Original Article

Perception of Drone Application and Practicality among Environmental, Health and Safety Practitioners at Building Construction Sites in Malaysia

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ABSTRACT: *Safety management in the construction sector is still lagging in terms of technological involvement. A new drone application was proposed as a new inspection tool for a small-scale aerial drone that will give advantages to Environmental, Health and Safety (EHS) practitioners at the construction site. A fundamental research was conducted to study the Perception of Drone Application and Practicality among Environmental, Health and Safety Practitioners at Building Construction Sites in Malaysia. A self-administered questionnaire was distributed to safety practitioners in Malaysia through an online survey using Google form. The relationship between the attitudes of the users towards the drone and the practicality of the drone was analysed using a multivariate statistical method known as Multi Linear Regression (MLR). From the result, the respondents show significant positive attitude towards the practicality of the drone system for the inspection of safety, security, fire, and environmental monitoring (R^2=0.76; p-value=0.01). There is generally a significantly good attitude of future users towards drone usage in the construction industry and the respondents show a good expectation and this is also supported by previous studies.*

Keywords: *Construction, Drone, Environmental, Health and Safety (EHS), Malaysia, Multi Linear Regression (MLR)*

1.0 INTRODUCTION

The construction sector remains to be one of the vital industries, strengthening its value and producing job opportunities to approximately 1.33 million people in Malaysia (Hamid et al., 2019). Despite the fact that this sector has had a significant impact on economic development, construction has been regarded as one of the most dangerous and hazardous sectors (Rahman, 2015). According to Azhar (2017), the construction sector registered

the highest accident rate in comparison to other sectors. Those accidents led to many cases of major and minor injuries as well as work-related fatalities among construction workers. Therefore, all safety measures should be prioritized in order to avoid the high number of accident occurrences (Tam et al., 2004). Good identification of the hazard was one of the main factors that can prevent accidents at construction sites.

The hazard monitoring method could effectively reduce the management cost and thus improve safety systems (Hamid et al., 2008). The hazard monitoring method could be more effective when there is involvement in cutting edge technologies. Drone application is one of the best technologies that could be implemented to monitor the hazards at the construction sites. A new drone application was proposed as a new inspection tool for a small-scale aerial drone that will support Environmental, Health and Safety (EHS) practitioners on the construction site. The drone is an aerial quadricopter that uses smartphone, tablet device or a computer that is remotely controlled by an authorized practitioner. A drone is an Unmanned Aerial Vehicle (UAV) that involves humans to control its operation without any pilot on board. The involvement of these EHS would be able to prove the features of an ideal, practical and efficient application at the jobsite.

This alternative also could help safety managers to reveal undiscovered hazards and various unforeseen issues specifically on the safety inspection context. The inspection could be faster rather than a walk-in inspection by the SHOs around the construction sites. By having this automated and secured monitoring tools inspection at the construction site, the delivery message between construction workers and the EHS practitioner would be successfully delivered.

A study needs to be conducted before producing and establishing the prototype of the proposed drone. This is very important to identify the needs and opinion of EHS practitioners regarding drone. Hence, this study was conducted to assess the perception of drone application among SHOs at the construction sites in Malaysia. This study was specifically aimed to evaluate the perception of application and practicality of drone technology among safety authorities as a new safety inspection tool at construction sites in Malaysia. Besides, it is also conducted to determine the attitude of future users towards drone utilization as a new safety inspection tool at construction sites in Malaysia. Last but not least, it was carried out to determine the association between the attitude and practicality of drone application among EHS practitioners in Malaysia.

2.0 LITERATURE REVIEW

Drones are Unmanned Aerial Vehicles (UAVs) that use a person to control their operation and do not have a pilot on board. An unmanned aerial vehicle is also known as a drone. Recent technologies have allowed for the development of many different kinds of advanced UAVs used for various purposes. UAVs are designed to be semi-autonomous or fully-autonomous aircrafts that can be equipped with cameras, sensors, communication devices and other components. UAVs mostly rely on human involvement human. The implementations of UAVs are still in the trial phase. Certain researches have been conducted to identify the potential and practicality of drones in construction sites. Several studies comprised of four phases such as scheduling and preparation, data gathering, image processing, video and image analysis (Kaamin et al., 2017).

Nonetheless, several socio-technical issues are inciting public outrage against the technology that is accused of delaying UAVs adoption. Although the literature addresses these concerns extensively, factors influencing public acceptance are rarely and insufficiently examined (Chamata & Winterton, 2018). Thus, several studies need to be conducted to assess the acceptance and perception of people regarding drone application from time to time.

