ISSN 2278-3091
Volume 9, No.1.1, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse4991.12020.pdf
https://doi.org/10.30534/ijatcse/2020/4991.12020

Blended Online and Offline Robotics Learning Program Using Low-Cost Mobile Educational Robot

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ABSTRACT

To compete with the fast growing economy and ever changing technology, students should be engaged and equipped with Science, Technology Engineering and Mathematics, STEM. However, robotics education is perceived to be intimidating to some students and a challenging subject to handle for professors. The objective of this research is to introduce an autonomous mobile robot, called the AMRoV, that can be used as an interactive tool in teaching robotics. A curriculum framework based on constructivism was also presented which can be used as a basis in developing robotics subject. The research further explores the possibility of delivering robotics education on a blended online and offline platform. The output of this research can be used as an alternative method in offering robotics subject.

Key words: Robotics, technology, STEM, autonomous, online and offline learning.

1. INTRODUCTION

Robotics is a multi-disciplinary area of engineering and science that involves combination of computer programming, mechanical engineering, electronics and electrical engineering. Robots aim to replace humans from jobs that are considered dirty, dull and dangerous. Robots are essential links in connecting technology with the industry, and therefore will play a big role in a fast growing economy. With this vision of the future, students need to be competitive to cope up with the fast growing and ever changing technology of the 21st century.

Many studies revealed that robotics can be used in education to enhance the students' thinking, social interaction analytical skills of the students. The study of robotics allows the student to be engaged in activities that may develop their skills in four distinct area of knowledge: computer programming, mechanical engineering, electronics and electrical engineering. Sometimes these skills are perceived to be intimidating prerequisites to learn robotics to some students, thus, imposing a huge challenge to many professors handling robotics subject to deliver the lesson in a simple, exciting and interactive way. Science, Technology Engineering and Mathematics, STEM is one of the areas in education considered to be prerequisite for modernization and national development. STEM has been characterized as one of the prime movers of industrialization and accelerator of economic development.

This study presents a proposed curriculum framework that aims to combine online and offline program that will offer essential skills on robotics to students taking up STEM. Technology has become readily accessible to anyone and the power of the internet has affected the way we learn new skills. Time, location and distance are no longer an issue using online learning materials. On the other hand, offline learning cannot be discarded.

A classroom setting allows student interaction and participation. When both online and offline education are combined, it will create a dynamic teaching and learning experiences that fits the modern digital economy.

2. MATERIALS AND METHODS

Robotics offers many benefits for getting students engaged in Science, Technology, Engineering and Mathematics, STEM through the use of real or simulated robots. The use of real robots as teaching material encourages creativity and critical thinking because knowledge is gained through hands-on experience. Robots enable educators to propose different models of teaching focusing more on constructivism approach or gaining knowledge through practical experience grounded by strong learning theories.

2.1 Curriculum Framework

The proposed curriculum framework proposed in this research work is shown in Figure 1. The foundation of the framework is based from constructivism, a learning theory wherein the student constructs knowledge from experience, which is unique for each individual. Constructivism focuses on critical and creative thinking. In constructivism students recognize that they are in control of their learning and failure reflects on them, and not on the teacher. Knowledge is therefore constructed by the learner.

The framework focuses on three interlocking components namely: Inquiry skills, scientific attitudes and content and connections. The framework addresses the need to develop the understanding of students and enables the smooth progress between stages of schooling.

Within the framework are the three essential elements for constructivism approach in teaching and these are: knowledge centered, assessment centered and learner centered. A knowledge centered learning environment introduces facts, ideas, concepts and principles during discussions. This gives emphasis on developing metacognitive skills which help students learn more about their own learning. Knowledge centered learning environment guides students to learn with understanding. Assessment centered learning environment is designed to provide continuous feedback about preconceptions and performances to both learners and instructors, this allows improvement in instructions and in identifying in what area does learners need further help. Learner centered learning environment allows the instructor to design ways to discover the knowledge and skills of the learner. This environment presents subject-related problems or challenges, soliciting the thoughts or ideas of the students on how to solve the problem and asking them to explain the reasons behind their thinking.

