2025 Journal of Engineering, Technology and Social Sciences
Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Volume 11 Special Issue: ICETISM
International Conference on Emerging Technologies, Information Science and Mathematics
e-ISSN: 27166848

EXPLORING INTERNET OF THINGS APPLICATION IN SARAWAK'S CONSTRUCTION INDUSTRY: A QUALITATIVE STUDY BASED ON SEMI-STRUCTURED INTERVIEWS

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ARTICLE INFO

Article history:
Received
14 July 2025
Received in revised form
18 Sept 2025
Accepted
3 Oct 2025
Published online
15 Oct 2025

Keywords:
Internet of things; IoT; Application; Sarawak; Malaysia

ABSTRACT

The construction industry is plagued by a variety of problems, including delays, cost overruns, low productivity, substandard quality, and poor communication. Previous researchers have noted that the Internet of Things (IoT) has the potential to mitigate problems in the construction industry by improving decision-making and efficiency in projects, which benefit from its accurate and automated data collection functions. In Malaysia, although considerable research on the IoT has been conducted, very little has been done in Sarawak, despite it being the largest state. Therefore, the present research addresses the existing gap by exploring the current and future applications of various IoT technologies in Sarawak's construction industry. A qualitative research method was adopted. Semi-structured face-to-face interviews were conducted to collect primary data from ten Grade 7 contractors. The responses from the interviewees were analysed using content analysis. The results show that the majority of interviewees who had applied IoT in their construction projects do not thoroughly understand the term. However, all interviewees agreed that IoT is essential because it helps shorten time, reduce cost, manage the project efficiently, and increase cooperation with project team members. Besides, the majority of interviewees are currently adopting WhatsApp, drones, CCTV, Microsoft Project, and AutoCAD in their projects. As for the future application, the interviewees were willing to invest in BIM software, human resources software (for attendance monitoring and payroll management), CCTV, sensors, and AutoCAD on the cloud. Apart from bridging the gap of the existing literature, the present research could also increase the awareness of construction players with regard to IoT applications, thereby reducing potential problems and increasing the efficiency and effectiveness of construction projects.

1. Introduction

The construction industry has often been characterized by low quality (Bariono & Kamaruding, 2025; Othman et al., 2020), ineffective communication (Fahad et al., 2025; Loh et al., 2022), and frequent cost and time overruns (Omran et al., 2023; Sa'ad et al., 2022; Sohu et al., 2024). Previous studies indicate that the IoT has the potential to address these challenges within the construction sector. IoT is very useful in the construction industry as it can be used in different stages, including the pre-construction stage, construction stage, and post-construction stage (Maru et al., 2020a). In addition, it can be used in several areas of construction, ranging from planning and control to quality, safety, equipment, and procurement management (Ding et al., 2025; Katiyar & Kumar, 2019). It can significantly enhance safety standards alongside the efficiency of meeting construction project objectives (Kineber, 2024). Khan et al. (2024) also noted that IoT technologies help improve safety and productivity on construction sites by supporting real-time construction monitoring systems and the overall construction management system. Through better field observation methods, precise monitoring, and improved operation oversight with IoT tools, the operating costs can also be minimized. In addition, mobile devices such as smartphones enable prompt communications and decision-making during the project's progress (Igwe et al., 2022). Furthermore, deployment of sensors guarantees rapid project information transmission, resulting in lower operational costs, time savings, and energy efficiency. According to Jamlus and Haron (2024), it is possible to combine IoT with Big Data and AI to enhance cost estimation, which can lead to better quantity takeoff, cost management, and cash flow projections.

A lot of research has been conducted on IoT in Malaysia. Mahmud et al. (2018) studied the application of IoT in the Malaysian construction industry. They found that the most common applications are websites, email, social media, and General Packet Radio Service (GPRS), while the least used applications were smartwatches, scan markers, and sensor technologies. Halim et al. (2021) mentioned that the majority of construction industry professionals do not use IoT to enhance client communication and business operations. According to Ibrahim et al. (2021), Malaysia still faces challenges in utilising the latest IoT technologies due to high costs and a lack of skilled professionals for installation and maintenance. Hong and Mansor (2023) studied the common IoT technologies that were adopted by contractors in their projects. They discovered that some of the most widely used technologies are wearable devices, sensors, and drones. Furthermore, Sekak et al. (2023) found a number of benefits of applying the IoT in the construction industry. These include easy information sharing, prompt responses to enquiries, easy access to the drawings and documents, and streamlined procedures throughout the design stage.

Although numerous studies have been conducted in Malaysia, very limited studies have been done in Sarawak, the largest state of Malaysia. Moreover, previous studies generally used quantitative approaches, which prevent the gathering of in-depth information from the participants. Thus, the present research attempts to fill the gap by examining the present and future use of different IoT technologies within the construction industry in Sarawak, by adopting a qualitative research approach. The present research may help stakeholders from the construction industry to become more aware and alert to the acceptance of state-of-the-art technologies for project management. This will also help reduce potential risks as well as

enhance construction project efficiency and effectiveness. Additionally, the present research aligns with the Construction 4.0 Strategic Plan (2021-2025) for the Malaysian construction industry, which encourages industry leaders to embrace the IoT and adopt new technologies to enhance productivity and competitiveness.

2. Literature Review

IoT in construction refers to a network of interconnected sensors, devices, appliances, and technologies that can share or exchange data over the internet, creating an intelligent and integrated system (Islam & Motakabber, 2025). It is a system of connected devices that can be connected and run through a network or internet without human interaction (Laghari et al., 2024; Maru et al., 2020b). Some of the applications of IoT for construction activities include messaging applications, email, websites, radio frequency identification (RFID), big data analytics, sensors, and artificial intelligence (AI).

