Implementation of Robotics Projects for Students

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Abstract

This article will discuss the delivery of STEM education to students through robotics and its training programs and projects. The use of technology in teaching can be effective in teaching of hardware and software courses at higher education institutions as well as mathematics, physics and biology classes at secondary school. The National University of Mongolia offered students who study engineering and computing extracurricular program. The students of software and information technology majors learned robotics, computer programming and the program developed students logical thinking, problem solving and critical thinking skills as well in project-based learning environment. Students accomplished several tasks and missions while developing logical and creative solutions to problems using LEGO Mindstorms NXT. Mindstorms NXT set includes programmable brick, sensors, and motor with visual programming environment. It enables new programmers; learners make a program for robot using this visual programming environment easily. This paper describes how to use ROBOTC in delivery of robotics learning and discusses the effects of robotics learning and teaching in STEM education.

Keywords*:* robot design, innovation, virtual environment, training program, training robot

Introduction

With the introduction of advanced technology into our daily lives, teachers are required to change the way they teach for students nowadays. Therefore, it has become common for most universities, colleges and high schools to use advanced technology in their teaching methods. It has been several years since the robotics were used as an educational tool in the world. However, in Mongolia STEM education and LEGO MINDSTORMS robotics learning and programs were introduced in 2010's with the first ever entry of WRO (World Robot Olympiad). Furthermore, robotics production is filling all the demands and requirements and grows even more. Components hardware costs are becoming reasonable and robots' capabilities are developing rapidly.

The experiment was completed by the students of the National University of Mongolia (NUM) majored in Information systems, software. ROBOTC was used in experiment, which enabled students to program robots easily. The students who completed the extracurricular program "Robotics Club" had basic knowledge of standard C programming language. Standard C programming is the foundation of ROBOTC, which is text-based programming and first language in robotics. Participants attended the program for three months.

Computational coding, script programming, programming, or computational thinking are key to 21st century education. In most parts of the world, governments encourage the

teaching of programming to students from primary school onwards. Beginning in the 2014-2015 school year, computing classes became compulsory for kindergarten-age children in the United Kingdom [1].

STEM Education

S.T.E.M education stand for:

- Science.
- Technology.
- Engineering.
- Mathematics.

STEM education is an approach to provide a wide range of knowledge focused on teaching and learning methods. The robotics systems are interactive, practical, and provides an opportunity for students to study in the field of STEM by studying interdisciplinary courses [2].

It is easy to change the training program based on different available resources and needs. Experience from non- formal education has a strong influence on their future studies in STEM fields, and that robotics training will undoubtedly have an impact on students' career choices [3].

The Purpose of STEM Education

- Inroduce new knowledge and technology.
- Prepare knowledgeable, engineers, students, pupils and workforce.
- To train scientists capable of implementing innovation projects.
- Teach problem solving skills.

Basic Principles of STEM Education

- It is considered to be a policy to reflect and introduce innovations in the education sector.
- Develop STEM education policy as a national priority.
- Allocate budget for the development of STEM education.
- STEM education is closely linked to the economic development of a particular country and the world.
- To train an educated and knowledgeable workforce and students, and to become a competitive country in science and technology in order to make a country competitive, secure, and constantly reforming on the world stage [4].

STEM Training Objectives

The main objectives are to expand the knowledge of university and high school students, introduces modern scientific concepts in school education activities in the field of science and technology, develops students' creative thinking skills, and uses modern techniques and technologies to acquire new knowledge by studying robotics systems.

Robotics Training Program

Part of the study purpose is to include robotics in the curriculum of universities, colleges and high schools, and to determine the possibility of conducting extracurricular activities of robotics for students.

The study selected an online training program and examined its availability.
Introducing the LEGO Mindstorms NXT robot programming training program in ROBOTC language (See Figure 1.)[5].