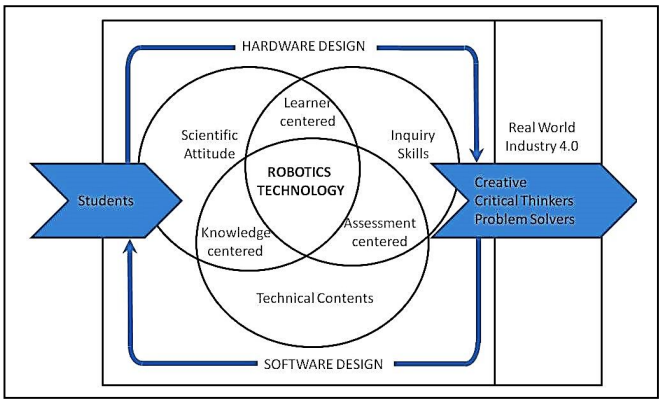

Figure 1: Curriculum Framework

The center of the learning components and environment covers the Robotics Technology which aims to prepare the students for the Industry 4.0 that requires them to be creative, critical thinkers and problem solvers in both hardware and software side of any robotic design.

2.2 Offline Learning Proposition

The offline learning will be done in typical classroom or laboratory facilities of the school or university. The proposed course outline is shown in Table 1.

Teachers will play a big role in influencing student interest in STEM and career pursuit. Teachers must be able to support students and provide guidance during the whole robotics course. Additionally, when designing problem-solving activities, teachers should consider how to help the students manage peer interaction and to recognize the importance of interdependencies in different situations.

Table 1: Course Outline

Wk	Modules	Sensors and components
1	Introduction to Robotics	
2	Basic Circuits	
3	Hardware and Software Design	Arduino IDE
4	Introduction to Microcontroller	Arduino
5	Digital and analog signals	Push buttons and LEDs
6	Pulse Width Modulation	Motor Driver
7	I2C communication protocol	HMC5883L Compass
8	SPI communication protocol	SD Card module
9	Serial communication protocol	GPS module HC-05 Bluetooth
10	Fundamentals of Navigation	
11	Printed Circuit Boards	Fritzing
12-14	Group Project	Robot behaviors

2.3 The AMRoV Teaching Robot

The AMRoV is an acronym for Autonomous Mobile Robot Vehicle and is shown in Figure 2. The robot was developed using off-the-rack components. The main chassis is made from an acrylic board wherein two DC geared motor wheels are installed. The steering system of the robot resembles a differential steering system. The robot will move in straight line when both wheels are rotating in tandem. If one wheel turns faster than the other, then the robot turns in a curved path. A caster wheel is attached at the rear end of the robot.

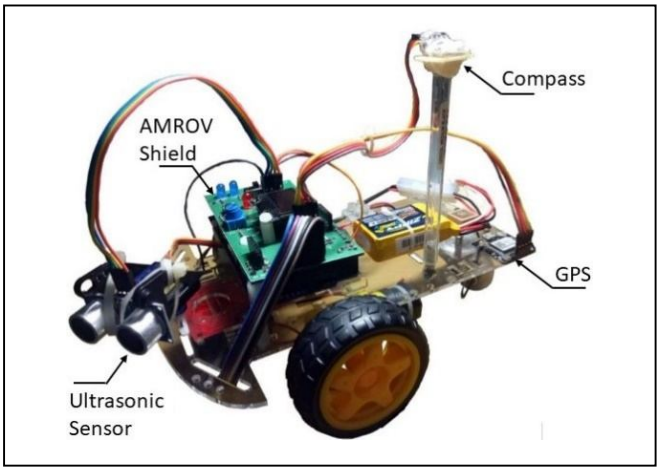

Figure 2: The AMRoV Robot

The unique component of the AMRoV robot is the Printed Circuit Board, PCB or the AMRoV Shield shown in Figure 3. The Printed Circuit Board or PCB was designed and developed by the researcher. The PCB integrates all the electronic components of the robot and simplifies programming. Another unique capability of the AMRoV PCB is that it was already used to convert different full-sized mobile machines to fully autonomous robot without too much alteration on the PCB design.

