DETERMINANTS OF EMERGING TECHNOLOGY ADOPTION FOR SAFETY AMONG CONSTRUCTION BUSINESSES

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ABSTRACT

This study aims to identify the antecedents of emerging technology adoption in construction businesses. The objectives of this study were to identify the determinants and barriers to the adoption of emerging technologies in the construction industry. This study used a descriptive research design, a quantitative research method, and a stratified simple random sampling technique to select contractors registered with the Construction Industry Development Board (CIDB) in the eastern region of Malaysia. Out of the 75 copies of questionnaire distributed to the contractors, only 24 completed and usable responses were received, yielding a response rate of 32 %. Inferential analysis and relative importance index were used to achieve the research objectives. Regarding the first objective, the findings from this research showed that project characteristics would influence the adoption of emerging technology for construction safety. The social-related factor is next to it. The other factors are environmental, technological, and organizational factors. Finally, individual factors had the least influence on adoption. Regarding the second objective of this study, the economic factor is the most influential barrier to adopting emerging technologies for construction safety, followed by personal factors in this trend. Organizational factors and time-related factors are barriers that have the least influence on adoption.

Keywords: Adoption, Construction, Emerging Technologies, Safety, Malaysia.

INTRODUCTION

Safety is not confined to a particular location; it is a significant concern in the global construction industry (Zhou et al., 2012). As a result, the construction industry is repeatedly described as one of the most dangerous industries with a poor safety record. Construction safety studies can be classified into two categories. The first category focuses on studies related to accident cause analysis, safety climate, safety culture, workers' safety perception and competency, behavior-based safety, hazard management, and safety management practices. The second category focuses on the application of emerging technologies for construction safety. The emerging technologies for construction safety include automation, building information modeling (BIM), data mining, geographic information systems (GIS), radio frequency identification (RFID), robotics, sensing technology, wireless networks, and virtual reality.

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Nevertheless, the construction industry lags behind other industries (Andresen, et al., 2000; Gonzalez, et al., 2008). Consequently, researchers have begun to focus on the factors and barriers that prevent industries from catching up with other industries (Mitropoulos and Tatum, 2000). This research complements the existing body of knowledge on the influencing factors and barriers for adopting emerging technologies for construction safety. Furthermore, the research findings will provide insights to policymakers and other construction industry players in enhancing construction safety by adopting emerging technologies. Hence, the objectives of this study are to identify the factors influencing the adoption of emerging technologies for construction safety and to identify the barriers to the adoption of emerging technologies for construction safety.

LITERATURE REVIEW

This section presents a review of the literature. It mainly focuses on the factors that affect emerging technologies in the construction business and the barriers to the adoption of emerging technologies in this sector.

Factors Influencing the Adoption of Emerging Technologies for Construction Safety

Organizational Size

Firm size has a significant impact on the leader or manager in deploying emerging technologies for safety purposes. Ghobakhloo, et al., (2011) state that "Business Size" is definable by turnover or the number of employees, as it can be one of the most critical determinants of new technology adoption. According to Mills, et al., (2014), the larger the firm size of a construction business, the higher the inclination to adopt the technologies will be compared to the smaller ones. This is because small firms with few workers may not feel that it is a priority to focus on safety-based issues (Lippert & Govindarajulu, 2006).

Organizational Culture

Jones et al. (2005) explained that organizational culture has the most supportive climate and flexible structure for approaching new technologies in any organization. When employees perceive their organization's culture as an open system, they can have positive attitudes towards organizational changes if a new technology is deployed. Abdullah, et al. (2014) assert that the strong organizational culture of a company has influence on the attitude of staff towards the adoption of safety technology. A manager might not require it, but staff with strong safety awareness will promote and support the adoption of new technology.

Cost Saving

Implementing emerging technology in each construction industry section reduces extra material costs and hiring of additional unskilled foreign workers (Irrma , et al., 2018; Naqvi et al., 2021). According to Rugiero (2016), adopting robotics and automation can lead to less dependency on foreign workers, and it takes less time to perform complex tasks. In terms of safety, advanced technology facilitates safer construction processes for each worker.

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Construction Time and Work Speed Required

Rugiero (2016), state that the application of emerging technology could take up less time for the construction process and increase work speed, encouraging safety and health among workers. Adopting emerging technologies in the construction business can speed up high accuracy compared to manual monitoring and control among materials, testing, or other phases of the stage without taking time from exposure to outdoor heat stress (Jiang, et al., 2011). According to Taherkhani , et al., (2012), a standard construction process with a safe and healthy environment is encouraged, enabling it to be completed faster without neglecting its quality. Instead of the staff to be in charge of handling any materials or other processes, a controlled pre-fabrication or machine installation is preferable as it maintains and ensures better finishes and quality. Everett (1994) state that automation and robotics could effectively become possible solutions to health and safety issues in construction, and that it can reduce the overexertion injury that occurs during repetitive motion and large forces.

