problem given to cover more possibilities/cases
Algorithm	Algorithm is a practice of writing step-by-step, specific and unambiguous, instructions for carrying out a process.	1 Explicitly state the algorithm steps. 2 Identify different effective algorithms a given problem 3 Find the most efficient algorithm.
Modularity	Modularity is the development of autonomous processes, which encapsulate a set of often used commands that perform a specific function and might use in the same or different problems	Develop autonomous part of code that will be used for the same or different problems
Decomposition	Decomposition is the process of breaking problems down into smaller parts that may be more easily solved	Solve problems to smaller/simpler parts that are more to manage

Adopted by S. Atmatzidou and S. Demetriadis (2016)

CONCLUSION

From the 35 literature reviews above, it can be concluded that computational thinking skills are needed in education, both early childhood education, and college. Then robotics can have a positive influence on learning and can support computational thinking skills. The 2013 curriculum system with a scientific approach has something in common with the concept of computational thinking. This is a great opportunity to apply computational thinking skills in learning with the 2013 curriculum.

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