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Integrating Emerging Technologies in Construction: Exploring Industry Awareness and Adoption

Shaza Rina Sahamir[1]*, Raja Rafidah Raja Muhd Rooshdi[1], Noor Akmal Adillah Ismail[1], Mohd Arif Marhani[1]

[1] *School of Construction and Quantity Surveying, College of Built Environment, Universiti Teknologi MARA, Shah Alam, 40450, MALAYSIA*

*Corresponding Author: shaza_rina@uitm.edu.my
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Abstract

The construction industry is undergoing significant transformation due to the integration of emerging technologies. However, awareness and adoption of these technologies may be limited, preventing broader application and full potential. A lack of adequate knowledge hinders the industry's ability to harness these technologies for improving construction processes. This study aims to assess the awareness and adoption of emerging technologies among key players in the construction industry. By identifying which technologies are well-known and which remain unfamiliar, the research seeks to analyze the most prevalent and widely recognized emerging technologies in the construction industry. A quantitative research approach was employed, using a probability sampling technique. A total of 120 questionnaires were distributed to participants within the construction industry, with 75 responses returned and analyzed. The data were summarized using nominal and interval scales and analyzed through frequency and descriptive analysis. The findings reveal significant variation in the awareness of emerging technologies among respondents. Technologies such as Drones, Building Information Modeling (BIM), and Radio Frequency Identification (RFID) are among the most recognized, reflecting higher levels of familiarity within the industry. Conversely, technologies like Blockchain and Digital Twin are less well-known, indicating a gap in awareness. Overall, the study finds that respondents' knowledge of emerging technologies is predominantly at a basic to average level, with limited advanced understanding. By focusing on increasing awareness of lesser-known technologies and enhancing overall technological literacy, the construction industry can better leverage emerging technologies to improve practices and performances.

1. Introduction

The construction industry, long considered a cornerstone of global economic development, is undergoing a transformative phase driven by the adoption of emerging technologies. Traditional construction processes, while reliable, often face challenges related to inefficiency, labor shortages, and safety risks. The rapid advancements in digital tools such as Building Information Modeling (BIM), Artificial Intelligence (AI), the Internet of Things (IoT), robotics, and 3D printing offer innovative solutions to these persistent issues.

Integrating these technologies promises not only to enhance productivity but also to redefine how projects are designed, built, and maintained. By improving decision-making, optimizing resource utilization, and reducing environmental impacts, emerging technologies provide a pathway for the construction industry to meet growing global demands while adhering to sustainable practices.

However, the integration of these technologies presents both opportunities and challenges. Aghimien et al., (2022) discovered that people-related factors necessary for advancing construction digitalization can be categorized into the technical capacity of staff, attracting and retaining digital talent, and the organization's digital culture supported by strong reliability, validity, and model fit indices. Additionally, industry must overcome barriers such as high implementation costs, resistance to change, skill gaps, and data security concerns. Gambatese (2011) claims that while some technological advances spread quickly throughout the construction sector, others take much longer to catch up or are never adopted. Understanding the awareness and knowledge for application such technologies within the construction sector offers suggestions for enhancing the innovation process. Singh (2020) presents a thorough examination of new technological developments in the building sector. The research discusses energy-efficient technology, drones, smart materials, and prefabricated and modular technologies to spur innovation in building processes.

The use of technology in the building industry, however, is undoubtedly extending. In Malaysia, there is a notable lack of awareness regarding emerging technologies. Despite the rapid global advancement in fields such as artificial intelligence, blockchain, and the Internet of Things (IoT), many individuals and organizations remain unfamiliar with these innovations. Thus, the objective of this study is to assess the levels of awareness and adoption of emerging technologies among key players in the construction industry.

2. Literature Review

The most significant challenge is defining what constitutes an emerging technology. Many technologists use the heuristic that an "emerging technology" is one that is nearing widespread adoption. Typically, a new technology with an adoption rate of no more than 30% is emerging (Cervone, 2010). Table 1 outlines the definition of emerging technologies.

