International Journal of Multimedia and Ubiquitous Engineering
Vol.10, No.7 (2015), pp.375-386
http://dx.doi.org/10.14257/ijmue.2015.10.7.38

Wireless Communication Network Tools Kits with Visualization Techniques: Design Consideration for Proposed Architecture

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Abstract

Wireless Communication network is an inescapable reality of our days, being part of curricular proposed by almost all institute. Effective learning and teaching of wireless communication however, require student to visualize and illustrate in understanding the technical and how the communication network is operates. This paper recommends a conceptual framework to overcome the inability student in learning wireless communication network course which is complex and difficult especially for novice student. The aim of the course is to teach student not only programming and hardware design but also basic team-work and project management skills in the field of wireless networks through the active learning using the tools that we proposed. In this paper we proposed the architecture named Wireless Kit (Wkits) as one of the support tools that help novice student in enhancing their understanding of learning wireless communication. This kits focus in wireless communication such as Bluetooth, Wi-Fi and FRID technology.

Keywords: *Active learning, wireless communication, network technology, visualization*

1. Introduction

Wireless communication and networking is a challenging subject to teach in a meaningful way because many students appear to find the subject rather dry and technical and quite boring [1]. Wireless communication and networking courses are becoming increasingly popular in universities, polytechnics, postsecondary colleges, and private training institutions around the globe. This is partly because of rapid developments in wireless communication and networking technology and the high demand for wireless communication networks skills in the industry worldwide. Visualization help student to understand how concept network are applied in the real world by using graphical [2].Student in computer and engineering (CSE) and electrical engineering (EE) are at best exposed to data communication aspect, while wireless communication system remain untouched, as it is relatively difficult to learn about wireless technology without having substantial background in communication technology [3]. Besides that, Education and Research Kit provides a comprehensive platform for education, research and development of applications for wireless communications and sensor networks to provides a graphical user interface to monitor the wireless sensor network, including visualization of the network topology and sensor readings [4] . Moreover, related study strongly believes that students grasp more effectively from courses that allows active involvement in hands-on learning experiences [1]. A good visualization tool increases understanding of the problem and allows us to approach in another dimension to find a solution [5]. Besides that, students can understand better and adapt the information from the subject, when they

ISSN: 1975-0080 IJMUE

can visually on how the system operates. [17]. In this paper we present the proposed architecture namely WKits in order to provide the students of wireless communication and networking with a hands-on learning experience. These WKits are designed via low-cost wireless modules which is affordable for any user. The projects are suitable for classroom.

2. Literature Review

2.1. About Training Kit

The training kit has been specifically developed to provide teachers with educational material that will assist them to inform, motivate and inspire young people about subject and their applications. It will allow teachers to develop a balanced syllabus containing both theoretical and experimental components to suit the various student levels and educational approaches of participating schools. Training kit is organized in self-contained modules that offer increased flexibility throughout the development of the related subject. Moreover, a case study approach provides teachers with practical applications and examples to discuss in class. The teacher's training kit equipped with the learning procedure and focuses on the concepts in related subject and an experimental module with experiments that exemplify some of the concepts in the theoretical related subject.

2.2. About Visualization

The visualization develops a concept of imagery which is the ability to create an imaged gestalt as a basis for comprehension and higher order thinking. The development of concept imagery improves reading and listening comprehension, memory retention and critical thinking. Visualize instruction develops comprehension for core or homeschooling curriculum and is highly effective as an intervention to develop the comprehension skills for students of all ages.

"Clinical research and experience over the last twenty-five years indicate there is a separate comprehension weakness *that is rarely identified. This weakness often undermines the reading process and goes beyond use of context, phonological processing, word recognition, oral vocabulary, prior knowledge, and background experience. It is a weakness, based in the sensory system, in creating an* imaged gestalt. *"*

Nanci Bell, Visualizing & Verbalizing

2.3. About Wireless Sensor Networks (WSN)

A Wireless Sensor Network (WSN) is a network comprised of numerous small independent sensor nodes or motes. They merge a broad range of information technology; hardware, software, networking, and programming methodologies. Wireless Sensor Networks can be applied to a range of applications [1] monitoring of space which includes environmental and habitat monitoring, indoor climate control, surveillance etc.; monitoring things for example structural monitoring, condition-based equipment maintenance etc.; and monitoring the interactions of things with each other and the surrounding space e.g., emergency response, disaster management, healthcare etc. The majority of these applications may be split into two classifications which are data collection and event detection.