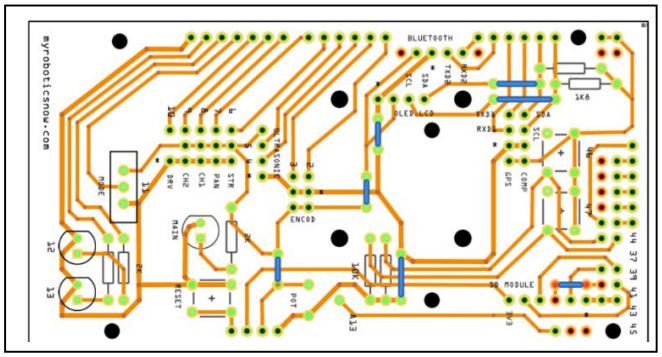

Figure 3: AMRoV PCB

Two LEDs and push buttons were installed to illustrate the basic programming lessons such as indicating robot state and starting a certain robot function. A potentiometer can be used to control the servo motor and an ultrasonic sensor was also installed for distance measurement. A Bluetooth and SD card capabilities are also included in the system. Table 2 shows the complete lists of sensors and motor interface.

2.4 The AMRoV Behaviors

The following are different robot behaviors that the AMRoV Robot can simulate. These robot behaviors will allow students to understand fundamental concepts used in developing autonomous mobile robots or "driverless vehicles."

Obstacle Avoidance Behavior: The program will begin with the ultrasonic sensor checking if there is an obstacle present in front of the robot at a specified distance value of 20 centimeters. If there is no obstacle present, then the robot will just continue to drive forward.

Wall Following Behavior: A simple program that will allow the robot to follow a wall surface. The difference between the actual wall distance measured by the ultrasonic sensor and the specified wall distance value will be the argument that we will be entered to the steering function.

Drive to Goal Bearing Behavior: The AMRoV robot can navigate through the environment by using some means of sensing or following a geometric coordinates or map reference. Compass sensors are widely used for navigation applications to measure the absolute orientation of the robot in an environment. The bearing and the goal should be in the same direction so that the robot will reach its destination. In other words, the difference between the goal and the bearing should be equal to zero for the robot to steer towards the desired destination. And from our steer () function, a zero steering angle will make the robot to move in a straight line.

Drive to Waypoint Behavior: Waypoint navigation relies on knowing the waypoint position, the current robot position, and the current robot heading. GPS coordinates are simply points without heading, the direction of the waypoint from the position of the robot is calculated. This uses trigonometry by taking the UTM values of Northing and Easting points of the robot and the waypoint and using the tan-1 function to calculate the angle between them.

Table 2: Sensors and Components

Sensor	***Details***	
GPS	Reports NMEA string GT-U7 GPS module	Serial 1
Compass	Reports orientation in degrees (0 – 360) with 0.5 degree resolution, HMC5884L Triple axis compass	I2C
Accelerometer	Angular velocity and linear acceleration in three axes and linear	I2C
Ultrasonic Sensor	Range 1 – 180 cm, outputs a pulse width proportional to distance, HC-SR04 Ultrasonic sensor	Pulse Width
Push Buttons	2 push buttons for program control	Digital
LEDs	Direct digital connections	Digital
Bluetooth	Bluetooth HM-05 module	Serial 2
OLED	Displays Data for Navigation	Serial 3
SD card	Reading and writing	SPI
DC Motors	2 DC geared motor for differential steering	Digital PWM
Motor Driver	Receives PWM signal, L298N Dual H-Bridge Motor Driver	Digital PWM
Pan motor	Pan the ultrasonic ± 40 deg	Digital PWM

Remote Controlled Behavior: Remote controlled robots receive instructions in real-time. These instructions are sent through a transmitter and received by the robot by means of a receiver. A toggle switch will be used to change the mode of the robot from manual remote control mode to autonomous mode, and vice versa. HC-05 Bluetooth module will be used to wirelessly control the robot. The Android application can be developed from MIT app inventor.