Research conducted by Mahmud et al. (2018) revealed that messaging apps, e-mail, and websites are the top three IoT tools in the Malaysian construction industry. Messaging apps and e-mail provide users with the ability to communicate and exchange messages. The three most popular messaging apps are WhatsApp, Messenger, and Telegram (Mahmud et al., 2018). Besides, websites are commonly used in the construction industry for price quotes, company profiles, and policies.

RFID technology relies on the transmission of radio frequency waves to send, store, and collect data for identifying worker and object status (Haupt et al., 2019). In the construction industry, RFID is used to track personnel, supplies, tools, and equipment. Consequently, this helps in boosting productivity and logistics (Ibrahim et al., 2021). This technology may improve safety at work by detecting collisions and sensing unsafe practices of workers, such as failing to wear personal protective equipment (PPE) (Ding & Chua, 2021; Karakhan et al., 2021). RFID may also prevent material theft by reporting the real-time location of materials. In addition, research conducted by Arowoiya et al. (2020) shows that RFID is one of the most used technologies in South Africa, and it contributed to timely completion and increased performance.

Building Information Modelling (BIM) is a data integration platform that facilitates collaboration among construction stakeholders (Nguyen, 2025). It integrates project-related information such as cost, time, materials, and lifecycle management into a comprehensive 3D model. According to Nguyen (2025), BIM can be integrated with the IoT and AR to enhance construction sustainability and efficiency. In China, driven by government policies, BIM-IoT (integration of BIM and IoT) has been applied to general and large-scale construction projects, in the design stage, construction stage, and operation stage (Hong & Guo, 2025). According to Mohammed et al. (2022), “BIM provides a high depiction of the project…while IoT improves the information by offering a real-time feed of operations…” Integration of BIM and IoT leads to a safer and smarter approach to construction, thereby contributing to sustainable development (Hong & Guo, 2025; Mohammed et al., 2022).

Big Data is employed to manage huge volumes of data exchanges and storage at every stage of the project lifecycle. This ultimately provides an organized database for optimizing

construction processes (Jia et al., 2019). Big Data plays a very crucial role in the context of a BIM project because it is able to deal with the vast quantity of data that is involved. Big Data can also be linked with cloud computing through the internet to enhance communication and coordination among project teams (Pandey et al., 2023). As noted by Berisha et al. (2022), cloud computing is "the best solution for storing, processing, and analyzing Big Data".

Sensors connect the IoT to smart devices such as smartphones, laptops, computers, and tablets. They contribute to construction companies by tracking progress, optimizing resources, and sites management. These sensors observe equipment, temperature, energy consumption, materials used, and labor efficiency (Ibrahim et al., 2021). There are different types of sensors available for different purposes. Research conducted by Maru et al. (2020b) in India found that fire threatening sensors are commonly used, while sensors for waste management have the lowest rate of usage.

AR enables integration of digital information and 3D methods with the real world via a mobile device (Lotfi & Karakouzian, 2025). By displaying real-time location, AR assists the construction team in tracking, monitoring, and reporting errors and collisions (Ibrahim et al., 2021). Results conducted by Said et al. (2025) revealed that AR can enhance visualisation, streamline processes, and improve communication. However, some key issues of concern were also identified, including technical limitations, high investment cost, lack of training, and resistance to change.

Based on the existing literature review, IoT technologies mentioned in previous research are summarized in Table 1.

Table 1. Internet of Things Applications in Previous Studies

Technologies	**Mahmud et.al (2018)**	**Xu & Lu (2018)**	**Jia et.al (2019**	**Reddy & Kone (2019)**	**Aroiwaya et.al (2020)**	**Maru et.al (2020a)**	**Maru et.al (2020b)**	**Ibrahim et.al (2021)**	**Igwe et al. (2022)**
Bluetooth			√		√				
E- tender/E-submitting						√	√		
E-Mail	√					√			
Long-term evolution (LTE)			√						
Near field communication (NFC)					√				
Scan Marker	√					√	√		
Social media (WhatsApp, Telegram, and Facebook Messenger)	√					√	√	√	√
Websites	√					√	√		
Wireless fidelity (Wi-Fi)			√		√		√		

Actuators					√				
Artificial intelligence					√				√
Autonomous Machinery						√	√		
Building structure health monitoring	√		√				√		
Closed-Circuit TV (CCTV)/ Video Cameras			√			√	√		
Drone	√	√				√	√	√	√
Internet protocol					√				
Micro controller							√		
Net Banking						√			
Robotics		√				√	√		√
Smart Watch	√					√	√		
Zigbee			√	√	√				
Electronic product code/ Barcode		√			√				
E-procurement (Online Price Quote, Ordering, Tracking)	√					√	√		
RFID		√	√	√	√	√	√	√	
3D laser scanner		√							
Addressing schemes (URL)					√				
Big Data	√		√			√		√	
Data storage and analytics					√				
Enterprise resource planning						√	√		
Microsoft Project						√			
Primavera				√		√			
GPRS/Location Services (Google Maps, Waze, GPS)	√	√		√		√	√	√	
AutoCAD						√			
Building Information Modelling	√	√		√		√	√	√	√
Augmented Reality (AR)	√	√			√	√	√	√	√
Gateway					√				
Smart Lock	√					√			
Air Quality Monitoring Sensors	√					√			
Automatic Lamp	√					√			
Fire Threatening Sensors	√					√			
Flood threat monitoring sensor	√								
Lighting & Electricity Sensors						√	√		
Maintenance Activity Sensor	√					√			
Traffic control sensor	√								
Waste management sensor	√					√			√
Wireless sensor networks (WSN)		√	√		√				

3. Methodology

The present research employed a qualitative research methodology because the authors intended to gain more insights into the present research topic. Semi-structured interviews were conducted for data collection. The interviews were interactive, allowing the present researchers to tailor follow-up questions based on the interviewee's responses, thereby fostering a dynamic exchange of information (Magaldi & Berler, 2020; Pyo et al., 2023). A total of six interview questions were developed to gather data for the present research, as shown in Tables 3 through 8.