2.4. About Wi-Fi

Wi-Fi, also better known as or Wi-Fi, is a local area wireless technology that allows an electronic device to exchange data or connect to the internet using 2.4 GHz UHF and

5 GHz SHF radio waves. Many devices can use Wi-Fi, e.g., personal computers, video-game consoles, smartphones, some digital cameras, tablet computers and digital audio players. These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square kilometers achieved by using multiple overlapping access points. Depiction of a device sending information wirelessly to another device both connected to the local network, in order to print a document [7]. Table 1 has shown the standard frequency for Wi-Fi.

Table 1. Standard Frequency for WiFi

Wi-Fi technology	Standard	Frequencies bands
Wi-Fi	802.11af	470 - 710MHz
Microwave Wi-Fi	802.11ad	57.0 - 64.0 GHz ISM band (Regional variations apply) Channels: 58,32, 60.48, 62.64, and 64.80 GHz

2.5. About RFID

Radio-frequency identification (RFID) is the wireless use of electromagnetic fields to transfer data, for the purpose of automatically identifying and tracking tags attached to objects. The tags contain electronically stored information. Some tags are powered by electromagnetic from magnetic fields produced near the reader. Some of the types collect energy from the interrogating radio waves and act as a passive transponder. Other types have a local power source such as a battery and may operate at hundreds of meters from the reader. Unlike a barcode, the tag does not necessarily need to be within line of sight of the reader, and may be embedded in the tracked object. Radio frequency identification (RFID) is one method for Automatic Identification and Data Capture (AIDC).

RFID tags are used in many industries. An RFID tag attached to an automobile during production can be used to track its progress through the assembly line. Pharmaceuticals can be tracked through warehouses. Livestock and pets may have tags injected, allowing positive identification of the animal. RFID systems can be classified by the type of tag and reader. A Passive Reader Active Tag (PRAT) system has a passive reader which only receive radio signals from active tags (battery operated, transmit only). The reception range of a PRAT system reader can be adjusted from 1–2,000 feet (0.30–609.60 m, allowing flexibility in applications such as asset protection and supervision. An Active Reader Passive Tag (ARPT) system has an active reader, which transmits interrogator signal and also receive authentication replies from passive tags. An Active Reader Active Tag (ARAT) system uses active tags awoken with an interrogator signal from the active reader. A variation of this system could also use a Battery-Assisted Passive (BAP) tag which acts like a passive tag but has a small battery to power the tag's return reporting signal. Fixed readers are set up to create a specific interrogation zone which can be tightly controlled. This allows a highly defined reading area for when tags go in and out of the interrogation zone. Mobile readers may be hand-held or mounted on carts or vehicles [8]. Table 2 has shown the standard frequency for RFID.

Table 2. The Standard Range Frequency for RFID

Band	**Range**	**Data Speed**	**Remark**
120–150 kHz (LF)	10 cm	Low	Animal identification, factory data collection
13.56 MHz (HF)	10 cm - 1 m	Low to moderate	Smart cards

			(MIFARE,ISO/IEC 14443)
433 MHz (UHF)	1–100 m	Moderate	Applications, with active tags
865-868 MHz (Europe)	1–12 m	Moderate to high	EAN, various standards
902-928 MHz (North America) UHF			
2450-5800 MHz (microwave)	1–12 m	High	802.11 WLAN, Bluetooth standards
3.1–10 GHz (microwave)	1–12 m	High	requires semi-active or active tags

2.6. Theoretical Framework

The theoretical framework of this study is grounded on Atkinson-Shiffrin Memory Model [8], and Cognitive Load Theory [9]. Learning is a process where information is received, processed, encoded and retrievable from memory structure [7]. Atkinson & Shiffrin, (1971) classifies memory storage into three categories which are sensory memory, working memory and long-term memory (Figure 1). Each of these memories has its own role in receiving and processing information. Typically, information stored in sensory memory is merely about 1 to 1 seconds, working memory will store information about 15 to 30 seconds and long-term memory will store information permanently (Ismail, 2011). New information can purely be stored in long-term memory after the first appearance and process in working memory. However, as disclosed, working memory capacity is limited and the duration of information storage is short span. Therefore, not all information which are penetrated through the memory structures will work successfully, and register permanently in the long-term memory, which is in the form of perfect schema [14].