3.0 METHOD

3.1 Study Design

A cross-sectional study was conducted at the construction sites located in Malaysia. In this research, a self-administered questionnaire was distributed among safety and health authorities such as Safety and Health Officer (SHO), Site Safety Supervisor (SSS), Safety Manager, Environmental Officers (EO), and any construction workers who conduct safety practitioner at construction sites in Malaysia.

3.2 Sample Size

Based on the report by the National Institute of Occupational Safety and Health (NIOSH), there were 5,984 registered EHS Practitioners involved in the construction sector in Malaysia. Thus, from that population number, a sample size could be calculated and determined by that number in order to make an observation. For this research, the sample size has been determined and calculated using the sample size formula in Equation 3.1 below as stated by Daniel (2012). The minimum sample that should be collected are 180 samples. The formula by Daniel can be formulated as below:

$$n = \frac{Z^2\, P(1-P)}{d^2} \tag{3.1}$$

Where:

Z = statistic for a level of confidence. For the confidence level of 95% which is conventional, Z value is 1.96.

P = expected prevalence or proportion. P is considered as 0.5

n = sample size needed.

d = Precision. d is considered as 0.05 to produce good precision and smaller error of estimate

3.3 Data Collection

The questionnaires were distributed through email in the Google Form format and were distributed throughout Malaysia in any kind of construction companies. The distribution of the questionnaire was conducted for three months for the data collection. The data was collected from 6th March 2020 till 6th May 2020.

3.3.1 Research Instrument

IMOSSED-1 is a modified drone which equipped with several sensors and modification. The selection of drone is based on its powerful aerial film making system with class leading agility and speed, redundancy features for maximum reliability, and new, smart features that make capturing complex shots easy. A new airframe was designed together with dual batteries to boost flight time up to approximately 25 minutes.

Furthermore, an additional set of sensors could be installed to enhance the collection of highly localized data and relaying the information to any Android device via Bluetooth. Just like a computer that could run many different applications, this set of sensors able to run multiple of sensor applications as well, including temperature sensor, wireless sensor, light sensor, gas sensor and gas detector, Carbon Monoxide sensor and CO detector, humidity sensor, colour sensor, Bluetooth sensor, networked sensor, environmental sensor, and infrared temperature sensor. A feasibility study was carried out with the main purpose to the application of Intelligent Malaysia Occupational Safety, Security and Environmental Drone (iMOSSED-1) as a new safety inspection tool at a construction site in Malaysia.

A questionnaire was developed to identify the perception of the respondents toward this IMOSSED-1. This questionnaire survey was created based on the Knowledge, Attitude and Practices (KAP) model (Ahmad et al., 2015) and also adapted from several previous studies as well as Acts and Regulations that related to the objectives of this study. The questionnaire consisted of five main sections which are Section A for socio-demographic, Section B for the current safety system, Section C on the attitude towards IMOSSED-1, Section D on the application and practicality of IMOSSED-1, and Section E for IMOSSED-1 investment willingness.

Section B, Section C and Section D had been composed based on the Likert Scale. Those scale need to be answered by the respondents according to the scale provided such as strongly agree, agree, disagree, strongly disagree and neither agree nor disagree.

3.4 Data Analysis

3.4.1 Correlation

Correlation is a statistical technique that can show whether and how strongly a pair of variables are related to each other. A positive correlation is defined as a pair of variables, which increases or decreases in parallel. A negative correlation, on the other hand, indicates an inverse relationship between two variables in which one variable increases as the other variable decreases. The correlation can be divided into two which are Pearson's correlation and Spearman's correlation. In this study, the correlation test was utilized to explore the association between knowledge and practices among construction safety practitioners toward safety requirements on the construction sites. Besides, it also used to determine the relationship between knowledge and attitude of the safety practitioners regarding safety matters.

3.4.2 Multiple Linear Regressions (MLR)

Multiple linear regression (MLR) or known as multiple regression is one of the statistical techniques used to predict the outcome of the response variables. It is the predictive analysis to predict the variability between the dependent and independent variables. In this study, the MLR was used to find the significant correlation between the good attitudes of future users towards drone usage at construction sites. Thus, it could be calculated using the Equation 3.2 below:

$$Y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \ldots . + \beta_{p-1} x_{i,p-1} + \varepsilon_i \quad (3.2)$$

Where:

Y = Response variable

p – 1 = Explanatory variable

$\beta_1, \beta_2 \ldots \beta_{p-1}$ = Regression coefficient

β_0 = The intercept

ε = Error associated with the regression

The coefficient of determination (R^2) and Root Mean Square Error (RMSE) are the important mechanisms that must be considered in the performance model. The value of R^2 establishes information on the reliability of fit of a model to the observed all data. Meanwhile, RMSE is applied to calculate the residual error and it will be included in the estimation of the mean difference between the observed and modelled value. All date collected in this study was analysed using the SPSS software.