Drive to Multiple Waypoints Behavior: In this behavior, the student needs to design the trajectory that will cause the robot to reach a goal. Navigation goals are set of waypoints that provide information to the robot to follow correct path towards its destination as shown in Figure 4. There are many tools that can be used for path planning and one of them is The Mission Planner, created by Michael Oborne, it is easy to use, open-source software that can be used to create robot trajectory in a point-and-click waypoint entry in a Google Maps.

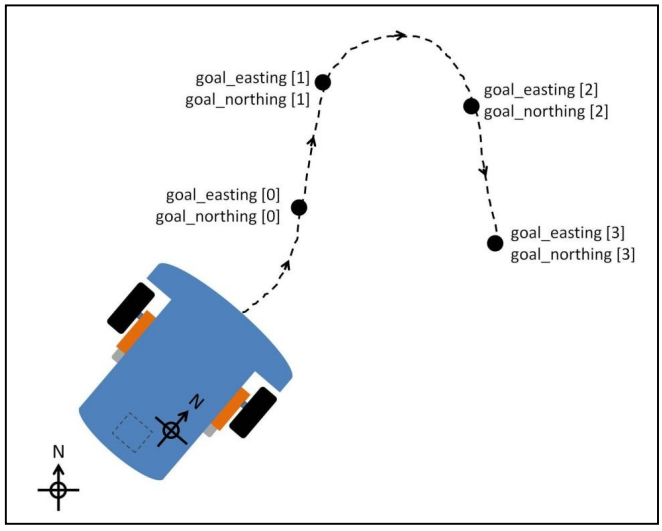

Figure 4: Drive to Multiple Waypoint Behavior

Fully Autonomous Robot Behavior: When an autonomous mobile robot navigates through an environment, it must have the capability to execute the planned action to reach the desired location and must also be able to move without collision with obstacles. To make the AMRoV robot fully autonomous, the students will need to combine the obstacle avoidance behavior and the drive to multiple waypoints.

2.5 Online Learning Proposition

An online learning involves the use of a website on presenting instructional content. The proposed home page of AMROv online platform is shown in Figure 5. The "AMROv tutorials" link provides FREE 5-10minute video tutorials presenting fundamental concepts in robotics and procedures on how to build the AMROv Robot.

The "Robotics Course" is a link where in short video tutorials are presented. Handouts, libraries and software codes are also available in the link. Each topic allows the student to identify their level of learning throughout the program.

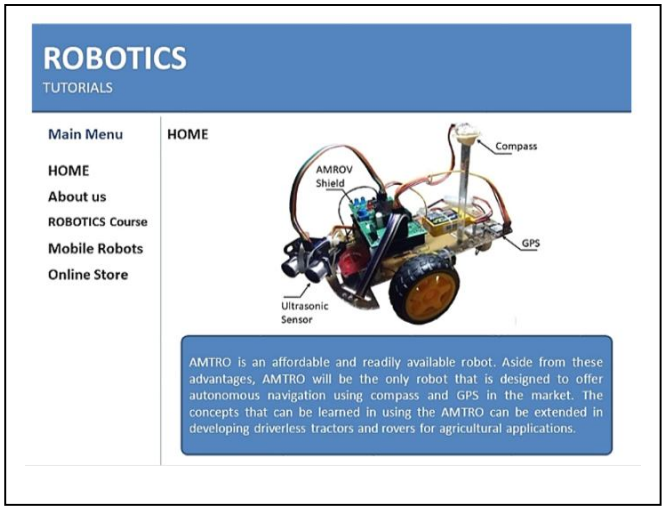

Figure 5: Website Sample Homepage

3. CONCLUSION

Science, Technology, Engineering and Mathematics, STEM, is one of the areas in education considered to be prerequisite for modernization and national development. STEM has been characterized as one of the prime movers of industrialization and accelerator of economic development. For the past decades, the Philippine government has been intensifying its support to modernize the local educational system and has been considered to be given the highest budgetary priority in the national government budget. The primary objective of presenting an interactive tool that can be used in teaching robotics was achieved through the AMRoV robot. This was supported by a curriculum framework based on constructivism approach. A blended online and offline learning platform was also presented and can readily be implemented as an alternative method of delivering robotics subject.

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