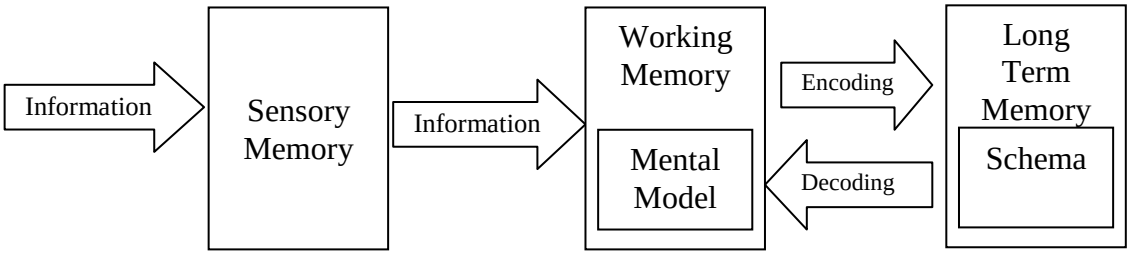

Figure 1. Information Flow in Memory System [8]

Cognitive Load theory [9] describes the learning process from the perspective of information processing system that keeps all information obtained from working memory in the long-term memory in the form of perfect schema. Scheme is a memory structure which creates path for students to deal with a large number of information blocks as if they are a single block. New information which enters the working needs to be integrated with pre-existing schemas in long term memory for sufficient mental model development in working memory. For this to take place, relevant schemas in long-term memory must be activated and decoded into working memory which is also defined as the process of schema acquisition. The inability of perfect mental models construction can be a barrier in the learning process, primarily to novice students who are not capable of recognizing the relevant pre-existing scheme in the learning process. Due to limited capacity of working memory, when student are overloaded with information and the complexity of teaching materials that are not well managed, it will result in a cognitive load that can potentially cause the process of loaded coding scheme to be affected. Cognitive load is divided into

three different categories of: i) intrinsic cognitive load, refers to the level of complexity or difficulty of the information to be learned; ii) extraneous cognitive load, refers to the technique and strategies used in presenting information; and iii) germane cognitive load, refer to impulse formation scheme through learning content management and integration of educational content to student knowledge [15]. Consequently, the development of instructional materials must be taken into consideration of principles which can reduce intrinsic cognitive load and extraneous cognitive load, and simultaneously will increase germane cognitive load. Optimizing the learning outcomes is through by balancing the three cognitive loads, for instance to reduce intrinsic cognitive load and extraneous cognitive load which will indirectly increase germane cognitive load [15].

3. Conceptual Framework

Based on theories, principles and literature overview, we put forward the framework of utilizing a visualization technique for the learning the program as depicted in Figure 2.

