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Establishing an IoT-Vocational Learning Center: A project to investigate the benefits of emerging technologies

Abstract

This study has three main goals: (1) to create a prototype Internet of Things (IoT) technology learning center that focuses on the community, (2) to design an IoT learning module, and (3) to establish a maintenance center. The development of the IoT learning center is an excellent example of how emerging technologies can revolutionize learning methods and enhance educational efficiency. The study covers both hardware and software and follows the structured ADDIE model for instructional design. It ends with a modern prototype for an open farming system that benefits local farmers and elderly residents in Chiang Rai province. The study uses an agile model to manage multiple stakeholders and meet time-sensitive deadlines. The project was carried out in collaboration with Chiang Rai Vocational College of Information Technology students, Chiang Rai Provincial Department of Education staff, and a community of elderly farmers. The system was designed for a private cloud-based server. The resulting smart device prototype facilitates wireless control of agricultural processes via a centralized unit, transmitting data to the cloud for monitoring through a dedicated mobile application. Research has shown that users were highly satisfied with the CVC-IoT laboratory environment (mean score of 4.65), but there is room for improvement in device readiness (mean score of 3.06). The IoT system circuit design satisfaction is high at 5.00 due to its ease of use, enhanced capabilities, and security. The IoT learning module scored 5.00, demonstrating strong compliance with technology standards. Participants achieved a 100% success rate in training assessments. In IoT device development and maintenance, senior Doi Hang community members expressed the highest satisfaction (mean score of 5.00), highlighting the system's potential to benefit smartphone-owning community members, simplifying their daily lives. The use case diagrams provide a clear visual representation of hardware and software maintenance processes.

Keywords: *IoT Application, Learning Module, Opening Smart Farm, Private Cloud, Smart PCB*

1 Introduction

The establishment of a learning and development center for IoT technology aims to facilitate the learning, dissemination, development, and practical application of IoT technology in community and elderly care settings. Additionally, it involves promoting and developing smart farm systems to showcase the value of IoT technology and its practical benefits for society, within the framework of a digital society (Al-Fuqaha et al. 2015). This initiative is viewed as a step towards advancing the country, aligning with rapidly changing technologies and facilitating the transition to an AI-driven society, as seen in Figure 1.

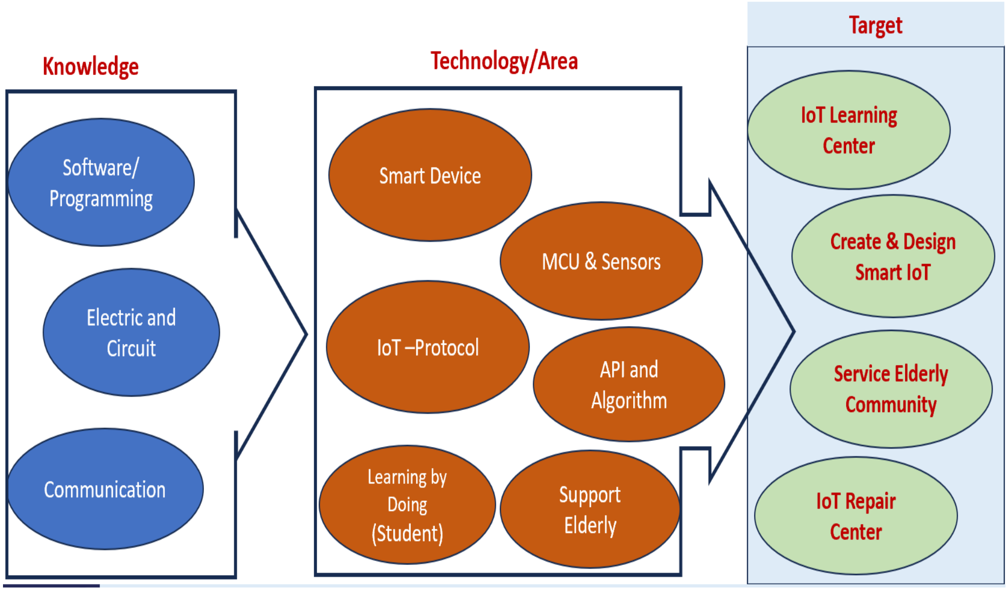

Figure 1: Material and Methodology (Source: author)

IoT technology is considered crucial for all societies and age groups. While implementing IoT is not inherently difficult, the challenge lies in overcoming the fear of change among learners and communities. If this project succeeds in promoting and distributing learning opportunities and enhancing technology understanding, it will benefit individuals and communities. Moreover, it can help notify them of potential losses, leading to a peaceful and prosperous life in the long term.

1.1 Objectives

1. The goal was to create a prototype IoT technology learning center for the community.
2. The objective was to research and design a Learning Module for IoT technology.
3. The aim was to establish a center for repairing and adjusting software and tools related to IoT technology. This center will consider the software and materials that have been studied.

1.2 Scope

Creating the IoT Technology Learning Center is a complex project and aligns with current technology trends. It can potentially revolutionize how we learn and improve teaching effectiveness in educational institutions. The aim is to establish a state-of-the-art learning environment by incorporating IoT technology. The research focus for developing the IoT Technology Learning Centre includes four specific areas (Yang et al. 2018 -a). Firstly, we will develop curriculum content for learning modules covering both software and hardware aspects. Secondly, we will conduct training for students and collaborate with various educational institutions and communities. Thirdly, we will design a modern and open agricultural system prototype. Finally, we will provide maintenance guidelines to ensure its sustainability. The methodology for this project is shown in Figure 2.

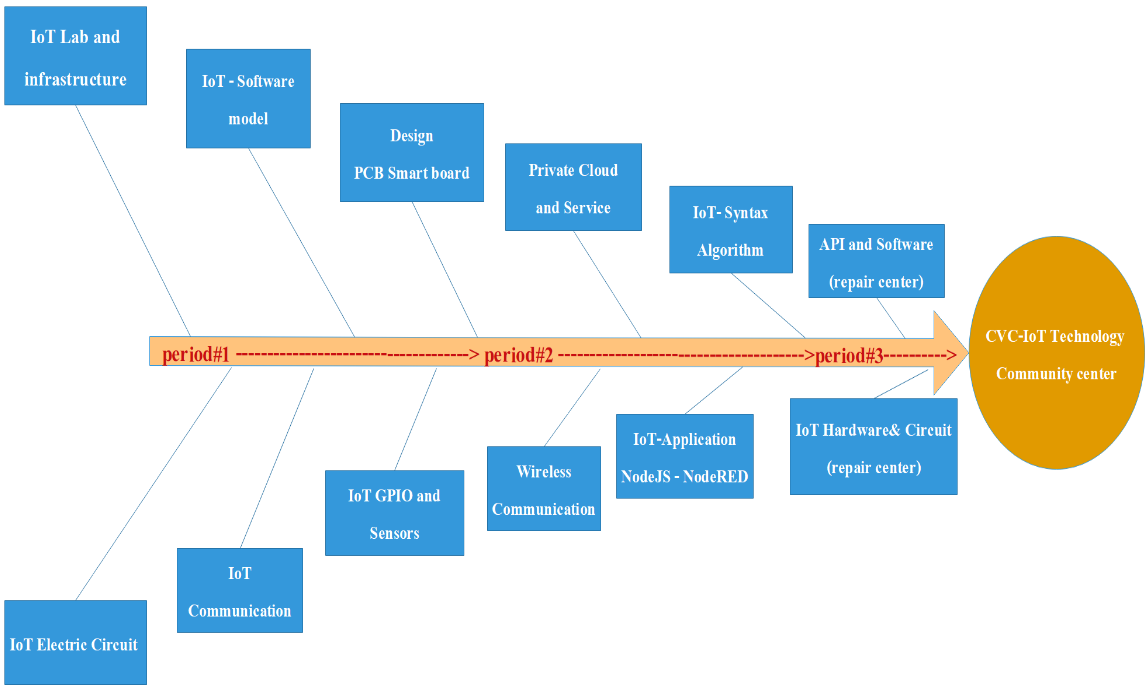

Figure 2: Methodology Diagram (Source: author)

