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IoT Education using Learning Kits of IoT Devices

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Abstract

The rapid growth of inexpensive and easily accessible communicating devices embedded into new or existing physical devices transform them into the intelligent devices that comprise the Internet of Things (IoT). The increasing use of these devices has attracted attention from various sectors, including consumer market, business, industry, health, government, education, research, and many others. In educational sectors, many institutions are exploring the advanced digital infrastructure applications to improve the learning and teaching abilities of the difficult subjects of Science, Technology, Engineering, and Mathematics (STEM). IoT devices in the classroom or in laboratory activities can enhance the learning process with innovative ideas to increase student motivation in much faster and effective ways. In addition to using IoT to enhance the educational process, IoT serves as an important topic of study. IoT education consists of diverse components including hardware, software, programming, and electronics. How IoT is incorporated into the curriculum is based on the programmatic objectives. For non-engineers, non-coders, and many others, IoT courses need to be designed and delivered in a different way than would be done with engineering, engineering technology, and computer science majors. This paper will discuss the use of widely available educational IoT kits that could be used for beginners or non-majors.

Keywords: Internet of Things, IoT, Learning Kit, IoT Education, IoT Application, IoT Development Kit, IoT Starter Kit.

1. INTRODUCTION

The Internet of Things (IoT) is a global platform of interconnected devices converted from dumb and immovable physical devices into intelligent devices that can respond and act to the environment, humans, and other devices in a real-time environment. However, IoT has been defined and interpreted in various ways by different authors and researchers that is appropriate for their application after the term IoT came into existence. This term was first used by Kevin Ashton during his presentation about radio frequency identification (RFID) at Procter & Gamble (P&G) in 1999 (Ashton, 2009). According to Oriwoh and Conrad (2015), IoT represents 'anything at all, depending on requirements.' Cisco (Noronha, Moriarty, O'Connell, & Villa, 2014) termed this as the Internet of Everything (IoE). Cisco states that "IoE brings together people, process, data, and things to make networked connections more relevant and valuable than ever before—turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries" (Barakat, 2016). According to Rose, Eldrige, and Chapin (2015), IoT generally refers to scenarios where network connectivity and computing capability extends to objects, sensors, and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention.

The present growth of IoT as an emerging technology has attracted many sectors from education, government, health, industry, and many others. International Data Corporation, IDC (2019) estimated that 41.6 billion connected things will be in use worldwide by the end of 2025. Gartner, Inc. (2014) also mentions that a typical family home could contain more than 500 smart devices by 2022. With such immense potential uses of IoT devices, it creates the necessity of learning IoT for students while it creates opportunities for educators for effective teaching practices.

2. IoT IN EDUCATION SYSTEMS

Many educational institutions and educators are continuously exploring new opportunities and seeking new technologies to enhance the learning and teaching process. On the way of exploration, many educators found the IoT as an exciting option to incorporate in their educational activities. There are two major categories of IoT in education activities:

a) Adopting innovative ways of using IoT devices to enhance teaching difficult subjects with ease
b) Incorporating IoT courses in the curriculum

IoT devices are the additional feature in the existing digital technologies used in the learning and the teaching environment with the addition of interactive smart boards, smart multimedia pens/stylus, graphic tablets, document cameras, digital podium, clickers, interactive LCD panels, microphones, speakers, etc. The use of IoT devices will lead the classroom into the smart classroom. This will offer a higher level of personalized active learning environment for the students.

The other category of IoT is teaching IoT to the students of various backgrounds. For institutions with existing courses related to electrical, electronic engineering, programming, microcontroller architectures, robotics, and others have very much an open discussion question whether they need something in addition to teaching IoT (Lyzhin, Efremov, Rolich, Voskov, & Abrameshin, 2019).

For those who are not related to the above fields, it needs to be approached in a different way. Lyzin et al. (2019) had used the general approach to teaching IoT is to design extensible educational constructors for carrying out multidisciplinary practice sessions.

Many institutions offer IoT courses ranging from introductory to the advanced level depending upon their program and curriculum. Some institutions also offer specialized course on IoT as a certificate program.

Burd, Barker, Divitini, Perez, Russell, Siever, and Tudor (2018) discussed challenges and decisions involved in an initial IoT course offering and suggests the design of IoT curriculum and the selection of the tools for a quick start that suited to novice learners. According to their paper, existing course approaches are can be described in four categories as follows:

a) Category 1: Broad Introduction to Internet of Things Concepts in a Single Course
b) Category 2: Integrate IoT Concepts into Existing Courses
c) Category 3: Focused Course Intended as Part of an IoT Specialization
d) Category 4: Courses about Specific Use-Cases that Employ IoT

Most IoT courses are mainly focused and involved in the hands-on hardware-centric project. These projects consist of the following platform and tools:

a) Hardware Platform
   e.g. Arduino, Raspberry Pi, BeagleBone, Intel Edison, Microbit, Particle Photon, etc.
b) Software Platform
   e.g. C, Java, Python, etc.
c) Cloud Platform
   e.g. MQTT, CoAPP, HTTP, etc.
d) Network Communication Platform
   e.g. WiFi, Bluetooth, Zigbee, Z-wave, etc.
e) Components and Accessories
   Sensors, Actuators, jumper wires, breakout boards, push buttons, etc.