Table 1 *Summary definition of emerging technologies*

Definition of Emerging Technologies	Author, Year of Publication
Emerging technology is a technology that is close to being adopted.	Cervone, 2010
Emerging Technology (ET) doesn't have a set, finite lifespan.	Halaweh, 2013
Are inventions that meet a user demand since they are still in the development stage and are not yet widely used.	Hayman, 2015
Quickly developing digital technologies	Hamalainen, 2022
Improve the overall and competitive performance of industries.	Hajirasouli, 2022

Technology is classified as emerging in a certain sector, location, or application, but it can also become established in other contexts. When a certain technology is not widely used, it is often referred to as emerging technology. Emerging Technology (ET) does not have a set, finite lifespan. When technological advancement drastically alters business, an industry, or society, it is said to be emerging (Halaweh, 2013).

The construction industry is increasingly adopting a range of emerging technologies that enhance various aspects of project management and execution. The following discussion is some key technologies and their applications.

Building Information Modeling (BIM) is a digital representation that includes data, 3D models, and project-related information. BIM facilitates improved project visualization, clash detection, and collaboration among project teams. By using digital simulations and models, teams can discuss and implement safety plans more effectively (Azhar, 2013).

Augmented Reality (AR) has a well-established history in the Architecture, Engineering, and Construction (AEC) sector. AR technology benefits multiple stakeholders throughout the building lifecycle by overlaying digital information onto the physical world, aiding in design visualization, project coordination, and maintenance (Piroozfar et al., 2018).

Virtual Reality (VR) is utilized for project collaboration, allowing stakeholders to identify potential conflicts and issues early in the design phase. This early detection helps minimize rework and costly construction errors, improving overall project outcomes (Song, 2020).

Artificial Intelligence (AI) is applied in various areas such as project scheduling, risk analysis, and preventive maintenance. AI aims to perform tasks that typically require human intelligence, leveraging technologies like machine learning, knowledge-based systems, robotics, and optimization to enhance construction processes (Dobrucali et al., 2022).

Drones (Unmanned Aerial Vehicles - UAVs), are employed for tasks such as surveying, inspection, and monitoring. These advanced technologies provide a range of benefits, including increased efficiency and accuracy in data collection, and can help streamline construction operations (Dastgheibifard, 2018).

The construction industry is increasingly incorporating automation and robotics to perform repetitive tasks, boost productivity, and improve safety. Examples include robotic bricklayers, autonomous machinery, and 3D printing robots. These technologies address challenges related to productivity, quality, safety, and labor shortages (Kumar et al., 2008).

The Internet of Things (IoT) has applications across various industries, with emerging uses in the construction sector. IoT technologies are applied in areas such as Building Information Modeling, construction management, remote monitoring, and tool tracking, offering enhanced data collection and analysis capabilities (Gamil et al., 2020; Oke, 2021). Table 2 provides a summary of all the emerging technologies available for use in the construction sector.

Table 2 *Summary of common types of emerging technologies in the construction industry*

No.	Emerging Technologies	Author, Year of Publication	No.	Emerging Technologies	Author, Year of Publication
1	Building Information Modelling (BIM)	Azhar, 2013	10	Smart Machinery	Sachs, 2012
		Smithwick, 2014			Tsai, 2021
		Xu, 2014	11	Wearable Technology	Awolusi, 2018
2	Augmented Reality (AR)	Piroozfar, 2018			Choi, 2017
		Dobrucali, 2022	12	Digital Twin	Sacks, 2020
3	Virtual Reality (VR)	Song, 2022			Madubuike, 2022
		Lee, 2018	13	Blockchain	Perera, 2020
4	Artificial Intelligence (AI)	Dobrucali, 2022			Mahmudnia, 2022
		Forcael, 2020	14	4D Simulation	Golpavar-Fard, 2009
5	Drones	Dastgheibifard, 2018			Hsieh, 2006
		Liang et al., 2023	15	3D Printing	Hossain, 2020
6	Robotics and Automation	Forcael, 2020			Pan, 2021
		Kumar, 2008	16	3D Laser Scanner	Nguyen, 2020
7	Internet of Things (IoT)	Forcael, 2020			El-Omari, 2008
		Gamil, 2020	17	Radio Frequency Identification Devices (RFIDs)	Ergen, 2007
		Oke, 2021			Kereri, 2019
8	Prefabrication and Modular Construction	Faiz Musa, 2016			Lu, 2011
		Pan, 2018	18	Network Camera	Bohn, 2009
9	Sustainable Technologies	Vanegas, 2014			Zhang, 2018
		Tam, 2020	19	Digital Signage	Li, 2020
					Tyukov, 2013

The exploration of emerging technologies in the construction industry reveals a diverse array of innovations enhancing various aspects of project management and execution. The ongoing advancement and integration of these technologies promise to revolutionize construction practices, highlighting the need for continued exploration and adaptation within the industry.

