Internet of Things (IoT) Implementation in the Malaysian Construction Industry

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ABSTRACT

The adoption of Internet of Things (IoT) technology in the construction industry holds significant potential for improving project efficiency, safety, and management. This research investigates the implementation of Internet of Things (IoT) in the Malaysian Construction Industry (MCI) by exploring the awareness, benefits and challenges. The research adopted a quantitative research strategy using a questionnaire survey to collect data from professionals in MCI. Purposive random sampling technique was used to select the respondents for the survey. The study revealed that despite the majority being aware of IoT in the MCI, its implementation is still lacking. Construction progress monitoring, health and Safety and security control were revealed as the key benefits of IoT by MCI professionals. Despite the benefits, Implementation costs, lack of expertise, and security issues were realised as the key challenges in implementing IoT technology in MCI. To overcome the barriers government initiatives in creating policies for IoT implementation are suggested. Additionally, investing in technological advancements and providing subsidies or tax incentives were also suggested as potential strategies to facilitate IoT adoption in the MCI. Overall, this study provides valuable insights into the current state of IoT implementation in the MCI and other developing countries, it also sets a path for further research on fostering its widespread adoption. Further study is recommended to investigate the causes of MCI professionals' reluctance to adopt IoT technologies and provide mitigations on encouragement of its implementation.

INTRODUCTION

The construction industry has seen a rise in technological advancements in many countries over the years. Ibrahim, Esa and A. Rahman (2021) purport this rise is due to the fourth industrial revolution which brings with it technological innovations, with the Internet of Things (IoT) at the forefront (Mahmud, Assan and Islam, 2018). The use of IoT has risen over the years, with the USA, China, Japan, South Korea and Germany at the forefront of their adoption (Vailshery, 2022). In the Asia-Pacific countries, China is leading in IoT usage with an estimated 6.4 billion IoT devices and market growth of 48 billion dollars followed by Japan and South Korea (IOT Analytics, 2023).

Malaysia's construction industry is a significant contributor to the nation's economic landscape and is a key driver of its development and growth. A study by (Hamid, 2022) indicate the industry employs roughly 1.2 million individuals, representing 9.5% of the total workforce. Furthermore, Malaysia's construction sector consistently contributes between 3% and 5% to the national Gross Domestic Product (GDP), ranking it 37th globally (Khan, Liew and Ghazali, 2014). Despite all this, the industry is still lagging when it comes to the implementation of IoT (Mahmud, Assan and Islam, 2018).

This research aimed to investigate the implementation of Internet of Things (IoT) in the Malaysian construction industry. To help achieve the set aim, the study looked at 3 objectives thus exploring the awareness, challenges and benefits of IoT among industry personnel. The research adopted a quantitative research strategy using a questionnaire survey to achieve the set aim and objectives. This research looks to bridge the knowledge gap by demonstrating the potential benefits of IoT implementation, paving the way for increased adoption and improved efficiency, safety, and overall project outcomes.

LITERATURE REVIEW

IoT and its application in the construction

Internet of Things (IoT) can be defined as "a type of network that connects everything to the Internet using established protocols and information sensing hardware to conduct information exchange and communications to achieve intelligent recognition, locating, tracking, monitoring, and administration" (Patel, Patel and Scholar, 2016). IoT encompasses several technologies and devices commonly used in the construction industry, such as big data, Virtual Reality (VR), Augmented Reality (AR), wearable technology, Building Information Modelling (BIM), Radio Frequency Identification (RFID), and drones (Friess and Vermesan, 2022).

Benefits of IoT in construction

IoT offers numerous benefits for the construction industry. IoT enhances efficiency, decision-making, and cost savings by monitoring site progress through drones, GPS, RFID, and sensors. This tracking plays a significant role in risk management and quality monitoring, allowing for real-time adjustments and proactive problem-solving (Prasad, 2023). IoT devices such as RFID tags and drones can deter theft and vandalism on construction sites, thereby preventing project delays and cost overruns. The use of these technologies enhances security measures, ensuring that valuable materials and equipment are safeguarded (Newton, 2023).