The present researchers interviewed ten Grade 7 contractors in Sarawak, selected from the list of registered contractors on the CIDB website (CIDB, 2024). Grade 7 contractors were chosen because they represent the highest grade of contractors in Malaysia and are responsible for larger projects that require advanced technologies. As for the sampling method, the researchers initially used purposive sampling to select the contractors (Isaac, 2023) and subsequently employed snowball sampling, which allows the initial contractors to refer the researchers to additional contractors (Baltes & Ralph, 2022). Each interview was conducted face-to-face, lasted approximately 30 minutes, and was audio-recorded. Subsequently, the data were transcribed into text. The researchers analysed the text and examined patterns and themes in the responses provided by the interviewees for each question (Mezmir, 2020). Bar charts were used to present the identified themes and their frequencies.

4. Results and Discussions

4.1 General Information about the Interviewees

The general information of the ten interviewees was presented in Table 2. All interviewees possess more than 10 years of working experience. There are also three interviewees with more than 20 years of experience.

Table 2. General information about the interviewees

No	Name	Working Experiences	Location
1	Interviewee 1	16 years	Kuching
2	Interviewee 2	20 years	Sibu
3	Interviewee 3	10 years	Kuching
4	Interviewee 4	18 years	Kuching
5	Interviewee 5	12 years	Sibu
6	Interviewee 6	11 years	Miri
7	Interviewee 7	10 years	Miri
8	Interviewee 8	34 years	Sibu
9	Interviewee 9	15 years	Sibu
10	Interviewee 10	22 years	Sibu

4.2 Figures and Tables

Question 1 was designed to assess the interviewees' perceptions of the IoT. As summarized in Table 3 and Figure 1, most contractors who have implemented IoT applications in their

construction projects do not have a thorough understanding of the terminology. However, when the interviews progressed, it was revealed that they do utilize various IoT applications in their projects, but they did not know that those applications are categorized under the big umbrella of IoT. According to Jamlus and Harun (2024), a lack of knowledge of IoT is one of the major challenges of implementing IoT. Similarly, Das and Rastogi (2023) noted that construction professionals often lack a clear understanding of how integrated data can connect various components to unlock greater potential, even though some construction organizations are already innovative and showcase a range of technological advancements.

Table 3. Content analysis of Question 1

Question 1	**How do you define/describe the Internet of Things?**
Interviewee 1	1. It is something connected to the internet.
Interviewee 2	1. Enables users to communicate with others through the internet. 2. It is used to share information, making work easier, safer, quicker, and more efficient.
Interviewee 3	3. I am not familiar with this term. I only know that it is a new technology.
Interviewee 4	1. The collective network of connected devices and the technology that enables them to collect and exchange data over the internet.
Interviewee 5	1. IoT? I do not know.
Interviewee 6	1. IoT? I do not have much experience with that.
Interviewee 7	1. I am not sure.
Interviewee 8	1. I do not know about it.
Interviewee 9	1. I do not know.
Interviewee 10	1. It allows interaction through the internet. 2. Some examples are WhatsApp, sensor, AutoCAD, and CCTV.

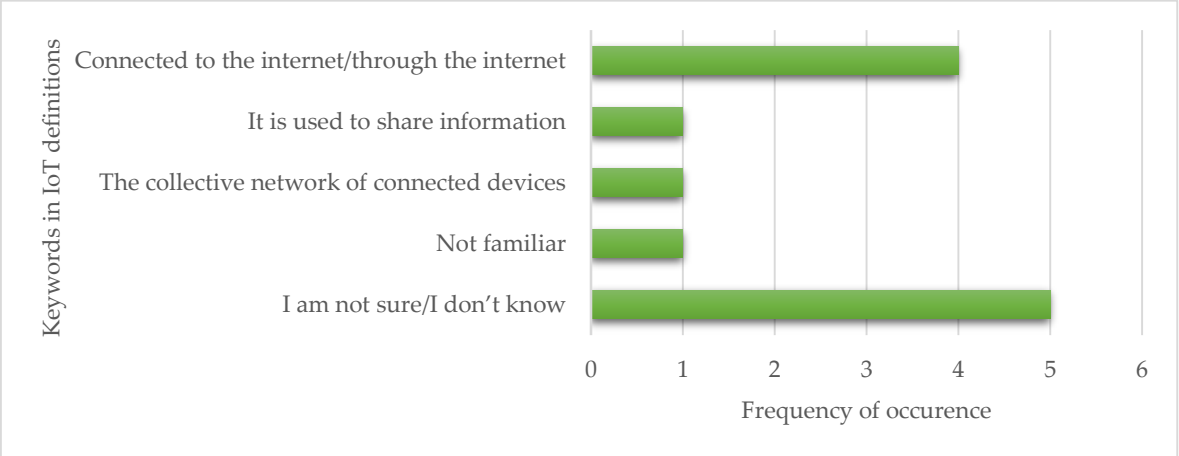

Figure 1. Most frequently mentioned keywords in IoT definitions.

