CITC GLOBAL
Construction in the 21st Century
11th International Conference (CITC-11)
September 9-11, 2019, London, UK

Springer
SPRINGER NATURE

How Can Mobile App Technology Further Benefit Project Managers by Improving & Increasing Working Productivity?

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Abstract. Innovative technology has been exploding and prevailing among various industries during the 21st century all over the world. Not only through its use and adoption of innovative technology which provides convenience and efficiency across various sectors, but by using technology to improve quality of life and influencing and shaping human behavior. Whilst some industries like business marketing and social media sectors have been quick to embrace these innovative technologies, it could be argued that the built environment sector has been hesitant and slow to embrace such innovative technologies. Innovation, as defined by the Chartered Institute of Building (CIOB) 2007, as *a "successful introduction of new technologies or procedures into the industry, although not always profit driven; it can enhance sustainability, energy saving and reduction in carbon emission."* With innovation and sustainability key drivers for the built environment sector this investigative research will review why technologies like Augmented Reality (AR), Virtual Reality (VR), Building Information Modelling (BIM), Modular Integrated Construction (MiC), Radio Frequency Identification (RFID) and Smart Mobility have been in-part resisted by the Hong Kong built environment sector and what impact this lack of engagement may have on productivity on construction /project management. In particular how adoption might increase working productivity in project administration throughout the entire construction period. This research included an investigation into the current position relating to utilization of mobile app technology in Hong Kong, appraised the performance of construction sector mobile app technology to increase productivity of project managers and compared productivity values by using "Productivity Equation" before and after the adoption of construction mobile app technology.

Keywords: Mobile app technology; Increased productivity; Project management; Adoption of mobile app technology.

1 Introduction

The construction industry has been criticized for its low productivity and old-fashioned practices for decades when comparing to other sectors in Hong Kong. Secretary for Development [1] argued that the whole construction sector is facing high construction cost, inefficient & ineffective practices and an ever increasing aging workforce. Therefore it would make sense for the built environment sector to adopt and adapt any new technology or new ways of working that would address this challenge and overall increase project productivity.

Numerous researchers have argued that the built environment and construction industry has not changed over the last decade, whereas other sectors have been swifter to embrace technology and many have embraced what has been termed the 3rd/4th industrial technological revolution. One of the ubiquitous technologies in recent years is the mobile application (App) technology. However, it appears that the mobile app technology for construction management or project management is not commonly utilized in the Hong Kong construction industry. Therefore, this investigation undertook research to locate why this reluctance exists and importantly evaluate how the adoption of these technologies might further benefit the construction practitioners as a Project Manager. Whilst undertaking this investigation it was also suggested that the main reason for the lack of adoption of these technologies was the aging population who has not grown up with these technologies.

1.1 Aging Working Population

Reference is made to “Women and Men in Hong Kong Key Statistics” published by the Census and Statistics Department in July 2017 [2], there are 90,200 nos. of male construction workers and 7,800 nos. of female construction workers at the age group of “50 – 59” in 2016 which sum up to constitute nearly 30% of the working population in the construction sector of Hong Kong. Also, there are 34,900 nos. of male construction workers and 1,900 nos. of female construction workers at the age group of “60 or above” in 2016 which sum up to constitute nearly 11% of the working population in the construction sector of Hong Kong. The above figures concluded that there were totally 134,800 nos. of construction workers in Hong Kong aged above 50 years old which accounted for 41% of the overall working population in the sector. The figures also implied that 41% of the working population will reach the retirement age of 65 in the coming few years to 15 years, which will create a significant loss of productivity as well as the skillful experience in the construction sector. The situation is becoming critical and worrying. The below Table 1.1 : Statistics of Construction Workers aged 50 or above in Hong Kong summarizes the above figures.

Table 1.1 : Statistics of Construction Workers aged 50 or above in Hong Kong

Construction Sector of Hong Kong in 2016					
Total nos. of working population = 328,300					
Age group	Female	Men	Total (Female + Male)	Percentage over Total Working Population	Total Percentage at Age 50 or above
50 – 59	7,800	90,200	98,000	30%	41%
60 or above	1,900	34,900	36,800	11%	

(Source : Census & Statistics Department, 2016)

2 Methodology

The methodology adopted for this investigation included a mixed methodology of literature review, data collection and targeted Naoum, S.G. [3] suggest the use of questionnaire has three main advantages, namely: economic (low cost), speed (fast response from respondents) and consultation (can contain a few qualitative questions in the questionnaire which require the respondents to answer at their own free will and in their own time). This methodology acquired large sampling and the questionnaire was designed with mainly quantitative questions in "Likert Scale" supported by a few open-ended questions. The data collection process was conducted by targeted sampling with identified group of population (ie: construction practitioners) which guarantees a focused and more reliable data collection. The questionnaire was provided in English & Traditional Chinese and a mobile app "Survey Monkey" online questionnaire platform supported the investigation.

