Available online at
https://jcrinn.com/
https://crinn.conferencehunter.com/

Journal of Computing Research and Innovation 9(1) 2024

Journal of Computing Research and Innovation

Enhancing IoT in Education: A Comprehensive Analysis of CS110 Students' Perceptions Towards Do-It-Yourself (DIY) Workshops at UiTM Sarawak Branch

Lee Yee Ann[1], Abdul Hadi Abdul Talip[2*], Zubaidah Bohari[3], Rumaizah Che Md Nor[4]

[1,2,3,4]*College of Computing, Informatics, and Mathematics, Universti Teknologi MARA Sarawak Branch, Kota Samarahan, Sarawak, Malaysia*

ARTICLE INFO

Article history:
Received: 15 January 2024
Revised: 26 February 2024
Accepted: 26 February 2024
Online first: 1 March 2024
Published 1 March 2024

Keywords:
IoT
DIY Workshop
Computer Science
Digital Electronic
Arduino
Experiential Learing

DOI:
10.24191/jcrinn.v9i1.398

ABSTRACT

The Internet of Things (IoT) revolutionizes by connecting everyday things to the Internet. Its growing use in diverse sectors has spurred innovative teaching methods and tools in education. Recently, a new topic called "Basic IoT" has been added to the Digital Electronics course offered in the Diploma in Computer Science (CS110) at UiTM. Before the topic was introduced, the students rarely worked directly with hardware components and knew little about IoT. Conventional teaching methods may fall short of providing students with hands-on experience. Therefore, five (5) DIY workshop sessions were conducted to expose the students to IoT. This research aims to determine the level of students' perceptions towards the DIY IoT workshop, evaluate the difficulty level for all modules throughout the DIY IoT workshop, and assess the effectiveness of DIY workshops in learning IoT. There were 21 students who participated in the workshop, where the students were introduced to the fundamentals of the Internet of Things, the ESP32 microcontroller and the installation of Arduino IDE software, the method of lighting LEDs using ESP32, the method of connecting ESP32 to a Wi-Fi network, as well as the method of reading data from sensors and sending data to Google Sheets. Online questionnaires were disseminated at the end of the workshop, and a short interview was conducted to gain the students' perceptions of the workshop. Data analysis was conducted in three primary phases: descriptive statistics, mean scores, and t-tests using the Statistical Package for the Social Sciences (SPSS). This study's outcome indicates that students have positive perceptions towards the DIY workshop in learning IoT ($t = -9.34$, p-value $(0.000) < 0.05$), contributing to SDG 4 (Quality Education). Hence, it offers invaluable insights into the role of experiential learning in IoT education and provides actionable recommendations for optimizing the workshop.

1.0 INTRODUCTION

[2*] Corresponding author. *E-mail address*: adie0951@uitm.edu.my
https://doi.org/10.24191/jcrinn.v9i1

The Internet of Things (IoT) has emerged as a transformative technology in today's digital age. It has the potential to revolutionize the way we live and work, connecting everyday objects to the Internet and enabling these objects to communicate and exchange data. IoT devices, which can vary from home items to industrial equipment, are mini-computer processors that employ machine learning to act on sensor data. Mouha (2021) described those sensors, connectivity, data processing, and the user interface as the four components that make up a full Internet of Things system. IoT is progressively becoming an important aspect of our life that can be sensed everywhere around us. Everything from healthcare and transportation to agriculture and manufacturing stands to benefit significantly from the IoT. As such, students need to acquire a solid understanding of IoT concepts and technologies.

The Digital Electronics course offered in CS110 has recently added Basic IoT as a new topic. However, before this topic was introduced, CS110 students generally dealt with software tools. They rarely worked directly with hardware components and were unfamiliar with the IoT. In addition, the traditional instructional approaches may not fully equip students with practical, experiential learning opportunities. To comprehend the concept of IoT, it is crucial for the students to recognize the hardware components that will be used in IoT systems, including the function of each component. Traditional methods of teaching IoT often involve theoretical lectures, laboratory exercises, and simulations. Although these methods are essential for teaching theoretical knowledge, they may be insufficient in equipping students with practical experiences that closely resemble real-world IoT implementation.

