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Development of Augmented Reality Module in Teaching Internet of Things *(IoT)* at TVET Institutions: A Needs Analysis

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Abstract

The Introduction of the Internet of Things (IoT) course in the third semester of the Certificate in Information Technology program at Community College presents unique challenges. Students need visualization skills and creative thinking to understand microcontroller concepts, describe installation processes, and write program code. Effective teaching aids are crucial for learning electronics, including circuit design, simulation, microcontroller connections, programming, and testing. However, the syllabus does not adequately address the visualization skills needed for understanding microcontrollers. This study focuses on developing an Augmented Reality (AR) module to address these issues. Using a qualitative approach, semi-structured interviews were conducted with three experienced instructors, including a curriculum developer with expertise in information technology and electronics. The interviews transcribed and analyzed using ATLAS.ti software revealed unanimous agreement on the need for teaching aids, particularly for microcontrollers and electronic components design. The respondents advocated for a digital learning platform, with an AR module as the proposed solution. The findings highlight the urgency and efficacy of developing an AR module for teaching the IoT course. This solution aims to bridge gaps in the educational system, enhancing student understanding and engagement, with implications for lecturers, researchers, and the Ministry of Higher Education.

Keywords: Internet of Things, Augmented Reality, Learning Module, Needs Analysis, Microcontroller

Introduction

The Internet of Things (IoT) represents the forefront of computing, encompassing smart devices embedded with uniquely identifiable, internet-enabled hardware components. This

burgeoning field is reshaping the way tasks are performed, introducing automation, and fostering communication. In his speech at the Opening Ceremony of the Industrial Revolution 4.0 Skills Development Conference, representing the Minister of Human Resources, Dato' Dr Mohd Ghazali Abas, the Secretary-General of the Ministry of Human Resources, highlighted the crucial importance of nurturing human capital for the nation's future development. He urged TVET institutions to ensure that their course offerings align with the latest skills and technologies. This sentiment resonated with the statements made by the Minister of Human Resources, Datuk Seri Richard Riot Jaem, who proposed that TVET curricula should integrate modern teaching and learning systems to meet the demands of the industry 4.0 revolution. This is essential to ensure that the human capital produced is of high quality and competitive in both local and global industrial markets (Annuar, 2017).

In line with this perspective, Edinyang et al. (2015) also recommended the revision of curricula in higher education institutions to be more universally applicable, especially in preparing graduates with qualifications that align with current market demands. Incorporating new technologies through curriculum and co-curricular interventions with IR 4.0 elements such as IoT as an effective module (Madarshah et al., 2022).

Aligning with this national agenda, the Department of Polytechnic and Community Colleges introduced STM30723: Introduction of Internet of Things as a new course in August 2017. This course is part of the Certificate in Information Technology program, scheduled for the third semester. It covers fundamental IoT concepts, sensor interfacing with the internet using Python programming for Raspberry Pi, and the use of low-cost programmable microcontroller Arduino boards. Students are evaluated through projects requiring programming boards for tasks such as reading digital and analog inputs from sensors and controlling outputs like LED activation.

The complexity of IoT education necessitates a foundation in subjects such as electricity, magnetism, electrical circuits, power systems, control systems, sensors, communication systems, analog and digital electronics, microprocessors, digital controllers, programmable devices, and programming. Additionally, the use of Arduino and Raspberry Pi platforms demands familiarity with Java syntax and semantics, along with debugging skills to address compilation errors. However, there are problems that arise in the teaching and learning process for the Introduction to the Internet of Things (IoT) course because students find it difficult to understand the concept of Microcontrollers that require visualization skills that can stimulate their thinking (Liono et al., 2021). In addition to that they also need to master the basics of electronics where there is no exposure for the topic in the syllabus used.

Augmented Reality (AR) technology also provides users with the experience of manipulating virtual objects and viewing them from various angles, akin to interacting with and handling a real object. Through Augmented Reality techniques, students can explore and engage in learning methods in a different and unique manner as they are directly involved in the process. Additionally, Augmented Reality offers significant opportunities in the fields of Science, Islamic Education, and Engineering (Baharudin et al., 2020; Ismail et al.,2021; Saforrudin, 2016). This Augmented Reality technology serves as a platform in the development of this learning module, harnessing the latest technology to enable manipulation and visualization in teaching and learning methods for increased engagement (Khazali et al., 2023; Ucelli et al., 2005).

