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Effects of Enhancing Computational Thinking Skills using Educational Robotics Activities for Secondary Students

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Abstract Robotics Programming presents enhances students' computational thinking, which is a vital skill in the 21st century. The purposes of this study were: 1) to study the learning achievement of computational thinking skills by using educational robotics activities for secondary students, and 2) to study the students' satisfaction on educational robotics activities to enhance computational thinking skills. This research was quasi-experimental research. The number of samples was 90 eleventh grade students. The instruments employed to collect data were: 1) a quiz that was performed as both pre and post testing, and 2) the satisfaction questionnaires. The statistical mean, standard deviation and paired sample t-test analyzed the collected data. The findings were as follows: 1) students learning outcome gained after learning by using educational robotics activities to enhance computational thinking skills was significantly demonstrated at the statistical level of 0.05 higher than the one demonstrated before learning by using educational robotics activities. 2) For students' overall satisfaction on educational robotics activities, it was in "high" level ($\bar{X}$= 4.12, S.D. = 0.50). Implications for future study and education are discussed.

Keywords: Computational Thinking, Robotics, Programming, Education, Students

INTRODUCTION

The development of students' 21st century skills has recently been raised as an important issue in the scope of education. Such skills include a wide range of knowledge, work habits and character traits which are expected to be applied in all academic subject areas as it is claimed to be critically important to success in today's world [1], [2]. Computational thinking (CT) is then considered one of the 21st century skills and correlatively becomes ever more vital in today's increasingly technological world [3]. The definition of CT is seen as a method or an approach that serves the development of problem solving, system designing, and human behavior understanding [4]. Its concepts are fundamentally inclusive of computer science, together with the intellectual skills, which are seen as a necessity for developing algorithmic thinking, abstracting, decomposing, and pattern recognizing [2].

CT is considered essential for school children and should be then appeared formally in the K-12 curriculum [3]. In this respect, A brand-new subject is introduced d expected to be used in teaching for students in grades 1, 4, 7 and 10 over the academic year 2018. Such subjects will be seen to replace the former subjects which were implemented in Computing and Information Technology. The category of the foundation subjects will also be shifted from Careers and Technology to Science. This shifting presents benefits to students not only for their learning on fundamental computer skills or basic use of computers but also acquiring CT skills which enable the students to use them in the competitive world creatively [5].

Since educational robotics is introduced as a tool which allows students to have more opportunities to develop CT skills and engage themselves with the technology, many schools have employed such innovative technology to create better learning environments, assisting and enhancing students' higher order thinking skills and abilities, and supporting students to have more complex problem-solving skills [6].

Educational robotics activities are a focus in some studies as they are considered appropriate learning environments for the development of CT skills. The implementation and evaluation of such CT skills development have been described by Soumela and Stavros in association with educational robotics activities for secondary Technical schools, which the basic skills of CT: abstraction, generalization, algorithm, modularity, decomposition, and problem solving were emphasized. It is suggested from the result of pre- and post questionnaires and a series of think aloud interviews that the students showed familiarities with the concept of CT, and integrated students to a satisfactory extent in the process of problem solving in ER activities [6].

Dimitris also supported such educational robotics activities by looking into the role of constructivist pedagogy and consequent educational methodologies during the use of robotics in school education or teacher training programmes with robotics being used as teaching purposes. In this respect, the integration between physics and informatics education and in professional teacher training and robotics are suggested as constructivist methodologies in school it is reported that the projects presented in the study were used as examples to manifest the learning potential of the proposed educational methodologies, which include teachers and students using robotics carried out to study kinematics and programming concepts in physics and informatics classes of secondary education respectively [7].

Moreover, new devices and methods in the education of programming were also created by Attila, Robert, and Erika in relation to the use robotics for educational development. At Kecskemét College programmable mobile robots and instead of behavioral, the constructivist pedagogical methods were employed. It is clear that the experiments regarding the hypothesis as the improved new methodical education using devices provide substantially practical programming knowledge, which shows an increase in the attitude towards programming and presents positive programming self-image. The comparison of the programming knowledge and motives of the control group was examined between the beginning and the end of the semester and it is resulted that there is a correlation between the use of model robots and students' experience reflecting motivation and enjoyment in their learning situations. Even though the direct motivational effects of educational toys usually are not permanent, in their study, the new methods and tools, such as model robots, can contribute the development of learning motives, especially programming self-concept. As a result, students' motivation is more improved and expanded and due to such motivation, it shows an impact in furthering their achievements in programming [8].

