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Research paper

Towards Revolutionizing Stem Education Via IoT and Blockchain Technology

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Abstract

Internet of Things (IoT) has been implemented in most advance technologies as part of the emerging 4th industrial revolution, and recently, blockchain technology is being welcomed. These rapid growing technologies giving a big challenge to the students. As such, learning these new technologies should be made easy and simple. However, current education does not specifically offer a curriculum to empower skills and knowledge in IoT and blockchain technology. The aim of this research is to develop learning kit that can provide suitable training to understand concept of IoT and blockchain technology. The kit consists of three parts namely "brain", "muscle" and "cloud". Raspberry Pi is used as "brain" of operation that will be interact with the Caiser Cloud platform. A testbox operates as "muscle" to provide simple data input. The input from testbox will be sent, stored and displayed on a platform created using Xojo software. The results show that the learning kit is successfully interact with Caiser Cloud platform and can be used as a training tools for education purpose.

Keywords: *Internet of Things (IoT); cloud platform; STEM education; blockchain technology.*

1. Introduction

Science, Technology, Engineering and Mathematics (STEM) education is a curriculum in schools to improve competitiveness in science and technology development. In STEM education, science, technology, engineering and mathematics components are taught separately and the integration can be done through project based learning. These approaches are expected to attract new generation's interest in science and technology and nurture their talent in professional fields such as engineering, invention, scientist and others [1]. Student interest in STEM is important to enhance country's competitiveness in growing global economy that rely on innovation-driven industries. Now, we are in fourth industrial revolution (4IR) where technology becomes embedded within societies. 4IR is current trend of automation and data exchange in manufacturing technologies such that includes Internet of Thing (IoT), cloud computing, cognitive computing etc. Physical system is materialized into internet system (IoT) which communicate and cooperate with human in real-time event through wireless network. To maintain competitiveness, Malaysia must prepare the young generations with knowledge and skills for the 4IR. That is why skills and knowledge that related to IoT are very demanding in this era. Thus, it is importance for young generation to acquire these skills starting at school level for their future career and growth of our great nation. Therefore, to enhance STEM integration in classroom, a learning kit is developed. IoT and blockchain is incorporated in the learning kit to introduce the concept of IoT and blockchain technology to students in simple, easy-to-understand and fun way.
This paper consists of four sections namely introduction, learning kit development, result and discussion, and conclusion.

1.1. STEM Education in Malaysia

Education policy in 1967 target the ratio of students with science / technical education to arts is 60:40. This policy however never been met due to several reason such as limited awareness about STEM, perceived difficulty of STEM subjects, content-heavy curriculum, inconsistent quality of teaching and learning and limited and outdated infrastructure [2-3]. In order to achieve the targeted policy, Ministry of Education have devised a strategic plan to strengthening delivery of STEM across the education system. The first move is to focus on strengthening the foundations of existing programme and encouraging upper secondary and post-secondary school students to enroll in Science stream.
To strengthening the foundation, the first step is to foster students' interest in science and technology. For instance, Bitara-STEM UKM Programme was created with the aim of attracting students between age 13-14 years old interest in Science, Techmology, Engineering and Mathematics. The programme is designed based on practical, experimental and demonstration involves cross-disciplines and multi-disciplines. About 80% facilitators of the programme are volunteers from UKM undergraduate students, whose taking STEM related courses. The programme which owed by Faculty of Education, Universiti Kebangsaan Malaysia manage to give a series of fun and interesting experiences to the participated students.
There are many method of teaching approach can be employed into STEM workshop training such as design-based learning [4-5], inquiry-based learning [6], problem-based learning [7-8] and project-based learning [9-10]. However, project-based learning is frequently used approach in STEM education because this method can achieve many learning attributes such as active learning, students' engagement, critical thinking and developing the solution

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upon project completion [11-12]. All these attributes help to develop students' confidence in choosing STEM career in the future.

1.2 IoT and Blockchain Technology

4IR was first introduced by Germany in 2011 where automation and data exchange in technology development including IoT, automation robot, computing with other technology that connected with internet has become main focus for next step of industry revolution. Various countries including Malaysia have already attempt to adapt 4IR concept in their future development plan that will greatly assist in their economic and continue to be competitive with other countries.