2.1 Research Strategy

The overall research process spanned over 5 months from December 2017 to April 2018 and this was underpinned by an extensive literature review was conducted from December 2017 to March 2018. Data collection via questionnaires was carried out from March to April 2018. Questionnaires were sent out and collected via emails, mobile app platform, printouts disseminated to colleagues & working partners at workplace in Hong Kong construction sites and through fellow built environment practitioners. A pilot batch of questionnaires was designed to try out prior to exercising the whole batch of questionnaires. The purpose is to test the effectiveness and validity of the questionnaire, the response rate as well as the responded satisfactory rate. Naoum, S.G. [3] recommended a pilot study as it can get the bugs out from the instrument (ie: the questionnaire), so that respondents will not experience

difficulties in completing it and preliminary problem-shooting on wordings or format can be perceived before the proceeding of main stage.

The overall response rate at 26% to the questionnaire was found rather satisfactory as previous experience indicated that the response rate would usually at about 20%. It was noticed that the response rate via the mobile app "Survey Monkey" (36%) was especially encouraging, which was also the main factor boosting the overall response rate. The reason was believed that the respondents were more interested to fill in the questionnaire in an innovative way and the mobile app could provide convenience & mobility to the respondents. The questionnaire could be answered during transportation time and even could be saved & continued at another free time. Almost half of the surveyed population (47%) possessed 11-15 years' experience in construction industry and the majority were Project Managers (40%) from Contactor companies (47%) undertaking construction management (38%) with tertiary educational background (43%) and almost two fifth (43%) of the surveyed population (20 out of 47 responses) had used construction mobile apps for less than 3 years. The hierarchy of the survey population was found ideal and sensible which were suitable for the research subject and made the collected data representable.

3 Result

The purpose of Part 1 is to differentiate the non-qualified respondents, such as non-construction practitioners & non-construction mobile app users and group the respondents into different categories for subsequent analysis. One qualitative question was asked in Question 1.8b with an intention to obtain descriptive answer on the most popular construction mobile app. Part 2 is to obtain information on respondents' comments on existing construction practices. Two qualitative questions were asked in Question 2.4 and 2.5 with an intention to obtain descriptive answers on the most unproductive and unsustainable area. Part 3 is to obtain comments from respondents on the effectiveness and pitfalls of construction mobile app from a subjective point of view. One qualitative question was asked in Question 3.7 with an intention to obtain descriptive answer on user's comments in regard of future development of the technology. Numeric data on the estimated time consumption for each pre-coded process were also requested in both Part 2 and 3 in order to collect raw data for subsequent productivity calculation to test the effectiveness of construction mobile app from an objective point of view. Finally, Part 4 was to obtain information from respondents on the most valuable feature that would raise the adoption rate in Hong Kong.

Table 5.1 : Overview of Statistics

Response Rate					
Phase	Period	Platform	Sent Out	Returned	Percentage
1	Mid – late March 2018	Emails	30	8	27%
2	Early – late April 2018	Emails	120	26	22%
3	Early – mid April 2018	Mobile app	50	18	36%
		Total response rate :	200	52	26%
		Disqualification rate :	5	5/52	10%
		Adjusted total response rate :	200	47	24%

4 Discussion

Main issues identified from the investigation where the increased use of APP technology might increase productivity.

4.1 Unsustainability

The traditional practice of printing hardcopies for drawings, forms and reports consumes a lot of papers. According to the "Blueprint for Sustainable Use of Resources" published by Environment Bureau in 2013, paper is the secondary main source of Municipal Solid Waste (MSW) in Hong Kong, which contributes to 22%, following putrescible of 44%, of the overall MSW composition. According to the "Hong Kong's Climate Action Plan 2030+" published by Environment Bureau in 2017, the HKSAR government has set a target of carbon intensity reduction of 65% - 70% by 2030 using 2005 as the base year, which is equivalent to 26% - 36% absolute reduction and a reduction to 3.3 - 3.8 tonnes on a per capita basis. The use of papers has to be reduced in order to meet the government's target. The investigation suggested that the increased use of APP technology would significantly reduce the above wastage and increase the speed of sharing project drawings/project information.

4.2 Miscommunication

Traditional procurement is still the most common contracting means for construction projects in Hong Kong. The tradition of multi-layer contracting is one of the characteristics. This contracting relationship is effective on one side but can be complicated on the other side. The complicated communication channel can lead to misinterpretation of messages and prolong the communication time through the various layers. The investigation concluded that use of smart technologies such as APP's would again significantly increase reliability and increase certainty of information sharing.

4.3 Low Productivity

Construction industry is known as a series of labor-intensive processes combining the outputs of different trades. It is not difficult to observe that workers are still wasting time in waiting for job allocation and walking to and fro the site office to look up a single Code of Practice or drawing which cause the overall productivity to descend. The research concluded that use of technology prevented unnecessary travel and increased instantaneous motivated response times.

4.4 Stringent Building Regulations & Heavy Workload on Project Documentation

As building technology and information technology advance, the Building Ordinance and Regulations have also evolved to cater for the new changes, such as the implementation of Minor Works Control System in 2011 and the introduction of pre-acceptance mechanism of Modular Integrated Construction in 2017 by the Buildings Department (BD). The new Ordinance and Regulations has better controlled the construction standard and quality, but at the same time induced lots of extra paperwork and documentation workload. The investigation suggested that updates and changes can be more easily reached and translated into project documentation.

