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Mobile Application Information Requirement in Construction Industry

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Abstract
The construction industry is information intensive. Although the amount of information has increased over the past years, the number of advanced information technology applications used to collect, access, and use this information has not grown accordingly. For instance, current commercial information technology applications are very specific and lack simplicity and functionality. This paper describes the information requirements of an on-site mobile application that can be used to improve information management in construction projects. To achieve the research objective, the information required to properly design the mobile application was collected by distributing an online questionnaire among construction professionals. It was found that Design Intent and Clarification, Daily Report, and Report Quality Control (QC) /Quality Assurance (QA) Problems required information from perspective of the consultants. Similarly, contractors need Schedule Updates, Reporting Violations, and Report QC/QA Problems. The results of this study can be used to develop a mobile application that can be used in medium- and large-size construction projects where the management of on-site information has a significant influence on achieving project objectives.

Keywords
Mobile Application, Information Management in Construction, Mobile Information Requirement

1. Introduction

The construction industry is labor-intensive. Various construction personnel require large amounts of information. This information ranges from drawings, which are produced in the design stage, to different project reports, which are prepared during the construction stage. Information is obtained from all stages until the end of the project. Thus, the fusion and management of construction information are crucial due to the diversity and intensity of the information. (Chen & Kamara, 2008; Soibelman, Wu, Caldas,

Brilakis, & Lin, 2008). This is a real challenge in construction projects, and is a primary step in productivity improvement (Bjork, 2003).

On-site information management is critically important because it is the fundamental element of successful project management (Tsai, 2009). Information and communication technology (ICT) tools are used in the construction industry for accurate and efficient information management. They are commonly available in administration offices or on-site offices.

Because carrying a PC or even a laptop is inconvenient for construction managers, particularly when they are climbing up and down in a construction site. All information regarding construction projects such as project progress records, site diaries, daily reports, and so on are recorded in the site office. Thus, recording the information will be postponed until the construction managers come to the site office. Therefore, there is a gap between the observation and recording of the information that causes loss and mismanagement of the information in conventional methods. This study intends to investigate the information requirements of a mobile application which can be used broadly in construction projects.

2. Information Management and Communication in Construction

The success of a construction project depends on a number of factors, including project complexity, contractual arrangements, relationships among project participants, competency of project managers, and the abilities of key project members (Chua, Kog, & Loh, 1999 ; Mohsini & Davidson, 1992). One of the key project members is a project manager who coordinates the whole construction process and stands at the center of the project network (Bayliss, 2002). Apart from coordination, the project manager has some responsibilities such as achieving the project goals, planning and management, and resolving disputes (Cherns & Bryant, 1984; Walker, 2002). The project manager must monitor differences between planned and actual work in terms of time, cost, and quality (Blackburn, 2002). To achieve this, the manager relies not only on the work progress system, but also on the system of managing information on-site, which is vital for the success of the project. This efficient communication has the added benefit of potentially reducing construction costs by as much as 25% (Mohsini & Davidson, 1992).

The construction industry is fragmented because of the many participants, the separation of design and construction phases, and the geographic dispersion of projects (Barrie & Paulson, 1992). As a result, communication is a critical challenge, and many researchers and participants have tried for years to improve these systems.

Many studies have investigated the particular communication barriers in construction. Feedback requirements and the sheer volume of information are major challenges that were investigated by Murray and Thrope (1996). Guevara and Boyer (1981) also explored communication problems in the construction industry, declaring that a lack of feedback causes three main problems: overload, distortion, and gatekeeping. Overload refers to the condition in which a person has more information than he is capable of using. Distortion occurs when there are omissions or additions in communicating information to various participants. Gatekeeping refers to the case of a person intentionally withholding information.

Therefore, construction managers and foremen will need to make more use of information and communications technology to schedule and report on-site, and they will require organizational and interpersonal skills to enable collaboration amongst multidisciplinary teams (CITB, 2003).