Wearable IoT technology can monitor the movement and health of workers, reducing accidents and ensuring a safer work environment. By tracking vital signs and environmental conditions, IoT can alert workers and supervisors to potential hazards, thus improving overall site safety (Mirkowski, 2021). Effective resource management on construction sites can be achieved using RFID and GPS, ensuring optimal utilisation and maintenance of materials and

equipment. This leads to better inventory management and reduced wastage, contributing to more sustainable construction practices (Kadam and Patil, 2013). IoT technologies like 3D models, VR, BIM, and digital twins can improve project management by providing real-time data, detecting errors, minimising costs, and enhancing quality. These technologies enable precise planning and execution, thereby increasing the likelihood of project success (Ibrahim, Esa and Rahman, 2021).

Research highlights both the potential and limitations of IoT in the Malaysian construction industry. Mahmud, Assan and Islam (2018) acknowledge industry awareness of IoT applications but also note a lack of skilled personnel to operate these technologies effectively, which hinders wider implementation. While the Malaysian government actively promotes IoT adoption through training initiatives led by the Public Works Department (PWD) and the Construction Industry Development Board (CIDB) (Ibrahim, Esa and Kamal, 2019), progress remains uneven. For instance, BIM has been mandated for large public projects since 2007 (Othman *et al.*, 2021), but some companies still rely on traditional methods like manual material tracking (Kasim *et al.*, 2019).

Challenges to IoT in construction

Several challenges impede the implementation of IoT in construction. High initial and maintenance costs deter organisations from experimenting with IoT, especially given the uncertain benefits (Solanki, Jain and Gaur, 2022). The financial barrier is particularly significant in an industry already characterised by tight budgets and low margins. Additionally, IoT requires professionals with specific skills to develop, manage, and maintain devices, sensors, and networks. Currently, the demand for such skilled personnel exceeds supply, although this gap is expected to narrow as more individuals acquire the necessary expertise (Nalioglu, Tokdemir and Artan, 2023).

Energy consumption is another critical issue. IoT applications often require significant energy, leading to increased costs and the need for frequent battery replacements (Lawal and Rafsanjani, 2022). This challenge is exacerbated by the construction industry's inherent need for mobility and flexibility, which can make consistent power supply difficult. Ensuring data security and privacy is also crucial for IoT's success in construction. Without assurance on these fronts, companies may be reluctant to adopt IoT, fearing data breaches and other cybersecurity threats (Madanayake, Seidu and Young, 2020). Finally, the vast amount of data generated by IoT makes it challenging to analyse accurately using traditional methods. Faulty devices can also lead to data inaccuracies, complicating decision-making processes (Byabazaire, O'Hare and Delaney, 2020).

Adoption of IoT in Malaysian construction industry

Despite significant contributions to the national GDP, Malaysia's construction industry lags in adopting new technologies like IoT, creating a critical gap for maintaining competitiveness in a rapidly evolving global market (Abdulaziz *et al.*, 2023). The Malaysian IoT Strategic Roadmap

identifies three primary components: connected devices, connectivity and infrastructure, and analytics and apps (MIMOS Berhad, 2015). These components enable devices to interconnect through a network and utilise sensors for performance detection and wear and tear indicators.

The adoption of IoT in Malaysia's construction industry presents significant opportunities and challenges. While the potential benefits in site monitoring, security, health and safety, resource management, and project management are substantial, barriers such as high costs, skill shortages, energy consumption, security concerns, and data accuracy must be addressed. This literature review identifies a research gap in understanding the implementation of IoT in the Malaysian construction industry. To help achieve the set aim, the study will investigate three objectives: exploring the awareness, challenges, and benefits of IoT among industry personnel. By addressing these objectives, this research can provide valuable insights and strategies for enhancing IoT adoption in Malaysia's construction sector, ultimately contributing to its digital transformation and global competitiveness

RESEARCH METHOD

To achieve the set aim and objectives the research adopts a quantitative research strategy following Bryman, (2016). The quantitative research strategy was deemed appropriate for this study as it offers subjective results (Creswell and Creswell, 2018) which are independent of the researcher's opinions. To overcome the shortcomings of this strategy in providing detailed interpretations (Saunders, Lewis and Thornhill, 2019), a comprehensive literature review is used for comparison with the findings.