The operational process of the scope includes the following steps:

- The project involves studying and analyzing existing learning centers that use IoT technology. This includes conducting interviews with relevant individuals such as teachers, administrators, users, and various communities. The goal is to gather information about the needs, experiences, and challenges of using IoT technology in learning centers.
- The aim was to define objectives and goals for developing an IoT technology learning center based on a survey and analysis of IoT-utilizing learning centers. The objectives include enhancing connectivity with IoT devices and sensors displayed in classrooms, aligning them with teaching activities, and creating a supportive learning environment for IoT technology.
- The Learning Center Design and Development project involves developing and designing various components essential for the efficient use of IoT technology. This may include improving the infrastructure and preparing suitable areas for IoT device installations, network connections, and cloud systems.
- Development and implementation of IoT Technology: Creating a learning center equipped with software and applications, sensor systems, and networks to ensure the effective use of IoT technology.
- Finally, measuring and evaluating the results is important to ensure that the developed learning center is effective and aligned with the defined objectives. This assessment should consider factors such as student learning outcomes, teacher and student

satisfaction, community involvement, and the utilization of IoT technology in various formats.

There are two types of maintenance: software and hardware. For hardware, devices should adhere to a list of equipment used for study and development, such as prototype equipment.

2 Methodology

2.1 AGILE Model

The Agile Model (shown in Figure 3 below) enables the team to promptly modify and enhance the system based on customer requirements and changes. By fostering collaboration and testing throughout the development cycle, the team can create high-quality software that meets customer needs (Farooq et al. 2020, 428-434). This approach also contributes to increased customer satisfaction by delivering software that can be used immediately and further improved as needed.

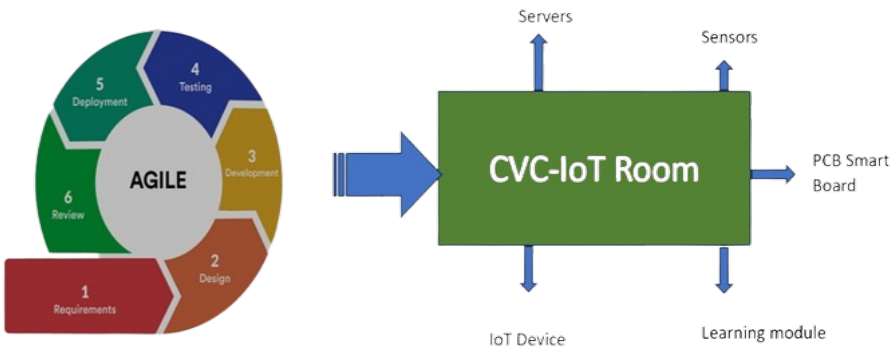

Figure 3: Figure 3: AGILE Model with CVC-IoT Classroom (Source: author)

Collaborating with team members and delivering short-term products can lead to improvements and revisions that meet the target audience's needs. Applying the Agile Model requires principles and processes that align with the Agile Manifesto and utilize appropriate tools and techniques. Using the Agile Model to develop systems and software makes it possible to meet the audience's changing needs quickly and with greater quality.

2.2 ADDIE model

The ADDIE model is a well-known design, training, and system development process widely used in educational and training programs (Smith et al. 2020). ADDIE is an abbreviation for five key steps, namely Analysis, Design, Development, Implementation, and Evaluation, which are used systematically to create a high-quality learning experience. A diagram of the ADDIE model is shown in Figure 4.

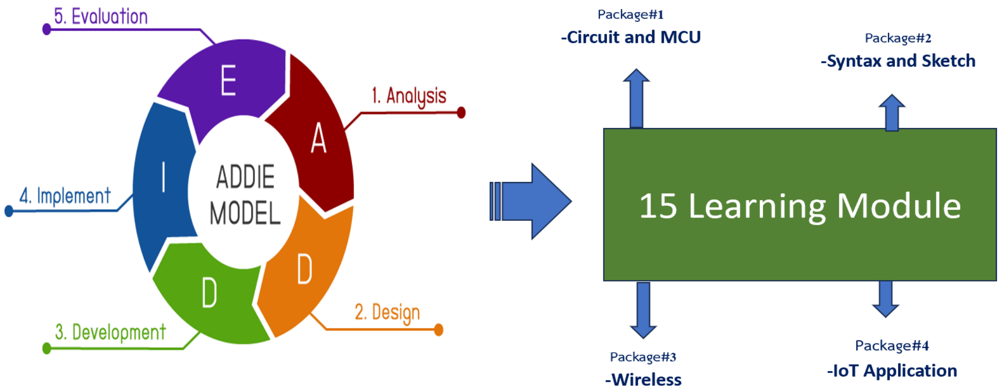

Figure 4: ADDIE with 15 Learning Modules (Source: author)

A study conducted by Smith & Johnson in 2020 found that the ADDIE Model was used to analyze and design the training process. For instance, research was conducted on capacity development for personnel in information technology organizations, where the ADDIE Model was utilized to design and develop online training courses. The research focused on designing and developing online training courses that aimed to enhance the potential of personnel in IT-related organizations, using the ADDIE Model as a framework for implementation. This research aimed to analyze the design process, develop the curriculum, and evaluate and improve it during its operation (Yang et al. 2018 -a; Zhang et al. 2017).

3 Results

The results of this investigation (illustrated in Figure 5 below) will aid the school in enhancing the learning experience for both teachers and students and help them meet their goals effectively (Zhu et al. 2019). Additionally, the findings will guide the design and implementation of effective training programs in other schools that follow high-quality and efficient processes.