Regarding this matter, this study aims to identify the need to develop an Augmented Reality learning module for the IoT subject that employs the approach from the perception of the lecturers and curriculum developer. Findings from the needs analysis shall focus on the

development of elements in this module. It serves the purpose of planning the curriculum in detail, identifies the issues in the target group, and closes the existing gap in the system. This study uses needs analysis to investigate the problems and obtain important information prior to deciding on the structure and development of instructional materials. Among the theories involved in this study include the Behaviourisme Theory, Mayer's Cognitive Theory of Multimedia Learning and SAMR Model as well as the elements in the learning strategies that are incorporated in the module that will be developed.

Objectives

The purpose of this study was to conduct a needs analysis for the development of Augmented Reality module in teaching Internet of Things (IoT) at TVET institutions. The specific objectives are outlined below:

1. Identify important elements and content for the development of a learning module for the introduction to Internet of Things at Community College, Malaysia.
2. Identify the applications needed in the process of designing learning applications that are adapted to the developed modules.

Methodology

This qualitative study involved 3 participants who are experts and lecturers in the field of information technology and curriculum development. The ideal number of qualitative participants is 1 to 3 or 30 to 50 people depending on the depth of the study (Creswell & Creswell, 2017). The selected informants are well-versed in information technology and have been teaching the course for over 5 years. They were purposively sampled as participants in the study. Selected informants can give information on the issues regarding IoT course. Moreover, they can express their personal views on the topic and the ongoing issues, especially their needs to facilitate in teaching and learning. Table 1 summarises the details of the research informants (Pseudonym).

Table 1
Research Informants

Pseudonym	Sex	Position (Background)	Teaching Experience
A1	Female	Lecturer (Information Technology)	>15 years
A2	Female	Curriculum Developer	10 – 15 years
A3	Male	Lecturer (Information Technology)	5 – 10 years

To gather data on module development needs, the researchers utilized a set of semi-structured interview protocols as the research instrument. The semi-structured interview was chosen because it allows in-depth exploration of a detailed data collection on the research participants' experiences and feelings (Markus, 2021).

After obtaining consent and ensuring confidentiality, the interviews with the three respondents were recorded and later transcribed. The analysis of the interview transcripts was conducted to extract the meaning and feedback provided by the study participants. A thematic analysis of the entire transcript was carried out by comparing responses from all respondents, facilitated using ATLAS.ti 9 software, a data analysis tool that aids researchers

in managing diverse data (Afriansyah et al., 2019). The raw data obtained from the interview transcripts were analyzed based on themes and categories outlined in the study objectives using the thematic method. This method is suitable for a needs analysis study as it can assist the researcher in identifying the underlying reason for an existing problem, and with the data gathered, the researcher can take the necessary action to solve the problem (Mckillip, 2011).

Result and Discussion

The interview protocol contained ten questions for the lecturers developed based on the literature review (Galletta, 2013). Three experts, including one expert for language, had reviewed, and validated the interview protocol to determine the construct credibility in gathering information from the informants (Barriball & While 1994; Nowell et al., 2017).

Thematic analysis of semi-structured interviews played a key role in our qualitative data analysis. Informants in the study had the opportunity to share their opinions during these interviews. The findings influenced the development of modules and learning aids for our IoT course at Community College Malaysia, designed for use by both lecturers and students in the Information Technology Program.

Identifying the needs for developing IoT modules and learning aids involved considering various technical requirements. This process was categorized into three themes: challenges in teaching and learning of IoT course, lecturers' skills and digital skills in educational requirements, and the needs for teaching and learning aids. ATLAS.ti 9 software assisted in analyzing the data. Figure 1 presents the results of the analysis using the ATLAS.ti 9 software, demonstrating its applicability in this research.

