# UMP STEM Bot as Educational Kit for Robotics and Computer Programming

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**Abstract: We present UMP STEM Bot, an open-source robotic platform, for educational use that covers a wide spectrum of black-box and white-box learning objectives. The building structure of UMP STEM Bot and its learning outcomes are described. The educational kit is scalable to a more advance application as it is built based on the open-source technology. The UMP STEM Bot is a viable low-cost robotic manipulator platform alternative for introductory courses such as basics of robotics, computational thinking, and programming, as well as for advance courses at the university level such as intelligent robotics.**

## 1. Introduction

In recent years, robotics has become a valuable learning tool kit for programming, electronic systems and robotics [1, 2]. Various platforms were introduced and its effectiveness in engaging students to gain knowledge has been studied and evaluated [1-12]. These platforms are clustered as Educational Robotics (ER), which focuses on researches on robots for pedagogical activities ranging from designing, implementation, instructional design and validation [13]. ER in general consists of three main domains; education, robotics and human control interface. Robotics in ER are categorized base on its role as a learning topic, learning tools or learning aid in the in the pedagogical setup [13, 14].

Over the years, ER has been related to constructionism learning theories [3, 12, 14, 15]. Constructionism, introduced by Papert, was inspired by Paiget's constructivism learning theory. Here, learning is perceived when students are immersed in the activities and construct their knowledge about the topic. For complex topics such as ER, it is important for students to engage in the constructions as it will influence their learning experience [14].

While robotics itself is a matured research area, the advance functionalities are often treated as a black box, as to allow learners to grasp the concept without having to start from scratch [15]. An important aspect in ER is to identify the right balance between what is pre-program invisible (black-box) robots and visible (white-box) designs as to excite student to discover and building up their knowledge in robotics [14, 15].

Open source robotics is becoming attractive in today's educational robotics due to its reduced cost and wide support community. The main characteristic of an open-source system design is affordability and accessibility. These platforms are made of over-the-hardware and easily available software [4, 6, 16-21]. Open-source robotic solutions offers a high degree of freedom for users to customise their lesson plan based on the black-box or white-box paradigm.

Motivated by these needs, UMP STEM Bot is developed. UMP STEM Bot is an open source Arduino nano-based development kit that enable learners to program it either in a text or block programming environment. In this paper, the design and implementation of UMP STEM Bot are described in section II. Section IV presents the lesson outcomes and Section V describes the teaching findings from engagement using UMP STEM Bot. In Section VI conclusions are drawn and some guidelines for future work are given.

## 2. UMP STEM Bot Design

### 2.1. UMP STEM Bot Structure

UMP STEM Bot is designed for a multidisciplinary course that includes topics such as programming, electronic systems, robotics and semiconductor device manufacture. UMP STEM Bot is targeted for participants with varying levels of programming and prototyping skills, hence the kit had to be simple enough for novice users, but powerful enough for further expansion such as advance control algorithm implementation. Arduino platform were chosen as it balances the trade-off between cost, complexity and scalability.

UMP STEM Bot is equipped with LEDs, infrared sensors, and Bluetooth module. Also available are an ultrasonic sensor and a pair of micro motors and tyres. Bluetooth communication module is also available for users to explore remote controlled projects. The expansion and components replacement of the UMP STEM Bot kit is convenient as it is developed using on-the-shelves products that are accessible online.

### 2.2. UMP STEM Bot Learning Outcomes

Learning outcomes associated with the use of UMP STEM Bot covers three main domains; robotics, computer programming and physical computing. The programming covers from novice user which is to construct and create simple program, progressing to higher level of abstraction and decomposition to address complex problem and higher order programming techniques to solve real-world problem.

In physical computing domain, a junior learner is able to utilize basic electronics and electromechanical components, followed with the ability to process and monitor input data to response with the environment and progress to automated advance systems to solve complex real-environment problem. Learning outcomes for robotics domain begins with the ability to describe the robot main structure, sensing, communication and actuation mechanism. Intermediate level progresses to the ability of programming the robot to a specific function such as following lines and obstacle detection. In the advance level, implementation of control algorithm and techniques such as Proportional