3. Methodology

The research methodology for this study involves the use of primary data collection through a quantitative research method. Quantitative methods are particularly suited for studies that aim to gather objective, numerical data that can be analyzed statistically to answer research questions. As noted by Apuke (2002), the quantitative approach is essential for collecting and analyzing numerical data to provide insights into questions such as "who," "how much," "what," "where," "when," "how many," and "how." This method allows research to explore patterns, trends, and relationships within the data.

In this study, 120 questionnaires were distributed to participants, and 75 were returned, resulting in a 63% response rate. This response rate is considered appropriate for the study, ensuring sufficient data to draw valid conclusions. The questionnaire used is structured, focusing on closed-ended questions to gather data on key variables such as respondents' employment sector, years of experience in construction, and type of construction organization. The closed-ended format is particularly useful for quantitative research as it allows for easy coding and statistical analysis.

The data collected from the returned questionnaires was analyzed using statistical techniques with the help of SPSS software. This tool enabled the identification of trends and relationships between variables by performing descriptive statistical analyses, allowing for a comprehensive interpretation of the dataset. These analyses aim to provide a comprehensive understanding of the respondents' professional background and insights.

This study adopts a random sampling approach to gather data from construction professionals on their perspectives and experiences with emerging technology in the industry. To create distinct sections, the sample was divided based on key characteristics expected to impact the views on technology adoption, including:

i. Job Role: Project managers, engineers, quantity surveyors, and site supervisors each have unique responsibilities and varying levels of interaction with new technologies.
ii. Years of Experience: Categories of experience (e.g., 1–5 years, 6–10 years, and over 10 years) were used to capture the perspectives of early-career professionals, mid-career professionals, and seasoned experts.
iii. Company Types: Professionals were grouped by the types of their firms (contractors, developers, consultants, etc), as technology adoption rates and resources differ significantly across firm types.

To develop the sampling frame, a list of professionals in relevant construction roles was sourced from industry directories, professional associations, and networks. The population was then segmented by organization, and a random sample was selected from each group to form the final sample of 120 respondents. Subsequently, a random number generator was used to randomly select 120 individuals from the entire list.

By using this method, the study can ensure that different perspectives, particularly those that might be influenced by employment sector or experience level, are captured adequately. This would make the data more reliable and reflective of the entire population of interest.

4. Results and Discussion

The analysis of the survey data reflects a solid response rate. Out of 120 surveys distributed, 75 were returned, which constitutes a 63% response rate. According to Story (2019), an effective survey requires a minimum response rate of 40% to ensure the reliability of the data. In this context, a 63% response rate is not only appropriate but exceeds the benchmark, which suggests that the findings derived from this sample are likely to be both valid and representative.

The response rate is a critical factor in survey research, as it directly impacts the reliability and generalizability of the results. The higher the response rate, the less likelihood there is of response bias, which occurs when the characteristics of those who respond differ from those who do not. Given the 63% response rate, the potential for significant bias in this study is minimized, providing confidence in the integrity of the data collected.

Moreover, Story (2019) emphasizes the importance of accuracy in survey results, recommending a margin of error of 5% or less for the data to be considered trustworthy. While this analysis does not provide explicit information about the margin of error, the sample size of 75 respondents is likely large enough to produce reliable estimates with a low margin of error, especially for general research purposes. As a result, the study aligns well with the best practices outlined for effective survey research.

Table 3 presents the key respondents' profile, will further aid in understanding the demographics or characteristics of the sample, adding depth to the analysis. A well-represented respondent profile ensures that the survey results accurately reflect the population being studied and supports the conclusions drawn from the data.