IoT is one of the key components in 4IR. IoT is referring to all physical devices that are connected to internet, collecting and sharing data without requiring human-to-human or human-to-computer interaction. IoT consist of four key elements namely sensing, communication, cloud based infrastucture, and delivery information. Sensing is the first step in IoT workflow where information is gathered. The information can be captured by several sensing devices in many forms including biometric, biological, environmental, visual or audible. In the second stage, all the captured information will be transmitted to cloud-based service for subsequent processing. The cloud-based service gathered all data from sensing devices and aggregates the data with other cloud-based to provide useful information for the end user. And the last step is delivery of useful information to the end user.

The rapidly emerging IoT has great potential to benefit businesses [13-14]. The overall IoT market is projected to be worth more than one billion U.S. dollars annually from 2017 onwards and the world is expected to have more than 30 million connected devices by the end of 2020, and the number is predicted increase exponentially [15].

Recently, blockchain technology is welcomed in several fields. Blockchain allows digital information to be distributed but not copied. It was originally devised for the digital currency such as Bitcoin. However, the tech community finding other potential uses for the technology [16].

A blockchain is a chain of digital "blocks" that contain records of transactions. Each block is connected to all the blocks before and after it. This makes it difficult to tamper with a single record because a hacker would need to change the block containing that record as well as those linked to it to avoid detection. In addition, the record is decentralized where it is distributed across network of computers. The record can only be tampered if the hacker can alter all the distributed records at the same time. It will require a massive amount of computing power.

The records on a blockchain are secured through cryptography. Network participants have their own private keys that are assigned to the transactions they make and act as a personal digital signature. If a record is altered, the signature will become invalid and the peer network will know right away that something has happened. Early notification is crucial to preventing further damage.

Nowadays, we have a lot of communicating devices around us (IoT devices), and the number keep increasing. Without security systems, these devices are vulnerable to cyberattacks. These problems can be solved by using blockchain technology, where tracking and distributing security software updates can be done.

2. Learning Kit Development

Project-based learning is one of effective teaching method for STEM education. In this research, a learning kit is developed to be used in a project-based learning. The learning kit is divided into three parts, namely "brain", "muscle" and "cloud" as shown in Figure 1. "Brain" consist of Raspberry pi 3 model B and functions to process any incoming data and communicate to the cloud. Raspberry pi is chosen because it is better in terms of processing speed, memory capacity, and money well worth when compared to other microcontrollers [17]. In addition, Raspberry pi 3 model B has built-in Wi-Fi card that are essential for project related to IoT.

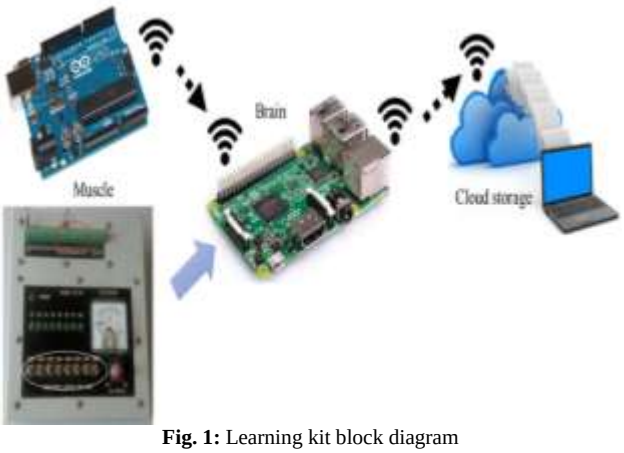


Fig. 1: Learning kit block diagram

"Muscle" part consist of a testbox that function as input devices. The testbox consist of 8 LEDs, 8 switches, one voltmeter and one analog output voltage knob as shown in Figure 2. There are two types of data can be generated from this testbox which are digital (0 or 5 V) and analog data (0-5 V). If analog data is used, an analog-to-digital converter (ADC) is required to convert the data into digital form before it is transmitted to Raspberry pi. Data from the testbox is transmitted to Raspberry pi using wired connection. Connector on the testbox is used to connect wire between testbox and Raspberry pi.