3. Methodology

Based on the critical literature review, a questionnaire was designed in order to determine the mobile application's information requirements. It consisted of three parts: Background Information, the Current Status of Adopting On-Site Information Management, and the Information Requirements of a Mobile

Application. The first and second parts of the questionnaire respectively asked yes and no and multiple choice questions. The third part of the questionnaire benefited from the Likert scale. The scale's options were Absolutely Not Required, Not Required, To Some Extent, Required, and Absolutely Required. The star rating design for online surveys makes it easy for respondents to answer five-dimensional Likert-type scales.

After the questions were arranged, an interview was conducted in order to gather the ideas of some of the research professionals at Universiti Teknologi Malaysia (UTM). Some amendments were made, and a pilot survey was conducted in order to observe the questionnaire's effectiveness. Additionally, this pilot survey helped to enhance the quality of the survey because it gathered worthwhile comments from well-experienced respondents.

In the pilot study, five construction professionals were randomly selected to answer the questions and make comments. Then, the necessary amendments were performed to ensure that the final survey could fulfill the objectives of the study. For instance, the number of questions was reduced, the type of questionnaire changed from a PDF format to the online survey format. Finally, the questionnaire was designed in Kwiksurvay's Website.

One of the most useful components of the Kwiksurvay Website is recording the response duration and Internet protocol of the respondents. As such, one person cannot participate twice in the survey. If a participant tries to answer twice, (s)he will face an error the second time. In addition, unreliable responses could be detected by checking the duration of the completed survey. For instance, if a participant answers without reading the questions, the recorded time would be less than a logical time. Thus, finalized data would be safe in terms of duplication and unreliable responses.

The link of the questionnaire was sent to 800 construction professionals from May to June in 2010 via their personal email addresses and also through social and professional networks.

The data obtained from the questionnaire were analyzed by the aid of Statistical Package for Social Science (SPSS) version 18. SPSS was selected because of the product's variety of statistical tests and also the simplicity of creating graphs.

4. Analysis and Results

To achieve the objective of this study, an online survey was established. 181 construction professionals participated from 20 countries. From those, 159 completed the survey and reliable responses were selected to be analyzed by the statistical package for social science (SPSS) version 17. This sample includes 101 contractors, 50 consultants, and eight clients. The low rate of clients' participation caused this study to be limited to the contractor and consultant organizations.

The reliability of the Likert scale was tested using Cronbach's alpha coefficient. According to Pallant (2001) the coefficient more than 0.7 would be considered as a reliable scale. The obtained alpha score is 0.955, indicating highly interrelated data and consistency of the scale with sample size.

4.1 Finding from Respondents Profile

The respondents profile includes participants' background information, company information, and current status of adopting IT in construction projects.

4.1.1 Findings from Mobile Information Requirement

In order to evaluate the demand for information for mobile applications, a mean value of each information group is calculated. The descriptive analysis of the contractor group illustrates that the mean score ranges from 4.12 to 2.76. The most important information required to be included in mobile applications for contractors' perspectives is Schedule Update, followed by Violation Report. The results of descriptive analysis on the Contractor data are shown in Table 1.

Table 1: Information Ranking Using Mean Value based on Contractor's Responses

Rank	Information (Contractor)	N	Mean	Std. Deviation	Variance
1	Schedule updates	99	4.12	1.091	1.189
2	Reporting violations	97	4.09	1.182	1.398
3	Report QC/QA problems	100	4.09	0.944	0.891
4	Accident reporting	96	4.07	1.207	1.458
5	Productivity information	101	4.05	1.099	1.208
6	Report inspection results	101	4.02	0.927	0.860
7	Progress Photo	101	4.01	1.063	1.130
8	Change Order	101	4.00	1.058	1.120
9	Daily Report	101	3.99	1.082	1.170
10	Delay recording	98	3.97	1.060	1.123
11	Site instructions	100	3.95	1.086	1.179
12	Material order status	101	3.90	1.229	1.510
13	Contract Drawing	101	3.86	1.105	1.221
14	Contract Specification	101	3.84	1.056	1.115
15	Request Material to site	101	3.84	1.164	1.355
16	Subcontractor information	101	3.83	0.981	0.961
17	Test results	101	3.83	1.105	1.221
18	Site Diary	100	3.83	1.207	1.456
19	Design intent and clarification	100	3.81	1.080	1.166
20	Budget	100	3.81	1.300	1.691
21	Material List	101	3.79	1.252	1.566
22	Initiate inspection	101	3.75	1.126	1.268
23	Work Package Information	101	3.73	1.130	1.278
24	As built records	99	3.69	1.275	1.625
25	Weekly Report	101	3.66	1.134	1.286
26	Variation Order	100	3.66	1.289	1.661
27	Place material orders	101	3.64	1.238	1.532
28	Material cost accounting	101	3.63	1.309	1.714
29	Implementation Problems	101	3.63	1.155	1.334
30	Equipment List	99	3.63	1.250	1.563
31	Employee List	100	3.60	1.310	1.717
32	Exception Reporting	101	3.58	1.219	1.485
33	Site meeting minutes	100	3.58	1.156	1.337
34	Monthly Report	101	3.56	1.252	1.568