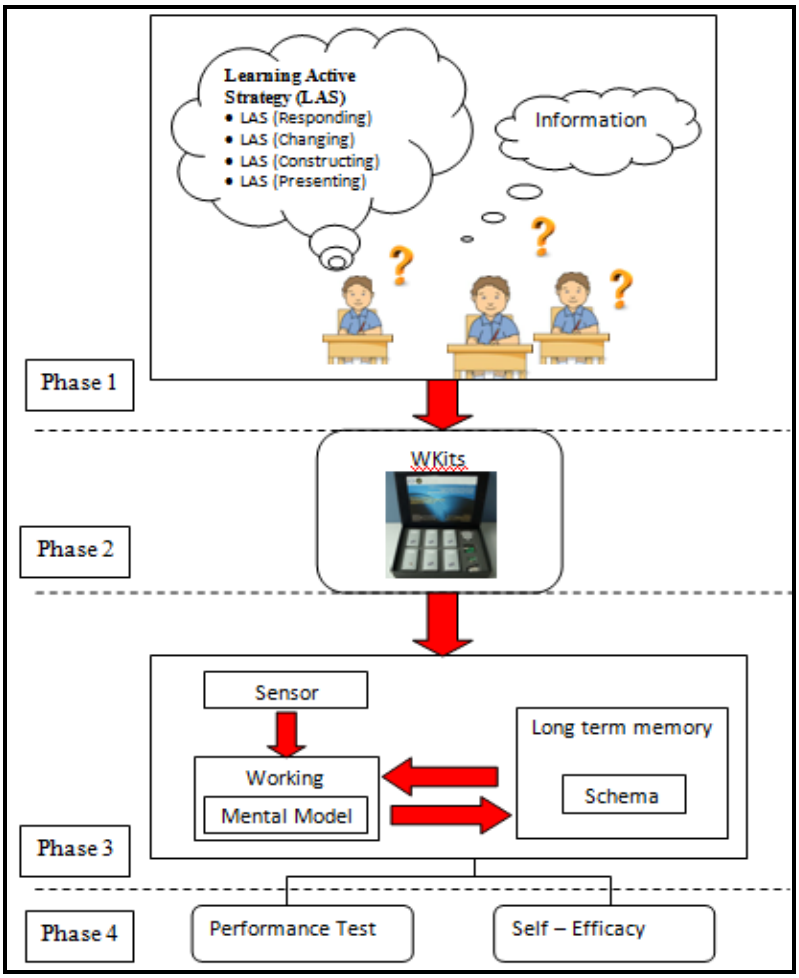

Figure 2. Conceptual Framework

Phase 1: Engagement Taxonomy (ET)

The central idea of the taxonomy is a higher-level engagement between learner and the visualization results for better learning outcomes. The ET consists of six levels of engagement and they are described in Table 4. Nevertheless question for novice students since they do not have strong existing knowledge related to topics studied. Without a

strong pre-existing knowledge, active involvement may be limited. In this regard, impact of the engagement level and learning performance would be of a great value and interest.

Table 4. Engagement Taxonomy Level

No	Engagement Level	Comment
1	No Viewing	There is no use of visualization tools
2	Viewing	Considered the core of student engagement with the visualization tool. Students only view the behavior of program activities from screen display.
3	Responding	Learner Interact with the visualization by responding to visualization's related question.
4	Charging	Visualization or state of visualization can be altered
5	Constructing	Learner can create awn visualization
6	Presenting	Leaner present visualization for discussion and feedback.

Phase 2: Support Tool

Students should be actively engaged with tool Kits in order to active processing occurs in working memory. Active learning is generally defined as any method of teaching that involves students in the learning process. It requires students to do meaningful learning activities and think about what they are doing. In the theory of constructivism, knowledge is constructed by students as a result of the learning experience through which they had [16]. It means during the learning process, students will activate prior knowledge stored in long-term memory and try to connect with new knowledge learned [16]. Consequently, this framework propose the implementation of active learning strategies based on the taxonomy levels of engagement with the central idea of ET of the higher level of student engagement with WKits tools, which would lead to better learning outcome.

Phase 3: Education Memory Model

Strategy and approaches of the visual representation of information is also essential to ensure effective use of information in long-term memory. Inappropriate use of strategies will lead to increase in cognitive load during learning activities, particularly if the visual information from the tool kits only focuses the characteristic of wireless network. Students should be actively engaged with WKits in order to activate the process occurring in the working memory. This is because the visual information conveyed by WKits tool should be able to render students in developing accurate mental models in working memory for processing. This will lead to creation of the perfect scheme to be stored in long-term memory

Phase 4: Performance

This framework involves the relationship of logical ability which incorporates the proposed active learning strategy using the WKits. This is because as understood, student's logical ability is recognized as one of the important elements needed to understanding the wireless network during the learning activities. Thus, it is important to

investigate whether the student's logical ability really affect the learning performance through the active learning strategies approach aided by WKits tool.