Table 3 *Respondents key profile*

Key items	Frequency	Percent
Respondents’ employment sector		
Private sector	62	82.7
Public sector	13	17.3
Respondents’ Years of Experience in Construction		
Less than 5 years	47	62.7
6-10 years	18	24.0
11-15 years	7	9.3
16-20 years	2	2.7
21 years above	1	1.3
Respondents’ construction organization		
Developers	11	14.7
Main contractors	31	41.3
Subcontractors	9	12.0
Construction management consultants	5	6.7
Suppliers	5	6.7
Consultants (Engineers, Architects & etc.	14	18.7

The survey reveals that most respondents (82.7%) work in the private sector, with only 17.3% employed in the public sector. This strong representation from the private sector could suggest that the issues and challenges faced by private sector professionals may dominate the study’s findings. Given that the private sector is often more competitive and project-driven, the insights provided by these respondents may highlight specific concerns such as cost efficiency, project timelines, and profit margins. Conversely, the smaller public sector representation may limit the generalizability of findings concerning government-run or public construction projects.

In terms of years of experience, the largest group (62.7%) consists of respondents with less than 5 years of experience in construction. This suggests that the study captures the perspectives of relatively new professionals in the field, who may be more familiar with current technologies and modern challenges in the construction industry. However, it also means that more seasoned viewpoints could be underrepresented. Only 1.3% of respondents have over 21 years of experience, which may limit the study's ability to reflect long-term industry trends or lessons learned from extensive careers.

A smaller but significant proportion of respondents (24%) have 6-10 years of experience, and the remaining have more than 10 years of experience, constituting 15.3%. This diversity in experience levels adds value to the study, allowing the data to reflect a range of perspectives, from newcomers to those with more established industry careers.

Respondents come from a variety of construction organizations, which provide a broad view of the industry. The largest group (41.3%) represents the main contractors, followed by consultants (18.7%), and developers (14.7%). The dominant representation from main contractors suggests that issues related to project management, execution, and coordination on-site are likely to be a major focus of the responses. Smaller groups include subcontractors (12%), suppliers (6.7%), and construction management consultants (6.7%), adding to the diversity of roles within the construction ecosystem. However, the lower representation of these groups may mean their specific concerns, such as subcontractor challenges with tight schedules or supplier issues related to materials procurement, may be less prominent in the overall analysis.

The distribution of respondents by employment sector, years of experience, and type of construction organization offers a comprehensive view of the industry, particularly from the perspective of private sector professionals and main contractors with less than 5 years of experience. While the strong focus on these groups provides valuable insights into contemporary practices and challenges, the underrepresentation of public sector employees and highly experienced professionals could limit the breadth of the study’s conclusions.

4.1 Overview of Respondents Organizations' Scope of Works (Field)

The survey results indicate a diverse scope of work among the respondents' organizations, with a clear emphasis on construction activities. Fig.1 examines the scope of works for organizations based on survey responses. The data provides a distribution of activities across various categories, reflecting the areas in which these respondents’ organizations are involved.

This distribution illustrates a comprehensive approach to managing and developing infrastructure, balancing new construction with maintenance, consulting, and upgrading efforts to ensure a well-rounded service offering. Emerging technologies are crucial and likely used to enhance these diverse work areas, helping the construction industry to be managed more efficiently.

The dominant category is construction, with 30% of respondents engaged in this area. This significant proportion indicates that construction is a major focus in responding to the survey. This could encompass a wide range of activities including residential, commercial, and industrial construction projects. The high percentage suggests that these organizations are heavily involved in building new structures, which likely involves substantial investment in resources, labor, and project management. The prominence of construction activities points to a robust demand for new developments and infrastructure projects in the sector.