Question 2 was designed to assess the importance of the IoT from the perspective of the interviewees. Since the interviewees were initially unfamiliar with the IoT, the researcher provided a brief overview of the technology. Following this explanation, the interviewees gained a clearer understanding of IoT and acknowledged its significance. Based on Table 4, all interviewees acknowledged the importance of IoT because it enables them to save time and

money, effectively assist and manage projects, and enhance collaboration with team members. The interviewees also mentioned that employing IoT is crucial in achieving success and sustainability. This finding aligns with the research conducted by Maru et al. (2020a) and Mahmud et al. (2018), which also emphasized that without implementing the IoT to streamline operations, the construction industry risks lagging behind other advancing sectors. As summarized in Figure 2, the most frequently mentioned importance is "better coordination/collaboration/communication", followed by "real-time monitoring/site monitoring".

Table 4: Content analysis of Question 2

Question 2	**Do you think that IoT is important in construction projects? Why?**
Interviewee 1	1. Save time.
Interviewee 2	1. Ensure a smooth project process. 2. Ensure safety, identifying problems, and alerting to potential hazards. 3. Enhance effective resource planning, decision-making, and project schedules monitoring.
Interviewee 3	1. For coordination. 2. Finding the problem.
Interviewee 4	1. Enable real-time monitoring. 2. Save cost, enhance sustainability, and better collaboration. 3. Achieve success and sustainability.
Interviewee 5	1. Help ensure that the project is managed effectively.
Interviewee 6	1. Important for collaboration. 2. Drones are essential.
Interviewee 7	1. Help produce drawings and ease material quantities measurement. 2. Better collaboration.
Interviewee 8	1. For site monitoring.
Interviewee 9	1. Convenient for communication. 2. Understand the site's situation.
Interviewee 10	1. Manage the project's finances.

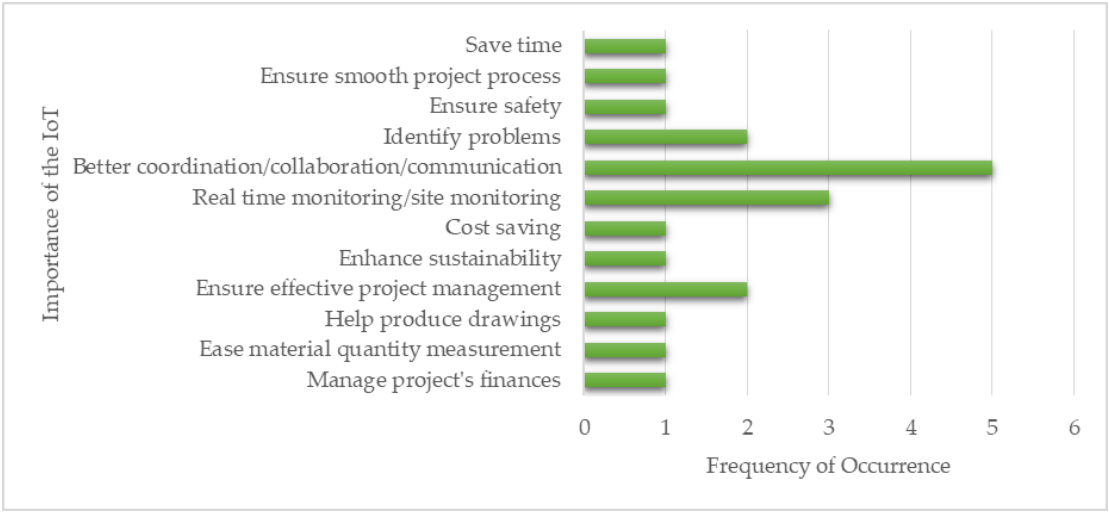

Figure 2. Importance of the IoT

Question 3 was designed to assess whether the interviewees were currently implementing any IoT technologies. According to Table 5 and Figure 3, the most commonly implemented technologies are WhatsApp and AutoCAD (mentioned by eight interviewees) as well as Microsoft Project (mentioned by seven interviewees). According to the interviewees, WhatsApp is the most commonly used technology for communicating, collecting, and exchanging project-related information in their work. One interviewee further emphasized that this technology helps reduce communication barriers, resulting in smoother processes, faster decision-making, and improved overall project coordination. These findings align with research conducted by Mahmud et al. (2018), which also revealed that WhatsApp is a popular communication medium that individuals utilize to share information, create discussion groups, and transmit documents more easily and rapidly. Most interviewees also use AutoCAD for civil projects, drafting plans, reviewing drawings, surveying, performing quantity take-offs, and checking measurements. Additionally, most interviewees mentioned that Microsoft Project is essential as it helps manage project schedules, submit work programs, and create reports. This finding aligns with research conducted by Wali and Othman (2019), which noted that construction companies tend to use Microsoft Project more for planning than Primavera. In the present research, Primavera was not mentioned by any interviewee during the interviews. As shown in Figure 4, most interviewees employed IoT tools for coordination or communication (mentioned 6 times), estimating materials from drawings (mentioned 5 times), and monitoring projects (mentioned 5 times).

Table 5: Content analysis of Question 3

Question 3	**Could you kindly share whether you have implemented any Internet of Things tools or technologies in your recent projects? If yes, can you briefly explain the functions of the IoT tools you implemented in your projects?**
Interviewee 1	1. AutoCAD for material estimation from the drawings 2. Microsoft Project and Excel 3. WhatsApp, and email for communication.
Interviewee 2	1. UBS accounting software to streamline the material procurement process.
Interviewee 3	1. AutoCAD for measurement purposes and drawings coordination. 2. Microsoft Project to manage the project schedule. 3. CCTV to monitor the project. 4. Drones and GPS. GPS is used to set piling points.
Interviewee 4	1. WhatsApp for collaboration.
Interviewee 5	1. AutoCAD for estimation. 2. WhatsApp and drones are for communication and reporting. 3. CCTV is for monitoring.
Interviewee 6	1. WhatsApp, AutoCAD. 2. Drones for taking photos and progress reports. 3. Microsoft Project to track delays, progress, and plan construction projects.
Interviewee 7	1. Microsoft Office, AutoCAD, and WhatsApp.
Interviewee 8	1. Microsoft Office. 2. AutoCAD for civil works, surveying, setting out plans, and positioning. 3. Drones for reporting.