Rank	Information (Contractor)	N	Mean	Std. Deviation	Variance
35	Equipment cost accounting	101	3.51	1.331	1.772
36	Extension of Time	101	3.50	1.246	1.552
37	Material Location	101	3.49	1.254	1.572
38	Equipment Location	98	3.42	1.226	1.504
39	Equipment inspections	98	3.35	1.211	1.466
40	Letters	100	3.28	1.334	1.779
41	Equipment servicing	99	3.15	1.232	1.518
42	Employee Records	99	2.98	1.301	1.693
43	Employee Training	98	2.79	1.204	1.448
44	Visitor's Log	100	2.76	1.304	1.699

Analysis shows that consultants' information needs ranged from design intent and clarification to employee training, with a mean score of 4.2 to 2.98 (Table 2). Consultants' requirements focus on designing part or giving instructions when contractors demand work progress.

Table 2: Information ranking using mean value based on consultants' responses

Rank	Information (Consultant)	N	Mean	Std. Deviation	Variance
1	Design intent and clarification	50	4.20	1.125	1.265
2	Daily Report	50	4.18	1.024	1.049
3	Report QC/QA problems	50	4.18	1.044	1.089
4	Change Order	50	4.18	1.137	1.293
5	Schedule updates	48	4.15	1.167	1.361
6	Site instructions	48	4.15	0.989	0.978
7	Accident reporting	49	4.14	1.291	1.667
8	Reporting violations	48	3.98	1.329	1.766
9	Progress Photo	48	3.98	1.000	1.000
10	Report inspection results	50	3.96	1.195	1.427
11	Site Diary	48	3.94	1.311	1.719
12	Employee List	50	3.92	1.307	1.708
13	Contract Specification	50	3.90	1.344	1.806
14	Initiate inspection	50	3.88	1.239	1.536
15	Test results	50	3.88	1.223	1.496
16	Variation Order	50	3.86	1.195	1.429
17	Contract Drawing	50	3.86	1.443	2.082
18	Material order status	48	3.83	1.419	2.014
19	Delay recording	48	3.81	1.283	1.645
20	Budget	49	3.80	1.472	2.166
21	Request Material to site	48	3.71	1.368	1.871
22	Extension of Time	50	3.70	1.249	1.561
23	Productivity information	49	3.69	1.278	1.634
24	Implementation Problems	49	3.59	1.337	1.788
25	Work Package Information	50	3.58	1.311	1.718
26	Material List	48	3.50	1.414	2.000

Rank	Information (Consultant)	N	Mean	Std. Deviation	Variance
27	Site meeting minutes	48	3.50	1.337	1.787
28	Subcontractor information	50	3.50	1.266	1.602
29	Equipment List	48	3.50	1.399	1.957
30	As built records	49	3.47	1.459	2.129
31	Place material orders	48	3.46	1.473	2.168
32	Exception Reporting	48	3.46	1.429	2.041
33	Equipment Location	49	3.45	1.473	2.169
34	Weekly Report	50	3.44	1.232	1.517
35	Equipment inspections	49	3.41	1.383	1.913
36	Material Location	49	3.41	1.442	2.080
37	Material cost accounting	49	3.41	1.442	2.080
38	Letters	50	3.40	1.414	2.000
39	Monthly Report	49	3.37	1.453	2.112
40	Equipment cost accounting	49	3.33	1.420	2.016
41	Equipment servicing	49	3.24	1.392	1.939
42	Employee Records	49	3.24	1.451	2.105
43	Visitor's Log	49	3.22	1.418	2.011
44	Employee Training	48	2.98	1.466	2.148

To develop the mobile application, this study considers the top 10 ranks from each group. Following that, two different statistical tests are conducted to assure that the selected information is statistically strong.