Structural Limitation

Taherkhani, et al., (2012) argue that most companies would adopt emerging technology to improve their multipurpose or objectives, one of which is the complexity of the structural joints and connections of building components. (Mydin, et al., 2014) identified building information modeling (BIM) as an emerging technology in construction that enables efficient data management and improves quality management, safety, effectiveness, and efficiency.

Government New Standards and Regulations

Instead of an organization's ability, government support is essential in policies, attitudes, regulations, and external spending. As mentioned in (Taherkhani, et al., 2012), standards regulations, such as new laws and regulations, health and safety laws, and waste disposal laws, will influence the organization to adopt emerging technology for safety purposes. Abd Shukor , et al., (2011) state that the government has the authority to dedicate more safety practices in the construction industry to conduct inspections and audits. Lippert & Govindarajulu (2006) state that some studies have been conducted. Delmas (2002) suggested that if technical standards of emerging technology need to be adopted, regulations and policies should be involved.

Competitive Advantages

Lippert & Govindarajulu (2006) state that competitive pressure has long been recognized as a determinant and motivator for an organization to deploy emerging technology. If more competitive pressure occurs, it will be a catalyst that would likely facilitate the push to promote the adoption of emerging technology in an organization. Competitive pressure can also be defined as a competitive advantage (Ghazal et al., 2021). To improve safety issues, Aguilar & Hewage (2013) found that IT adoption can improve the safety issues in monitoring modules, which are often in touch with heavy equipment, power tools, and others. The application of RFID tags or barcodes for this construction phase can improve the safety inspection standards. At the same time, some actions are required so as to be aware of and to detect the hazardous gas concentrations. In terms of competitive pressure, safety-based organizations must have the

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capability to implement new strategies based on the organization's strength and ability to respond to opportunities so as to avoid faults that may occur in the future (Preece, 2015).

Effectiveness of Proven Technology

From the TAM, perceived usefulness and ease of use are the key determinants that can influence the adoption decision of a particular technology. The effectiveness and function of a particular technology can be assumed to be a belief dimension that shapes a potential user's attitude and shows the intention to use and purchase (Chuah et al., 2016). In terms of effectiveness, it characterizes a technology that can bring more benefits to a person. In contrast, a person who uses any particular technology will enhance the effectiveness and efficiency of their jobs (Hamid et al., 2016; Nnaji, 2018).

Organizational Innovativeness

According to Perveen & Sulaiman (2008), organizational innovativeness is one characteristic that significantly affects the acceptance or adoption of new technology. An innovative organization is defined as an organization that is relatively quick in adopting innovation in terms of technology than other members. The willingness of an organization to accept and try out new technology can be influenced by organizational factors, such as innovative culture (Noraini, et al., 2016).

Barriers to the Adoption of Emerging Technology in Construction Safety

High Initial Investment Capital

In adopting advanced emerging technology for construction safety, cost-related issues are significant. Adopting it requires a high start-up financial budget for setting up the entire related system, software, or besides this, it can be the operation product. For example, drones can be listed as an emerging technology which can be monitored and controlled by one operator or smart technology, such as self-driving cars and autonomous heavy equipment. As stated in (Borhani, 2016, Zahrizan, et al. 2014), the start-up cost can be called adopters' development and initial costs. There are a variety of cost issues when adopting a technology: during the acceptance of the new techniques, an organization decides to make a change in substituting the old system into the new system, which means stopping an investment of the specific assets, which can be referred to as switching costs and cost of capital. A study on adopting emerging methods in house building in the United Kingdom showed that it was not easy to apply them because of higher capital costs (Pan, et al., 2007). It is concerned with the anxiety of the contractors if it cannot be foreseen on the return of their investments.

Complex Operation

"Complexity for operating or applying" or "difficulty in using" can be explained as one hindrance that impacts the willingness to deploy technology. Most people prefer that the desired outcome be simple, made at a low cost, and be able to perform daily tasks (Parida, 2010). The adoption of a new method of operations is based on the complexity and extent to which safety technology can help reduce the percentage of risks and accidents (Borhani, 2016).