4. Proposed System Architecture

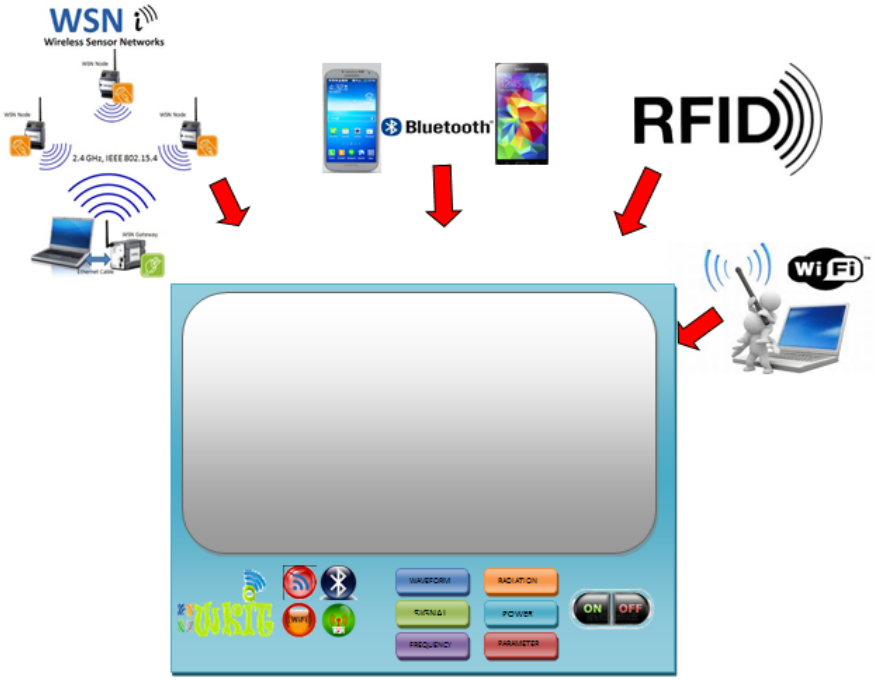

Figure 3. The Proposed System Architecture

We present the architecture system for WKits in Figure 3. In this system we propose the multiple wireless networks for optimum learning. Other research has concluded that, learning activity involving literature search and application of learned concepts and techniques. This helps students to learn the relationship between scientific theory and its practical applications in technology, visualize the processes occurring in the system [16]. WKits is capable in receiving the signal wireless networking such as Bluetooth, RFID, Wi-Fi, and WSN. WKits will visualize the information from the wireless networking with the characteristic that user expects. There are the functions for the button that WKits used which is shown at Table 4 and Table 6. Using the WKits, user can select the type wireless network that is used to visualize the characteristic of wireless network by selecting the square button.

Table 5. Type of Wireless Network

Table 6. Characteristic to Visualize Types of Wireless

Label	Type of wireless network
	WSN
	Bluetooth
	RFID
	WIFI

Label	Characteristic to visualize
	Waveform
	Frequency
	Signal strength
	Radiation pattern
	Parameter Wireless
	Power Consumption

In our study, we conducted several experiments to ascertain capabilities of the hardware to be used. The experiments that we conducted are fir RFID system networking. We used 2.45GHz Application Programming Interface (API) develop in Universiti Pendidikan Sultan Idris (UPSI), adopted through the ZigBee technology to support wireless communication network in this experiment. Figure 4 shows the experimental setup and Figure 5 shows the graph of performance. The scenarios of the experiment are as stated below:

Use case 1: Point to point between tag and reader with one tag.
Within point to point between tag and reader using one active RFID tag were placed to communicate to the RFID reader. Result showed that 100% real time data deliveries were accepted by reader.

Use case 2: Point to point between tag and reader with two tags.
Second experiment within point to point between tag and reader using two active RFID tags were placed to communicate to the RFID reader. Result showed that 100% real time data delivered by two tags were accepted simultaneously by reader.

Use case 3: Point to point between tag and reader with five tags.
Third experiment within wireless mesh network (WMN) between tag and reader using five active RFID tags were placed to communicate to the RFID reader. The same result showed that 100% real time data delivered by five tags were accepted simultaneously by reader.

Use case 4: Point to point between tag and reader with ten tags.
Last experiment that we conducted within wireless mesh network (WMN) between tag and reader using ten active RFID tags were placed to communicate to the RFID reader. Result showed that 99.9% real time data delivered by ten tags were accepted simultaneously by reader.

In this proposed system wireless communication experiment for RFID networking showed that possibility data to missing is low. From the experiment point to point conducted between tag and reader there no problem that occurs during the data from tag was transmitted whether in single point to point data transmitter or in multiple point to point for RFID experiment. The data that transmitted using API reader was successful received whether in simultaneously.