4.1.2 Difference between Information Needs of Contractor and Consultant

Is there any significant difference in the information requirements of the contractor and consultant? Although there are some similarities between the two, the exact demands for information might be different. To answer this question, a Mann-Whitney test was conducted to compare the mean score of the selected data.

Table 3 shows the result of the Mann-Whitney test. Based on the results, the Mann-Whitney U of the different information from consultants' and contractor's perspective is gradually coming down to reach the minimum amount, which is design intent and clarification. It can be viewed that the significant value for design intent and clarification is less than 0.05, and there is a significant difference between the contractor's and the consultant's point of views in selecting this information for the mobile application.

Apart from designed intent and clarification, there is no significant difference in information demands from both parties. So, it can be concluded that the information needs of both parties are almost the same.

Table 3: Mann-Whitney Test Results based on Mean Rank

Rank	Information	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
1	Material order status	2412.0	7563.0	-0.052	0.959
2	Implementation Problems	2458.0	7609.0	-0.069	0.945
3	Material Location	2441.0	3666.0	-0.138	0.890

Rank	Information	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
4	Report inspection results	2473.5	7624.5	-0.215	0.830
5	Request Material to site	2373.0	3549.0	-0.216	0.829
6	Site meeting minutes	2336.0	3512.0	-0.271	.786
7	Budget	2380.0	7430.0	-0.300	0.764
8	Exception Reporting	2352.0	3528.0	-0.302	0.763
9	Reporting violations	2256.0	3432.0	-0.327	0.744
10	Progress Photo	2347.0	3523.0	-0.330	0.741
11	Equipment List	2288.0	3464.0	-0.375	0.708
12	Delay recording	2266.0	3442.0	-0.376	0.707
13	Equipment servicing	2332.0	7282.0	-0.390	0.696
14	Equipment inspections	2307.0	7158.0	-0.397	0.691
15	Schedule updates	2280.0	7230.0	-0.430	0.667
16	Place material orders	2317.0	3493.0	-0.449	0.653
17	Equipment Location	2288.0	7139.0	-0.478	0.632
18	Work Package Information	2392.5	3667.5	-0.544	0.587
19	Test results	2387.0	7538.0	-0.571	0.568
20	Letters	2356.0	7406.0	-0.588	0.556
21	Accident reporting	2217.5	6873.5	-0.614	0.539
22	As built records	2262.0	3487.0	-0.689	0.491
23	Equipment cost accounting	2297.0	3522.0	-0.731	0.465
24	Monthly Report	2296.0	3521.0	-0.740	0.460
25	Employee Training	2177.0	7028.0	-0.748	0.454
26	Site Diary	2223.0	7273.0	-0.762	0.446
27	Material cost accounting	2275.5	3500.5	-0.823	0.410
28	Variation Order	2296.5	7346.5	-0.844	0.398
29	Report QC/QA problems	2291.5	7341.5	-0.889	0.374
30	Extension of Time	2300.0	7451.0	-0.920	0.358
31	Initiate inspection	2301.0	7452.0	-0.923	0.356
32	Contract Drawing	2295.0	7446.0	-0.954	0.340
33	Site instructions	2170.5	7220.5	-0.998	0.318
34	Employee Records	2184.5	7134.5	-1.006	0.315
35	Contract Specification	2276.0	7427.0	-1.030	0.303
36	Daily Report	2272.0	7423.0	-1.065	0.287
37	Weekly Report	2264.5	3539.5	-1.067	0.286
38	Material List	2161.0	3337.0	-1.110	0.267
39	Subcontractor information	2209.5	3484.5	-1.303	0.193
40	Change Order	2181.0	7332.0	-1.450	0.147
41	Productivity information	2103.0	3328.0	-1.581	0.114

Rank	Information	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
42	Employee List	2107.0	7157.0	-1.629	0.103
43	Visitor's Log	2012.5	7062.5	-1.818	0.069
44	Design intent and clarification	1894.0	6944.0	-2.542	0.011

4.1.3 Information Needs of the Different Countries

Does gathered information depend on the location of the respondents? Does the mean score of the sample differ significantly from one country to another? To answer these questions, the first 10 countries, which had the highest respondents, were selected. Then a Kruskal-Wallis test was conducted, because the normality was questionable and sample sizes within each group were small.

