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by

Submission date: 16-Nov-2020 05:05AM (UTC+0700)
Submission ID: 1446826997
File name: 23.docx (1.93M)
Word count: 3813
Character count: 22785

Do Educational Robotics Competitions Impact on Students' Learning?

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Abstract. The development of robot technology has grown rapidly. Robots have been widely used in various aspects to help human interests. In the education sector, robots have also been used as a learning tool that is used to assist in studying fields such as science and technology. Currently, to encourage the development of robots in the education sector, robot competitions are held with various kinds of events. The types of robots developed to participate in robot competitions are also various, such as mobile robot contest, modular robot contest, humanoid robot contest, flying robot contest, underwater robot contest, innovation robot contest, brick robot contest, and VR robot contest. The robot competition event can be national and international. The purposes of this study are to identify what kind of skills are obtained by students after following the learning process using educational robotics competitions and to determine the appropriate learning model for the use of educational robotics competitions in studying the field of science and technology. The research to be carried out is a literature review research. The research method is the Comprehensive Literature Review (CLR). This method has three phases such as exploring phase, 2) interpretation phase, and communication phase. The results showed that the learning model that was widely used in educational robotics competitions was project-based learning and was followed by problem-based learning. The skills obtained are to assist understanding science and technology, to develop computer programming skills, to sharpen problem-solving capability, to foster creativity and innovation, to bridge the gap between theory and practice, to practice teamwork and social skills.

1. Introduction

Many robot competitions have been held both in Indonesia and in the world. Robot competition also has many kinds. There are some famous world robot competitions such as Abu Robocon, Trinity College International Robot Contest, RoboCup Soccer Humanoid League, and RoboCup Soccer. Meanwhile, robot competitions in Indonesia have also been widely held both locally and nationally. The national robot competition which is held regularly every year is the Indonesian Robot Contest (KRI). KRI is intended to be followed by university students in Indonesia.

The hold of robot competitions can promote the development of robots in the sector of educatio rapidly. Through the robot competition, it able to give information and to get access for students to advanced accomplishments in science and technology (Paturca, Enescu, Ilas, & Morega, 2010), to supply gr nts for the development of knowledge and technology (Stier, Zechel, & Beitelschmidt, 2011), to provide educational institutions with modern teaching programs for achieving practical skills

and theoretical knowledge (Caro, 2011). The impact of the robotics competitions on the student's interest is to make students more deepen knowledge toward science and technology (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014).

Robots can attract students' attention to learn learning materials related to robots. The use of robots as a learning tool has been widely used to assist learning. Learning using robots or often referred to as educational robotics can be used for different environments. The educational robotics can be held in an ordinary school or after-school programs. Meanwhile, using educational robotics for the competition taught in schools is called educational robotics competition (Patiño, Diego, Rodilla, Conde, & Rodríguez-Aragón, 2014). The educational robotics competition is capable to develop students to encourage knowledge and achieve practical skills and scientific experience during the learning process. As a consequence, new skills are immediately applicable to implementation in using robotics practice (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014). The objectives of this research are to identify what kind of skills are obtained by students after following the learning process using educational robotics competitions and to identify the appropriate learning model for the use of educational robotics competitions in studying the field of science and technology.

Robotics Competition

A robotic competition is an event in which robots have to complete an assignment. Every robot competition has different objectives. For instance, RoboCup as an event of robotic competition has the main objective to promote research related to Artificial Intelligence. Meanwhile, The First Lego League is a robot competition particularly aimed at education where elementary and junior high school students participate (Okada, Inamura, & Wada, 2019). Meanwhile, according to (Masar & Bahnik, 2011), the objective of the educational robot competition is a practical application of knowledge learned during class by solving various assignments. The students can deepen their knowledge from various fields and skills.

Some robot competitions are held around the world, ranging from national to international scale. In Indonesia, the Indonesian Robot Contest is divided into 6 divisions, namely (Indonesia, 2020): 1) Indonesian ABU Robot Contest (KRAI); 2) Indonesian Fire Extinguisher Robot Contest (KRPAI); 3) Indonesian Dance Robot Contest (KRSTI); 4) Indonesian Football Robot Contest (KRSBI) Humanoid; 5) Indonesian Football Robot Contest (KRSBI) Wheeled; and new division 6) Indonesian Thematic Robot Contest (KRTMI). For international robotic competitions are FTC (First Tech Challenge), FLL (First LEGO League) in the United States, ELROB (European Land-Robot Trial) in Europe, and ABU ROBOCON (Asia-Pacific Broadcasting Union Robotics-Contest) in Asia. RoboFest is a robotics competition in Rusia that has the main types of competition such as mobile systems is made under the regulations, android is an android robot competition, freestyle with categories such as robotic assistants, creative class, sports category, and “Hello, robot!” is for novice to engage in robotics (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014). Another world's class robotics competition is The World Robot Summit (WRS) is a competition held to realize a world where humans and robots can collaborate and coexist and goals to compete for robot technology that can be used as a familiar product. The WRS presents robot technology competitions designed, especially, to enable humans and robots to collaborate with and complement each other (Okada, Inamura, & Wada, 2019).