Thus, this is where the Do-It-Yourself (DIY) IoT workshop comes into play, whereby it offers students the opportunity to actively engage in building IoT devices, experimenting with sensors and actuators, and developing their own IoT solutions. The study by Kuznetsov and Paulos (2010) mentioned that DIY projects can enhance students' creativity, problem-solving, and critical thinking skills while promoting sustainable development. The primary goal of this workshop was to teach students how to build a basic IoT system by introducing them to the necessary hardware components. Through these hands-on activities, students could gain a deeper understanding of IoT hardware, explore its capabilities, and witness firsthand how these components contribute to the broader IoT landscape.

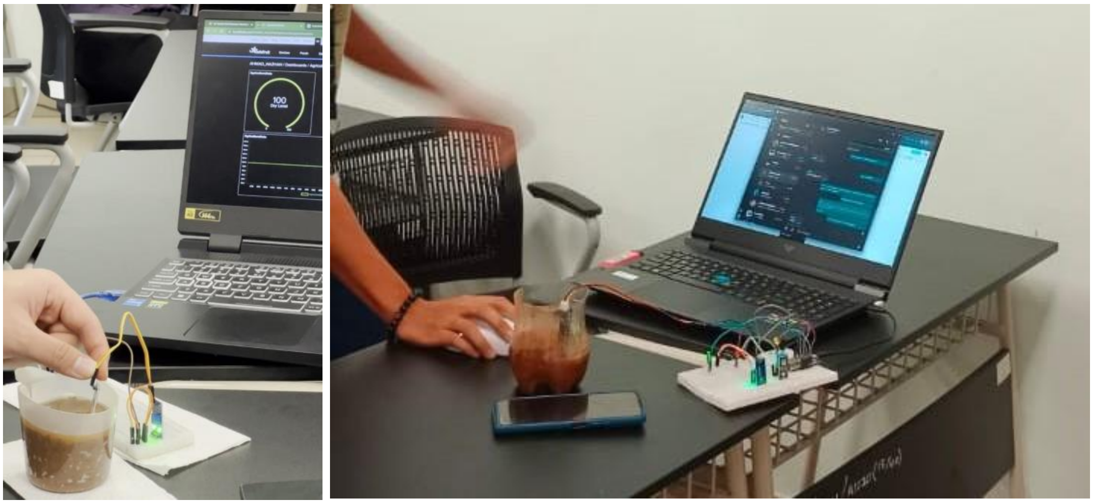

Fig. 1. Demonstration of an IoT project during the DIY IoT workshop using a soil moisture sensor, an ESP32, and an Adafruit IO Dashboard.

https://doi.org/10.24191/jcrinn.v9i1

Incorporating IoT into the curriculum has resulted in a significant pedagogical shift, necessitating a bridge between software-centric learning and hands-on hardware experiences. In this research paper, we aim to explore the level of students' perceptions of DIY workshops in learning IoT, focusing on students' experiences in higher learning institutions. To address the challenges of this transformation, this study aims to evaluate the difficulty level for all modules throughout the DIY IoT workshop. The difficulty of these modules will reveal students' learning curves in learning IoT through hands-on activities. Another central objective of this research is to assess the effectiveness of the DIY workshop in facilitating IoT education, as it is vital in tailoring instructional methods to their needs and expectations.

1.1 Objectives

(i) To evaluate the difficulty level for all modules throughout the DIY IoT workshop.

(ii) To assess the effectiveness of the DIY workshop in learning IoT.

(iii) To determine the level of students' perceptions towards the DIY IoT workshop.