	4.	CCTV for site monitoring.
	5.	WhatsApp for communication.
Interviewee 9	1.	AutoCAD for estimation.
	2.	SketchUp for estimation and material procurement.
	3.	Microsoft Excel and Project.
	4.	Microsoft Project for project planning.
	5.	Drones for reporting.
	6.	WhatsApp and email for communication.
Interviewee 10	1.	WhatsApp and email for communication.
	2.	AutoCAD and Microsoft Excel for estimation.
	3.	SQL accounting software is used to manage project finance.
	4.	Lorry tracking app/system to monitor drivers' status.
	5.	CCTV to monitor progress and security.

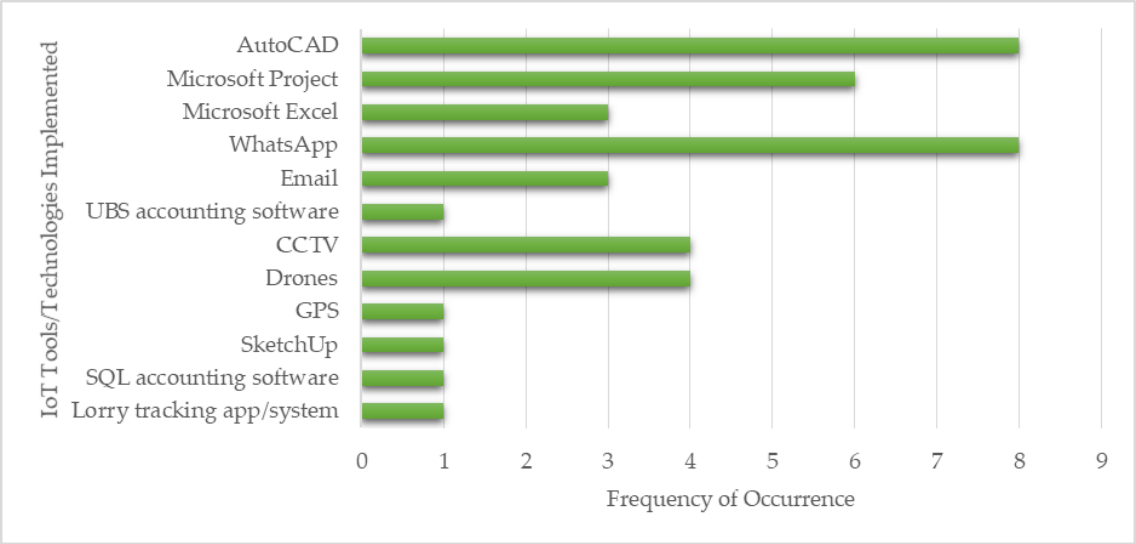

Figure 3. IoT tools/technologies implemented

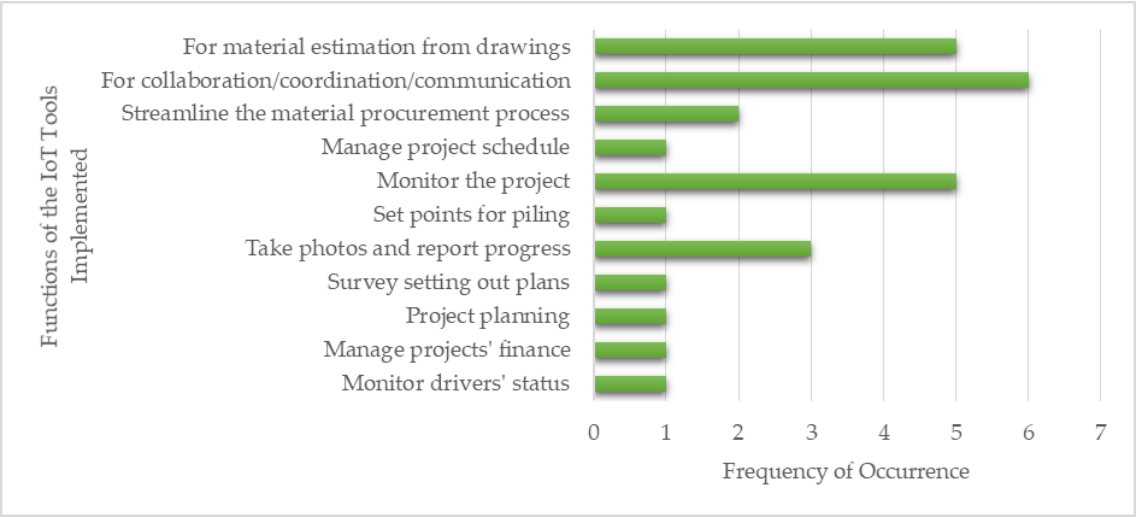

Figure 4. Functions of the IoT tools implemented

Drones were also frequently mentioned by the interviewees. Drones are used to capture site images for progress reports. CCTV cameras are set up at construction sites to monitor weather, progress, and material security. Li and Liu (2018) found that using drones in construction significantly improved access to high-quality 3D mapping data, and their main contributions in construction management include cost effectiveness, work safety, and carbon emission reduction. Mahmud et al. (2018) noted that drones can receive remote instructions and are useful in monitoring construction progress and workers' health and safety. In Sarawak, drones are used at the pre-construction stage for site survey, at the construction stage for daily inspection and progress monitoring, and post post-construction stage for final inspection (Donnis & Rahmat, 2024). Donnis & Rahmat (2024) concluded that although 74% of respondents acknowledged the ease of drone deployment, more efforts are needed to promote its broader adoption in Sarawak.