Most projects use one or more hardware and software platforms. Among these categories, the selection of the hardware platform is the most challenging. IoT hardware platforms are the mediums to establish a relationship between device sensors, actuators, and data networks to relay information. The two most popular and commonly used IoT hardware platforms are Arduino and Raspberry Pi.

Dobrilovic and Zeljko (2016) had proposed an IoT platform for university curricula using an IoT education kit consisting of an Arduino Uno board. Raspberry Pi is selected because of its low cost, efficient, and flexibility that can assist in introducing IoT the paradigm in the education system (Mahmood, Palaniappan, Hasan, Sarker, Abass, & Rajegowda, 2019).

The study by Zhong and Liang (2016) presents and provides the project-based teaching and learning approach devised in an IoT course for undergraduate students in computer science major using Raspberry Pi platform as an effective vehicle to greatly enhance students' learning performance and experience. The paper by Kurkovsky and Williams (2017) presents the experience of incorporating IoT projects into an existing Systems Programming course using Raspberry Pi. At the two-year college, the course on IoT introduces IoT platforms using Raspberry Pi and Arduino for non-majors in the hope of generating interest in the STEM fields (Maullett, 2018).

Raspberry Pi and Arduino platform are selected because of its huge community support, low-cost, open-source codes, and easy availability of many samples of IoT projects.

3. IoT EDUCATIONAL KIT

IoT educational kit consists of a set of components including breadboards, jumper wires, development controller boards, sensors, motors, and electric components like resistors, capacitors, inductors. Commonly used development boards are Arduino-Uno, Raspberry Pi, Intel Galileo boards, beagle bone, etc.

In the study by Ilia et al. (2019), most used educational projects and learning kits are mainly with the use of Arduino or PCBs based on the ESP8266. Kusmin (2019) had discussed the co-designing of the kits of IoT Devices for inquiry-based learning. Kits are designed by interviewing teachers and students from different schools for their choice of kits given the list of kits.

Preliminary projects are designed to learn the basic function of IoT devices. Some of such projects are:

a) Led Blinking
b) Dimming LEDs
c) Temperature and humidity reading
d) Activating/Deactivating relay switches

The advanced project for the next level of the project can be designed to solve real-time problems. Some of these projects are:

a) IoT based smart parking system using RFID
b) Smart irrigation system using IoT
c) Cloud based temperature monitoring system
d) Smart streetlights
e) IoT based smart fire alarm system
f) IoT Face Recognition AI Robot

These advanced projects are designed that uses tremendous applied research skills and use of kits to solve real-time problems.

These IoT educational kits can be categorized into two groups.

a) Raw kits that do not come with instruction and the uses of components are completely depends on the students' and educators' instructions.
b) All-in-one Educational Kit that comes with full instructions of assembling the given project along with all hardware and software components. These kits are often called as do-it-yourself (DIY) kits or IoT development kits or IoT starter kits.

These kinds of kits come as all in one packet kits along with all the required components and step by step instructions. Most of these kits come with a smart phone app that allows easy connection with preloaded projects. Example of such kits are

a) SparkFun IoT Starter Kit with Blynk Board
b) Osoyoo Robot Car Starter Kit
c) Makeblock Ultimate 2.0 10-In-1 Robot Kit
d) Sunfounder Robot Raspberry Picar-S Kit
e) Lego Mindstorms EV3 kits

These development kits are suitable for the entry-level learners of IoT. So, these types of kits are used by the high school students and STEM students of non-technical majors, beginners of programming. These are also useful for the business who are stepping in the IoT technologies.

4. BENEFITS OF EDUCATIONAL IoT KITS

There are several benefits of adopting Learning IoT Kits. Some of these benefits are as follows:

- There are many kits available in the market which can be selected based on affordability.

- Educational kits are available for different age groups and learner groups.
- Educational kits are very suitable for the beginners since it does not require much experience. The kits come with step by step instructions and online tutorials are highly available.
- Most of the Kits come with cloud application integrations.

5. CHALLENGES OF EDUCATIONAL IoT KIT

Some of the challenges of educational kits are as follows:

- There are many available DIY kits available in the market and it will be hard for the beginner to know which one to choose.
- The cost of the kits may range from $60-$200. These costs may not be affordable for some students.
- Troubleshooting the hardware components could be difficult to diagnose for the beginner.
- Some IoT devices and applications may not be compatible making it difficult to deploy.

6. CONCLUSION

The increased use of IoT devices has attracted the attention of many sectors, including the education sector. The need for innovative teaching methods is imminent because of its diverse nature. Learning Kits serve learners at all levels. There are numerous educational kits available for beginners, advanced users, and applied researchers.

There are enormous opportunities for adopting educational kits for the learners. Making use of education kits speeds the learning process and the realization of the potential of IoT. Increasing awareness and knowledge of IoT across disciplines could lead to the development of new smart things. The dreams of a smart world may become reality.

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