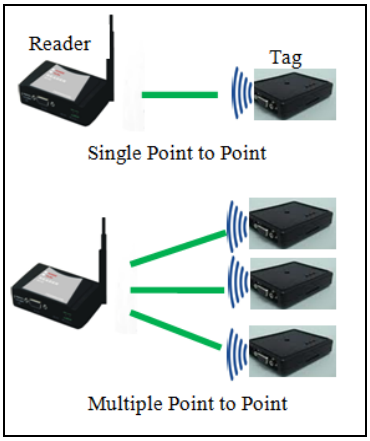

Figure 4. Experiment Setup

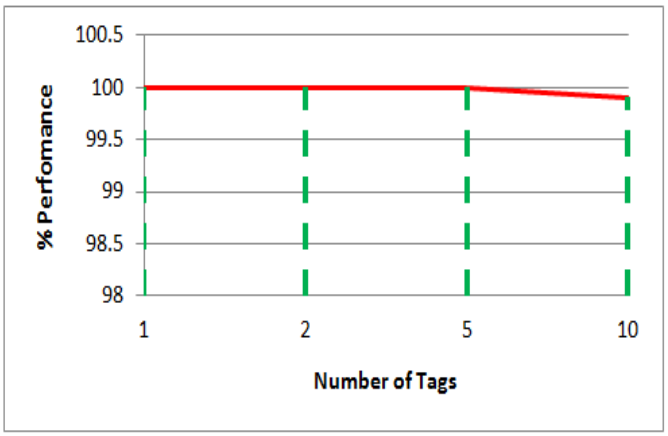

Figure 5. Experiment Graph

5. Different Existing Product in the Market

According to the study, there are several products in the market for wireless communication kits but do not have a lot of things displayed. WKit present a few additional things that can be used as teaching kits for students shown at Table 3.

Table 3. Different Existing Product in The Market Ability to Visualize the Wireless communication

Name of Product/ Type of wireless network	Crossbow Training Kits	Beekit Wireless Connectivity Toolkit	WKits (Proposed)
RFID			√
Bluetooth			√
Wi-Fi		√	√
WSN	√		√

5.1. Crossbow Training Kits

The Crossbow Starter Kit enables us to get first-hand experience with wireless sensor networks either in the 2.4 GHz or 868/916 MHz ISM bands. This entry-level kit provides all the components needed for rapidly deploying with a basic wireless sensor network. The sensor nodes and gateway are pre-configured with Crossbow's reliable, self-forming, self-healing mesh networking software (XMesh).

The MoteView application for Windows-based PCs provides an intuitive graphical user interface to monitor and manage the wireless sensor network. It displays network topologies, charts and graphs of sensor readings, as well as configuring sensor nodes, MoteView lets the user understand the sensor data and network while allowing easy configuration of sensor nodes.

5.2. BeeKit Wireless Connectivity Toolkits

BeeKit is a standalone software application that provides a graphical user interface (GUI) in which the user can create, modify, save and update wireless network solutions based on Freescale's protocol stacks. BeeKit provides a wizard and solution explorer that allows the user to configure and parameters, which reduce the need to sift through individual files and manually configure visualize parameters. With the comprehensive code base of wireless networking libraries, application templates, and sample

applications, the user generates the appropriate workspace files to be imported into an integrated development environment (IDE) for continued development and debugging.

6. Conclusion

Wireless communication and networking technology courses are rapid developments in and the high demand for wireless communication networks skills in the industry worldwide. However, the subject is said to be difficult and complex. This is because novice students require a proper understanding to capture an abstract concept of the learning and difficult to imagine. Previous finding shows that some factors that reveals in students' difficulty to master in wireless communication and networking technology is because they could not visualize the wireless process. Therefore, the design and development of WKits functions as the potential learning support tools to strengthen student's understanding on the wireless communication and networking technology in learning process. WKits use the approaches and techniques of visualization and illustration of the characteristic of wireless network. These help students to understand the operation of technology network. Nevertheless, using Wkits merely without the active engagement of students will not be able to give an effective impact on students in learning performance. Therefore, an active learning strategy functions as an approach that must be embedded in the learning process of learning process. Through active learning strategies aided by WKits, It is hoped that it will help to develop student's confidence in mastering the basic concepts of wireless communication and technology networking.

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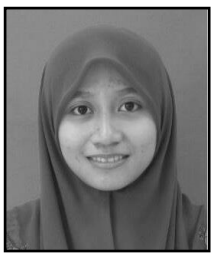
Che Zalina Zulkifli, she has over 15 years professional researcher and teaching experience as a Senior Lecturer in the University. She has gained valuable lectureship experience in leading students with extensive exposure to Electronics Engineering, IT, Multimedia & Networking areas. In addition, she has industry working experience as a Test Engineer at Multinational Company which supervised 16 technicians in multiple areas. Hence, she believe that the knowledge and skills she has gained from her academic research, teaching, and industry working experience prepare her to be the Creative Inventor and an effective researcher in global Engineering, Science and Technology. Four of the research projects have been collaborated with multinational company which contributes to a network that lead to new ideas and concrete research project. Three of the developed projects that focused on Embedded System, Software, IoT and Wireless Communication fields have been successfully adopted by the industry to date. She also enhanced her expertise in the agriculture sector with new invention to improve the crop production adopted high technology. To date, she has won several international awards and national award based on her patented innovation. Through all her participations, she has developed confidence and interest in researching and teaching areas to enhance Creative Innovation in Engineering, Science & Technology.



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