4.0 RESULTS

4.1 Demographic Data

The survey questionnaires of the Safety and Health Officer (SHO), Environmental Officer (EO), Site Safety Supervisor (SSS), and other construction safety practitioners resulted in a total of 180 respondents. The age range of respondents collected was from 21 years old to 60 years old. The list of registered SHO, SSS, and safety practitioners were selected from the Department of Occupational Safety and Health (DOSH) website to be respondents in this study. Table 1 shows that the highest percentage of age range among safety practitioners were between 21 to 30 years old with the percentage of 61.10% (n=110), while the lowest percentage was 60 years and above with the percentage of 0.56% (n=1). Next, male gender dominated this sector with the percentage of 71.10% (n=128), while the percentage of female employees was 28.9% (n=52). Lastly, there was approximately 57.20% (n=103) of safety practitioners, who hold Bachelor's degrees as their highest qualification. Meanwhile, there were only 0.6% (n=1) practitioners who obtained LCE/LSA, PhD and others qualification, respectively. Table 1 below shows the overall demographic data for this study.

Table 1 Demographic Background of the Respondents

Variable(s)		(N = 180) n (%)
Age		
	21-30 years	110 (61.10)
	31-40 years	52 (28.8)
	41-50 years	10 (5.56)
	51-60 years	7 (3.89)
	60 years and above	1 (0.56)
Gender		
	Male	128 (71.10)
	Female	52 (28.9)
Academic Qualification		
	LCE/LSA	1 (0.6)
	MCE/SPM	3 (1.7)
	Certificate	5 (2.8)
	Diploma	45 (25)
	Degree	103 (57.2)
	Master	21 (11.7)
	PhD	1 (0.6)
	Others	1 (0.6)

4.2 Relationship between Attitudes and the Practicality Expectation towards the Usage IMOSSED-1

Multiple linear regressions (MLR) test was used to determine the relationship between the attitude of the respondents towards the usage of the IMOSSED-1 at the construction site as a tool for safety inspection, fire inspection, security system and environmental monitoring with the application and practicality of the IMOSSED-1. According to the findings Table 2, there was a significant relationship between the attitudes of the users towards the system IMOSSED-1 as the safety inspection, fire inspection, security system and environmental monitoring at the construction site on the practicality of the IMOSSED-1. This was because the significant value of the finding was p-value=0.01 which is less than 0.05. The findings also show that the variance of the R^2=0.76 which considers that 76% of the variance of the practicality of IMOSSED-1 was explained by the attitude of respondents in using IMOSSED-1 at the construction sites.

Table 2 Multi Linear Regression (MLR) Test between Attitude and Practicality of IMOSSED-1 System at the Construction Site

Variables	R^2	Significant value (p-value)	Significant value (p-value)
Safety Inspection	0.760	0.011**	0.01**
Fire Inspection		0.123	
Security System		0.002**	
Environmental Monitoring		0.001**	

Multiple Linear Regression (MLR) test
**Significant at $\alpha<0.001$

4.3 The Association between Attitudes and Practices of the Workers toward Safety Requirements at the Construction Sites

For further analysis, the Pearson's correlation test was utilised to determine the relationship between attitudes and practices of the workers towards safety requirements at the sites. As shown in Table 3, there was a significant positive correlation between the attitudes and practices of the workers towards the safety requirements at the sites (r=0.819; p-value=0.001). The correlation coefficient (r) showed a strong positive correlation between variables total attitudes score and total practices score, with the r value was within the range of 0.8 to 1.0.

Table 3 Correlation Test for the Relationship of the Attitudes and Practices of the Workers towards Safety Requirement

	Mean (SD)	r	p-value
Total attitudes score	89.3(17.32)	0.819*	0.001**
Total practice score	88.7(17.21)		

Spearman's Correlation Test
*Correlation is significant at the 0.01 levels (2-tailed)
**Significant at $\alpha<0.001$.

5.0 DISCUSSION

The knowledge of the respondents towards their current system that is applied at construction sites shows a high level of knowledge and it was proven that the safety practitioners were mostly aware and agreed that their systems were acceptable and efficient for safety inspection. Section 24(1)(a) of Occupational Safety and Health Act 1994 (OSHA 1994) states that it is the responsibility of every employee to take reasonable care for personal safety and health, as well as others who may be affected by his work or omission at works (OSHA, 1994). Please quote the act properly. Therefore, it was meant that every single employee including the safety practitioner has to ensure the safety of him and others.