2.1. Skills in educational robotics competitions

Skills are one of the learning outputs resulting from the learning process in the classroom. Skills are needed to determine the level of student understanding of the theory being learned. The skills that students acquire can be trained in the learning process (Valls, Albó-Canals, & Canaleta, 2018). The various types of skills obtained are following the learning design in the classroom. The use of robotics competition in classroom learning can develop the skills of students (Gueorguiev, et al., 2018).

The usage educational robotics competitions have some advantages such as: to inspire the student to interest in learning STEM, to help the student to understand science and technology, to develop computer programming skill of the student, to sharpen problem-solving capability of the student, to

develop design and integration skill of the student, to foster creativity and innovation of student, to cultivate the technical skill of the student, to bridge the gap between theory in the class and practice in the real world, to practice teamwork and social skills and to improve presentation skill (Christoforou, et al., 2020).

2.2. Learning model in educational robotics

The use of robotic competition in classroom learning is an interesting thing. This is because students can directly practice the theory they get in class to be practiced directly in the face of a robot competition they want to participate in (Ziaeefard & Mahmoudian, 2018). For this reason, it is necessary to determine how the appropriate learning model is to teach robot competition in the classroom. Some researchers suggest using project-based learning (Daniel, Csorba, Szaloki, Beck, & Tevesz, 2012), and (Oksanen, Kostamo, Tamminen, & Tiusanen, 2011). This is because students can directly apply robot projects aimed directly at the competition (Yudin, Vlasov, Salmina, & Sukhotskiy, 2019), and (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014).

Some researchers use problem-based learning using educational robotics competitions. The use of problem-based learning can train students in solving problem-solving (Chen, 2019), (Neves, Silva, Gonçalves, & Costa, 2016), and (Fujita, et al., 2019). This skill is needed when there are problems that arise when the robot competition is taking place, how students can solve the problems that arise as quickly as possible so that they can win the competition (Rativa, 2019), and (Christoforou, et al., 2020).

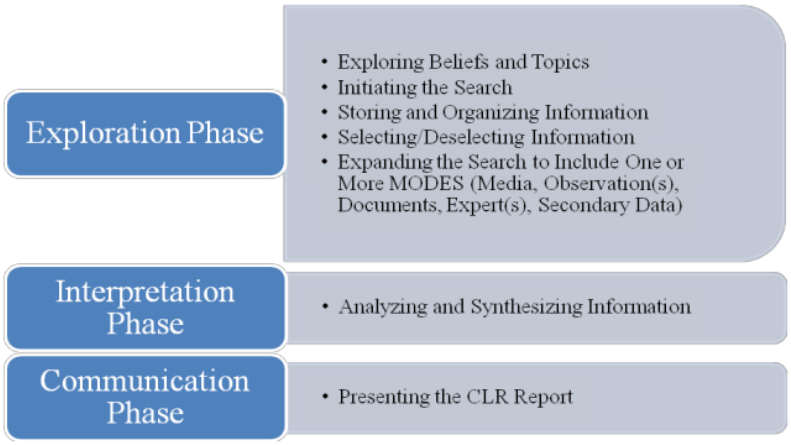

Figure 1. Comprehensive Literature Review (CLR) method

3. Methods

This study used the Comprehensive Literature Review (CLR) method (Onwuegbuzie & Frels, 2016). The CLR method has seven steps, such as 1) Exploring Beliefs and Topics, 2) Initiating the Search, 3) Storing and Organizing Information, 4) Selecting / Deselecting Information, 5) Expanding the Search to Include One or More MODES (Media, Observation (s), Documents, Expert (s), Secondary Data), 6) Analyzing and Synthesizing Information, and 7) Presenting the CLR Report. This CLR method has 3 phases consisting of the seven steps, namely Exploration Phase (Exploring Beliefs and Topics, Initiating the Search, Storing and Organizing Information, Selecting / Deselecting Information, Expanding the Search to Include One or More MODES (Media, Observation (s)), Documents, Expert (s), Secondary Data)), Interpretation Phase (Analyzing and Synthesizing Information) and Communication Phase (Presenting the CLR Report). Figure 1 shows the phases and steps of the CLR method.

