The Contribution of Educational Robotics and Constructivist Approach to Computational Thinking in the 21st Century

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Abstract. Recent years later, there have been researches exploring the importance of computational thinking as an important skill needed by the students to manage activities in all disciplines. The development of computational thinking requires media or tool to help the students develop skill through their experience. Robotics can be used as a media to give students opportunities with the learning by their experience. The correct approach is needed to help the students develop computational thinking through their experience with robotics. A constructivist approach is a prominent approach to teaching with the learning experience. The constructivist approach may potentially be considered of the development of computational thinking skills. This paper reviews the contribution of robotics and constructivist approach to computational thinking. The insight from the reviewed papers, subsequently, was analysed the effect of the use of the robotics and constructivist approach to computational thinking.

Keywords: educational robotics, computational thinking, constructivist approach.

1 Introduction

Since the industrial revolution era in the late 20th-century, the technology and computer science has become the main focus on around the world [1]. The technology leads the all activities development countries, the significance of a good academic must be considered as a high aspect of the educational system [2]. Therefore the educational system must be prepared their students with good skills including computational thinking skill. Recently, there has been growing recognition of the importance of computational thinking in controlling and managing cognitive activities, as well as understanding and solving problems in a wide range of contexts, not only in the field of computer science but in all disciplines [2].

Computational Thinking (CT) has been described as an essential skill which everyone should learn and can include in skill set [3]. Computational thinking is an important skill for everyone and it should be considered as an important component of students' analytical ability along with reading, writing, and arithmetic [4]. CT conceptualizing not programming, not just technical details for using software [5]. The ability to use CT tools to carry out scientific inquiry is quickly becoming required in the modern scientific landscape. Despite this fact, high school math and science curricula have been slow to react to this trend[6].

Therefore the development of new teaching strategies is essential for all-round developments of students. Constructivist teaching is based on constructivist learning theory

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which has emerged as a prominent approach to teaching during this past decade [7]. Robotics can be used as a tool that offers opportunities for students to engage and develop computational thinking skills[8]. Furthermore, a guided instruction approach using robots facilitates teamwork, develops conceptual understanding, enhances critical thinking, and promotes higher-order learning in the domains of mathematics and science[3].

This paper aims to review the contributions of the constructivist approach through educational robotic to developing students' computational thinking. As in many similar projects[2], describes the implementation of educational robotic activity in school, focusing on the different possible impacts that the instructional approach might have on the development of students' CT skills depending on their age and gender. The paper seeks to contribute to the literature by suggesting the strategy to improve the computational thinking using the constructivist approach and educational robotics.

2 Method

This article adopted a literature review approach suggested by Okoli & Schabram[2]. The literature review was conducted on the journals in advancing students' computational thinking. The following keywords were utilized: computational thinking, constructivist theory, and educational robotics. Relevant articles from several conference proceedings also examined. The following online databases and websites were employed in this search-collection effort Google Scholar. This website was employed to search for and acquire specific references.

In addition studied from Elsevier of Computer in Human Behavior, Elsevier of Computer & Education, Elsevier Robotic & Autonomous System. Articles reviewed are within ten years period. Total papers studied were 15 from the computational thinking journal, 11 from the constructivist journal, 9 from Educational Robotic journal and 20 from the other journal. The number of articles reviewed along with the relevant articles obtained in the search was depicted in Fig 1.

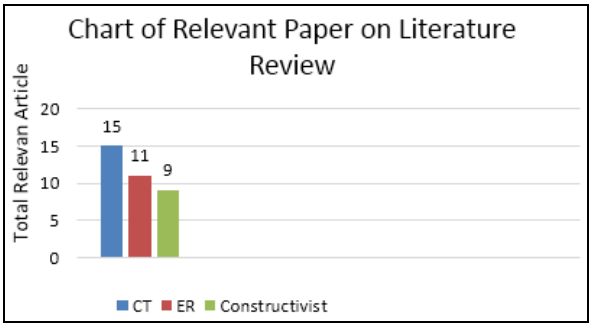

Fig. 1. Papers reviewed in the study.

3 Theoretical Foundation

3.1 Educational Robotics

Recently, many research used the advantage of robotics that offers opportunities for students to engage in computational thinking skills[2]. The results from the research indicated that educational robotics after the intervention were improved their computational thinking, can be used to teach concepts such as designing, programming and other disciplines[2].

Table 1. The Various Educational Robotics Studies.

Article	Context	Result
Atmatzidou et al. [2]	Junior High and High Vocational Students	The positive impact that students may overcome their initial difficulties and successfully develop their CT skill
Bers et al. [9]	Childhood students	A positive result that using robotics were relevant CT concepts relevant to sequencing and choosing the correct instructions
Chen et al. [8]	Elementary School Student	The result indicated that the using robotics programming has the potential to reveal the students learning challenges and growth in terms of CT
Cruz-Martin et al.[1]	Undergraduate Students	The result indicated asses the higher motivational using a complete robot and the real fulfillment of the other requirement in several academic years.
Hutamarin et al. [10]	High School Students	Positif impact that the using robotics in a workshop, helping students to develop their CT.

Based on table 1, the results showed that positive impact on the development of students' computational thinking skills by using the robotics. Another issue is to understand how the student improves and how to teach those computational thinking skills progressively[2].