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Lack of Top Management Support/Lack of Financial Support

Leadership and ownership's approach is another barrier that can negatively influence the deployment of advanced and emerging technologies. As top management, their support is significant in assigning resources, providing sufficient financial supply, and training users and operators. If the top management refuses to provide support and resources, a variety of problems might arise in the sustainability of the adopted technology for construction uses and improvement of safety issues (Borhani, 2016). Some companies have been worried about the value of their investment in adopting new technologies to substitute for the old method. Furthermore, additional training chance for the users or any person involved requires financial costs to support the persons to be trained so as to become an expert (Yahya, et al., 2019).

Lack of Knowledge and Incentives

Zahrizan, et al., (2014) found that a lack of knowledge about emerging technology could hinder the implementation of innovative technology because it involves various parties in the construction industry. Many parties are reluctant to use emerging technology, as they believe it is difficult to learn and it increases operating costs. In addition, most traditional old school companies or employers lack knowledge about how emerging technology can provide benefits for the construction process and operation, maintenance phase, and hidden issues within each section of the task (Steward & Mohamed, 2007).

Lack of Experience and Skill

Lack of experience and skill is a barrier that causes an organization to be less confident in adopting new technologies. Organizations must attract and optimize their talent and skills for each related work (Irrma et al., 2010). Furthermore, according to (Eastman et al., 2011) and (Zahrizan et al., 2014), it is difficult to guarantee that each person participating in an organization has the required technology, experience, and skill; therefore, organizations need to consider other expenses for third parties, such as outside technical support groups catering to learning problems that may arise.

METHODOLOGY

This study adopted a descriptive research design, quantitative research method, and simple random sampling to collect data from target respondents. The researchers used the formula (Gill, et al., 2010) to determine the minimum sample size of 75 for this study. The following formula (Gill, et al., 2010) was used to determine the sample size for this study:

$$n = \frac{93\times0.25}{92\times(0.000651)+0.02} = \frac{23.25}{0.309892} \qquad \text{Equation (1)}$$

Where, N=93, p=0.5, B=0.05, C=1.96

$$n = \frac{93\times0.25}{92\times(0.000651)+0.02} = \frac{23.25}{0.309892}$$

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$$= 23.25/0.309892 = 75$$

The target population for this research consists of contracting 93 companies registered in the Construction Industry Development Board of Malaysia (CIDB) located in the eastern region of Malaysia. Respondents were sent copies of the questionnaire with stamped self-addressed envelopes to send back their responses. Seventy-five copies of questionnaire were distributed to the respondents, and 24 completed responses were received, yielding a response rate of 32 %. (Zahrizan , et al., 2014) Note that 30%–40% is the average response rate in the construction industry. Hence, the 32% response rate obtained in this study was considered adequate. The Statistical Package for Social Science (SPSS) version 22 software was used to analyse the data. Descriptive analysis and an important relative index (RII) were performed to achieve the research objectives. Frequency and percentages were used to obtain the respondents' and their companies' profiles in this study. In addition, the mean values were obtained to assess the factors and barriers influencing the adoption of emerging technologies among construction businesses.

RESULTS

Relative Importance Index

This analysis was used to determine the relative importance of each factor and barrier influencing the adoption of emerging technologies for construction safety. Relative index analysis was used to rank the criteria according to their relative importance. In the present study, a five-point scale rating was applied to measure respondents' perceptions, such as those that completed the questionnaire. The Table below shows the relative importance index (RII) based on the 5-point Likert scale shown in Table 1. Descriptive analyses were performed using the SPSS software. The percentages, frequencies, and means were derived by understanding the respondents' profiles.

Table 1
RELATIVE IMPORTANCE INDEX INTERPRETATION BASED ON 5-POINT

Likert Scale	Relative Importance Index	Level of Concern/Agreement
1	0.20	Strongly Disagree
2	0.40	Disagree
3	0.60	Slightly Agree
4	0.80	Agree
5	1.00	Strongly Agree

Table 2 presents the demographics and profiles of the respondents who participated in the survey. In addition, the table presents the frequencies and percentages of each profile in the questionnaire.

Table 2
DEMOGRAPHIC PROFILE OF RESPONDENTS

Respondent's Profile	Frequency	Percentage (%)
Organization's Age		

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Less than 10	4	15.38
10 – 15	8	30.77
16 – 20	5	19.23
More than 20	9	34.62
Grade Level		
Grade5 Contractors	4	15.38
Grade 6 Contractors	13	50
Grade 7 Contractors	9	34.62
Number of Employees		
Less than 50	12	46.15
51– 100	8	30.77
More than 100	5	19.23
Work Experience		
1 – 5	8	30.77
6 – 10	9	34.62
11 – 15	8	30.77
More than 15	1	3.85
Age Range		
20 – 30	7	26.92
31 – 40	15	57.69
41 – 50	3	11.54
More than 50	1	3.85
Technologies Applied		
Wearable Devices	11	42.31
Digital Tech	13	50
Robotic & Automation	18	69.23
Drones or Unmanned Aerial Vehicles	1	3.84
Virtual Reality & Augmented Reality	2	7.69
BIM & IBS	10	38.46
Software Programmed	23	88.46