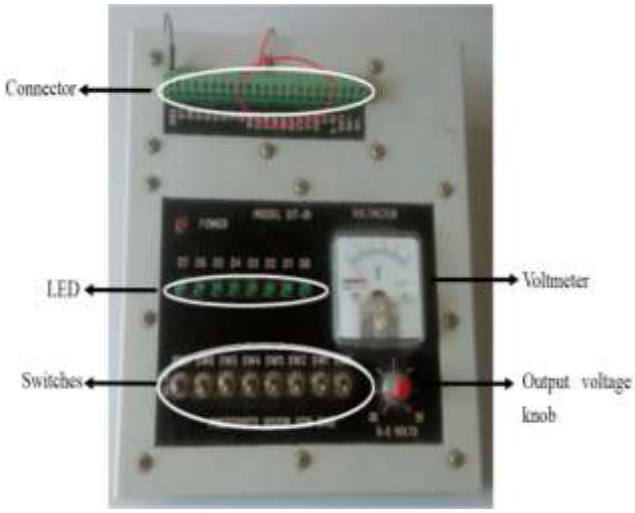
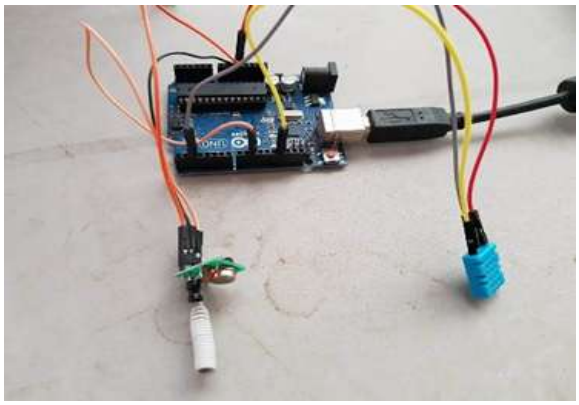


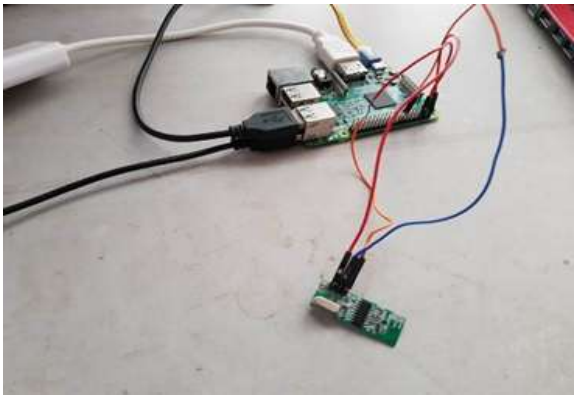
Fig. 2: Muscle part of the learning tool - testbox as simple testing tool

Although raspberry pi are overall better than other microcontroller but it has its own weakness, such as no build-in ADC (analog-to-digital converter) chip. Hence, Raspberry pi cannot accept any analog signal. In addition, the output pin drive only 3.3 V, but many devices such as sensor require 5V to operate. Another option to overcome these limitations is by using Arduino UNO as a "muscle". Arduino UNO provides several digital and analog general-purpose input output (GPIO). The digital input output pin handles 5.0 V voltage, which is commonly used voltage in sensing devices. Arduino has 6 analog input pins with built in ADC to convert the analog data into digital signal.

To function as a "muscle" Arduino can be connected to one or several sensors. Data from the sensors is captured by the Arduino and need to be sent to Raspberry pi that act as the "brain" in the system. Data transmission from Arduino to Raspberry can be done by using RF 433MHz transmitter/receiver module. The transmitter module is connected to Arduino, meanwhile the receiver module is connected to Raspberry pi as shown in Figure 3.



(a)



(b)

Fig. 3. Connection RF 433 MHz module (a) Transmitter module connects to Arduino (b) receiver module connects to Raspberry pi.

After Raspberry pi gathers data from "muscle", the data need to be sent to cloud. In this learning kit Caiser Cloud platform is used. Before sending data to the cloud platform, Xampp server should be started first. Xampp is chosen because it is free and open source web server. HTTP POST method is used for the data transmission to the server. The data is taken from text file that have been saved in the Raspberry pi. For the cloud platform development, a Xojo web app developer software is used. The platform must be able to display digital and analog data from Raspberry pi at all time as long as data is transmitted to the platform. The platform also able to plot graph based on received data. In addition, the platform should always auto refresh the table and graph regularly so that updated data can be displayed. The layout of the cloud platform is shown in Figure 4.

To introduce the concept of blockhain technology, data in the Raspberry pi can be encrypted before transmitted to the cloud platform. That data in encrypted so that it cannot be tampered by other users once it is available to public.