3.2 Computational Thinking

Computational thinking is a concept, practices, and perspectives[9]. Computational thinking concept such as abstraction, automation, analysis, decomposition, modularisation and iterative design[2]. There are multiple definitions of CT and several suggestions about which skills and abilities are relevant to CT and how to integrate CT in the curricula of all grades[2]. Wing [10] asserts that CT has the potential to advance the students' problem-solving skills through processes such as abstraction, generalization, decomposition, algorithm design and separation of concerns. To encompass more fields, CT concepts are generalized as the usage of one of the computer science principles listed in Table 2 in solving a problem.

Table 2. Computational Thinking Concept and Related Computer Science.

Steps	Description
Algorithmic thinking	The steps to complete a task. Operators and expressions are also included.
Abstraction	The generalized representation of a complex problem, ignoring extraneous information
Problem decomposition	Managing the parts that can be solved independently of each other
Data Collection	The collection, representation, and analysis of data
Parallelization	Simultaneous processing of a task
Control Flow	Direct an algorithm's steps when to complete
Incremental	Building small parts of the program at each step instead of the whole program at one
Testing and Debugging	Performing intermediate testing and fixing problems while developing
Questioning	Working to understand each part of the code instead of using code that is not understood well

Thus, finding ways the computational thinking in many research, such as proposed framework of computational thinking for the education where the robotics has the potential to reveal student learning challenges and growth in terms of computational thinking[2]. CT is an important skill that we should be teaching students of all ages[11].

3.3 Constructivist Approach

Constructivist approach refers to knowledge constructed by connecting new experience to existing ideas[7]. The simplest definition of constructivist evokes the idea of learning-by-making and this is what was taking place when the students worked on their project[11]. Constructivist practices and according to student needs and interests so as to encourage their participation[12].

Table 3. Computational Thinking Concept and Related The Measure of Constructivist Approach

Computational Thinking [2][13]	Constructivist Approach [14]
Abstraction is the process of creating something simple from something complicated, by leaving out the irrelevant details, finding the relevant patterns, and separating ideas from tangible details. Wing argues that the essence of CT is abstraction [13]	Begin with the whole is the step of expanding to parts and pursuit of student questions or interests about the topic
Generalization is transferring a problem-solving process to a wide variety of problems	Primary Sources is manipulating materials to solve the problem
The Algorithm is a practice of writing step-by-step specific and explicit instructions for carrying out a process.	Learning is interaction is building on what students already know and in this step, the instructor interacts to negotiates with students
Modularity is the development of autonomous processes that encapsulate a set of often used commands performing a specific function and might be used in the same or different problems	
Decomposition is the process of breaking down problems into	Knowledge is a step that students

smaller parts that may be more easily solved. Break down a problem into smaller/simpler parts that are easier to manage.	change with experiences and give

This study seeks on constructivist approach as a means for improving students' computational thinking, we concisely review next CT theoretical framework and studies on the Constructivist-ER-CT relationship. Papert suggests that learning is most effective when students are experiencing and discovering things for themselves[15].

Table 4. The various constructivist studies.

Article	Result
Kim [16]	Constructivist teaching has some effect on motivation, self-development, and self-monitoring
Adak [7]	The result found that the constructivist approach recommend to development of students' higher achievement in science
Qarareh [17]	Constructivist approach scores higher than the traditional method on language subjects
Enok & Joel [18]	The result found that constructivist had a statistically significant effect on communicative competency and attitudes towards computer science
Jong [19]	The constructivist approach had higher scores than traditional teaching in social science

The table 4 showed that literature from many researchers finding that constructivist has some effect on students' achievement, motivation, self-development, self-monitoring, communicative competence, and attitude.

4 Discussion

4.1 The contribution of the constructivist approach

The constructivist approach is an interpretive, building process by active learners interacting with their surround[20]. Based on table 4 and the other research found that constructivist has some effect on students' achievement, motivation, self-development, self-monitoring, communicative competency and attitude[21]. Improving computational thinking can be using the multidisciplinary approach [22] included the constructivist approach and educational robotic. The teacher can be using the constructivist approach to helps students developing their idea from the experience[7]. Relevant to this paper reviews how to constructivist approach with educational robotic for improving students' critical thinking.

4.2 The contribution of the educational robotic

The educational robotic applied in the current study [2], [8], [10] found that the positive impact to develop students' CT skills. Educational Robotics has become an important skill to express ideas, inspiring student's originality while helping develop logical thinking. Many research attempts to use robotics technologies in education is increasingly common and has the potential to impact students' learning[23]. Based on table 2 and reviews the literature about

educational robotic showed that the using of robotics gives a positive impact on the development of students' computational thinking skills.

4.3 Combination of the educational robotic and constructivist approach to computational thinking

Course development was guided by the main principles of the constructivist approach and computational thinking[11]. The alternative combine of the constructivist approach and educational robotics to improve the computational thinking, shown in table 4. Robotic can be used as a media or tool to help student learning experience with the tangible object include robotics[24]. The guide five principal to develop computational thinking in Hambursh et al [22] lay the groundwork for computational thinking such as present examples in a language familiar to the students, teach in a problem-driven way, the programming language should right away allow a focus on computational principles, and make effective use of visualization.

5 Conclusion

The literature reviewed indicated that constructivist approach with educational robotic will be very helpful to improve the computational thinking. The concept of the constructivist approach in accordance with the concept of computational thinking. The students can be gained experience on their own projects to build knowledge and computational thinking through the constructivist approach. The use of the combining robotics with the constructivist approach to learning can be given a positive influence to develop of student computational thinking.

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