As shown in Table 2, most of the organizations in operation are more than 20 years (34.62%), followed by organizations in operation between 10 and 15 years (30.77%). Each contractor firm must be registered under the CIDB, which might be under different red levels, such as red 1 to red 7. Three grade levels were selected as the research target, with the highest level being Grade 6 (50.0%), and followed by Grade 7's contractor firm (34.62%). The bar chart shows that the number of employees will be a research determinant for each organization. Most of the respondents are from small-sized organizations, which consisted of fewer than 50 employees supporting the adoption of emerging technologies (46.15%).

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The results from the table show that the work experience of respondents between6 and10 years is approximately 34.62%. However, respondents whose work experiences are between 1and 5 years as well as between 11and15 years amount to 30.77% each. As shown in the table, the highest number of participants in this research is approximately between the ages of 31 and 40(57.69%). Respondents between the age range of 20 and 30 constituted 26.92% of the sample. The percentages of the least number of participants are 3.85% and 11.54%. Results above show that most organizations apply software programs, such as Autocad or new Glodon Software (88.46%). Furthermore, it is followed by robotics and automation, as it is known that there are such operations of machinery despite manual operation (69.23 %).

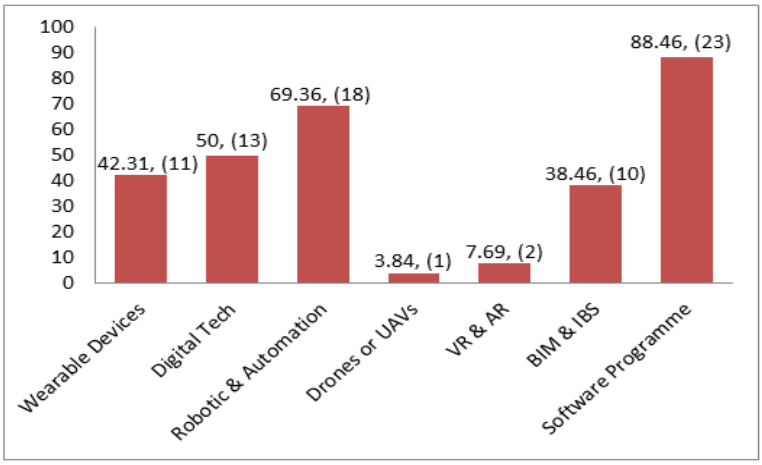

FIGURE 1
TECHNOLOGIES APPLIED

Results of Factors Influencing the Adoption of Emerging Technologies

In Table 3 below, the 20 identified factors are re-grouped into six factors influencing the adoption of emerging technology for construction safety among contractors in the surveyed construction companies. The table shows the average mean and deviation response analysis with the group's ranks of factors influencing the adoption of emerging technology.

Table 3
RANK FOR EACH GROUP

Factors Influencing Adoption of Emerging Technology	Average Mean	Standard Deviation	RII	Rank	Remarks
Project Characteristics	4.04	0.64	0.81	1	Agree
Social Influences	3.86	0.71	0.77	2	Agree
Environmental Attributes	3.69	0.66	0.74	3	Agree
Technological Factors	3.57	0.68	0.70	4	Agree
Organizational Factors	3.50	0.76	0.70	5	Agree
Individual Factors	2.98	0.86	0.60	6	Neutral
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

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The ranks are arranged from the highest to the lowest. Thus, the present study's highest result regarding the table shows that the project characteristics consist of the relative importance index (RII) of 4.04, 0.64, and 0.64. Therefore, project characteristics are one of the main variables that affect each industry's willingness to adopt emerging technologies with regard to safety issues. The "social influences" can be factors that have 3.86 of average mean, 0.71 of standard deviation, and 0.77 of RII. The top and second strongest determinants are environmental attributes, as they can also be called external factors. Most responses from this finding show that it has a 3.69 of average mean, 0.66 of standard deviation, and 0.74 of RII. These three factors can be considered to be what the majority agreed on, as they can, directly and indirectly, affect the willingness of people to afford and adopt emerging technology to achieve and improve safety. The table shows that respondents slightly agreed to the determinants of technological, organizational, and individual factors. From these three factors, technological factors are higher than the other two, with an average mean of 0.68 of standard deviation and RII of 0.70, followed by organizational factors with average means of 3.50, 0.76, and 0.70. Although it has the lowest mean score and RII, it can also be considered as a factor affecting the implementation of emerging technology with reference to safety problems and issues. Finally, individual factors have a 2.98 average mean, 0.86 standard deviations, and a relative importance index of 0.60. To conclude the overall group of variables, the highest factors that people supported as specific determinants are project characteristics, social influences, and environmental attributes.