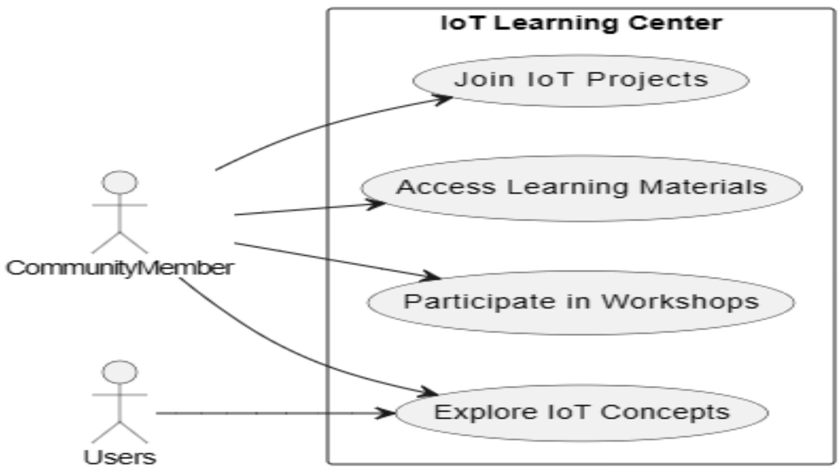

Figure 5: IoT Learning Activity Diagram (Source: author)

3.1 The Private Cloud and IoT Server

Creating a network system for the Internet of Things (IoT) is like building a virtual space where devices can communicate with each other seamlessly and efficiently. It involves understanding the needs and objectives of the IoT system and choosing appropriate network equipment that can support wireless connections, manage many connected devices, and ensure stability (Bhunia et al. 2015, 42-60). To design a network structure that can support IoT devices and communicate effectively with server-side systems, it is important to use suitable network technology such as Wi-Fi for short distances or Bluetooth Low Energy (BLE) for low-power close-up connections. Security is also crucial in IoT systems. Therefore, appropriate standards and technology should be used, such as data encryption technology and authentication to prevent unauthorized access to information (Borgia 2014, 1-31; Buyya et al. 2011). After creating the network for IoT jobs, regular monitoring and administration are required to maintain long-term system stability (Díaz et al. 2018). This includes checking for problems and fixing them promptly, as well as system testing to ensure performance and stability (Dou et al. 2014). The CVC-IoT Server is shown in Figure 6.

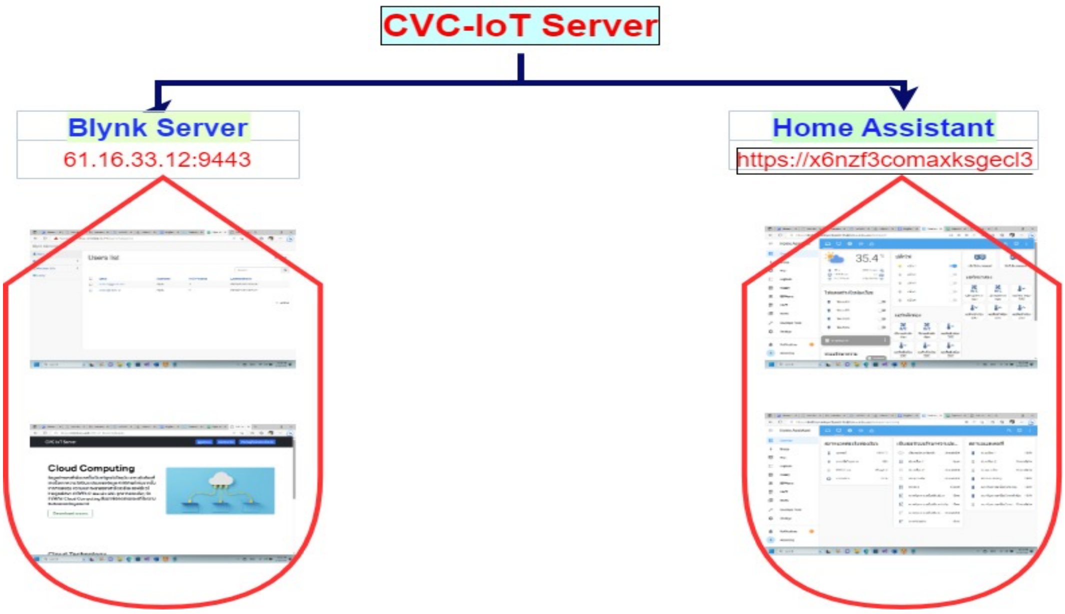

Figure 6: CVC IoT Server Model (Source: author)

IoT technology has undergone significant development since 2000. According to Atzori, Iera, & Morabito (2010), RFID technology and wireless communication have been crucial in connecting and controlling devices in industrial systems. IoT technology has made connecting and controlling devices through the internet easier and more convenient. Typically, IoT device connections use the MQTT (Message Queuing Telemetry Transport) protocol, which facilitates Publish/Subscribe communication between devices and services or even among themselves. MQTT is highly efficient, user-friendly, and can be used with multiple platforms. Moreover, IoT is linked to the use of cloud systems, which enable users to store and manage data more effectively. IoT technology is also compatible with AI (Artificial

Intelligence) and Big Data for data analysis and system management. It is a technology with immense potential for the future. For readers interested in studying IoT, we recommend additional references such as Li, Xu, & Zhao (2015).

3.2 Smart Devices in the IoT Classroom

Security is an essential process that involves protecting people and their belongings from potential harm or danger caused by intruders, environmental hazards, or natural disasters. Nowadays, developing security surveillance systems requires wireless technologies such as Bluetooth, Zigbee, or WiFi. For these systems to be effective, they must have distinct features of each signal available for use (Bandyopadhyay & Sen 2011, 46-69). Additionally, timely meetings must be held to ensure the system functions optimally (Farooq et al. 2020, 428-434). Figure 7 shows a classroom with smart devices.

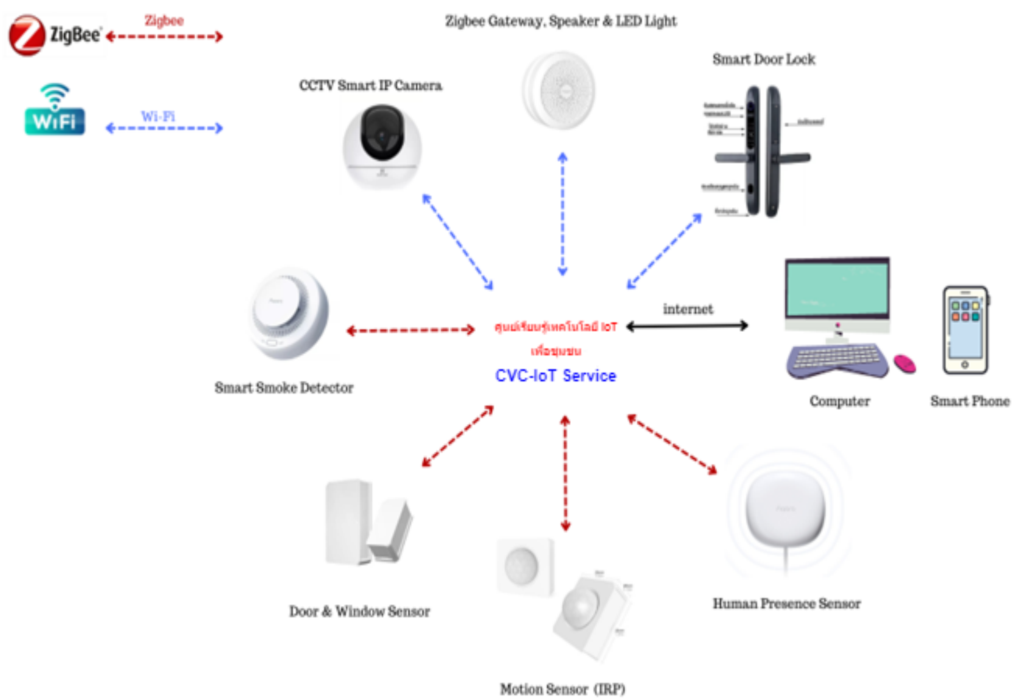

Figure 7: IoT classroom with Smart Devices (Source: author)

3.3 Smart PCB-Board Control

When developing Internet of Things (IoT) technology, it is crucial to use a microcontroller unit (MCU) to establish the processing framework (see Figure 8 below). This framework should follow the Sketch format and receive signals via GPIO in digital or analog patterns. After that, sensor detection devices should be used, followed by setting up the application control program. These processes can be carried out on a mobile or web application (Gao et al. 2017, 46-51).