To gather data from Malaysian construction industry (MCI) personnel, a closed-ended questionnaire survey was employed. The survey was divided into two sections. The first section focused on collecting demographic data from respondents, while the second section addressed the research objectives outlined previously. Questionnaires were designed by adapting factors identified in relevant literature to the specific context of this study

Purposive random sampling technique was used to select the respondents for the questionnaire. This technique was used as it allowed the researcher to approach respondents deemed knowledgeable about the subject in question (Trochim and Donnelly, 2006). The questionnaire survey was distributed to 100 respondents, and a total of 52 were received an equivalence of 52%. This response rate compares favourably with the average response rate reported in similar studies within the field and according to studies by Akinci and Saunders (2015) and Baruch and Holtom (2008) a response of between 35% and 55 % is considered realistic.

Data collected from the selected sample size was analysed using the Relative Importance Index (RII), in which charts and tables will be used to present the interpreted data. RII is a statistical measure used to assess the relative significance of factors or variables based on respondents' perceptions (Tholibon *et al.*, 2021). It offers a numerical value for the importance

of each factor, enabling objective analysis. The Relative Importance Index (RII) is calculated using the following formula:

$$RII = \frac{1}{5} \times \frac{\sum_1^5 FiRi}{\sum_1^5 Fi} \times 100$$

where RII – is the average weighted perceived significance; Ri –is the response type on the Likert scale, 'i' ranging from 1 to 5 on the Likert scale; Fi – is the frequency or total number of respondents choosing response type 'i' on the Likert scale, with 'i' ranging from 1 to 5 as earlier described.

RESEARCH RESULTS

This section presents the findings of the study based on the survey conducted among professionals in the Malaysian construction industry. The results are analysed to understand the current state of IoT awareness, perceived benefits, and the barriers to its adoption.

Awareness of IoT in Malaysia's construction industry

To explore the respondents' awareness of IoT, they were asked to choose between 'Yes' and 'No' on whether they had heard of IoT in the construction industry. The results, as seen in Figure 1, revealed that 96.15% were aware of IoT while only 3.85% were not.

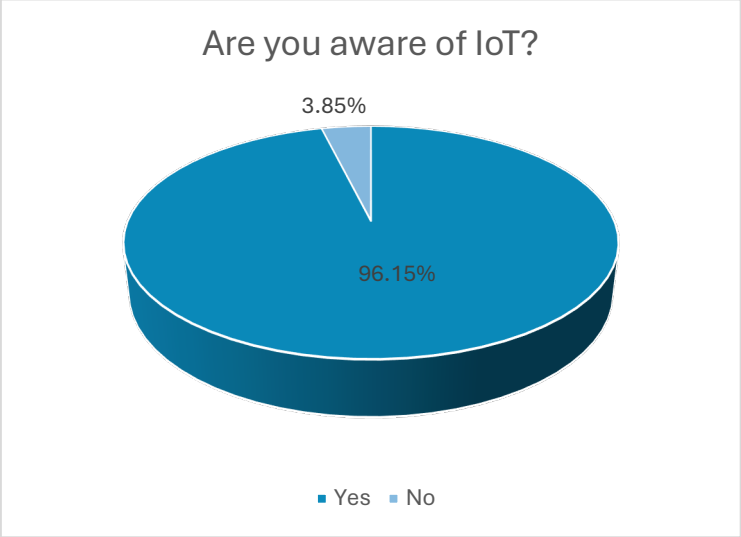

Figure 1. Awareness of IoT

IoT Technologies

To identify the awareness of IoT technologies or devices in the construction industry, the respondents were asked to rank the given technologies between 1 and 5, with 5 being the most significant. Using the Relative Importance Index (RII), seen in Table 1, 'Drones' was revealed as the most significant technology of IoT, followed by 'Big data' and then 'RFID'.