2.0 LITERATURE REVIEW

2.1 Internet of Things (IoT)

The Internet of Things, or IoT, refers to a network of physical objects that are embedded with sensors, software, and other technologies, allowing them to communicate with other devices and systems over the Internet or other communication networks (Gillis, 2021). Mouha (2021) said IoT involves the connection of sensors and actuators embedded in physical objects through wired and wireless networks, often using the same Internet Protocol (IP) that connects the Internet. IoT is a revolutionary approach that has transformed various aspects of our daily lives, including smart cities, smart homes, pollution control, energy saving, smart transportation, and smart industries (Alam et al., 2020). IoT has garnered considerable attention in recent years due to its capacity to transform multiple industries profoundly. A systematic literature review by Granell et al. (2019) identified the advantages of integrating IoT technologies across various sectors and industries. The research shows that the Internet of Things (IoT) can improve efficiency, sustainability, and production. Kumar et al. (2019) viewed IoT as an emerging paradigm that allows smart devices to communicate with the internet, offering inventive resolutions to many challenges and concerns. As the IoT continues to evolve, experts and developers are working together to make the technology bigger and better, fixing many problems with the systems that are already in place.

2.2 IoT in Education

Alzahrani and Alshahrani (2020) highlighted the benefits and challenges of integrating IoT into education. They found that IoT can enhance students' critical thinking, problem-solving, and collaboration skills. In a literature review by Chen and Wu (2019), the authors emphasized the importance of user-centred design in developing IoT applications for education. The study highlighted the need for a user-centred approach to ensure that IoT applications are accessible, usable, and effective for learners. The incorporation of IoT into the curriculum of computer science studies is not new. Bajracharya et al. (2021) explained that there are two (2) categories where IoT is incorporated into educational activities by adopting IoT to help with teaching and learning or by including IoT courses in the existing curriculum. Ahmed et al. (2022) reported the inclusion of the IoT module into the computer science curriculum, and the students reported increased interest in exploring IoT in the future. IoT was also introduced into the curriculum of computer science in high school (Abichandani et al., 2022) and the first year of college (Izumi et al., 2022), where the students were reported to be able to grasp the concept of IoT and sensors.

https://doi.org/10.24191/jcrinn.v9i1

2.3 IoT DIY Workshop

Kuznetsov and Paulos (2010) discussed the potential roles of user-centred technology, specifically DIY projects, in empowering learners while promoting sustainable development. The study found that DIY projects can enhance students' creativity, problem-solving, and critical thinking skills while promoting sustainable development. Many approaches have been employed to teach IoT concepts to students. Ronoh et al. (2021) presented a survey of IoT learning methods, including problem-based learning, flipped laboratories, flipped classrooms, cooperative learning, and collaborative learning. The same authors found that Arduino and Raspberry Pi are the most common hardware platforms used for teaching IoT. Budihartono et al. (2022) conducted a series of workshops consisting of presentations, demonstrations, and training to improve the students' learning of IoT technologies. Results from a questionnaire conducted after the workshop showed that almost all students could understand the IoT topics discussed during the workshop.

A study by Wang and Wang (2019) discussed the use of widely available educational IoT kits for beginners or non-major students. The study found that IoT kits can enhance students' understanding of IoT concepts and provide hands-on experiences. The authors emphasized the need for innovative teaching methods to integrate IoT into the curriculum effectively. A study by Bajracharya et al. (2021) also discussed the benefits and challenges of choosing an education kit for learning IoT and concluded that there are many opportunities for using educational kits for teaching and learning IoT. The use of educational kits will speed up the process of learning IoT concepts.

3.0 METHODOLOGY

This section outlines the methodology employed to conduct a quantitative survey to assess students' perceptions towards DIY workshops in learning IoT. The target respondents are all computer science diploma students of UiTM Sarawak branch, Samarahan Campus 2, who registered for the ITT270 Digital Electronics course during the March–August 2023 semester. A structured questionnaire was utilized as the primary data collection instrument. This questionnaire was developed based on a review of the existing literature. It comprises closed-ended questions featuring a 5-Likert scale response format, enabling students to provide feedback regarding their perceptions of the conducted DIY workshop. Additionally, in-depth information about the workshop is gathered through student interviews. At the final session of the DIY workshop, students were provided with a link to complete an online questionnaire. 19 out of 21 students enrolled in ITT270 courses responded to the survey, resulting in a response rate of 90.47%.