This study also identified several tools not covered in previous research, such as UBS accounting software, SQL accounting software, and a lorry tracking mobile app. Interviewee 2 described the UBS accounting system as a means to streamline the material procurement process. When the procurement officer places an order through the UBS system, suppliers are immediately notified. This facilitates smooth communication between the project team and suppliers. After materials are delivered, the UBS system updates accounting records in real-time, allowing accountants to track expenses and manage budgets more effectively. Interviewee 10 uses SQL accounting software to create invoices, check official receipts, and track expenses to produce account reports. Interviewee 10 also uses lorry tracking technology to monitor driver locations and destinations via a mobile app.

Question 4 aimed to assess the potential future uses of IoT based on interviewees' views. As shown in Figure 5, nine interviewees intended to invest in more IoT tools in the future. According to Table 6, most interviewees expressed a willingness to use Glodon Software for BIM in their construction projects because of its accuracy in measurements and calculations, which ultimately saves time. However, challenges remain in East Malaysia, where fewer organizations adopt BIM compared to West Malaysia. These findings align with research conducted by Chen et al. (2020), which pointed out that users expect new technologies to improve performance while also worrying about the complexity and effort needed to learn them. Ibrahim et al. (2021) mentioned that the Malaysian government requires BIM for large projects, encouraging compliance and the use of big data for better data management. Nevertheless, only one interviewee reported using BIM in their construction projects, indicating limited acceptance of IoT in the field. According to Lee et al. (2022), the adoption of BIM in Sarawak's construction industry is still low, with only 14% of respondents having ever experienced projects utilising BIM. Additionally, it was discovered that the awareness and knowledge of BIM is still on a "low-average level" (Lee et al., 2022). Although most respondents were willing to accept BIM, their organisations are not ready to implement it. Nonetheless, the benefits of BIM are acknowledged by the Sarawak government. It is targeted that by 2030, all the public projects valued above RM10 million for buildings and above RM100 million for infrastructure should be integrated with BIM to minimize issues of delay and to streamline the construction process (DayakDaily, 2024).

The interviewees showed strong interest in adopting new software and technologies to improve their operations. They mentioned acquiring HR software for attendance and payroll, accounting software for documentation, CCTV and sensors for site security, and AutoCAD for project management. However, they pointed out challenges such as implementation difficulties and limited resources. The interviewees 2 and 8 also intended to invest in human resources management software and cloud-based AutoCAD, respectively.

Table 6: Content analysis of Question 4

Question 4	**In the future, will you invest in any more Internet of Things tools or technologies?**
Interviewee 1	1. BIM is more convenient for my work. I will invest in Glodon software.
Interviewee 2	2. Yes. 3. Plan to invest in software for HR purposes and account management.
Interviewee 3	1. We are using BIM now. 2. We will also use sensors when necessary.
Interviewee 4	1. Yes. 2. No specific tools or technologies. 3. IoT is essential due to technical advances, environmental competition, and client demands.
Interviewee 5	1. Not sure yet. 2. Maybe accounting software to do our paperwork or anything suitable for our works.
Interviewee 6	1. Glodon software to assist with measurements.
Interviewee 7	1. CCTV for monitoring and sensors. 2. BIM or other measurement software.
Interviewee 8	1. AutoCAD on the cloud for monitoring and reporting.
Interviewee 9	1. BIM software such as Glodon for estimation.
Interviewee 10	1. Yes, because the technology is always evolving. 2. BIM software.

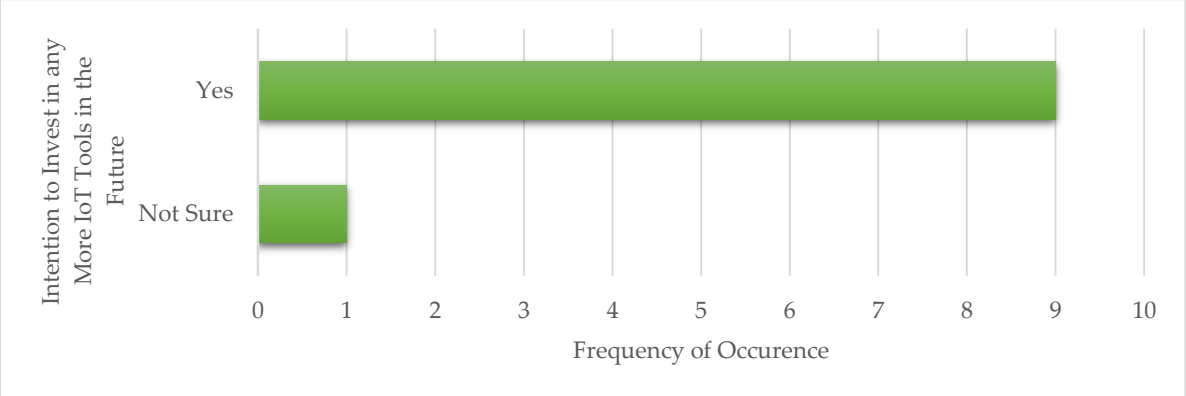

Figure 5. Intention to invest in any more IoT tools in the future

Based on the findings for Question 5 (refer to Table 7 & Figure 6), the most frequently mentioned challenges include high cost/budget constraint, time needed for learning, hard to understand, and frequent technology updates, with the first two being mentioned three times,

and the other two being mentioned two times, respectively. These findings align with the research conducted by Maru et al. (2020b), which mentioned that a lack of budget and a lack of skill are the challenges to IoT implementation. Besides, research conducted by Jamlus and Haron (2024) also revealed that the most significant challenge is the requirement of extra budget and lack of knowledge. Besides, they highlighted that the low cost-benefit ratio associated with the IoT was also a concern. This is because the initial cost of implementing the IoT may surpass the benefits in certain situations. Similarly, Sekak et al. (2023) found that high implementation cost is a critical challenge, which ranked 2nd based on the research findings. However, there are also other critical challenges that are not mentioned by the interviewees of the present research, including a lack of expertise, threats to job market, and data security reasons. According to Bassi (2025), the two significant challenges of IoT implementation are cybersecurity and data management.