Table 1. IoT technologies

IoT Technologies/ Devices	Ranking					Response count	RII (%)	Rank
	1	2	3	4	5			
Drones	0	1	4	36	11	52	81.92	1
Big Data	0	2	26	22	2	52	69.23	2
RFID	2	13	25	8	4	52	59.62	3
AR &VR	10	19	14	5	4	52	50.00	4
Wearable Technology	17	15	11	8	1	52	45.00	5

Implementation of IoT in Malaysia's Construction Industry

Asked whether they have used any of the IoT devices in their projects, 37 (71.2%) chose no that they had not used them while 15 (28.8%) chose yes that they had used them before.

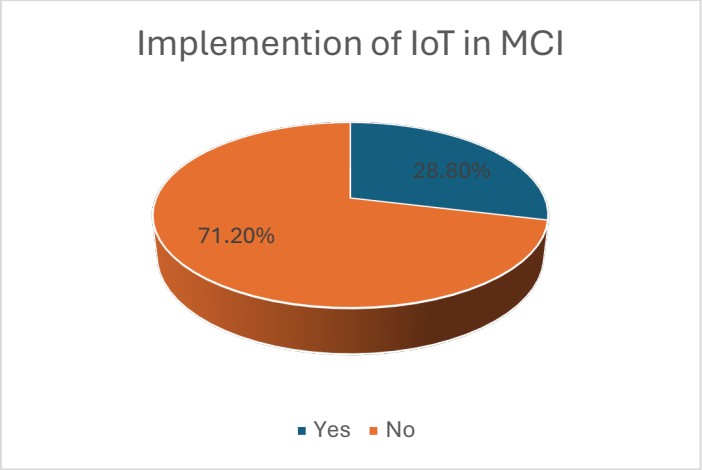

Figure 2. Implementation of IoT in MCI

Benefits of IoT in Malaysian construction industry

To investigate the benefits of IoT in the Malaysian construction industry, the respondents were asked to rank the given benefits between 1 to 5, with 5 being the most significant. Using the Relative Importance Index (RII), seen in Table 2, 'construction progress monitoring' was revealed as the most significant benefit of IoT, followed by 'health and safety' and then 'security control.'

Table 2. Benefits of IoT in MCI

Benefits	Ranking					Response Count	RII (%)	Rank
	1	2	3	4	5			
Construction progress monitoring	1	0	4	29	18	52	84.23	1
Health and Safety	0	2	10	31	9	52	78.08	2
Security control	1	4	12	24	11	52	75.38	3
Project management	0	3	25	15	9	52	71.54	4
Resource management	0	5	23	17	7	52	70.00	5

Barriers impeding the implementation of IoT.

To identify the barriers impeding the implementation of IoT in the Malaysian construction industry, the respondents were asked to rank the given barriers between 1 to 5, with 5 being the most significant. Using the Relative Importance Index (RII), seen in Table 4, 'implementation cost' was revealed as the most significant barrier impeding the implementation of IoT, followed by 'lack of expertise' and then 'security to privacy.'