Statistical Package for the Social Sciences (SPSS) was employed in this study for comprehensive data analysis. The analysis was conducted in three primary phases. First, descriptive statistics were performed to summarise the demographic profile comprehensively. Secondly, mean scores were calculated to determine the difficulty level and students' perception of the DIY IoT workshop. Lastly, t-tests were employed to assess the effectiveness of the DIY workshop in learning IoT.

4.0 RESULT AND DISCUSSION

4.1 Demographic Profile

Table 1 lists the demographic profile of respondents according to gender, semester of study, age, and race. Most of the respondents (68.4%) were male, and the other 31.6% were female students. About 94.7% of the respondents were from semester 4, and only one respondent was from semester 3 of the study. This study was participated with the most respondents by Malay students (31.6%), followed by Iban (26.3%), and the least by Bajau, Banjar, and Melanau with 5.3% for each race.

https://doi.org/10.24191/jcrinn.v9i1

Table 1: Demographics of respondents

Demographic	Label	Frequency	Percentage (%)
Gender	Male	13	68.4
	Female	6	31.6
Semester of study	3	1	5.3
	4	18	94.7
Age	19	1	5.3
	20	18	94.7
Race	Bajau	1	5.3
	Banjar	1	5.3
	Bidayuh	3	15.8
	Iban	5	26.3
	Kadazan - Dusun	2	10.5
	Malay	6	31.6
	Melanau	1	5.3

4.2 Levels of difficulty for all modules throughout the DIY IoT workshop

All the respondents are required to answer questions about the difficulty level of the modules that had been used throughout the workshop so that the level of difficulty of the modules can be determined. The questions are provided in 5 Likert-scale for each item. Scale 1 is very difficult, while scale 5 is very easy. To determine the levels of difficulty, we averaged the difficulty level score and categorized it into five levels of difficulty, which are very high, high, moderate, low, and very low (Moidunny, 2009), as shown in Table 2.

Table 2: Level of difficulties

Mean Score	Mean interpretation table
1.00 – 1.80	Very High
1.81 – 2.60	High
2.61 – 3.20	Moderate
3.21 – 4.20	Low
4.21 – 5.00	Very Low

Source: Moidunny (2009)

The mean score in Table 3 concludes that the level for all modules used throughout the DIY IoT except Module 5 is easy for students to understand and follow since the mean score is between 3.21 to 4.20. Module 5 was categorized as moderately difficult since the mean score is 3.1930, which is neither easy nor difficult to understand by the students.

Table 3: Mean score for level of difficulties

Variables	Mean Score	Level of Difficulty
Module 1(a): Installation and Setup of Arduino IDE for ESP32	4.0000	Low
Module 1(b): Programming ESP32 to print to serial monitor and blink an LED	3.8070	Low
Module 2: Reading data from sensors	3.5965	Low
Module 3: Connecting ESP32 to Wi-Fi network	3.7400	Low

https://doi.org/10.24191/jcrinn.v9i1

Module 4: Sending data from sensor to cloud	3.5614	Low
Module 5: Developing a DIY-based IoT system	3.1930	Medium

4.3 Assessing the Effectiveness of the DIY Workshop in Learning IoT

Table 4 tabulates the mean and analysis of the Paired t-test for students' knowledge level before and after they attended the DIY IoT workshop. The result reveals that there is a difference in the mean of students' knowledge level towards the DIY IoT workshop. Therefore, a further analysis has been done to assess whether there was a significant improvement in students' knowledge level before and after they attended the DIY IoT workshop. Analysis of the Paired t-test in Table 4 concludes that there is a significant improvement in knowledge level among students toward DIY IoT workshop (p-value < 0.05). This means that students have an improvement in knowledge level after attending the DIY IoT workshop. Thus, we can conclude that the DIY workshop is effective in learning IoT.

Table 4. Paired t–test analysis

	N	Mean (Before)	Mean (After)	t-test (p-value)	Conclusion
Knowledge	19	1.74	3.95	-9.340 (0.000)	Significant Effective

4.4 Reliability Analysis

The accuracy or reliability of data that was used in this study was analysed by conducting a reliability test. The data is concluded as reliable if the value of Cronbach's Alpha is more than 0.7 (Pallant, 2011). The Cronbach's Alpha value for all variables is displayed in Table 5. The analysis shows that all the variables used in this study were reliable, as Cronbach's Alpha values were more than 0.7 for all variables.