Project Characteristics

Table 4 below presents the relative importance index of project characteristics as perceived and ranked by respondents. In addition, the table presents the mean score, standard deviation, and RII value of the project characteristics.

Table 4
THE RANK OF PROJECT CHARACTERISTICS' GROUP

Project Characteristics	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Construction time and speed for work	4.35	0.55	0.87	2	1
Standardization of construction process and product	4.31	0.54	0.86	3	3
Construction easiness	4.38	0.68	0.88	1	2
Structural limitation, joint and connection system	3.69	0.61	0.74	4	9
Less affected operation by weather condition	3.46	0.84	0.69	5	12
Total:	**4.04**	**0.64**	**0.81**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)

Table 4 shows the various factors that may influence the adoption of emerging technologies for construction safety. The construction ease has a 4.38 mean score and 0.88 RII.

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Next is "construction time and speed for work," having 4.35 of mean and an RII of 0.87. Finally, the third-ranked item is "standardization of construction process and product".

Social Influences

Table 5 below presents the social factors that could influence the adoption of emerging technologies. As shown in Table 5, "enhancement safety value and level" has a mean score of 3.96 and 0.79 RII; "motivation for knowledge and awareness of safety issues" has 3.85 mean and 0.77 RII; the lastly ranked within this group is the purpose for "increasing professional workforce by skilled training".

Table 5
THE RANKING OF SOCIAL INFLUENCES' GROUP

Social Influences	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Enhancement safety value and level	3.96	0.59	0.79	1	6
Motivation for knowledge and awareness of safety issues	3.85	0.66	0.77	2	7
Increasing professional workforce by skilled training	3.77	0.89	0.75	3	8
Total:	**3.86**	**0.71**	**0.77**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)

Environmental Attributes

Table 6 below presents environment-related factors. As shown in the table, "government standard and new regulation" has the mean score of 3.73 and 0.75 RII, followed by the second factor within this group, "competitive advantage," with 3.65 mean and 0.73 RII.

Table 6
THE RANKING OF ENVIRONMENTAL ATTRIBUTES' GROUP

Environmental Attributes	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Government standard and new regulation	3.73	0.59	0.75	1	9
Competitive advantage	3.65	0.73	0.73	2	10
Total:	**3.69**	**0.66**	**0.74**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)

Technological Factors

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As shown in Table 7 below, the first ranking factor within this group is "reliability and durability of each purchased technology", with a mean of 4.24 and RI index of 0.82. In addition, it is the top-ranked factor within the overall group of variables, meaning that it can affect the adoption and willingness of the contractor or organization to implement this action. The next highly ranked within this group is "effectiveness of proven technology," with a mean of 3.65 and 0.73 RI index.

Table 7
THE RANKING OF TECHNOLOGICAL FACTORS' GROUP

Technological Factor	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Brand of appointed technology	2.81	0.79	0.56	3	18
Effectiveness of proven technology	3.65	0.68	0.73	2	10
Reliability and durability of each technology	4.24	0.57	0.82	1	5
Total:	**3.57**	**0.68**	**0.70**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)

Organizational Factors

As shown in Table 8 below, the ranking reflects the respondents' perceptions. The first significant factor within this group is "cost savings for hiring foreign workers," having a 4.12 mean score and an RII of 0.82. The second-highest factor, "technology for multipurpose uses," has a mean of 0.68 and standard deviation of 0.72.

Table 8
THE RANK OF ORGANIZATIONAL FACTORS' GROUP

Organizational Factors	Mean	Standard Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Company size	3.31	0.77	0.66	3	13
Goal and need accident reduction	3.19	0.88	0.64	5	15
Organizational culture and mind-set changed	3.27	0.76	0.65	4	14
Technology for multipurpose uses	3.62	0.68	0.72	2	11
Cost savings for hiring foreign workers	4.12	0.70	0.82	1	4
Total:	**3.50**	**0.76**	**0.70**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 =Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)

Individual Factors

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As shown in Table 9 below, the lowest mean score is "individual factors," having a mean score of 2.98. Within this group, the highest-ranked item is "personal innovativeness," which has 3.08 mean and 0.62 RII. The final item is "self-attitude and enjoyment with technology adoption," with 2.88 mean and 0.58 RII.