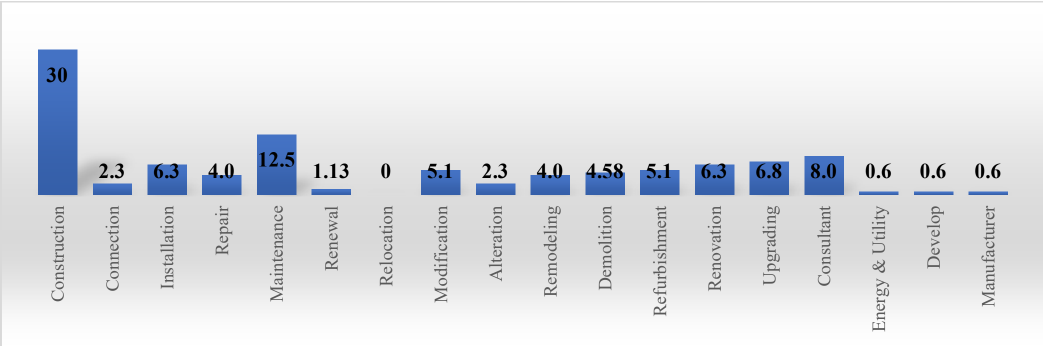

Fig. 1 *Organisations' scope of works*

Maintenance activities account for 12.5% of the organizations' work. Maintenance is crucial for the upkeep and repair of existing facilities and infrastructure. This includes routine servicing, preventive maintenance, and corrective repairs. The percentage reflects the essential nature of maintenance in ensuring that structures and systems remain operational and safe over time. Although maintenance represents a smaller share compared to construction, it is vital for extending the life of assets and minimizing downtime.

Consultancy constitutes 8% of the activities reported. This category involves providing expert advice, strategic planning, and specialized knowledge to support construction and infrastructure projects. Consultancy services may include project management, engineering solutions, and regulatory compliance. The 8% allocation indicates that while consultancy is a specialized service, it is a significant component of the organizations' offerings, contributing to project efficiency and success.

Upgrading works make up 6.8% of the organizations' scope. Upgrading involves enhancing or modernizing existing facilities and infrastructure to improve performance, efficiency, or capacity. This can include technological upgrades, expansion of facilities, or improvements in building systems. The percentage reflects a focused effort on improving existing assets, which is crucial for adapting to new standards and extending the functional life of infrastructure.

The remaining portion, categorized as others, includes various activities not specifically detailed in the main categories. This may encompass niche services, administrative support, or additional functions relevant to the organizations' overall operations. While this category is less defined, it highlights the diverse range of activities that support the core functions of construction activities. It reflects the variety of additional services and functions that complement the primary areas of focus.

4.2 Respondents' Understanding Level

Understanding how familiar respondents are with the latest technological advancements helps inform educational, training, and policy decisions aimed at bridging knowledge gaps. The data consists of 75 respondents classified into five levels of knowledge: Very Poor, Poor, Average, Good, and Excellent. The frequency and percentage distributions are shown in Table 4.

Table 4 *Level of respondent's knowledge in emerging technology*

Level of knowledge	Frequency	Percent
Very poor	19	25.3
Poor	16	21.3
Average	26	34.7
Good	12	16.0
Excellent	2	2.7
Total	75	100.0

4.2.1 Majority of Respondents Have Limited Knowledge

Most respondents fall into the lower levels of knowledge (Very Poor, Poor, and Average), accounting for 81.3% of the total sample. Specifically, 25.3% of respondents rate their knowledge as Very Poor, while 21.3% consider it Poor. 34.7% of respondents rate their knowledge as Average, indicating that while some are familiar with emerging technologies, they do not perceive themselves as highly proficient.

4.2.2 Low Percentage of High-Level Knowledge

Only 2.7% of respondents classify themselves as having Excellent knowledge of emerging technology, and 16.0% consider themselves to have a good understanding. These figures suggest a small group that is confident in their knowledge of emerging technology, but it is significantly outnumbered by those with less knowledge.

The data suggests a significant knowledge gap, with nearly half of respondents (46.6%) rating their knowledge as either Poor or Very Poor. This presents an opportunity for targeted interventions such as training programs, educational resources, or awareness campaigns.

Training and Education: Given that most respondents have limited knowledge in emerging technology, targeted educational initiatives are crucial. Training programs could focus on increasing awareness and practical skills related to emerging technologies to enhance respondents' competencies.

Organizational Strategies: Organizations and institutions should assess the technological awareness and readiness of their workforce. Regular upskilling efforts should be considered, especially in sectors where technological literacy is a key driver of success.