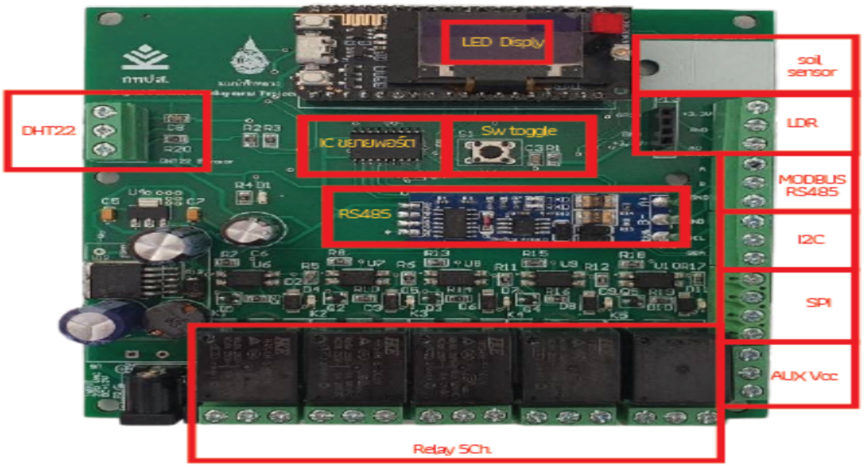

Figure 8: The Smart PCB (Source: author)

This educational board is designed as a printed circuit board (PCB) and can be used with an MCU (Circuit Schools 2024). The ESP32 TTGO-OLED board has GPIO pins and 32 pins that allow wireless communication through Bluetooth, WiFi, and LoRa (Koyanagi n.d.). In the future, it can be used to develop applications that support various controls through mobile and web applications. The activity diagram is shown in Figure 9.

Figure 9: Activity Diagram (Source: author)

To provide adequate learning opportunities to students interested in IoT technology and applications (Lu et al. 2017), it is recommended that 15 learning modules using the ADDIE model be created. These modules should cover detailed information about electrical circuits and MCU sensors, which will help design circuits and applications that efficiently meet present and future demands.

The sequence diagram in Figure 10 illustrates the completion of all training related to the ADDIE Model (Jones & Smith 2021), with communication between the trainer and learner through the following steps.

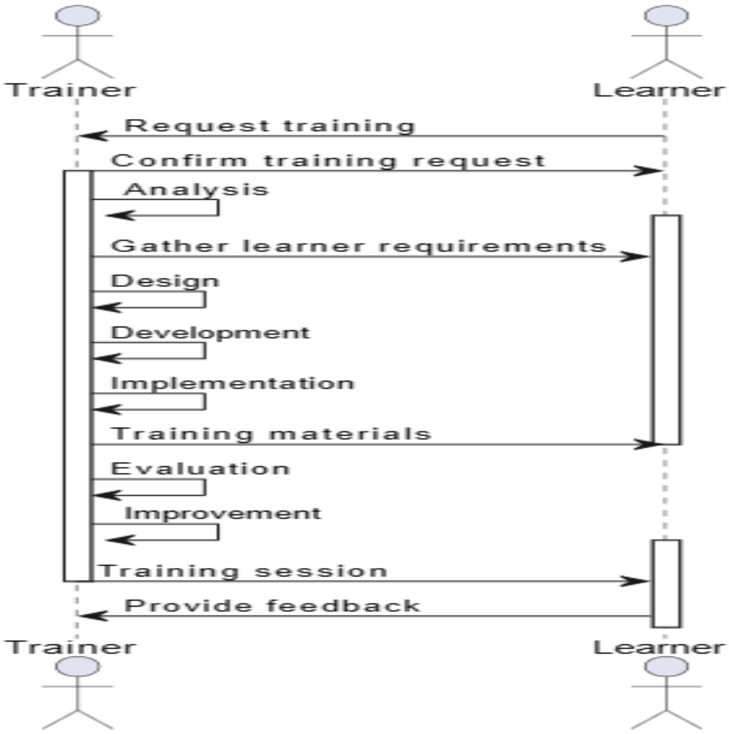

Figure 10: Sequence Diagram (Source: author)

3.4 IoT Application Overview

Home Assistant is an open-source software designed for automated control tasks, primarily used by various organizations and educational institutions. It has gained high acceptance and popularity across numerous countries worldwide (GitHub n.d. –a). Unlike other home automation software that usually relies on a cloud server system, Home Assistant uses an internal or local server (Arduino Web Editor n.d.). It can be installed on a Raspberry Pi or other computer and run within the house or building, making it highly secure and faster. This system allows the program users to send work orders directly to the Home Assistant server without going through the Cloud Server (Ashton 2009, 22). The Home Assistant system can still operate without interruption during an internet outage. It is compatible with almost 500 electrical equipment and sensors, making it a reliable system for home and building automation (GitHub n.d. –b). The Home Assistant interface is shown in the figure below.

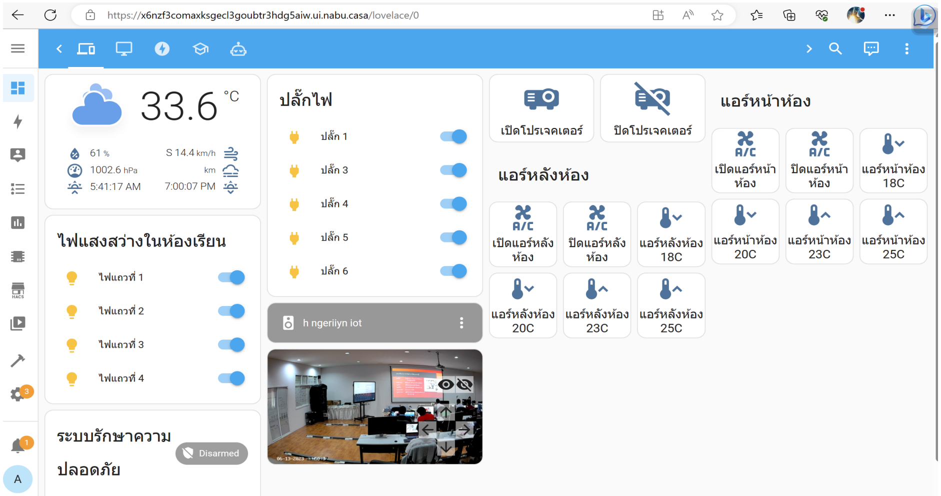

Figure 11: IoT Application-Home Assistant (Source: author)