Table 9
THE RANKING OF INDIVIDUAL FACTORS' GROUP

Individual Factors	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Factors
Personal innovativeness	3.08	0.87	0.62	1	16
Self-attitude and enjoyment with the adoption of technology	2.88	0.85	0.58	2	17
Total:	**2.98**	**0.86**	**0.60**		

(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree).

Discussion on the Factors Influencing the Adoption of Emerging Technologies

Project Characteristics

The findings of this study are similar to that of (Taherkhani, et al., 2012). The highest-ranked factor is "construction easiness," as respondents agreed that most of the emerging technology installed makes their job and task more straightforward to complete without taking a long time to construct or maintain. Extension of the construction time will cause hidden safety and health problems for each person, such as ergonomic hazards, which must be considered. For better work to be done by professionals, the application of emerging technology is preferable in helping to reduce unnecessary reworks and additional time after or before the construction begins on site. The second highly ranked of the factors within this group, "construction time and speed," will be considered if there is motivation to adopt emerging technologies for construction safety. The determinant has a 4.35 mean and an RI index of 0.87. In terms of improving the construction time and speed up the process, emerging technology can offer a wide range of benefits during the construction process, potentially improving the overall safety performance. Elimination of the possibility of risk and uncertainty is the most satisfying hidden goal if the construction time and speed increase; hence, it will reduce the time for making additional prevention measures for the likelihood of hazards and risks (Natee et al., 2016). Literature has shown that less construction time is required with emerging technologies, such as IBS. It requires very little time to cast the precast element, which will speed up and minimize the process of the construction task in a controlled environment (Taherkhani et al., 2012).

Social Influence

Enhancement with safety value and level item ranks first in the social influence group. It was ranked first in a previous study (Taherkhani , et al., 2012). It has the highest mean (3.96), compared with other variables, and the RI index is 0.79 within the social influence of this group. The item that motivates workers with safety knowledge and awareness of safety issues has 3.85 scores and 0.77 RII value. The lastly ranked within this group is the willingness of the

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organization to increase the professional workforce by training, as it has a 3.77 mean score and 0.75 RI index. However, these factors were discussed and mentioned in a previous study (Taherkhani , et al., 2012). According to (Charehzehi and Ahankoob, 2012), a recommendation to enhance safety performance and level is needed, as it can adequately alleviate the frequency of accidents; hence, the value of safety increases. In addition, safety is important for construction activities, which can be a way the owner desires to apply and hire a contractor who has proven good safety performance. It is also considered a qualification of contractors for bidding work and ranking during contract awards.

Environmental Attributes

Environmental factors have also been found to influence the adoption of emerging technologies (Lippert & Govindarajulu, 2006). Based on Table 6, government standards and new regulations are the influencing determinants discussed in (Taherkhani , et al., 2012) . As stated in (Lippert & Govindarajulu, 2006), government regulations need to be experienced by each organization, as it can likely influence the adoption and affordability of emerging technology. Delmas (2002) also noted that regulatory and government standards are any requirements on the technical standards which can be changed into a new qualification so thata firm can experience high transaction costs to meet their necessary objectives. Thus, organizational non-compliance with these environmental attributes will produce additional issues for each company to consider the suitability of adopting an emerging technology within the requirement of a potential legal outcome.

Technological Factors

The technological factor was ranked second in previous research (Nnaji, 2018). According to (Lippert & Govindarajulu, 2006) and (Gambatese & Nnaji, 2017), the higher the perceived service reliability, the better the possibility of adopting and using these technologies will be. Most respondents indicated that an expectation of technology must be reliable, easy to use, and can be used in long-term without frequent maintenance (Joghee et al., 2020). If safety technology is deemed valuable and effective for its operation, it is evaluated to ascertain its expected impact. This study and previous studies have shown that the brand of technology does not affect safety technology adoption.

Organizational Factors

Previous studies have identified organizational factors as essential determinants of emerging technology adoption (Irrma et al., 2010). Additionally, (Kamaruddin, et al., 2016) noted that most barriers to developing and adopting advanced technology are related to cost issues. Both the previous and present findings have the same ranking within the group.

Individual Factors

Literature has shown that innovativeness has a significant influence on the adoption of emerging technologies. The findings of this study are consistent with those of previous studies (Perveen & Sulaiman, 2008). In this study, the mean score of "personal innovativeness" is approximately 3.00. Furthermore, last but not least, "self-attitude and enjoyment with the

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adoption of technology" issimilar to prior research findings which revealed that this item does not significantly influence the adoption of emerging technology.