Table 7: Content analysis of Question 5

Question 5	**What do you think are the major challenges while applying IoT tools?**
Interviewee 1	1. High cost. 2. Lack of knowledge.
Interviewee 2	3. Hard to understand how IoT technologies work. 4. Security is a big concern. 5. Challenging to fit the new technologies into the existing system (interoperability issues).
Interviewee 3	1. BIM demands close collaboration among construction players to come out with the coordination drawings.
Interviewee 4	1. Lack of understanding. 2. Lack of skills.
Interviewee 5	1. Frequent technologies updates. 2. Some technologies are immature. 3. Time needed for learning.
Interviewee 6	1. Budget constraints. 2. Challenging to use some technologies in large or complex projects.
Interviewee 7	1. The AutoCAD version is different, so the staff cannot open the file (compatibility issues). 2. Frequent technologies updates.
Interviewee 8	1. Technically challenging. 2. Time needed for learning.
Interviewee 9	1. Learning can be challenging and time-consuming. 2. High cost.
Interviewee 10	1. Regardless of the challenges, everyone should learn to embrace new technologies.

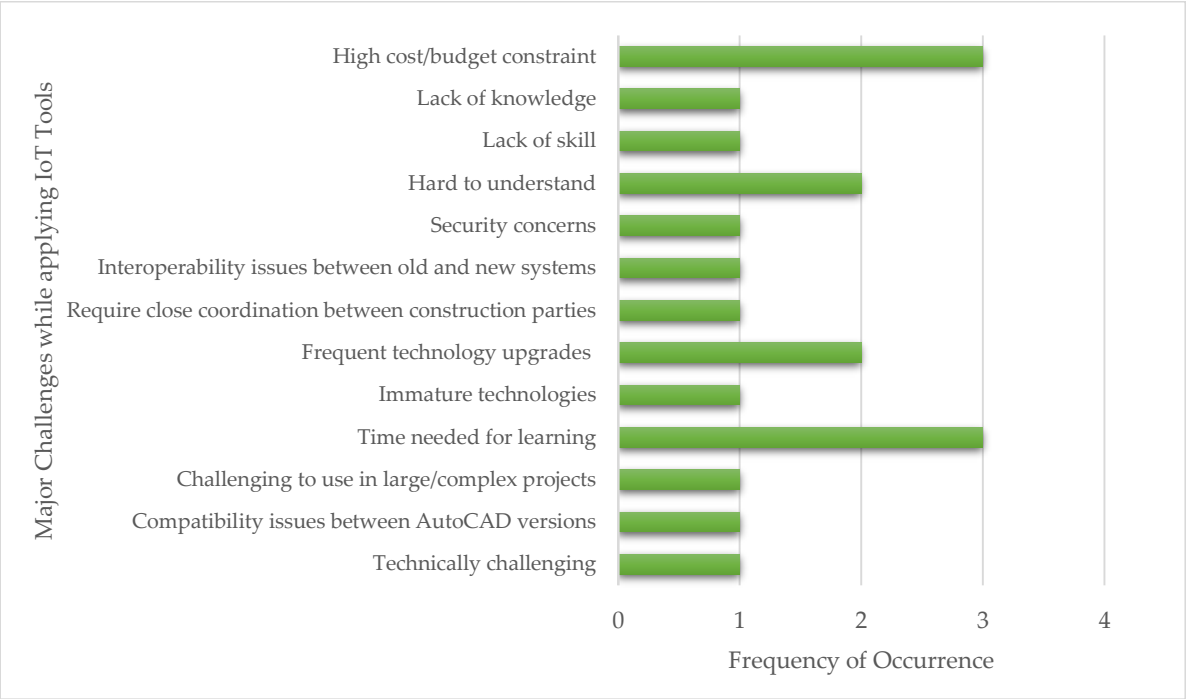

Figure 6. Major challenges while applying IoT Tools

Question 6 focused on receiving recommendations regarding important IoT tools for construction professionals to learn for future developments. As presented in Table 8 and Figure 7, the most commonly mentioned tools are BIM (5 times), followed by AutoCAD (3 times), Microsoft Excel (3 times), and WhatsApp (2 times). Apart from the findings of the present research, previous researchers (Hong & Guo, 2025; Mohammed et al., 2022; Nguyen, 2025) also emphasized the integration of BIM and IoT (also referred to as BIM-IoT) as an important direction of future development. In China, BIM-IoT has been applied to construction projects to improve efficiency, safety, and decision-making (Hong & Guo, 2025). Besides, Aryal et al. (2023) reported that the most commonly used tools are office software, CAD apps, cost estimating software, and communication networks. Besides, there is a rapid growth of internet-based communication. For instance, WhatsApp is a good tool to make sure all the people involved can receive important information during the construction of a management project.

Table 8: Content analysis of Question 6

Question 6	**Could you kindly share your recommendation on the essential Internet of Things tools that construction professionals should learn for future development in the industry?**
Interviewee 1	1. BIM.
Interviewee 2	1. WhatsApp and UBS accounting software. 2. Many other IoT technologies (construction professionals must be adaptable).
Interviewee 3	1. BIM is a trend. However, Sarawak does not use it as much as West Malaysia.

