

# Using Lego Mindstorms Robotics Programming in Enhancing Computational Thinking among Middle School in Saudi Arabia

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**Abstract---** *The study employed will employ LEGO Mindstorms Ev3 robotics in the learning environment of the computer curriculum of the 3rd level of Saudi Arabia middle schools to examine whether this kind of learning environment enhances computational thinking skills and learning programming concepts and attitude toward learning. The study will conduct in Riyadh of 60 student participants will be selected through purposive sampling techniques to participate in a quasi-experimental study. Before the implementation of the experimental study, a preliminary study will be conducted through a descriptive survey among students who are randomly selected of middle schools in Saudi Arabia to respond to computational thinking tests and attitude questionnaires to determine their level of CT and their attitude toward learning programming. After that, the researcher will do the experimental study with both groups. The T-test will be conducted to compare both groups' scores for CT, and test for programming skills form their books and questionnaires for students' attitude toward learning to program with LEGO Mindstorms Ev3. However, the results of the pre-test and post-test will help to reveal the differences between both groups in this study. Furthermore, the result will help to build a framework for implementing CT with LEGO Mindstorms robotics in learning programming in the computer curriculum of Saudi Arabia middle schools.*

**Keywords---** *Lego Mindstorms, Robotics Programming, Computational Thinking (CT), Saudi Arabia.*

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## I. INTRODUCTION

Programming knowledge is essential. The knowledge revolves around empowering people and presenting opportunities for the successful completion of goals. In this regard, the young generation is considered a digital native, given their higher technology usage (Meccawy, 2017). Nevertheless, most users of technology are consumers, as opposed to creators. Resnick et al. (2009) liken the technology consumption to individuals who "read" and not "write." They challenge the current consumption trends, arguing that digital fluency extends beyond the ability to browse, chat, and interact. It covers aspects such as design, creates, and the invention of new media. The idea of learning to code or program is similar to learning to think. In this regard, students are capable of solving a problem using a systematic approach. Students will have a chance to develop new ideas, which manifests in different computational media. Most of these skills, such as develop, create, systemically solve problems, are characteristics of computational thinking, according to Wing (2006). From this point, this study will focus on enhancing computational thinking by learning to program using Lego Mindstorms to support the learning environment and to

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change students' attitudes toward the learning process.

Moreover, Saudi Arabia, as many other countries try to develop and improve education. Also, Saudi Arabia announced its plans to reform the economy in 2016, which sought to diversify its economy from overreliance in oil to focus on other supportable resources. Saudi Arabia's vision of 2030 agrees that education, training, and entrepreneurship are aspects necessary in developing the Saudi society (GASTAT, 2016).

However, Computer science as a curriculum has become compulsory in Saudi high and middle schools in 2002 and 2009, respectively, and learning basic programming is part of the computer curriculum. Hence, to improve and motivate student learning in programming, many studies advise to create rich programming environments that usually used with younger students, and especially if we are planning to teach students programming with other skills, like annalistic thinking and creativity (Liu et al., 2013).

### ***Learning Programming***

In the present time, the process of teaching computer programming faces several challenges for students and teachers. Sartatzemi et al. (2008) categories the obstacles as orientation, notional machine, the rules and the structures of programming language.

However, the definition of computer programming is to be given instructions by a person that will communicate, plan, strategy, and practice to a machine. A specific programming language should be used to code this set of instructions (Buitrago et al., 2017).

Learning programming is not easy for young students because they need to deal with codes and variables, which are impalpable. Therefore, by bringing robotics to school may ease programming for them and encourage them to involve in programming. It is like making the environment of programming real; they code and watch the result of their coding directly. Many types of research have done on robotics as a learning tool. However, robots are real tools, which help students to realize the conceptual element of programming; students will experience a motivated, joyful learning environment while they program robots (Pásztor et al., 2010).

### ***Lego Mindstorms***

The most common robotic found suitable for middle school is the Lego Mindstorms. In 1998, the LEGO Company discharged a new product named LEGO Mindstorms Robotic Kit, which became an instant commercial success. Most of the purchasers used the kit as a toy, whereas engineers further analyzed how these tools could be useful open-source programming. The LEGO robot derives its name from Seymour Papert's 1980 book, with a similar name.