4.5 Benefits from Construction Mobile Apps

The construction mobile apps were devised to help Project Managers with more convenience & mobility without sacrificing standardization, systematization and formality. The seven routine administration activities were designated and modelled in Question 2.6a – 2.6g because they also corresponded with the anchor functions of the construction mobile apps as designated in Question 3.1a – 3.1g. For the purpose of identifying the most helpful functions perceived by respondents, similar exercise of calculating the Relative Importance Index (RII), Arithmetic Mean (Mean) & Sample Standard Deviation (SD) was also carried out and the statistics are shown in the following Table1.2: RII, Arithmetic Mean & Standard Deviation on Helpfulness of Construction Mobile Apps.

Table 1.2 : RII, Arithmetic Mean & Standard Deviation on Helpfulness of Construction Mobile Apps

No.	Functions of Construction Mobile Apps	RII	Arithmetic Mean	Standard Deviation
3.1a	Online RFI, CVI and Progress Report function	0.87	4.33	34.78
3.1b	Photos taking and uploading to cloud storage	0.73	3.64	19.01
3.1c	Information distribution via communication function	0.87	4.36	37.75
3.1d	Online instruction issuance function	0.79	3.97	25.02
3.1e	Data retrieval from cloud storage function	0.89	4.45	39.25
3.1f	Instant emergency incidents reporting from site staff	0.65	3.24	17.94
3.1g	Standardized format and online central filing system	0.86	4.30	34.71

From the above table, once again both the RII and Arithmetic Mean had reached compromise with expected Standard Deviation that the highest three values are the same three functions (highlighted in yellow above), namely in order of precedence "data retrieval from cloud storage function", "information distribution via communication function" and "online RFI, CVI & Progress Report function". The ranking implied that the top three functions had helped respondents the most in saving time, increasing productivity and serving their needs. The respondents perceived huge progression and enjoyed much benefit by applying the three functions at works. Another finding is that the top three functions call on the three most unproductive practices as in Table 6.1 to some extent. The function of "online RFI, CVI & Progress Report" was addressing the traditional practice of "filling in RFI, CVI & Progress

Report" and the functions of "data retrieval from cloud storage" & "information distribution via communication function" were somehow improving the traditional practices of "taking & transferring site photos to database" & "travelling to & fro office to attend emergency incidents".

As identified in the literature review, productivity is a ratio between an output value and an input value used to produce the output [4]. Also, Chan, Paul [5] construed that productivity should be bound by time, cost & quality frameworks. Productivity can be calculated [6] and represented as a percentage by a simple equation as below:-

$$Productivity = \frac{Output\ Value}{Input\ value} \ x \ 100\%$$

Estimated daily time consumption (minutes) for the seven routine administration activities and the seven functions of construction mobile apps were collected from respondents in Question 2.6a – 2.6g and 3.1a – 3.1g respectively. The simple equation is used to calculate and compare the productivity before and after the adoption of construction mobile apps. It is assumed that all other variables eg: number of workforce , equipment & material used to produce one unit of output value are held constant and the only variable is the time consumed to execute such task.

It is therefore suggested that innovative construction mobile apps can provide many solutions and deliver various levels of improvement within and across the built environment /construction industry including: reducing and promoting paper-less working environment & contributing to sustainability, enhancing communication & information promulgation, increasing overall working productivity, maintaining systematic online filing system and relieving the demand for human resources. On the contrary, the technology has its demerits, such as lacking of face-to-face non-verbal expression (at the moment) and increasing initial capital cost (despite cost-saving in the long run). However the overall use of mobile app technology was shown in this investigation to be a significant catalyst to increase strategic and operational productivity for construction and project managers,Subsequent paragraphs, however, are indented (here insert the second paragraph).

5 Conclusions

In conclusion, the aim of this research was accomplished by conducting an in-depth investigation into the areas of construction mobile apps that can further help project managers in construction management. Meanwhile, the objectives of this research were also achieved respectively by exploring the role of project manager in modern construction management, identifying the bottlenecks & low productivity traditional practices, reviewing the existing functions of construction mobile apps, calculating the productivity as evaluation on current performance, investigating the low utilization rate in Hong Kong, exploring the potential improvement areas and recommending new innovative features for construction mobile apps.

The research question was answered by finding out the existing functions of construction mobile apps that addressed the traditional practices of low productivity and the existing areas that were most helpful, most in need of improvements & innovative features. The answers could help to further benefit project managers by improving construction management and increasing working productivity.

Hypothesis was also proved true that once construction mobile app is adopted to perform construction management, then the working productivity of specific administration activities can be significantly increased (productivity boosted with a mean value of 120% as substantiated in Table 6.3 : Calculation and Comparison of Productivity) and some of the traditional inefficient practices can be substituted with the use of construction mobile apps (eg : online filling-in of RFI, CVI & Progress Report) which can help to achieve output in a more systematic and standardized format while minimizing the amount of input (ie: time).

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