3.5 The opening smart farm

Modern agriculture relies on technology and innovation to increase production and management efficiency. Various development approaches, such as Information and Communication Technology (ICT), enable faster and more efficient access to agricultural information and management systems. For instance, an agricultural information system can help analyze crop area data, deliver and manage chemical use quotas, and implement environmental management systems (Reganold et al. 2016). Such technologies help reduce resource wastage and optimize resource utilization in production. Machine learning and artificial intelligence are used to analyze agricultural data and create automated processing systems (Atzori et al. 2018, 964-987). AI-based automated machines can improve various agricultural processes, such as analyzing satellite images to monitor the condition of cultivated areas or identifying and triaging plant pests or diseases. It is important to note that the agriculture industry is undergoing a revolution with the integration of AI, which could bring about significant change in the future. A prototype of a smart farm is shown in Figure 12.

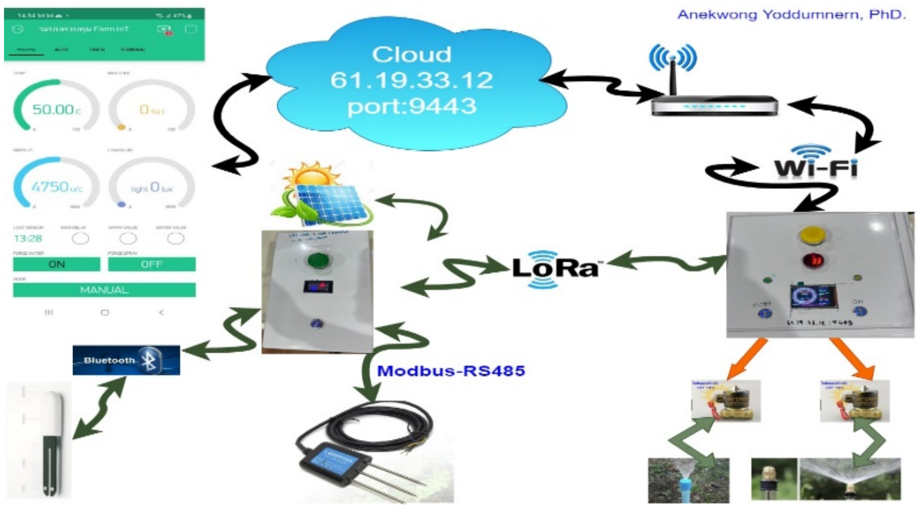

Figure 12: The opening smart farm prototype (Source: author)

Agriculture is an essential activity that involves the production of food and agricultural materials crucial for human life. Agricultural development should adapt to meet consumers' needs and address emerging agricultural challenges. Recognizing the significance of producing food sustainably is paramount. Agricultural experts and innovators have introduced a new concept known as the "Open Agriculture System" to develop and enhance food production systems towards sustainability and efficiency. Open agriculture systems prioritize knowledge-sharing among farmers and researchers, utilizing digital technology and communication tools to consolidate essential information and resources (Wang & Zhang 2016). Additionally, these systems offer opportunities for experts to engage and exchange knowledge through online platforms such as agricultural websites, databases, and knowledge exchange platforms. Social networks and applications provide quick and convenient access to information about agriculture and food production. The adoption of technology, including ICT, machine learning, and artificial intelligence, plays a crucial role in open agriculture by enabling the analysis of agricultural data and the creation of automated processing systems (Teweldemedhin et al. 2016). IoT systems facilitate the efficient monitoring and control of the environment for agricultural cultivation and animal rearing. Sensor devices connected to the Internet enable real-time tracking and control of agricultural production processes. Furthermore, the open agricultural system fosters creativity and innovation in farm development, allowing stakeholders to share and seek new ideas to enhance production efficiency and address agricultural challenges. It also serves as a collaborative space for researchers and developers to develop technologies and innovations that can be readily applied in agriculture (Bandyopadhyay & Sen 2011, 46-69).

The advancement of open agriculture systems allows farmers and other stakeholders access to the knowledge and technology essential for modern agricultural development. This facilitates the positive exchange of information and experiences between experts and farmers across various regions, leading to quicker and more efficient development. Open agriculture represents a novel approach to agricultural development that aligns with the changes in the modern world (Azuma 1997, 355-385). By connecting and sharing knowledge, we can enhance food production efficiency, minimize the utilization of natural resources, and foster sustainable agriculture.

Integrating smart equipment with agricultural information systems facilitates farmers' timely access to environmental data, enhancing production processes. For instance, incorporating sensors measuring soil moisture, temperature, lighting, and water levels, among others, into agricultural information systems enables data analysis and feedback dissemination to farmers, empowering them to monitor environmental conditions and optimize production in real time. The advent of open agriculture signifies a compelling and transformative technological paradigm shift that augments production and management efficiency within the agricultural sector (Atzori et al. 2010, 2787-2805). Moreover, it mitigates resource consumption and curtails the use of environmentally detrimental chemicals. Open agriculture also allows farmers to secure sustainable livelihoods and elevate their overall quality of life. As such, it heralds an epochal evolution in agricultural practices and serves as a pivotal blueprint guiding future agricultural advancements.

4 Conclusion

4.1 The satisfaction of CVC-IoT community central

A user satisfaction study conducted in Operational Room 942 of the CVC-IoT Laboratory found that 48 users (37 students and 11 teachers) were highly satisfied with the laboratory environment, with an average satisfaction score of 4.65. However, the availability of operational tools received the lowest score, with an average score of 3.06. The results of the study are shown in Figure 13.