Technological Advancements: As emerging technologies continue to play a vital role across industries, understanding the knowledge distribution within a population can help guide strategic decisions in technology adoption, workforce training, and innovation policies.

4.3 Respondents' Awareness Level

This section examines the awareness levels of respondents regarding various emerging technologies, specifically focusing on their familiarity or knowledge of each technology. It provides insights into how familiar different organizations are with these technologies. Table 5 presents the varying levels of awareness of emerging technologies as indicated by respondents' selections.

Table 5 *Descriptive statistics on awareness in type of emerging technologies*

Item	Type of Emerging Technologies	Minimum	Maximum	Mean	Rank
1	Drones	1.00	5.00	3.7681	1
2	BIM (Building Information Modeling)	1.00	5.00	3.7639	2
3	RFID (Radio Frequency Identification)	1.00	5.00	3.6957	3
4	Digital Signage	1.00	5.00	3.5797	4
5	AI (Artificial Intelligence)	1.00	5.00	3.5224	5
6	3D Printing	1.00	5.00	3.4412	6
7	Network Camera	1.00	5.00	3.3913	7
8	Sustainable Technologies	1.00	5.00	3.3824	8
9	Internet of Things (IoT)	1.00	5.00	3.3382	9
10	Robotics & Automation	1.00	5.00	3.2687	10

Item	Type of Emerging Technologies	Minimum	Maximum	Mean	Rank
11	Prefabrication & Modular Construction	1.00	5.00	3.2647	11
12	3D Laser Scanner	1.00	5.00	3.2319	12
13	Virtual Reality (VR)	1.00	5.00	3.2090	13
14	Smart Machinery	1.00	5.00	3.2029	14
15	4D Simulation	1.00	5.00	3.1159	15
16	Wearable Technologies	1.00	5.00	3.0294	16
17	Augmented Reality (AR)	1.00	5.00	2.9242	17
18	Blockchain	1.00	5.00	2.6429	18
19	Digital Twin	1.00	5.00	2.4783	19

4.3.1 High Awareness Technologies

Drones are the technology with the highest mean score (3.7681), indicating that respondents are most familiar with this technology. BIM (Building Information Modeling) ranks closely behind Drones with a mean score of 3.7639. This technology is widely used in construction and architecture, which may explain its higher awareness. RFID (Radio Frequency Identification) also ranks high with a mean score of 3.6957, showing that respondents are relatively knowledgeable about this technology.

4.3.2 Moderate Awareness Technologies

Technologies such as Digital Signage (3.5797), AI (Artificial Intelligence) (3.5224), and 3D Printing (3.4412) fall into the middle range of awareness. These are rapidly growing technologies, and the moderate level of awareness suggests respondents are familiar but not highly knowledgeable. IoT (Internet of Things), with a mean of 3.3382, is an important technology for automation and connectivity. Its moderate awareness suggests that more education may be needed to increase understanding of its practical applications.

4.3.3 Low Awareness Technologies

At the lower end of the awareness scale are emerging technologies such as Blockchain (mean = 2.6429) and Digital Twin (mean = 2.4783), which rank 18th and 19th, respectively. These technologies are still evolving and might not yet be widely adopted or understood by the general population. Augmented Reality (AR) and Wearable Technologies also fall into the low awareness group with mean scores of 2.9242 and 3.0294, respectively, indicating the need for greater awareness efforts for these innovative technologies.

4.3.4 Technology-Specific Insights

Sustainable Technologies and Robotics & Automation have moderate awareness, but as these technologies are critical to future advancements, especially in environmental and industrial sectors, further promotion could help raise awareness. Virtual Reality (VR) and Smart Machinery, though ranking 13th and 14th, have substantial potential across various industries, and increasing knowledge about their use cases might foster better integration into mainstream usage.

4.4 Emerging Technologies Adoption Rate

Table 6 presents a crosstab analysis of drone adoption across different types of organizations within the construction sector. The data is categorized by percentage of drone use, ranging from "Never" to "Always," and provides insights into how various organizations are incorporating drone technology into their operations.

Main contractors demonstrate a relatively high level of engagement with drone technology, with a substantial portion using drones either sometimes, often, or always. This suggests that drones are becoming a valuable tool for main contractors, likely for tasks such as site surveying, monitoring, and inspections.