Interviewee 4	1. Some clients start using BIM to carry out their work. However, current quantity surveying practices remain deeply rooted in traditional methods.
Interviewee 5	1. WhatsApp and BIM.
Interviewee 6	1. BIM.
Interviewee 7	1. AutoCAD for drawing and measuring. 2. Microsoft Excel formulas for measurements.
Interviewee 8	1. Microsoft Project for monitoring the schedule. 2. AutoCAD.
Interviewee 9	1. Microsoft Excel for creating bills of quantities and estimating cost. 2. AutoCAD for producing drawings.
Interviewee 10	1. Microsoft Excel is important for our project.

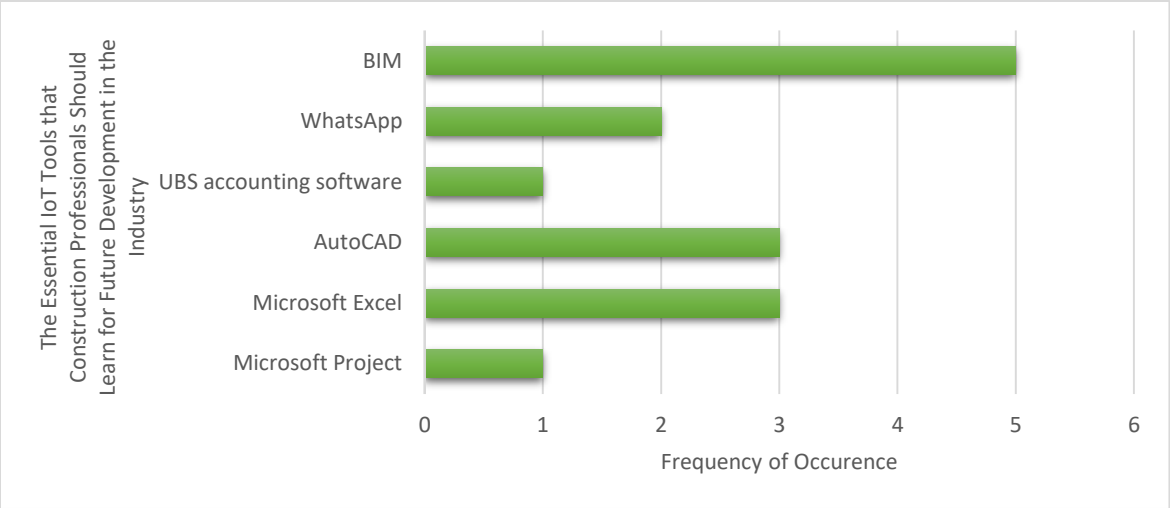

Figure 7. The essential IoT tools that construction professionals should learn for future development in the industry

Based on the interview findings from Questions 3 and 4, the summary of current and potential IoT applications is summarized in Table 9. Out of 46 technologies or tools presented in Table 2.1, there are only less than 50% are mentioned by the interviewees, indicating many IoT technologies such as robotics, RFID, VR, and sensors, are still underutilized. This finding aligns with research conducted by Maru et al. (2020b), which revealed that only 14 types of IoT applications were higher in usage rate, while 22 applications were less used.

Table 9: Summary of current and potential IoT applications

	Current Application														Potential Application					
Interviewee	*AutoCAD*	*BIM*	*CCTV*	*Drone*	*Email*	*GPS*	*Lorry Tracking Mobile App*	*Microsoft Excel*	*Microsoft Office*	*Microsoft Project*	*MysCAD*	*Sketchup*	*SQL accounting software*	*UBS accounting software*	*WhatsApp*	*BIM*	*Accounting software*	*AutoCAD on the cloud*	*CCTV*	*HR software*	*Sensor*
Interviewee 1	√							√		√					√	√					
Interviewee 2														√	√					√	

Interviewee 3	√		√			√				√						√					
Interviewee 4		√													√						
Interviewee 5	√		√												√		√				
Interviewee 6	√		√	√						√					√	√					
Interviewee 7	√								√		√				√	√			√		√
Interviewee 8	√			√				√	√	√					√			√			
Interviewee 9	√			√	√			√		√		√			√	√					
Interviewee 10	√		√		√		√	√					√		√	√					

5. Discussion

The findings revealed that the most commonly employed Internet of Things (IoT) tools by the 10 contractors in Sarawak are WhatsApp, AutoCAD, and Microsoft Project. These tools are effective and widely used for coordination or communication, materials estimation from drawings, and monitoring the projects. Nine contractors intend to invest in more IoT tools in the future, especially in BIM. Currently, most of the contractors still have not invested in BIM software. The contractors also acknowledged the usefulness of drones for site survey and progress monitoring. However, more efforts are needed to promote its broader adoption in Sarawak. Additionally, it was also discovered that out of 46 technologies or tools presented in the Literature Review, there are only less than 50% were mentioned by the interviewees, indicating many IoT technologies, such as robotics, RFID, VR, and sensors, are still underutilized. Furthermore, the study identified several challenges to implementing IoT in construction, including high cost/budget constraint, time needed for learning, hard to understand, and frequent technology updates. The research indicated that Sarawak is lagging in the adoption of IoT technology within the building sector. Therefore, there is an urgent need for local companies to embrace these advancements to remain competitive. Universities and educational institutions could integrate IoT tools such as BIM and AutoCAD into their curricula to better prepare future professionals. Additionally, governments can facilitate this transition by providing training programs, certifications, and mandating the use of such technologies in public projects.

6. Research Limitations

The scope of the present research is limited to Sarawak, and only ten contractors were interviewed. Therefore, the findings of the present research cannot be generalized to the larger population.

Acknowledgements

The present research is fully supported by the University of Technology Sarawak.

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