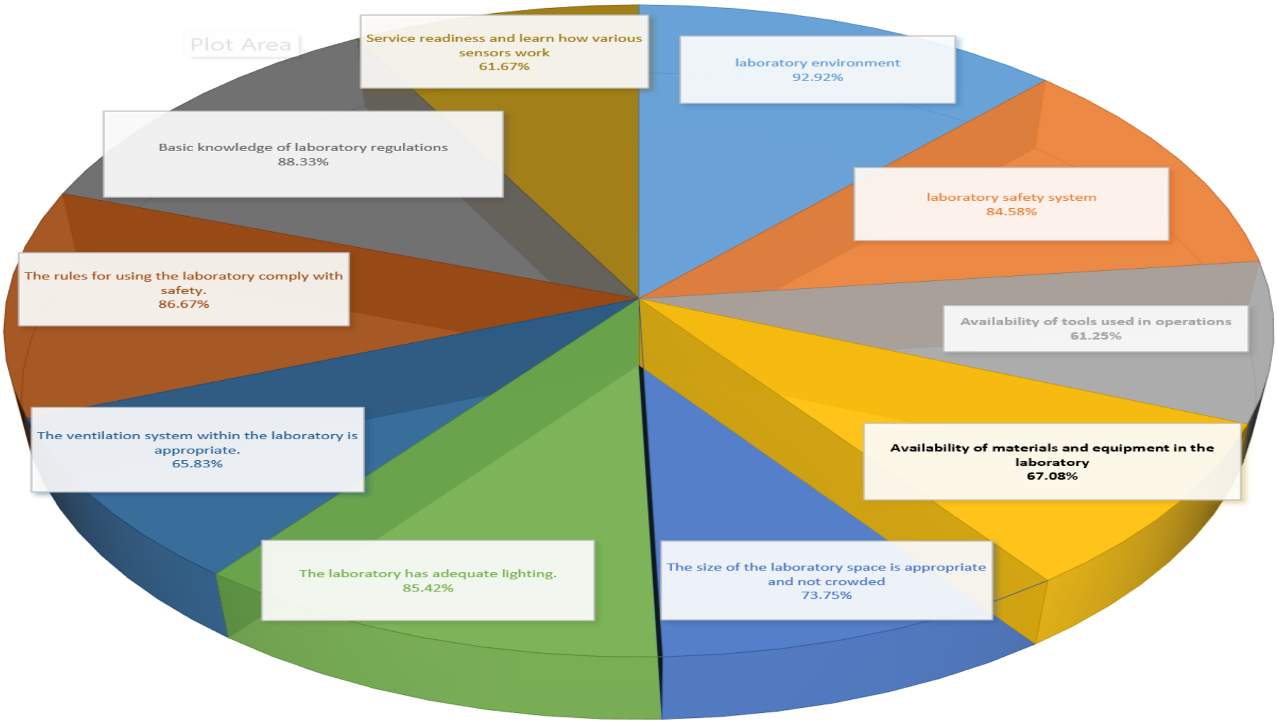

Figure 13: The satisfaction of CVC-IoT Community Central
(Source: author)

Furthermore, the learners suggest labeling various symbols, adjusting to the appropriate and clear position, supplementing the system, and simplifying service procedures. Additionally, they have requested more counseling.

4.2 The Efficiency of the Learning Module

Five experts have evaluated this system and assessed 15 Learning Module Units (see Figure 14).

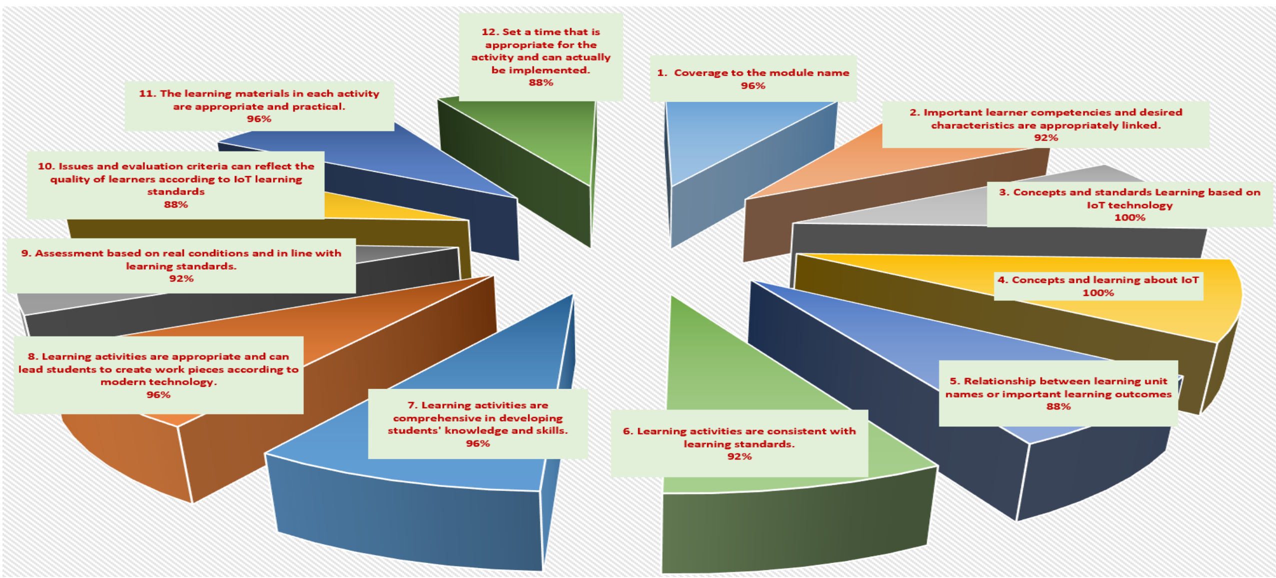

Figure 14: The efficiency of the Learning Module (Source: author)

The study findings revealed the highest level of consensus (mean score of 5.00) among the results derived from the evaluation of 12 analyses conducted by a panel of five experts tasked with assessing a Learning Module comprising 15 study units. Two notable issues emerged: firstly, concerns regarding the consistency of core concepts and standards within IoT-based learning, and secondly, the paucity of locally tailored course content addressing IoT technology in Thailand. The dearth of indigenous resources, predominantly available in English, restricts comparative analyses and may engender the perception that reliance solely on modern technology suffices for effective learning.

4.3 The Efficiency of Smart Devices

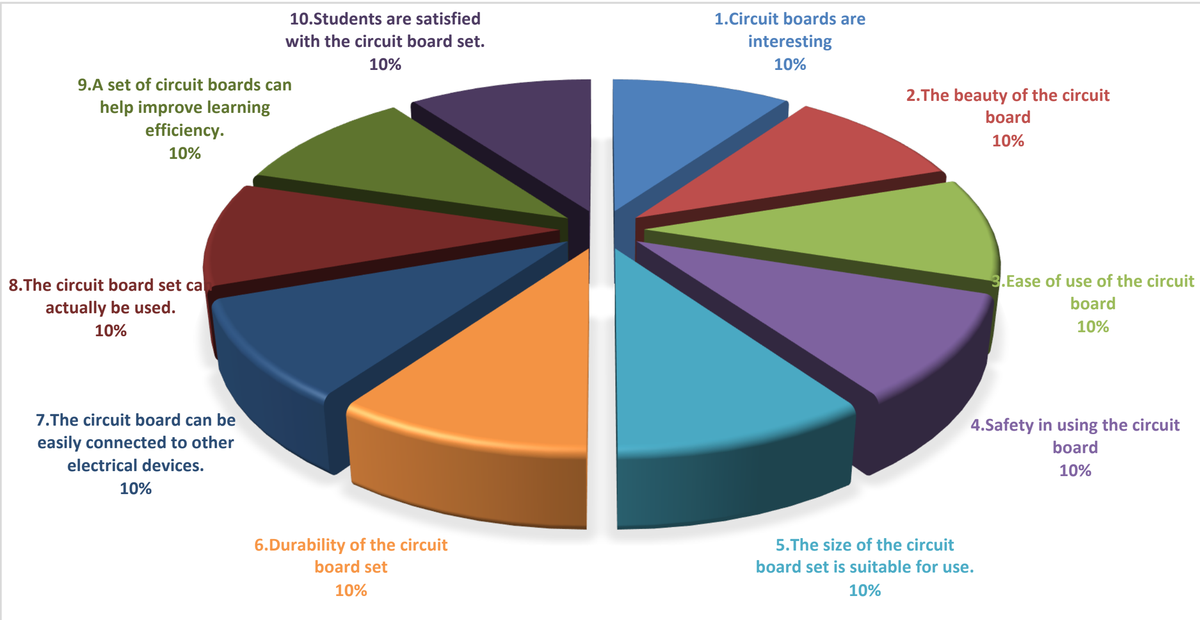

Figure 15: The efficiency of smart devices (Source: author)

The satisfaction rating concerning the utilization of circuit board sets involved 24 participants, including 18 undergraduate students and 6 teachers/lecturers engaged in the course (see Figure 15 above). Analysis of their responses reveals that the circuit board sets are perceived as valuable tools for both learning and practical application. Notably, participants expressed particular satisfaction with the safety features associated with using the circuit board sets and their efficacy in enhancing learning efficiency. Remarkably, this aspect of the evaluation recorded the highest level of satisfaction ($\overline{x} = 5.00$).