However, a study conducted to investigate students' attitudes toward learning STEM and robotics drew participants from middle school. The research findings indicated that students demonstrated positive attitudes in learning and were highly motivated to learn about robotics (Kaloti-Hallak et al., 2015). Many educators believe that robots can motivate learning and enforce it. As such, they emphasized on using student growth interest and interaction. Indeed, adopting a teaching strategy that combines robots and a supportive learning environment

presents numerous advantages (Sartatzemi et al. 2008).

Besides, Wu and others made a study in 2008 to rival the effects of using physical robots (Lego Mindstorms) and robot simulators (Lego Mindstorms simulator) for teaching programming concepts. They found that there was not any significant difference between both groups in performance. However, Álvarez and his colleagues found out that the group working with physical robots was more interested in learning (2016).

Physical robots assist students in enhancing understanding program performance that allows learners to link the gap between concept and practice. Since there is no single programming environment is sufficient for all situations, work with robots that later allow different programming environments such as Lego Robots should be considered (Álvarez et al., 2016).

Table1 shows that most of the studies have a positive impact on learning programming through Lego Mindstorms.

Table 1

Researcher	Purpose	Levels
Witherspoon et al. (2017)	Developing CT through Robotics programming	Middle school
Alvarez & Larrañaga (2016)	Basic programming concepts	Undergraduate
Korkmaz (2016)	Conducted research to explore the effects of Lego Mindstorms Ev3 and Scratch programming, particularly in improving academic performance, problem-solving, and harnessing learners' logical thinking skills.	Undergraduate
Merkouris et al. (2015)	Compare learning programming through Robotics with desktop	Middle school
Berland et al. (2015)	Compare virtual robot with Lego Mindstorms	Middle school
Kaloti-Hallak et al. (2015)	Students' attitude during robotics activities	Middle school
Tsang et al. (2014)	Using Lego Mindstorms to learn Java programming	Undergraduate
Siever et al. (2011)	Compare Lego Mindstorms & scratch	Primary school
Kaye and Liu (2010)	Using Lego Mindstorms to improve computer course	Undergraduate
Kopp & Algloban (2010)	Introduce programming through Lego Mindstorms	Middle school
Jomento-Cruz (2010)	Increase students 'achievement and attitude toward science through Lego Mindstorms	Middle school
McWhorter et al. (2009)	How does LEGO Mindstorms help students in their computational skills?	Undergraduate

## II. COMPUTATIONAL THINKING

In 2006, Jeannette Wing became the first scientist who mentioned the meaning of computational thinking. According to Wing (2006), CT is described as a universally applicable attitude and includes a skill set that every need. Computational skills should not be confined to a computer scientist, but to all individuals willing to learn

(Wing, 2006). Wing asserts that it is important to treat CT as a fundamental skill for reading, writing, and arithmetic. Every child must have gained this ability to think not by chance but by an organized method. CT means solving problems effectively, designing systems, understating human behavior, and engaging the power of computing (Wing, 2006; Basu, 2016). In 2009, a new definition of CT for K-12 has developed by the Computer Science Teachers Association (CSTA) and the International Society for Technology in Education (ISTE), categorizing the core CT conceptions as data collection, data analysis, data representation, problem decomposition, abstraction, algorithms and procedures, automation, parallelization, and simulation (Barr & Stephenson, 2011; Basu, 2016).

Tedre & Denning (2016) claim that CT is not programming but can be the outcome of learning programming, considering the widespread of CT in helping individuals master programming skills.

Major et al (2012), conducted a systemic literature review for teaching programming using robots, which called to conduct more researches in order to determine the true effectiveness of robots as programming teaching tools. The ability of programming can lead students to solve problems, to predict solutions, and to test them, then manipulate those solutions to achieve program goals.