Besides that, the attitudes of the respondent towards the IMOSSED-1 system mostly showed a satisfactory positive attitude. This could be shown when the respondents agreed that IMOSSED-1 system be utilised at construction site as the inspection tool. But then, a previous study found that there was no significant relationship between the attitudinal variable with the safety outcome variable (McDonald & Hrymak, 2002). This implied that good standards of compliance for safety requirements did not inherently impact workers' attitudes. Therefore, this study suggested that more research must be conducted to have a clear explanation regarding the relationship.

Safety practices could also be affected by the good cultures of the safety committee of the site (Chamata & Winterton, 2018). It can be defined as the good principles and practices on safety values at workplaces. By obeying the act and practicing safety measures. The statement could support the result of the practicality expectation of drone technology. Overall, the respondents mostly agreed and showed good practicality expectations towards the IMOSSED-1system which acted as a safety inspection system, security system, fire inspection system and environmental monitoring. If the drone was applied by the safety practitioner as the safety inspection tool, good safety culture among the employees could be implemented and good and healthy safety practices would be generated.

5.1 Relationship between Attitudes and the Practicality Expectation towards the Usage IMOSSED-1

Based on the objective of this study, the findings showed that there was a significantly good attitude of future users towards drone usage in the construction industry. This was because the respondent of the study had a positive attitude towards the system that would be expected in the IMOSSED-1 as a new safety inspection tools at construction sites in Malaysia. The result also showed that the respondents had a higher percentage in showing a positive attitude towards the system in IMOSSED-1 if it was as a safety inspection tool at construction sites. This could be supported by the study of Irizarry et al. (2012) as they concluded that drone technology had the potential to encourage the awareness of safety assessment and to improve safety industry practices. The drone is also being tested and proven to perform similar and practical roles as a man, but, more efficiently, safely, faster and cost-effective (Ames et al., 2015). The purpose of the application of drones in the construction industry was to ease the job scope of safety practitioners at the construction site since the construction industry was well-known to be listed as dangerous workplaces which required safety awareness among the workers.

Accidents like permanent or temporary disabilities, fatalities and materials or product losses were still liable to all construction employees (Irizarry et al., 2012). The safety manager at the construction site had to inspect their workers, the procedures and the environment site (O'Toole, 2002). Most of the safety practitioner conducted a walk-in inspection which might require longer time, mainly in the bigger construction project. Thus, with the assistance from the system utilised in IMOSSED-1 such as communication tool, real-time video camera, environmental sensor, and RFID system, the regular inspection for daily, weekly or monthly safety inspection on the condition at the construction could be helpful to them.

5.2 The Association between Attitudes and Practices of the Workers toward Safety Requirements at the Sites

In the previous study by Irizarry (2012), the drone applicability had been tested and proven that drones were able to provide good real-time communication between the workers and the safety managers during the inspection and it could observe and monitor the real condition if construction site either comply with safety criteria or not.

As shown in the findings, the percentage of respondents had good practicality expectations towards the IMOSSED-1 system. This study could be supported by previous studies where using drones was beneficial in term of low cost, the ability to move freely, provide safety support, high visual assets, and capability of information transfer (Kim & Irizarry, 2015). Furthermore, Kim and Irizarry (2015) also stated that UAVs could assess the areas which are difficult for human entry, monitor the workflow, logistic and stock counts of the materials, and able to lower the cost of safety monitoring at the construction site.

6.0 CONCLUSION

This study assessed the effectiveness of drone application among safety officers at building construction sites in Malaysia. The findings generally showed that there was a significant good attitude of future users towards drone usage in the construction industry tested by the MLR test and Spearman's Correlation test. Overall, the total attitudes score had a strong positive correlation with total practicality of the system in the drone. This study demonstrated that the safety officers in Malaysia were aware of the current system that their company used, and had good attitudes towards the IMOSSED-1 system. The respondent also showed a good practicality expectation towards the IMOSSED-1 system for safety inspection, fire inspection, security system and environmental monitoring at the construction site in Malaysia.

Moreover, the aim was achieved as there was a significant good attitude of future users towards drone usage in the construction industry. This could be exhibited through the MLR test where the attitudes of the respondents were significant to the practicality of the IMOSSED-1 system. Drone technology usage is applicable and is practical at construction sites. Lastly, the third objective was achieved when most respondents showed a good practicality expectation towards drone usage, and this was also supported by the previous study.

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