Table 3. Barriers to implementation of IoT in MCI

Barriers	Ranks					Response count	RII (%)	Rank
	1	2	3	4	5			
Implementation cost	1	0	5	26	20	52	84.62	1
Lack of expertise	1	1	12	33	5	52	75.38	2
Security and privacy	1	4	22	22	3	52	68.46	3
Accuracy of data	2	13	18	15	4	52	62.31	4
Energy consumption	7	24	8	8	5	52	52.31	5

DISCUSSION

The data analysed shows that most of the respondents are aware of IoT in the MCI. Despite this, it was revealed that the majority were yet to implement IoT in their projects. This aligns with Abbas (2023) that although the potential of IoT is known, its uptake in the MCI is still slower than desired. Drones, Big Data, and RFID were revealed as the main IoT technologies or devices familiar to MCI professionals, which aligns with Friess and Vermesan (2022)

Construction progress monitoring was revealed as the key benefit of IoT by MCI professionals which meant they perceived it would help in their monitoring of the construction site activities as seen by Engineering New Zealand (2022). The next key benefit revealed was health and safety, which according to Prasad (2023) the incorporation of IoT will improve health and safety in construction sites by collecting real-time data on personnel and equipment movement therefore mitigating the risks. Security control was another key benefit realised from the analysis which according to Mahmud, Assan and Islam (2018), the use of IoT will improve security against site thefts and vandalism in construction sites.

The key barriers impeding the implementation of IoT in the MCI were realised to be implementation cost, lack of expertise and security and privacy. Ang (2019) agrees with the implementation cost, by eluding that organisations need enough finances to afford the high initial cost of IoT technology and devices followed by recurring maintenance costs. Mahmud, Assan and Islam (2018) point out that the IoT in Malaysia is still in its infant stages, thus a lack of expertise and knowledge in the industry and there is a need for assurance on the security and privacy of IoT technologies.

To overcome the barriers identified, Government initiatives are suggested, such as developing policies and master plans like the National Internet of Things (IoT) Strategic Roadmap (MIMOS

Berhad, 2015) which was instrumental in bringing awareness, however, awareness does not usually translate to implementations, therefore, there is a need to encourage implementation. The government can consider giving subsidies or tax incentives to encourage the use of IoT in the industry. Investing in technology integration is another potential strategy that can help facilitate IoT adoption in the MCI.

In general, most of the respondents are aware of IoT and its benefits, they are also in support of its implementation in the MCI. The findings indicate that IoT has the potential for extensive implementation due to its appreciation by professionals in the industry. This correlates with what is existing in the literature. Its adoption in the MCI can improve performance, efficiency and production by giving real-time and quick access to data. However, the barriers that impede IoT, realised by the respondents must be addressed for its successful implementation.

CONCLUSION

This research looked to investigate the implementation of the Internet of Things (IoT) in the Malaysian construction industry. It investigated the awareness, challenges and benefits of IoT among industry personnel. The study revealed that despite the majority being aware of IoT in the MCI, its implementation is still lacking. It was realised that drones, Big Data, and RFID were the most common IoT technologies or devices familiar to MCI professionals. Construction progress monitoring, health and Safety and security control were revealed as the key benefits of IoT by MCI professionals.

The key barriers that impede the implementation were revealed to be Implementation cost, lack of expertise and security and privacy. To overcome these barriers government initiatives are suggested which will look at creating policies which will facilitate the implementation of IoT. Additionally, investing in technology and providing subsidies and tax incentives can help overcome the barriers and encourage IoT implementation. The implementation of IoT in the Malaysian construction industry although still in its infant stage, can be appreciated as its awareness and benefits are well known among the industry professionals which can be perceived as a good indicator for its future adoption.

A key limitation of this study is the reliance on a quantitative research strategy. Although it is significant, reliable, and valid, it neglects the richness of qualitative data that could provide a deeper understanding of the underlying reasons and interpretations behind these perceptions. Additionally, the sample size may not fully capture the diverse perspectives of the entire Malaysian construction industry, potentially limiting the generalisation of the findings. Future research could explore incorporating qualitative methods to complement the quantitative data and consider employing a larger, more representative sample to enhance the generalisability of the results.

Further study is recommended to investigate the causes of MCI professionals' reluctance to adopt IoT technologies and provide mitigations on encouragement of its implementation. Qualitative research is also recommended to gain more depth and expand on this study. Also, further in-depth research to investigate how the barriers revealed in this study can be addressed is recommended.

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