In connection with such educational innovation, Cagin, Kiernan, Bacon, and MacKinnon invented an innovative game model for learning CT skills through digital game play. A game framework has been designed for students who possessed little or no programming knowledge in CT to practice and enhance their skills. The analysis of the study shows how this game supports various CT concepts and how these concepts can be mapped to programming constructs to facilitate learning introductory computer programming. As an initial evaluation, some analysis of feedback was provided by a survey response group of 25 students who have played their game as a voluntary exercise. The results showed that most students firstly reflect their interest in seeing the game stimulating and applicable and project their feedback positively towards the use of the game as it helps to enhance their problem-solving skills during the learning of their introductory programming [9].

This paper investigated the implementation of educational robotics activities for secondary students and focused on the development of CT skills on the following CT concepts: abstraction, generalization, algorithm, modularity, decomposition.

Considering the above, the researchers focused on the following research questions:

1) Do the use of educational robotics activities improve students' computational thinking skills?

2) How do students satisfy on educational robotics activities?

METHOD

Participants

Participants consisted of 90 eleventh grade students (32 males, 58 females). The age of students was between 16-17-year-olds. The purposive sampling design was used for the students in Science Mathematics programme (SMP) at Private Islamic Schools in Yala Province, Thailand.

Instruments

The instruments used in this study were 1) the quiz to be performed as both pre- and post testing. The quiz consists of 20 multiple-choice questions. And 2) the satisfaction questionnaires which are divided into 2 parts. The first part is a 5 Likert rating scale (1 = very high, 2 = high, 3 = average, 4 = fair and 5 = poor) to evaluate the satisfaction on learning activities by using robotic programming. The second part is an open-ended question (optional) for additional views and suggestions. The obtained data were analyzed regarding average, standard deviation and paired sample t-test.

RESULTS

This section presents assessment results for the students' learning achievement and the satisfaction of learning activities by using robotic programming.

The learning achievement of students

Table 1. Pre- and posttest scores of the experimental students on computational thinking skills

	Score of experimental group (*n*=90)		t	p
	Pretest	Posttest		
Computational thinking skills	6.29 (2.35)	15.97 (2.20)	18.46*	.000

* $p < 0.05$

The results are presented in Table 1. These results showed the students' improvement after learning with robotic programming activities and a significant difference in CT skills conditions: t=18.46, p=.000.

The satisfaction on educational robotics activities

The results presented in Table 2. show the validity scores of the satisfaction on educational robotics activities; robotic programming with Arduino IDE and robot football competition for two days (15 hours).

Table 2. The validity scores of the satisfaction on educational robotics activities

Criteria	$\bar{X}$	S.D.	levels of the satisfaction
1. Processes and procedures for the learning of robotic programming	**3.95**	**0.66**	**High**
1.1 Advertising the activity.	3.97	0.78	high
1.2 Appropriate venue for the activity	4.20	0.75	High
1.3 Appropriate duration of the activity	3.71	0.82	High
1.4 Appropriate time periods of the activity	3.94	1.05	High
1.5 Appropriate sequences of the activity	3.94	1.11	High
2. Content delivery of the teaching staff.	**4.07**	**0.63**	**High**
2.1 Content delivery of C Programming	3.94	0.83	High
2.2 Content delivery of the use of Joysticks	4.11	0.67	High
2.3 Content delivery of the controlling of the robot using sensors	4.17	0.92	High
2.4 The competence and willingness of teachers	4.31	0.86	High
2.5 The learning outcome which can be used in the future	3.83	0.70	High
3. The organizing of robot football competition	**4.09**	**0.56**	**High**
3.1 The competition was fun and full of knowledge	4.34	0.76	High
3.2 The competition was straight forward and practical	3.77	0.69	High
3.3 The readiness of the organizers	4.17	0.92	High
3.4 The duration of the competition	3.86	0.91	High
3.5 The usefulness of the competition	4.31	0.75	High
4. Media and equipment for robotics activities	**4.30**	**0.50**	**High**
4.1 Learning handouts	4.30	0.50	High
4.2 Material and equipment for the activities	4.29	0.75	High
4.3 Refreshments and beverages	4.34	0.87	High

Table 2. The validity scores of the satisfaction on educational robotics activities (Cont.)