Figure 1. RobotC Curriculum for LEGO Mindstorms

Course duration – 6 weeks:

1. Week One
   a) Setup
   b) Thinking about programming
   c) Basic Movement using Motors and Timing
2. Week Two
   a) Conditional Statement
   b) While Loops
   c) ROBOTC Debugger
   d) Encoders
3. Week Three
   a) The Sonar Sensor
   b) The Touch Sensor
4. Week Four
   a) Threshold Values
   b) The Light Sensor
   c) If – Else
   d) Line Tracking

Implementation and Method

At the National University of Mongolia (NUM) the students of the NUM offered extracurricular program as a pilot for the first time in fall semester of academic year of 2020-2021, with the coauthors serving as the instructors. Almost all of the assignments and activities in the program both at the NUM and in middle schools, were team-based, challenging groups to work together.

During the program the participants learned to program virtual robots and experimented their program designed virtually on physical robots. After the program the students competed as a team in four different competitions of “Line follower”, “Labyrinth”, “Sumo Robot” and “Can picking and up and carrying”(see Figure 2. and Figure 3.).

Figure 2. Line Follower

The students who completed the program developed stronger skills in logical thinking, critical thinking, in working as a team, as well as increasing their understanding of the value of their fields they are majored in such as information systems, and software engineering and their motivation and interest in science and technology.

The content of the program was designed with the LEGO MINDSTORMS robotics product. The product, LEGO Mindstorms NXT robot allowed young students to learn the concepts of robotics technology and computer programming in a fun and engaging environment. The participants included 15 students who study at the first to the third –year the National University of Mongolia (7 software engineering majors, 8 information systems). Three students had never previously worked with LEGO Mindstorms, and had any prior engineering experience or knowledge such as algorithm programming, and C programming languages etc.

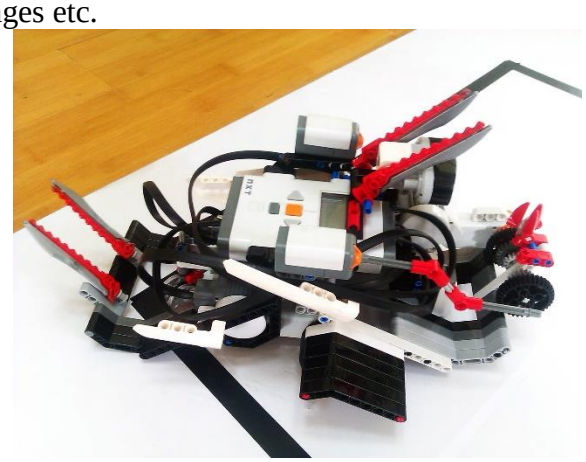

Figure 3. Sumo robot

A. Software

The following software was used in the study. These include:

- ROBOTC Development Environment.
- ROBOTC Virtual Worlds Mindstorms.

The LEGO Mindstorms NXT robot was programmed using both software. ROBOTC 30-day trial version has been downloaded and used for research.

B. Hardware

The complete collection of LEGO Mindstorms NXT robots can be used for training. Compared to other set of robots, this collection is considered to be suitable because of its average price and the abundance of software and syllabus, training programs for it.

C. Programming Environment

The robot programming environment can be as follows. ROBOTC development environment. These include:

1) Virtual robot programming, testing robots in virtual environment.
2) Program a physical robot and test the robot in a real environment.

A physical robot was re-tested based on the performance result of a virtual robot programmed in a virtual environment. Observations were made on robots programmed in two different real and virtual environments.

A simple "training robot" can be used for training and can be assembled according to special instructions (See Figure 4.).

Figure 4. Training Robot

D. Virtual Environment

Using a training robot, we performed the simplest task. The tasks given in the virtual robot programming environment are shown below.

Name of the competition: "Labyrinth".

Race description: The robot is given a series of transitions to reach the end of the maze. The robot's goal is to reach the finish line by moving forward and backward from the starting point. Robots are not allowed to touch any line. The size and data of the table equipped for the competition in the virtual environment (See Figure 5.) [6] :

1) The robot starts from the start line and moves forward and takes turns to reach the finish line.
2) The robot enters the finish line (excluding the line at the finish line) without touching any black lines.