4. Result

The first phase of CLR provides the necessary aspects of discussing educational robotics competitions. These three aspects are the Name of Robot Competition, Knowledge and Skill, and Learning Model / Method. Determining the aspect of the Name of Robot Competition to find out what kind of robot competition is being carried out and to focus on what kind of robot competition. The Knowledge and Skill aspect is determined to find out what skills and knowledge are being trained in this learning. Identifying Learning Model / Method is to identify the learning model used in an educational robotics competition in the classroom.

Table 1. The aspects of educational robotics competitions

References	Name of Robot Competition	Technical Skill	Non-Technical Skill	Learning Model/Method
(Zainal, Abdullah, & Prabuwono, 2012)	Robot soccer competition	Programming skills	critical thinking skills, problem-solving, Personal skills	Student self-centered learning method
(Fujita, et al., 2019)	the Amazon Robotics Challenge 2017	Programming, gripper design, sensor	Problem-solving,	Problem-based learning
(Daniel, Csorba, Szaloki, Beck, & Tevesz, 2012)	Eurobot contest	Mechanical and electrical robot design	Collaboration skills	Project-based learning
(Eguchi, 2015)	RoboCupJunior	STEM	Innovation and creativity	The hands-on, project-based and goal-oriented learning experience
(Neves, Silva, Gonçalves, & Costa, 2016)	MicroFactory competition	Localization, scheduling, navigation	Cooperation problem	Problem-based learning
(Oksanen, Kostamo, Tamminen, & Tiusanen, 2011)	Field Robot Event	Mechatronics, computing development	Team working	Project-based learning
(Zuhrie, Munoto, & Buditjahjanto, 2020)	KRPAI	Programming skills	Problem-solving in the project,	Contextual Teaching and Learning
(Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014)	RoboFest	Computer programming and control theory	Team working	Project-based learning
(Okada, Inamura, & Wada, 2019)	The World Robot Summit	Robot design	Cooperate skills, practical problem	Project-based
(Masar & Bahnik, 2011)	Online robot contest	Programming skills, mechatronics system	Problem-solving skill	Problem-based
(Christoforou, et al., 2020)	Robotex International	Robot design, programming skill	Problem-solving skill	Problem-based

The second phase of CLR produces some literature that discusses three aspects that mention in the first phase. Table 1 shows that there is almost a variety of skills trained in robotic competition in the classroom. The most widely used problem-solving skills are shown in references (Zainal, Abdullah, & Prabuwono, 2012), (Fujita, et al., 2019) and (Neves, Silva, Gonçalves, & Costa, 2016). Next are the Programming skills shown in references (Zainal, Abdullah, & Prabuwono, 2012), (Fujita, et al., 2019) and the collaboration skills or team working skills shown in the references (Daniel, Csorba, Szaloki, Beck, & Tevesz, 2012) and (Oksanen, Kostamo, Tamminen, & Tiusanen, 2011). Meanwhile, the most widely used aspects of learning models/methods are those that use project-based learning as shown by references (Daniel, Csorba, Szaloki, Beck, & Tevesz, 2012), (Eguchi, 2015) and (Oksanen, Kostamo, Tamminen, & Tiusanen, 2011). This is followed by problem-based learning as shown in references (Fujita, et al., 2019), and (Neves, Silva, Gonçalves, & Costa, 2016).

4.1. Discussion

The third phase of CLR produces a report on the results of the literature review. The results of the literature review show that educational robotics competition provides many benefits for learning. Educational robotic competitions are an excellent way to foster research and to attract students to technological areas (Zainal, Abdullah, & Prabuwono, 2012). Educational robotic competitions have helped students to learn a lot, especially on materials related to science and technology. In line with this, research (Akagi, Fujimoto, Kuno, Araki, Yamada, & Dohta, 2015) stated that educational robotics competition makes the learning process more effective and to make students learn to be independent to study the subject material of robotics and mechatronics and to enhance the students' motivation for competing in the robotics competition. This is also supported (Eguchi, 2015) stated that educational robotics competition can also be used to deepen subject matter such as in the fields of physics, programming, mechanical engineering, electronics, and science. Likewise, the results of research (Barker & Ansorge, 2007) show that using educational robotics competitions intervention in a scientific field material can improve student learning outcomes.