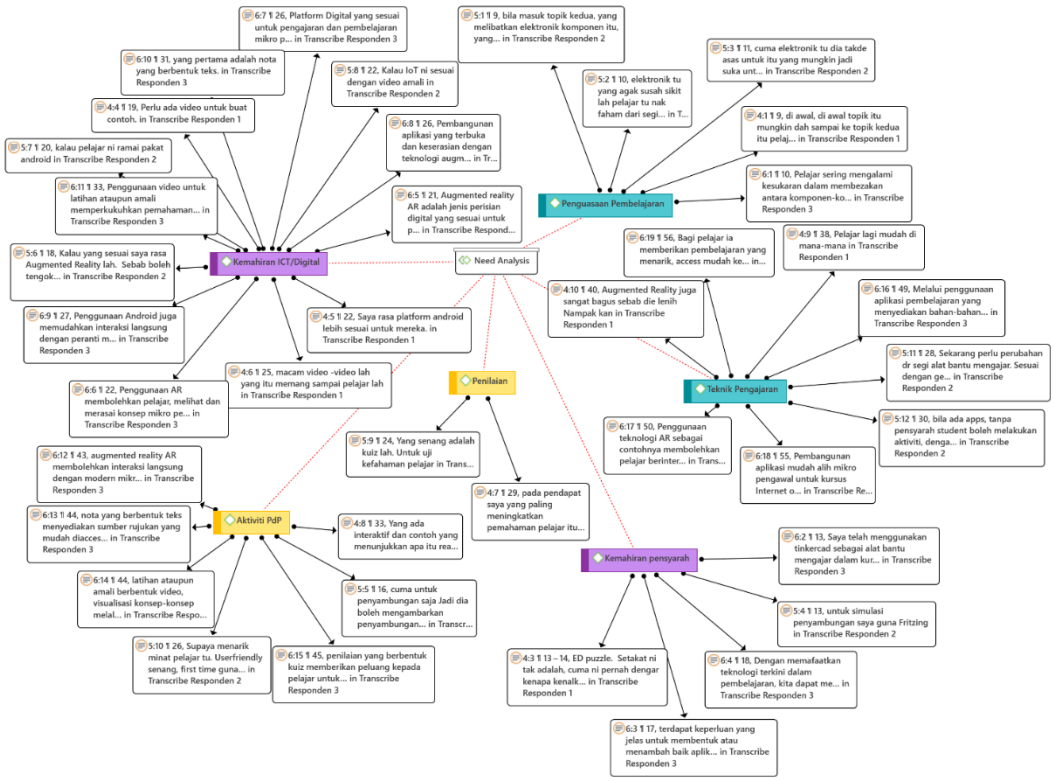

Figure 1: Results of the analysis

The findings show that there are three main themes that researchers need to consider. These themes will be described in more detail in the following subtopics.

a. Challenges in teaching and learning of IoT course

The Introduction to Internet of Things (IoT) Course is a mandatory course for all Certificate in Information Technology students at the Community College in semester 3. This course incorporates theoretical and practical learning in the laboratory. It is designed to provide students with exposure and understanding of the fundamentals and methods of IoT for developing IoT applications. At the end of the course, students can identify IoT concepts for technological solutions, establish device connections, and program for IoT application control or data monitoring. They will also practice the ability to lead IoT development teams to complete assigned tasks. This implies that students require visualization skills and creative thinking to comprehend concepts within the microcontroller itself to achieve the set learning outcomes of the course. This is because students need to illustrate the methods of microcontroller installation and write programming code to operate the developed projects. The Microcontroller topic is more challenging to comprehend compared to other topics as it involves programming and the installation of electronic circuits (Idris et al., 2022). This process can be complicated without specific guidance, or references related to this topic. The findings of this study show that all respondents agree that the difficult topic to understand in this IoT course is found inguidance, which involves electronic component connections and microcontrollers. This is because students lack exposure to this topic in the syllabus used for information technology students without an electric and electronics background. Evidence noted by respondents are as follows:

A1: *“At the beginning of the topic, students may already face difficulties in mastering and comprehending the concepts within IoT, particularly when it comes to the second topic."*

A2: *"When it comes to the second topic, which involves electronic components, that becomes a problem… When entering the second topic, they may be able to follow the programming aspect, but they lack a foundation in electronics, which could make it difficult for them."*

A3: *"Students often encounter difficulties in distinguishing between these components and understanding their respective functions. Additionally, students also face challenges in making circuit connections using input-output components such as LEDs, buzzers, and sensors."*

In the Microcontrollers topic, students are exposed to visuals for installation and programming through demonstrations, videos, and diagrams. The concept of Microcontrollers requires visualization skills that can stimulate their thinking (Liono et al., 2021). The difficulty of the Microcontrollers topic also poses a challenge to lecturers in conducting teaching and learning sessions. Studies conducted on lecturers indicate that there are issues where lecturers need to adapt to the knowledge, skills, and attitudes towards the new and current curriculum content. Lecturers also attempt to diversify methods and incorporate the latest teaching techniques. However, there are still constraints in utilizing existing teaching and learning aids. Although there were some applications for teaching the students, but there hasn't been much comparative evaluation of them in a formal classroom setting (Merkouris et al., 2017).

A2: *"Okay, if we use Fritzing for arranging device connections. Then, we can request the code there, but the application doesn't provide the capability to run it and check for errors or issues."*

b. Lecturers' skills and digital skills in educational requirements

In addition to mastering the subject matter they teach, lecturers also need to diversify teaching techniques. The implementation of teaching by lecturers in higher education institutions is still seen to adhere to conventional teaching and learning methods (Abdul Halim, 2016; Ghani et al., 2019).