Table 5: Reliability analysis

Variable	Number of Items	Cronbach's Alpha
Challenge	7	0.917
Interest	7	0.913
Readiness	8	0.818

4.5 Students' Perception Towards DIY IoT Workshop

The students' perception of the DIY IoT workshop was measured using three variables: challenge, interest, and readiness. In order to measure the perception, the respondents needed to answer the questions for these three variables. Like the questions for the level of difficulty of the modules, the questions need to be answered using a 5 Likert scale for each item. Scale 1 refers to strongly disagree while scale 5 is for strongly agree. To determine the level, we calculated the mean score for all variables and categorized it into five levels, which are very low, low, moderate, high, and very high (Moidunny, 2009), as shown in Table 6.

https://doi.org/10.24191/jcrinn.v9i1

Table 6: Level of perceptions

Mean Score	Mean interpretation table
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.20	Moderate
3.21 – 4.20	High
4.21 – 5.00	Very High

Source: Moidunny (2009)

Table 7 displays the mean score for all the variables used to measure students' perception of the DIY IoT workshop. The variable challenge gives a mean score of 3.2331. It means that the students moderately agreed that the condition caused some challenges for them while attending the DIY IoT workshop. In terms of interest and readiness, they highly agreed with their preferences and preparations when attending the DIY IoT workshop. The findings reveal that they are interested in joining the workshop and prepared well before attending it.

Table 7: Mean score for perception level

Variable	Mean Score	Level of Perception
Challenge	3.2331	Medium
Interest	3.7820	High
Readiness	3.9605	High

5. CONCLUSION

In conclusion, the DIY IoT workshop was conducted to address the limited knowledge of IoT among students taking the Digital Electronics course. The workshop aimed to expose students to the components of IoT systems and develop a simple IoT system. The integration of the DIY workshop in learning IoT has shown promising results. This hands-on learning experience provided students with valuable insights into the fundamentals of IoT, allowing them to work directly with hardware components and gain practical skills. The students' positive perceptions further supported the effectiveness of the DIY workshops in learning IoT. Besides, by incorporating the DIY IoT workshops into the curriculum, educators can better prepare students for the IoT-driven future and equip them with the skills and knowledge necessary to excel in the rapidly evolving digital landscape. Overall, the DIY IoT workshop has been a valuable initiative in bridging the gap between theoretical knowledge and practical application, enabling students to gain hands-on experience and a better understanding of IoT concepts and components. Therefore, in keeping with the present technical advancements in the Fourth Industrial Revolution (IR4.0), we hope that this kind of program can be continued to highlight students' talent and creativity in developing products based on the IoT concept. Finally, it is believed that the incorporation of IR5.0 principles, such as advanced connectivity, artificial intelligence, and human-machine collaboration, into DIY workshops can provide students with a more immersive learning environment and better prepare them for the evolving technological landscape.

https://doi.org/10.24191/jcrinn.v9i1

6. ACKNOWLEDGEMENTS/FUNDING

The authors would like to acknowledge the support of Universiti Teknologi MARA (UiTM) Cawangan Sarawak, Kampus Samarahan 2 for providing financial support through Tabung Amanah Pembangunan Akademik (TAPA) for the DIY IoT workshop.

7. CONFLICT OF INTEREST

The authors declared that they have no conflicts of interest to disclose.

8. AUTHORS' CONTRIBUTIONS

Lee Yee Ann played a pivotal role in shaping the project's direction by contributing to the initial conceptualization. Abdul Hadi and Zubaidah took charge of the practical aspects and actively engaged in the writing process. Their collaborative efforts extended to crafting the original draft of the article, followed by meticulous revisions. Meanwhile, Rumaizah brought her expertise to the forefront, undertaking data analysis using statistical or computational methods. Collectively, these contributions reflect a well-rounded and collaborative approach, showcasing the varied skills and responsibilities undertaken by each team member in the successful execution of the research endeavor.