4.4 The Efficiency of Control box-circuit

Upon the implementation of the Smart Farm system within the Doi Hang community area, it was predominantly utilized by elderly users, who expressed contentment with the technological features and operational efficiency of the system (Wang & Zhang 2016).

Evaluation of various system components revealed notable satisfaction levels, with design aesthetics and report format appropriateness both garnering a maximum rating of 5.00. Furthermore, community members indicated high satisfaction with the system's coverage. Users also reported a commendable level of satisfaction, also rated at 5.00, regarding the tangible benefits offered, particularly emphasizing the precision of the timer function.

In the predominantly elderly community of Doi Hang, a sample of 5 respondents expressed satisfaction across all facets of the system, encompassing its composition, value, design, and implementation, all of which were rated at the highest level (Wang & Zhang 2016). This underscores the potential of the system to bolster community well-being. This trend correlates with the prevalence of smartphones among elderly residents, facilitating greater convenience in their daily routines. Results for the efficiency of the box-control system and IoT application are shown in Figure 16.

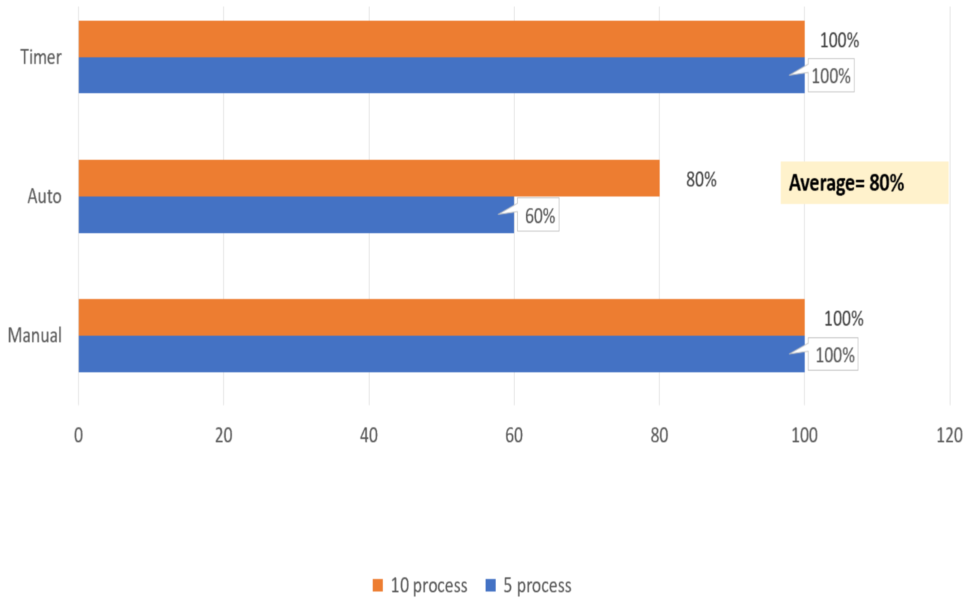

Figure 16: The efficiency of the box-control circuit and IoT application (Source: author)

Instances may arise where the system's response does not align with expectations, potentially attributable to instability in both the sensor and LoRa transmission functionalities.

4.5 TVET and IoT career development

Technical and Vocational Education and Training (TVET) is part of an education system that emphasizes training skills and knowledge related to various professions and crafts. The goal is to develop skilled workers who can work effectively in various industries and businesses. TVET emphasizes learning that focuses on understanding and practicality in related tasks. It offers courses that respond to local and international labor and industry market needs. TVET studies are often characterized by continuous theory and practice. Teaching and learning often focus on working in actual locations such as factories, industries, or hotels to give students experience and expertise in their chosen jobs. TVET is an important part of career development and a good choice for higher education, especially in a society that needs skilled and high-quality workers in various industries and businesses in the real market.

TVET is an important channel for developing professional expertise and skills related to information and communication technology (ICT) and the Internet of Things (IoT) in the work of industries and businesses in the digital age. IoT career development has become an integral part of the competition in the labor and industrial markets, with industries requiring people with the knowledge and skills to design, develop, and maintain complex IoT systems (Yang et al. 2018 -a). TVET can play an important role in preparing people with expertise in IoT by providing them with relevant technical knowledge and skills, such as programming, device and sensor connectivity, and the application of network technology and data analysis. TVET can also help people understand trends and developments in IoT-related industries and businesses by providing hands-on training and learning in the workplace. TVET, therefore, can play a major role in creating a workforce with expertise in IoT, which is in key demand in industries and businesses now and in the future.

5 Discussion

This research study presents a conceptual framework for establishing learning centers and illustrates the practical integration of IoT technology within the community. Utilizing circuit design as a fundamental component, various IoT systems can be developed through MCU processing and integrating diverse detection circuits with circuit board kits. Furthermore, the system has undergone subsequent refinement and enhancement. Ultimately, the training provided to students aims to cultivate a comprehensive understanding of IoT technology, empowering the learner to leverage this knowledge to advance their society and communities.

The full potential of an IoT system capable of facilitating coding education can be realized through its utilization in both practical application and instructional contexts (Zhu et al. 2019). Given their comprehensive support for communication protocols typical of IoT systems, including Wi-Fi, Zigbee, and Bluetooth, among others, such systems are proposed for integration into systemic learning environments. Furthermore, they offer compatibility with various programming platforms such as ESPHome, VSCode, Nodered, and others.

The framework and devices developed in this research can help enhance the well-being of the elderly by implementing systems such as Smart Homes or Smart Farms. These systems contribute to community safety following established frameworks, resembling the Smart City models adopted by many cities. In the development of a learning center, it is essential to establish a supervisory department or organization responsible for overseeing operations. Within the center, diverse learning content must be designed and developed. Integrating the Agile Model with the ADDIE Model offers a flexible approach to operations and streamlines complex processes (Yang et al. 2018 -b).