Barrier to Adoption of Emerging Technologies for Construction Safety

As shown in Table 10 below, economic-related factors have the highest average mean of 4.17, 0.62 standard deviation and RII 0.83. The second highly supported by respondents is personal-related issues as shown by the average mean of 3.88, 0.60, and 0.78. Next, organization-related issues which may hinder the adoption of emerging technologies in construction safety are considered. From the table below, there is an average mean of 3.75, 0.72, and 0.75 RBI. Finally, the time-related issue is also an important barrier that is considered to be faced and solved if any organization is willing to be become advanced. For "time-related factors," the result shows it has 3.67 average mean 0.71 standard deviation and 0.73 RII.

Table 10
RANKING FOR EACH GROUP

Barriers Influencing Adoption of Emerging Technology	Average Mean	Std. Deviation	RII	Rank	Remarks
Economic Related Factor	4.17	0.62	0.83	1	Agree
Personal Related Factor	3.88	0.60	0.78	2	Agree
Organization Related Factor	3.75	0.72	0.75	3	Agree
Time Related Factor	3.67	0.71	0.73	4	Agree
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

Economic Related Factors

Table 11 below shows the ranking of each barrier in the group of "related economic factors," as conducted by descriptive analysis. As Table 11 shows, this group is getting a high ranking, even within overall barriers by taking the first to the third place. The first ranked attribute of this group of barriers is "high initial investment capital," which is identified with 4.50 mean and 0.57 standard deviation. The high mean score among this barrier indicates that a firm mind-set about a specific variable can seriously influence the adoption of emerging technology. The "poor economic condition" has a mean score of 4.04 with 0.59 standard deviation. Another cost-related issue is the fees for each worker to be a professional in operating the emerging technology for every day's task, which has 3.96 mean and 0.71 standard deviation. Among the overall ranking of the barriers, these three hindrances are considered the most significant influencers of the willingness of respondents to afford, purchase, and adopt high-tech safety technology.

Table 11
RANKING OF ECONOMIC RELATED FACTORS

Economic Related Issues	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Barriers
High initial investment capital	4.50	0.57	0.90	1	1

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Poor economic condition	4.04	0.59	0.81	2	4
Additional training and courses learning fees	3.96	0.71	0.79	3	5
Total:	**4.17**	**0.62**	**0.83**		
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

Personnel Related Issues

Last but not least, the last group of barriers would be "personal related issues". The highest score for the mean in this group is "traditional attitude, or being used to the old-school method," with 4.08 mean, 0.55 standard deviation, and 0.82 RII. The second-highest is "lack of experience and skill," with 3.96 mean and 0.79 RII; the last item from this group which took the last rank is "lack of knowledge and incentives," with 3.62 mean and 0.72 RII.

Table 12
THE RANKING OF PERSONNEL RELATED ISSUES' GROUP

Personnel Related Issues	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Barriers
Lack of knowledge and incentives	3.62	0.74	0.72	3	9
Lack of experience and skill	3.96	0.52	0.79	2	5
Traditional attitude used to the old-school method	4.08	0.55	0.82	1	3
Total:	**3.88**	**0.60**	**0.78**		
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

Organization Related Factor

"Organization-related issues" is another barrier that can have influence on applying technologies. The table below shows that this group's high score means is 4.27, 0.65 standard deviation, and 0.85 RII, which is "lack of financial support". Another significant factor is the "lack of top management support," which means 0.64 standard deviation and an RII of 0.78.

Table 13
THE RANKING OF ORGANIZATION RELATED ISSUES' GROUP

Organization Related Issues	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Barriers
Lack of top management support	3.88	0.64	0.78	2	7
Lack of financial support	4.27	0.65	0.85	1	2
Lack of technical infrastructure support	3.50	0.69	0.70	3	10
Uncertainty in obtaining benefits	3.35	0.87	0.67	4	11

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Total:	**3.75**	**0.72**	**0.75**		
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

The "time-related determinant" consists of 5 items ranked from the highest to the lowest: they are "complexity to use" and "need to learn and adopt the tool". Both items have the same ranking with 3.96 mean and an RII of 0.79 and followed by "take time for additional training" with 3.92 mean and 0.78 RII; "additional initial setup of appointed technology" has 3.64 mean and 0.70 RII while "big chances in routine method and process" has 2.88 mean and 0.58 RII which is the last item in this group.