9. REFERENCES

Abichandani, P., Lobo, D., & Shekhar, P. (2022). An introductory internet of things curriculum for grades 9-12 computer science classes. In *2022 IEEE Frontiers in Education Conference (FIE)* (pp. 1-6). IEEE. https://doi.org/10.1109/FIE56618.2022.9962612.

Ahmed A. A., Bellam, K., Yang, Y. & Preuss, M. (2022). Integrating IoT technologies into the CS curriculum at PVAMU: A Case Study. *Education Sciences*, *12*(11), 840. https://www.mdpi.com/2227-7102/12/11/840

Alam, M., Shakil, K. A., & Khan, S. (Eds.). (2020). *Internet of Things (IoT)*. Springer International Publishing.

Alzahrani, A. I., & Alshahrani, A. M. (2020). Internet of Things (IoT) in education: Benefits, challenges, and future directions. *Education and Information Technologies*, *25*(6), 5365-5385. https://doi.org/10.1007/s10639-020-10298-5

Bajracharya, B., Gondi, V. & Hua, D. (2021). IoT education using learning kits of IoT devices. *Information Systems Education Journal*, *19*(6), 40-44. https://eric.ed.gov/?id=EJ1329491

Budihartono, E., Maulana, A., Rakhman, A., & Basit, A. (2022). peningkatan pemahaman siswa tentang teknologi IoT melalui workshop teknologi IoT [Improving students' understanding on IoT technology through IoT technology workshop]. *Jurnal Masyarakat Mandiri*, *6*(3), 1595-1602.

Chen, Y., & Wu, F. (2019). Human-computer interaction in the Internet of Things era. *Human-Computer Interaction*, *34*(1), 1-7. https://doi.org/10.1080/07370024.2018.1554205

Gillis, A. (2021). *What is internet of things (IoT)?* TechTarget IoT Agenda. https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F. O., & Trilles, S. (2019). Internet of Things. In H.

https://doi.org/10.24191/jcrinn.v9i1

Guo, M. F. Goodchild & A. Annoni (Eds.). *Manual of Digital Earth* (pp. 387-423). Springer Singapore. https://doi.org/10.1007/978-981-32-9915-3_11

Izumi, S., Sato, K., Takahashi, A., & Chiba, S. (2022). Introductory education for IoT technology for first-year students. In *2022 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)* (pp. 715-718). IEEE. https://doi.org/10.1109/TALE54877.2022.00125.

Kumar, S., Tiwari, P., & Zymbler, M. (2019). Internet of Things is a revolutionary approach for future technology enhancement: A review. *Journal of Big Data*, *6*(1), 111. https://doi.org/10.1186/s40537-019-0268-2

Kuznetsov, S., & Paulos, E. (2010). Rise of the expert amateur: DIY projects, communities, and cultures. *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*, 295-304. https://doi.org/10.1145/1868914.1868950

Mouha, R. A. (2021). Internet of Things (IoT). *Journal of Data Analysis and Information Processing*, *9*, 77-101. https://doi.org/10.4236/jdaip.2021.92006

Moidunny, K. (2009). *The effectiveness of the national professional qualification for educational leaders (NPQEL)* [Unpublished doctoral dissertation, Universiti Kebangsaan Malaysia].

Pallant, J. (2011) *SPSS survival manual: A step by step guide to data analysis using the SPSS program*. (4th ed.). Allen & Unwin, Berkshire.

Ronoh, K., Muli, E., Ngwawe, E., & Njuki, S. (2021). Internet of Things learning methodologies, teaching tools and teaching platforms. In *2021 International Conference on Electrical, Computer and Energy Technologies* (ICECET) (pp. 1-6). IEEE. https://doi.org/10.1109/ICECET52533.2021.9698711.

Wang, Y., & Wang, X. (2019). An educational IoT kit for beginners or non-majors. *IEEE Transactions on Education*, 62(3), 214-221. https://doi.org/10.1109/TE.2019.2909269.