Before we can complete this task, we need to study the first week of the ROBOTC programming program.

To perform this task, we write code that programs the basic movements of the robot to move straight forward and turn left and right in place. The program code was improved by testing the robot on a given competition site in a virtual environment.

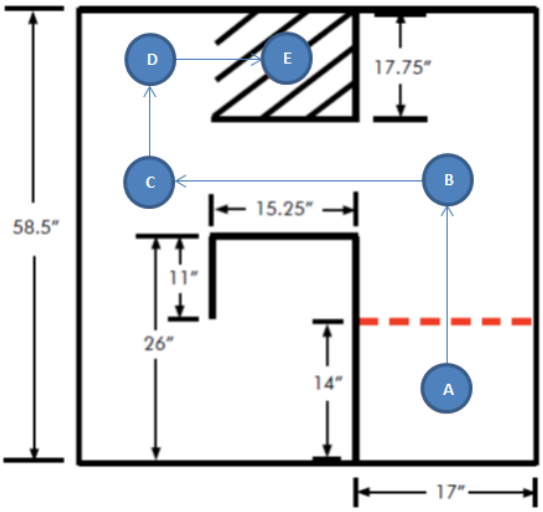

Figure 5. Graph of robot movement on the competition field

An algorithm for crossing the maze is written as follows:

1) Go stright from point A to point.
2) At point B, turn left on its axis.
3) Go stright from point B to point C.
4) At Point C, turn to the right on its axis.
5) Go stright from point C to point D.
6) At point D, turn to the right on its axis.
7) Go straight from point D to point E.

The algorithm to complete the labyrinth in ROBOTC programming language is written like [7]:

```
task main ()
{                       //Go straight from point A to point B.
                        motor [motorC] = 50;
                        motor [motorB] = 50;
                        wait1Msec(4000);
                        //Turn left at point B
                        motor [motorC] = -50;
                        motor [motorB] = 50;
                        wait1Msec(800);
                        //Go  straight from point B to point C.
                        motor [motorC] = 50;
                        motor [motorB] = 50;
                        wait1Msec(4000);
                        // Turn right at point C.
                        motor [motorC] = 50;
                        motor [motorB] = -50;
                        wait1Msec(800);
                        // Go straight from point C to point D.
                        motor [motorC] = 50;
                        motor [motorB] = 50;
                        wait1Msec(3000);
```

```
// Turn right at point D.
motor [motorC] = 50;
motor [motorB] = -50;
wait1Msec(800);
// Go straight from point D to point E.
motor [motorC] = 50;
motor [motorB] = 50;
wait1Msec(3000);
}
```

The above code was tested on a virtual robot, and after successfully completing the maze, the program code was competing the maze, the program code was compiled into a physical robot.

Survey Results

A program written in the ROBOTC language was tested on a virtual robot in a virtual environment. During the writing of the maze program, basic movements to control B, C motors were examined. The examination shows that:

- Move motors B and C back and forth.
- Pause motors B and C for period of time.
- Calculate the total distance traveled by motors B and C.
- Adjust the timer of motor C and B.

Depending on the environment, certain changes in the direction of movement of physical robots have been observed. For example, a robot may change direction from a straight path due to a bumpy surface. It happened due to defects, bumps, depressions and bumps on the table surface.

Conclusion

We believe that programming robotics is suitable for students who are majoring in computing and appropriate to use in programming courses. If students cannot afford, they are able to program robots in virtual environment. Also, the LEGO MINDSTORMS kit is a suitable low-cost option.

The students were able to experiment the programming on physical robots. Participants' developed their robotics designing skill, a knowledge of programming, critical thinking and teamwork skill. Experiments can be performed in combination with virtual and physical robots. It is possible to provide STEM education by developing a robotics training program, conducting research, and organizing non-formal training for students.

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