Table 4: Result of Kruskal-Wallis Test

Rank	Information	Chi-Square	df	Asymp. Sig.
1	Delay recording	2.837	9	0.970
2	Change Order	3.930	9	0.916
3	Place material orders	4.242	9	0.895
4	Progress Photo	4.322	9	0.889
5	Work Package Information	4.540	9	0.872
6	Site instructions	4.704	9	0.859
7	Contract Drawing	4.973	9	0.837
8	Design intent and clarification	5.006	9	0.834
9	As built records	5.240	9	0.813
10	Employee List	5.345	9	0.803
11	Report QC/QA problems	5.383	9	0.800
12	Extension of Time	5.709	9	0.769
13	Implementation Problems	5.972	9	0.743
14	Site meeting minutes	6.291	9	0.710
15	Schedule updates	6.518	9	0.687
16	Subcontractor information	6.720	9	0.666
17	Initiate inspection	8.593	9	0.476
18	Test results	8.731	9	0.462
19	Accident reporting	9.372	9	0.404
20	Employee Training	9.417	9	0.400
21	Equipment Location	9.479	9	0.394
22	Visitor's Log	9.584	9	0.385
23	Equipment cost accounting	9.807	9	0.366
24	Contract Specification	9.833	9	0.364
25	Material Location	10.112	9	0.341
26	Material order status	10.315	9	0.326

Rank	Information	Chi-Square	df	Asymp. Sig.
27	Report inspection results	11.217	9	0.261
28	Employee Records	12.123	9	0.206
29	Variation Order	12.133	9	0.206
30	Equipment servicing	12.260	9	0.199
31	Letters	12.335	9	0.195
32	Material List	12.408	9	0.191
33	Equipment List	12.486	9	0.187
34	Daily Report	12.832	9	0.170
35	Equipment inspections	12.971	9	0.164
36	Reporting violations	13.011	9	0.162
37	Productivity information	13.238	9	0.152
38	Monthly Report	14.564	9	0.104
39	Exception Reporting	14.869	9	0.095
40	Site Diary	14.968	9	0.092
41	Weekly Report	15.078	9	0.089
42	Request Material to site	15.743	9	0.072
43	Material cost accounting	15.936	9	0.068
44	Budget	17.175	9	0.046

The result reveals that, apart from the budget, there is no statistically significant difference in the distribution of the sample in these countries, because in all these cases the significant value is greater that 0.05 (See Table 4). Therefore, gathered data are independent of the location of the respondents. It demonstrates that the methods of construction and the requirements of the construction professionals are the same in different countries. The above results prove that the selected information can safely be used in the development phase.

5. Conclusion

This study investigated the information requirements of a mobile application that can be used broadly in construction projects. It looked at what information would be most important from the perspectives of consultants and contractors: Contractors want work performance and progress as well as safety. The top 10 critical information is as Table 5.

Statistics shows that apart from design intent and clarification, there is no significant difference in the information demands of consultants and contractors. Moreover, although different countries have different cultures and different adoptions of IT in construction projects, there were not significant differences in the information requirements of the respondents from different countries.

Table 5: Final Selected Information

Rank	Contractor	Consultants	Selected Information
1	Schedule updates	Design intent and clarification	Design intent and clarification
2	Reporting violations	Daily Report	Reporting violations

3	Report QC/QA problems	Report QC/QA problems	Report QC/QA problems
4	Accident reporting	Change Order	Accident reporting
5	Productivity information	Schedule updates	Productivity information
6	Report inspection results	Site instructions	Report inspection results
7	Progress Photo	Accident reporting	Progress Photo
8	Change Order	Reporting violations	Change Order
9	Daily Report	Progress Photo	Daily Report
10	Delay recording	Report inspection results	Delay recording
11			Schedule updates
12			Site instructions

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