Appendix: IoT career guidelines

IoT Careers

IoT careers are one of the most interesting approaches in today's digital age. Here are some ways you can build and pursue an IoT career:

1. IoT Software and Application Developer: This profession involves developing software and applications used in IoT systems, such as applications to connect and control IoT devices over the Internet, or software to analyze data from IoT devices for business decisions
2. IoT Software Engineering: IoT software engineering aims to design efficient and secure software systems for IoT devices and networks, such as communication protocols between IoT devices and software for device control and management.
3. IoT System and Network Administrators: This position involves efficient and secure management of IoT systems and networks and long-term maintenance of IoT equipment and network performance.
4. IoT Data Analyzer: This position involves analyzing the data obtained from IoT devices to obtain useful and meaningful information, such as trend detection, prediction, or deep learning from data.
5. IoT Project Manager: In this position, you will be responsible for planning and executing IoT projects from the design stage, development, and testing to long-term use and maintenance.
6. Device and Program Coordinator: This role coordinates between the software development and engineering teams, with an understanding of both IoT software and hardware.
7. Technical consultant specializing in IoT: This profession involves consulting on design matters such as technology selection and project planning related to IoT.

The above careers are related to IoT and are subject to development and change as technology advances in the future.

IoT career paths are diverse and have varying levels of expertise. Here is an IoT career chart divided into different levels of expertise:

1. Beginner Level:
- IoT Technician
- IoT Support Specialist
- IoT Installer
2. Intermediate:
- IoT Developer
- IoT Network Administrator
- IoT Data Analyst
3. High Level:
- IoT Architect

- IoT Security Specialist
- IoT Project Manager

4. Executive Level:

- IoT Consultant
- IoT Business Strategist
- IoT Director/Executive

Each level has different expertise and responsibilities. The entry level emphasizes the basic level of equipment operation and installation. The intermediate level focuses on developing and maintaining IoT systems, while the advanced level focuses on designing and managing projects using IoT technology. The executive level is responsible for formulating policies and strategies for using IoT technology to support the organization's business and operations.

Essential Skills for a Career in IoT

- Technical skills: the knowledge of hardware, software, networking, and communication.
- Problem-solving skills: the ability to identify and solve problems.
- Analytical thinking skills: the ability to analyze data and draw conclusions.
- Communication skills: the ability to effectively communicate ideas and ideas.
- Teamwork skills: the ability to work with others to achieve common goals.

Learn essential skills: Several courses and resources are available online that can help you acquire the skills you need for a career in IoT.

For an internship: find an internship or volunteer job in IoT-related jobs.

Network: attend IoT conferences and connect with industry experts.

Keep up with the latest trends: IoT is an evolving technology, so it is important to stay up to date with the latest trends and learn new skills.

The Future of IoT Jobs: IoT is a fast-growing technology. By 2025, billions of IoT devices are predicted to be connected to the Internet.

References

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of things: A survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials, 17(4), 2347-2376.

Arduino Web Editor (n.d.). Arduino IDE 2.3.2. Online: https://www.arduino.cc/en/software (retrieved 22.07.2023).

Ashton, K. (2009). That 'internet of things' thing. RFID journal, 22(7), 97-114.

Atzori, L., & Santoro, G. (2018). The internet of things: A survey of topics and trends. Information Processing & Management, 54(5), 964-987.

Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. Computer Networks, 54(15), 2787-2805.

Azuma, R. T. (1997). A survey of augmented reality. Presence: Teleoperators and Virtual Environments, 6(4), 355-385.

Bandyopadhyay, D. & Sen, J. (2011). Internet of things: applications and challenges in technology and standardization. Wireless Personal Communications, 58(1), 49-69.

Bhunia, S. S., Pal, S., Dasgupta, S., & Ghosh, S. (2015). Design and implementation of a private cloud for e-government applications. International Journal of Cloud Computing, 4(1), 42-60.

Borgia, E. (2014). The Internet of Things vision: Key features, applications and open issues. Computer Communications, 54, 1-31.

Buyya, R., Broberg, J., & Goscinski, A. (2011). Cloud computing: principles and paradigms. John Wiley & Sons.

Circuit Schools (2024). Interfacing SHT31 with ESP32 TTGO LoRa32 and display on its OLED display. Online: https://www.circuitschools.com/interfacing-sht31-with-esp32-ttgo-lora32-and-display-on-its-oled-display/ (retrieved 07.06.2024).

Díaz, P., Moreno, P., & Guerrero, C. (2018). Smart campus based on Internet of Things: A review. IEEE Access, 6, 67147-67161.

Dou, W., Zhang, X., Zhu, X., & Chen, H. (2014). Cloud computing: An overview and open research issues. Journal of Internet Technology, 15(5), 633-644.

Farooq, U., & Awan, T. (2020). Design and development of a smart classroom model for educational institutes. International Journal of Advanced Computer Science and Applications, 11(10), 428-434.

Gao, L., Han, R., & Lu, R. (2017). Security in mobile crowd sensing: A review. IEEE Communications Magazine, 55(9), 46-51.

GitHub (n.d. –a). Arduino LoRa. Online: https://github.com/sandeepmistry/arduino-LoRa (retrieved 10.08.2023).

GitHub (n.d. –b). Heltec_ESP32 Library. Online: https://github.com/HelTecAutomation/Heltec_ESP32 (retrieved 22.09.2023).

Jones, S. & Smith, M. (2021). Applying the ADDIE Model in the Design and Development of an Educational Training Program: A Case Study in a School Setting. In: Journal of Educational Research, 25(3), 201-218.

Koyanagi, F. (n.d.) Introduction to ESP32 WiFi LoRa. In: Autodesk Instructables. Online: https://www.instructables.com/Introduction-to-ESP32-WiFi-LoRa/ (retrieved 29.08.2023).

Li, S., Xu, L. D., & Zhao, S. (2015). The internet of things: a survey. In: Information Systems Frontiers, 17(2), 243-259.

Lu, R., Li, X., & Hu, X. (2017). Internet of Things (IoT) for smart agriculture: Technologies, practices, challenges, and prospects. In: Journal of Cleaner Production, 167, 1-14.

Reganold, J. P. & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. In: Nature Plants, 2(2), 15221.

Smith, J. & Johnson, A. (2020). Application of the ADDIE Model in Developing Information Technology Training Programs: A Case Study. In: Journal of Information Technology Education, 19(2), 145-162.

Teweldemedhin, M. Y. & van der Werf, W. (2016). Integration of Agronomic Practices with Digital Agriculture Tools to Improve the Sustainability of Crop Production Systems. In: Frontiers in Plant Science, 7, 1–7.

Wang, J. & Zhang, Y. (2016). Application of IoT technology in agriculture: A systematic review. In: Computers and Electronics in Agriculture, 123, 202-211.

Yang, C., Cheng, B., & Wang, X. (2018 -a). The application of IoT in smart campus. In: Journal of Physics: Conference Series, 1091(1), 012015.

Yang, H., Lee, W. Y., & Cho, J. (2018 -b). A Study on the Development of Smart Classroom System Using IoT. In: Indian Journal of Science and Technology, 11(18), 1-8.

Zhang, K., Liu, W., Ren, S., & Guo, S. (2018). Internet of things security: A survey. In: Journal of Internet Technology, 19(2), 455-468.

Zhu, Q., Yang, Z., Wu, Q., & Zhu, Y. (2019). Smart campus based on the Internet of Things: Design and implementation. In: Journal of Ambient Intelligence and Humanized Computing, 10(5), 1827-1840.

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