Criteria	$\bar{X}$	S.D.	levels of the satisfaction
4.4 Facilities of the homestay	4.11	0.71	High
4.5 Staff members	4.46	0.74	High
5. The appropriateness of the location of the activities	**4.17**	**0.66**	**High**
5.1 The venue for the opening and closing ceremonies	4.23	0.80	High
5.2 Computer laboratories	4.49	0.65	High
5.3 Refreshments and Beverages Space	4.03	1.01	High
5.4 Rooms for robot football competition	4.37	0.69	High
5.5 Homestay and toiletries	3.74	1.17	High
Total	**4.12**	**0.50**	**High**

According to Table 2, the results showed that overall satisfaction with learning activities by using robotic programming, it was in "high" level ($\bar{X}$= 4.12, S.D. = 0.50)

The conclusion of additional views and suggestions is as follows:

- I enjoyed and had fun with the activities. I hope that there will be more robotic programming events hosted again.
- I was so impressed with the robot football competition. I felt that the participants gained the knowledge in robotic programming with Arduino IDE and could utilize it practically.
- I would suggest the duration of the activities be longer.

DISCUSSION AND CONCLUSION

According to the current study, researchers offer the after-school extracurricular as educational robotics activities for students (see Figure 1, 2). These results showed the success of enhancing CT skills with educational robotics activities which were appropriate ways to make a learning motivation. In the 21st century education, content knowledge, specific abilities, literacy, numeracy, and technology uses are seen as the skills which students are required to have in order to follow the trend of the 21st century proficiency and, as a result, teaching and learning are focused to include such skills [10]. In this respect, educational robotics activities are looked into and presented as innovative teaching tools, which boost students' learning aligned with such modern proficiency. By acquiring it, students are able to have more complex problems-skills via the use of robot programming activities [6]. One limitation of the study was that two days (15 hours) was insufficient for the participants to experience robotics activities fully, especially robotics programming.

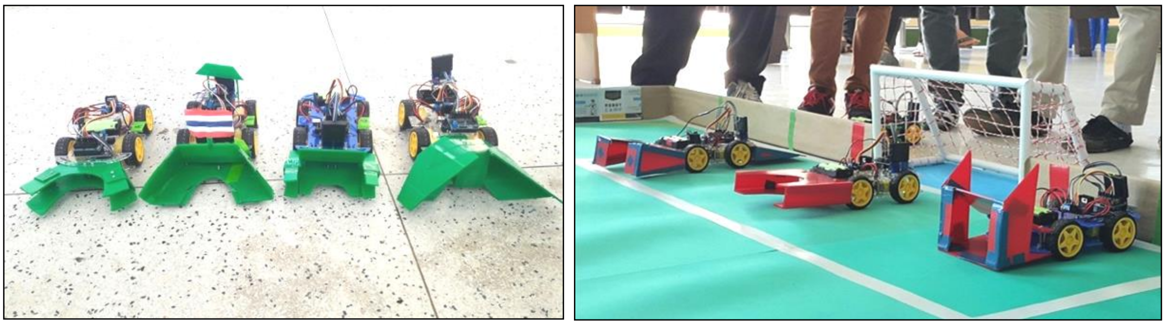

Figure 1. Each student group decorated different vehicles

Figure 2. Robot football competition

In summary, results of this study indicated that the positive effects of students' learning achievement on CT skills and the satisfaction on educational robotics activities. It has been noticed that these activities stimulate, engage, and teach students as an instructive aid in the classroom. For future study, the researchers would like to study as qualitative research from the interview or focus groups, and they would like to support the impact that learning activities have on students' interest and learning achievement.

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