Table 14
The Ranking of Time Related Issues' Group

Time Related Issues	Mean	Std. Deviation	RII	Rank Within This Group	Rank Within Overall Barriers
Complexity to use	3.96	0.59	0.79	1	5
We need to learn and adopt the tool	3.96	0.52	0.79	1	5
Take time for additional training	3.92	0.67	0.78	2	6
Big Chances in routine method and process	2.88	0.85	0.58	4	12
Additional initial setup of appointed technology	3.64	0.94	0.70	3	8
Total:	**3.67**	**0.71**	**0.73**		
(Note: 1.00 to 1.49 = Strongly Disagree; 1.50 to 2.49 = Disagree; 2.50 to 3.49 = Neutral; 3.50 to 4.49 = Agree; 4.50 to 5.00 = Strongly Agree)					

Discussion on the Barrier of the Factors Influencing the Adoption of Emerging Technologies

In discussing the first and prior barriers within this group and within the overall barriers, "high initial investment capital" was supported by most previous studies, such as (Noraini, et al., 2016), who mentioned this barrier as highly ranked by respondents. For instance, Taherkhani, et al., (2012) demonstrated that the capital cost for the initial investment is also the most ranked. Furthermore, it is said that an initial cost of application of component emerging technology, such as IBS, usually includes the cost of constructing, casting, and supporting machinery. Therefore, in the beginning, the adoption of emerging technology requires an investment, as this can be related to poor economic conditions, which are ranked the second-highest in the present study.

Personnel Related Factors

As noted in (Noraini et al., 2016), people in construction might perform their tasks using old and traditional methods. However, this attitude leads to unproductive behaviours as regards safety issues. It keeps them away from taking a more proactive safety approach, being patient for trying new things and thinking about the long-term benefits that safety technologies may bring to them.

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Organization Related Factors

Based on a previous study by (Noraini, et al., 2016), the barriers were identified as having the lowest ranking compared to economic issues. Sarawak's contractors agreed that for the successful adoption of new technology, it must be signed and made compulsory. There is also need for the top management to support in terms of time and proper training by providing enough money for each person involved. As noted in (Mehmood et al., 2019; Noraini et al., 2016), different places have different perceptions of "top management support". This may not be a barrier for larger construction companies and small-and medium-sized firms.

Time Related Factors

According to Table 13, two barriers have the same mean and RII, 3.96 and 0.79, respectively, but different standard deviations. The same ranked barriers are "complexity to use" and "need to learn and adopt the tool". A previous study (Noraini, et al., 2016) on barriers had ranking different from the present finding. From the previous study, "complexity to use" was ranked 2, while "need to learn and adopt the tool" was ranked three based on respondents' opinions. According to the first objective's findings of the present study, the majority of the respondents who work in the Sarawak construction industry agreed to the factors that influence the willingness to adopt emerging technology to improve construction safety in the construction industry. The present findings indicate that the top three important factors, which are "Project Characteristics," "Social Influences," and "Environmental Attributes," have been identified as the factors that can affect the adoption among contractors in the Sibu construction industry. The present findings for the second objective establish that contractors ranked economic-related issues as the first among the group of significant hindrances that can impact the adoption of emerging technology in terms of safety among contractors concerning safety and health.

CONCLUSION

The present study has shown how to conduct practical implication management for the Sarawak construction industry. First, the findings of this study have provided a better understanding and comprehension of the factors and barriers that influence the implementation of emerging technology with regard to construction workers' safety in Sarawak. According to each detail, project characteristics are the most highly ranked determinants as regards objective 1. Most respondents agreed that those reasons would make it difficult for each company to adopt emerging technology in terms of safety. It is therefore required that employers and contractors should have better understanding of the importance of emerging safety technologies. This will facilitate their identification of the hidden advantages for the workers' safety, health, and welfare purposes. Furthermore, a better understanding of why each working site should prioritize a safe working condition and environment is needed. Since the process of constructing safe projects has become a concern in recent times, contractors should make the construction work easier by applying emerging technology, as this is safer than applying manual labor to complete the overall project structural stage from the beginning to the end of completion. For instance, when the construction site is easily accessible, worker will be saved from various hazards and risks in every daily task. The most common and significant hindrance found in this research is related to economic issues, which has to do with financial problems. This suggests that financial issues are the main problems that hinder people's perception and willingness to adopt emerging safety

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technology. Also, firm contractors need to consider the benefits to be gained in terms of productivity and overall physical, psychological, and ergonomic issues with regard to human beings.

Limitation of Research

Although the objectives of this research were successfully achieved, there are some limitations. First, the survey was conducted only on contractors with large construction projects. Most contractors were unwilling to participate in this research because they were busy with their businesses or having other personal things. Apart from unwillingness to cooperate, most contractors still have the traditional and old-school culture mind-sets; this seriously influenced the respondents' understanding and the manner of responding to the content of the survey. Future research can focus more on investigating how emerging technology can prevent safety issues, activities hazards, and risks so that there can be improvement in the overall quality of work performed and the working environment.

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