Computer-assisted learning strategies are one of the interesting teaching innovations that develop students' competencies and motivation (Nurutdinova, 2016). Furthermore, students now prefer lecturers who utilize modern technology in teaching as it has the potential to enhance motivation and academic achievement (Bujeng et al., 2018). However, teaching and learning techniques and methods are now changing according to technological advancements. Cyberogy-based learning is one of the new dimensions in educational pedagogy, requiring lecturers to use different strategies in the teaching system, such as interactive multimedia learning Hilmi et al (2021); Tracey & John (2007) and modern technology (Ali & Julkifleh, 2022; Aziz et al., 2020; Masingan & Sharif, 2021). From the study conducted, two of the respondents, A2 and A3 had chosen Augmented Reality as the suitable digital module and application for teaching and learning the topic of Microcontrollers.

A2: *"If suitable, I think Augmented Reality is the right choice. Because you can see how the connections are made, right? Students can visually observe it."*

A3: *"The use of Augmented Reality (AR) enables students to see and experience the microcontroller concepts immersively, enhancing understanding and engagement in the learning process."*

Various studies on the use of technology employing learning modules such as Augmented Reality have proven that the use of technology can help improve student achievement and motivation. Augmented Reality can be achieved by using mobile devices such as smartphones and tablets. The use of mobile devices as a learning platform in the classroom serves as a catalyst for connecting teachers, students, peers, and virtual materials through educational applications for the teaching and learning process (Abd Samad et al., 2022). All respondents also agreed that Android is a suitable digital platform for teaching and learning in Microcontrollers.

A1: *"I feel that the Android platform is more suitable for them."*

A2: *"many students use Android."*

A3: *"The use of Android also facilitates direct interaction with microcontroller devices, enhancing student engagement and meeting course requirements more effectively."*

c. The needs for teaching and learning aids

When questioned about the teaching and learning requirements for the module and application related to microcontroller topics, respondents expressed the need for videos, notes, and quizzes as part of the assessment. The consensus among all respondents was that the module and application should incorporate a quiz to gauge students' understanding upon completion of the topic.

A1: *"After completing a topic, we can create a quiz. Let's assess their understanding."*

A2: *"If it's about IoT, it's suitable for practical videos, where students can watch repeatedly. It means that to do this thing, how do you connect it. As long as they can't do it, they can repeat it."*
"The easiest way is through quizzes, to test students' understanding."

A3: *"Text-based notes assist students in reviewing learned topics easily."*
"The use of videos for exercises or practical sessions strengthens the understanding of concepts through visualization."
"Quizzes are the most effective way to assess students' understanding."

Furthermore, features in modules and applications should also be considered to attract the interest and motivation of students. A good learning experience for students not only helps them achieve learning goals but also enhances their interest and motivation (Nordin et al., 2022).

A1: *"Those that are interactive and provide examples demonstrating what reality is."*
A2: *"Not only for students, even for us, if we want a user-friendly application, for students, it must be interactive. So that it captures the students' interest."*
A3: *"Enabling direct interaction with modern microcontrollers creates an immersive and dynamic learning experience for students."*

Regarding the views of respondents on the development of a module based on mobile learning application for microcontrollers for the Introduction to the Internet of Things topic, how it can benefit lecturers and students, the majority of respondents believe that there should be an application development to assist students and lecturers in facilitating the management of learning for this microcontroller topic to enhance student understanding. Respondent A2 states that with the existence of this learning module and application, students can engage in activities even without a lecturer by engaging in self-learning. Meanwhile, respondent A3 believes that the development of these learning materials can provide lecturers with interactive teaching tools to monitor progress and provide easy access to learning materials.

A2: *"When there is an app, it means students don't have to face the lecturer. This implies that students can use the application anywhere and at any time."*

A3: *"Providing lecturers with interactive tools for teaching to monitor progress and offering easy access to learning materials. For students, it offers engaging learning experiences, easy access to learning materials, in-depth understanding, and continuous assessment."*

Conclusion

In conclusion, the findings of the study have supported the need for developing an Augmented Reality learning module in teaching Internet of Things (IoT) at TVET institutions, especially community colleges as a teaching and learning aids resources. The development of a module and application provides an opportunity for the lecturers and students to better acquire the knowledge about microcontroller and the skills in electronics.

The study's results emphasize the importance of addressing challenges through comprehensive teaching and learning aids. Videos, notes, quizzes, and interactive features are deemed essential for facilitating a dynamic and engaging learning experience. The development of an Augmented Reality learning module for microcontrollers, responsive to lecturers' and students' needs, emerges as a viable solution to bridge existing gaps in the educational system.

Overall, the research advocates for a holistic approach to educational development, aligning curriculum content with industry demands, fostering pedagogical innovation, and leveraging modern technologies to create an enriching learning environment for both educators and students.

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