Fig. 4. Cloud platform layout developed using Xojo web app developer

3. Results and Discussion

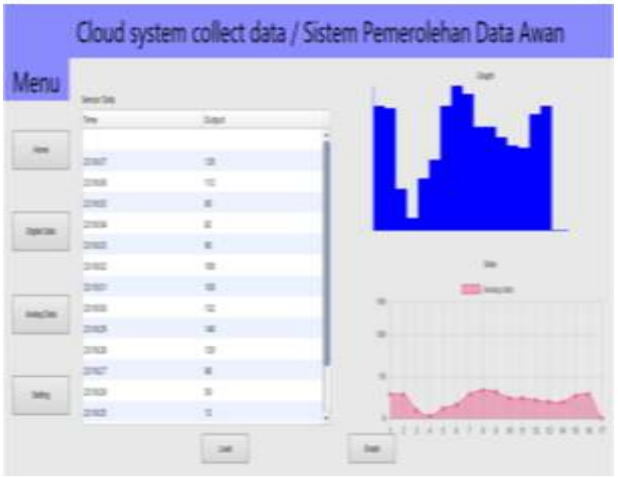
Figure 5 shows cloud platform interface displays the digital and analog data that have been received from Raspberry pi. These data are obtained from the testbox before it is sent to Raspberry pi. Then Raspberry pi send the data to cloud. The process is shown in Figure 6. It proves that the learning kit able to communicate with cloud platform. For digital data as shown in Figure 5(a), only 0 or 1 value is displayed, representing digital signal either 0V (0) or 3.3V (1) that received from Raspberry pi. On the other hand, analog data as shown in Figure 5(b) contains various value from 0-3.3V, which also received from Raspberry pi.

Besides the graph, the cloud platform interface also displays tabular of the received data. The left column of the table shows the time when the data is recorded. Therefore, user can know whether the data is updated or not. The data can be keep updating automatically by setting the platform to be refreshing regularly. With the Xampp software running, the cloud platform can be shared and accessed by multiple user as long as the webpage ip address are known.

The learning kit is designed to be used for workshop training and provide early exposure to young generation in the field of IoT and blockchain. Students can acquire basic knowledge in all four elements of IoT. The first element, which is sensing devices is provided by "muscle" part of the kit. Testbox is used to representing sensing device where switch of the testbox provide input signals to the system. Alternatively, Arduino and sensors can be used as explained in previous section. Arduino and sensors indicates real application, but it increases the complexity to the students.



(a)



(b)

Figure 5:. Cloud platform displays data received from Raspberry pi (a) digital data, (b) analog data

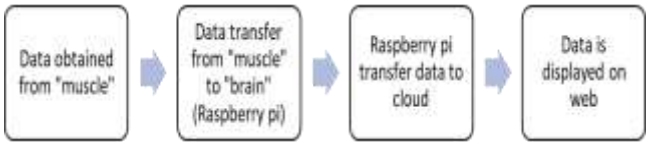


Fig. 6: Flow chart on data transmission from "muscle" to "brain" to "cloud"

The second element of IoT, which is communication is provided by communication between Raspberry pi and the cloud platform. By doing the process, students be able to understand how the communication between hardware device and cloud platform works. If Arduino and sensors act as "muscle" in the project, communications also occurs between Arduino and Rasberry pi, where data from sensors gathered by Arduino need to be sent to Rasberry pi. The communication part is followed by cloud-based service. For this IoT element, student will get experiencing in developing cloud platform using simple apps. Finally, data captured by the sensors can be displayed using the cloud platform interface to make it accessible by multiple users.

By using the developed learning kit, students are expected to get basic understanding on the concept of IoT and blockchain technology. As the learning kit is simple to be used, students are expected to enjoy the learning process and increase their interest in science and technology.

4. Conclusion

STEM education is introduced to overcome decreasing number of students taking science stream in Malaysia. In order to attract student's interest in STEM subject, it is important to make the learning interesting and simple. Therefore, this research developed a learning kit to introduce basic concept of IoT and blockchain technology in STEM education. The learning kit uses project-based learning approach to provide experience to students. The kit consists of "brain", "muscle" and "cloud" parts to cover all elements in IoT and blockchain technology. IoT and blockchain concepts is important to be introduced to students to prepare them with 4IR. However, the developed learning kit only concentrate on sending data from Raspberry pi to the cloud. For future work, more modules can be introduced to give more opportunity for students to explore. For instance, more experiments at "muscle" part using Arduino and sensors can be introduced. In addition, students also should be introduced on how the data from the cloud can be used to control other electronic devices.

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