Figure 2. Firefighter robot model used in robotic competition in KRPAI

Universitas Negeri Surabaya, a state university in Surabaya-Indonesia, has implemented an educational robotic competition in the microprocessor course. In this course, students are taught to program to move robots, detect fires, and blow the wind. Students can learn what problem-solving happens during robotic competitions and how to overcome problems that arise when the competition occurs (Zuhrie, Munoto, & Buditjahjanto, 2020). Figure 2 shows the firefighting robot used by the Universitas Negeri Surabaya in the KRPAI competition on a national scale. This robot is also used in classroom learning to train programming skills and to introduce robot-forming components. This refers to the literature review that the use of educational robotic competitions can train students in

skills such as programming skills, problem-solving skills, and collaboration skills. This is in line with the opinion (Eguchi, 2015) which states that using educational robotics competitions can enhance confidence in using technology, to enhance understanding of the value of working in teams, to enhance self-confidence, and to increase skills of teamwork, personal development, and communication. Likewise with the results of research (Zainal, Abdullah, & Prabuwono, 2012) which showed that the application of robot soccer competition in the class has shown increased performance in analytical and critical thinking skills in problem-solving, and programming skills and technical report writing. Educational robotics competitions can be used with objectives that have been set such as to let students apply theoretical knowledge in practice; to teach team working skills, and to get acquainted with robot design (Oksanen, Kostamo, Tamminen, & Tiusanen, 2011).

Educational robotics competitions can provide students with hands-on and real-time practical experiences so that students can experience the activities. (Grandi, Falconi, & Melchiorri, 2014) stated that with Educational robotics competitions students not only acquiring many technical skills but also the students felt involved in practical activities thus increasing their interest in the subject. Also supported by (Eguchi, 2015) who stated that some of the educational robotics competitions have reported their positive impacts on participating students, especially on their learning and increased understanding of the role of science and technology in solving real-world problems.

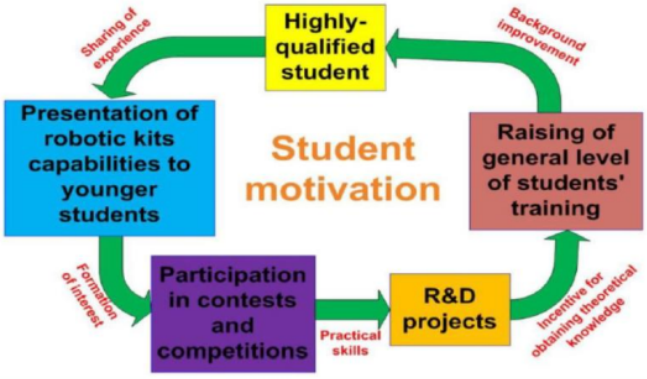

Figure 3. Educational robotics competition

The results of the literature review show that there have been many studies that have implemented educational robotic competition using a project-based model. This is because project-based learning can involve students directly in projects that will be used in educational robot competitions. This is in line with research (Oksanen, Kostamo, Tamminen, & Tiusanen, 2011) which implements project-based learning in teaching students to build robots according to agricultural areas. The results obtained from the project-based learning were in the form of various robot models according to students' creativity in the challenges given. (Zuhrie, Munoto, & Buditjahjanto, 2020) also implemented a project in building fire fighting robots. The project built is modular, so students can observe their learning progress per module before moving on to the next project. (Daniel, Csorba, Szaloki, Beck, & Tevesz, 2012) used project-based learning by dividing projects for robot mechanical aspects and electric design built for the Eurobot competition. (Bazylev, Margun, Zimenko, Kremlev, & Rukujzha, 2014) modeled educational robotics competition as shown in Figure 3. The learning model emphasizes projects that are realized in research and development (R&D). This project-based learning function is to facilitate students to develop practical skills. The output of the implementation of project-based learning can make students increasingly master theoretical knowledge.

5. Conclusion

Conventional learning which has only been involved in theories is deemed less attractive to students, especially those who study science and technology. The development of practical skills and mastery of theoretical knowledge is needed by students in facing today's challenges. Educational robotics competition is one way for students to develop practical skills and mastery of theoretical knowledge. The use of educational robotics competitions can develop students' practical skills through the direct practice of arranging modular robots and operating robots. The use of learning models such as project-based learning, problem-based learning, student self-centered learning, and goal-oriented learning experiences in educational robotics competitions can help students to increasingly master theoretical knowledge.

6. Acknowledge

The research work was supported in funding grant by the Ministry of Education and Culture under Research agreement task KEMENDIKBUD 2020, Number B/11621/UN38.9/LK.04.00/2020.

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