- Never (2.9%): A small percentage of main contractors report no awareness of or use of drones.
- Rarely (4.3%): A slightly higher proportion rarely utilize drones.
- Sometimes (11.6%): A significant number use drones occasionally.
- Often (11%): A notable percentage frequently employ drones.
- Always (10.1%): A considerable group consistently integrates drones into their operations.

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Table 6 *Crosstab analysis for drones' adoption according to organization*

Count		Drones (%)				
Organization		**1** (Never)	**2** (Rarely)	**3** (Sometimes)	**4** (Often)	**5** (Always)
	Main Contractors	2.9	4.3	11.6	11	10.1
	Subcontractors		4.3	7.2	1.4	1.4
	Construction Management Consultants			2.9	2.9	
	Consultants		1.4	1.4	4	7.2
	Developers			1.4	4.3	7.2
	Suppliers				2.9	2.9

The analysis reveals that main contractors are the most active in adopting drone technology, utilizing it more frequently compared to other organizations. Subcontractors show lower levels of adoption, while consultants and developers are progressively incorporating drones into their practices. Construction management consultants and suppliers have the least involvement with drones, suggesting potential areas for growth or further adoption. Overall, the data indicates a growing awareness and use of drones in the construction sector, with varying levels of integration across different types of organizations.

Table 7 provides a crosstab analysis of Building Information Modeling (BIM) adoption across different types of organizations within the construction sector.

Table 7 *Crosstab analysis for BIM adoption according to organization*

Count		BIM (%)				
Organization		**1** (Never)	**2** (Rarely)	**3** (Sometimes)	**4** (Often)	**5** (Always)
	Main Contractors	5.5	4.1	11.1	12.5	8.3
	Subcontractors	1.4		4.1	4.1	2.7
	Construction Management Consultants			2.7	2.7	
	Consultants		1.4	2.7	5.6	9.7
	Developers			1.4	2.7	9.7
	Suppliers			2.7	1.4	2.7

Main contractors show a relatively high level of engagement with BIM technology, with a substantial proportion using it frequently or always. This suggests that BIM is becoming an integral tool for main contractors, aiding in project planning, design, and coordination.

- Never (5.5%): A small percentage of main contractors report no awareness of the use of BIM.
- Rarely (4.1%): A slightly higher proportion rarely utilize BIM.
- Sometimes (11.1%): A moderate number use BIM occasionally.
- Often (12.5%): A significant percentage use BIM frequently.
- Always (8.3%): A notable group consistently integrates BIM into their projects.

The analysis reveals that main contractors are among the most engaged with BIM technology, utilizing it frequently or always. Consultants and developers also show notable adoption, with many using BIM consistently. Subcontractors and suppliers demonstrate more limited but present use of BIM. Construction management consultants show minimal engagement, suggesting potential areas for increased adoption. Overall, the data indicates a growing awareness and use of BIM across the construction sector, with varying levels of integration depending on the organization type.

5. Conclusion

The analysis indicates that the overall knowledge of emerging technology among respondents is predominantly at a basic to average level. Only a small proportion has advanced knowledge. This highlights the need for concerted efforts to enhance technological literacy to ensure broader understanding and effective use of emerging technologies across different sectors.

The awareness of respondents on emerging technologies varies significantly, with Drones, BIM, and RFID being the most well-known, while technologies like Blockchain and Digital Twin lag. The analysis suggests the need for targeted initiatives to improve understanding and promote adoption of lesser-known technologies, ensuring that individuals and organizations are well-prepared for the rapid advancements in the technology landscape.

By implementing some recommendations (i.e.: support research and development, foster industry collaboration, and others) organizations and individuals can improve their understanding and use of emerging technologies, positioning themselves to better adopt advancements in the rapidly evolving technological landscape.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Shaza Rina, Raja Rafidah;* ***data collection:*** *Shaza Rina;* ***analysis and interpretation of results:*** *Shaza Rina, Noor Akmal Adillah;* ***draft manuscript preparation:*** *Shaza Rina, Mohd Arif. All authors reviewed the results and approved the final version of the manuscript.*

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