Yadav and other researchers (2014) claim that the core objective of teaching students CT is to improve their skills as they master how to think like economists, artists, and physicists do. These students learn the application of computation in solving problems, creating, and discovering the new questions, which can be fully explored.

There is proof to help the application of CT in schools and higher education. First, children, these days are exposed to extensive a staggering amount of information, sometimes not organized, delivered randomly, and mostly not connected. CT can give children the tools to take out the grasp that might be invisible in the data. Second, reduction science is used to be taught- for instance, isolated mechanisms or metabolic pathways; however, teaching the systems is needed, as they are complex. Teachers do not encourage their students to connect the materials they get because they don't have enough time. Third, CT is useful to build up the abilities to think as individuals can combine and overlies multiple layers of abstraction as it is done when developing algorithms.

### **III. PROJECT-BASED LEARNING**

Project-based learning (PBL) is a learning model centered on projects. As documented by Thomas (2000), a project refers to a complex task, which included challenging problems or questions. Therefore, students are encouraged to participate in the design, problem-solving initiative, decision-making, or participating in investigative activities. It gives students a chance to work autonomously for a long time. Besides, the learning process includes realistic presentations and products. PBL is a wide-ranging approach used by educators in engaging students, encouraging them to investigate further about the authentic problems.

PBL is designed to be used for complex problems that require students to investigate more in order to understand which provide deep learning by allowing students to use an inquiry-based approach to engage with problems that are real, rich and relevant to the topic being studied (Mohamed, 2012). Moreover, it is believed that PBL can provide authentic learning necessary for students that can build meaningfully powerful science, technology, engineering, and

mathematics concepts supported by language arts, social studies, and art (Capraro et al., 2013).

In this study, we plan to use PBL integrated with robotics in order to have a rich and real environment. The design of PBL will be affected by making content accessible and thinking visible (which includes using visual elements to help the learner and using learner constructed visual elements to assess learning), helping students learn from others, and promoting independence and lifelong learning (Slough et al., 2013). In this way, we are highlighting STEM in the design of our learning environments.

#### ***Attitude toward Learning Programming***

Attitudes could refer to an overall evaluation of groups, people, and objects within our social world. The process of reporting an attitude involves making choices relating to liking versus disliking, or it could be favoring versus disfavoring (Jim, 2010). There is plenty of evidence proposing that attitude presents a positive influence on learning and cognition (Korkmaz, 2016; Hwang et al., 2012). Scholars have argued that negative attitudes, motivation, and perceptions are critical factors, which have a profound effect on academic performance, in comparison to other factors (Korkmaz, 2016; Anastasiadou & Karakos, 2011; Erdogan et al., 2008).

The students' attitudes towards learning programming remain the most common challenge.

#### **IV. METHODOLOGY**

Since the conditions and experiences of the participants of this study are not able to be manipulated, the quasi-experimental design is the most suitable for this study (Creswell, 2009). Moreover, Quasi-experimental designs are mostly adopted for nonrandomized respondents in order to assess the effectiveness of a program (Creswell, 2009).

A quasi-experimental research design is based on pre- post-experiment design for two groups (experimental and control). The experimental group students will study the selective unit, which is unit 4 (Smart Devices and Robot), through using educational robotics (Lego Mindstorms) with PBL while using a conventional method with the control group students for the same selective unit.

The researcher has selected this unit because it has programming concepts. The research sample will be 60 students, the control group will have 30 students, and the experimental group will have 30 students.

To achieve the research aims, the researcher will develop the instruments for attitudes and basic programming knowledge and use the computational thinking test of González (2015).

#### ***Expected Finding***

The study will reveal the effectiveness of using Lego Mindstorms with PBL strategy in enhancing students' programming achievement of Middle school in Saudi Arabia, on the other hand, it will develop students' computational thinking skills, and help them to gain a positive attitude toward learning programming.

#### **V. CONCLUSION**

This paper explores the impact of integrated robotics in computer curriculum for elementary schools in Saudi

Arabia. Overall, the study proposes that robotics have positive learning experiences in programming achievement, developing computational thinking skills, and having more positive attitudes toward learning programming.

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