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Effect of Using Building Maintenance Information Management System in Maintenance Process in Ministry of Education

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ABSTRACT

Educational buildings and Schools are one of the important facilities in community directly related to all families and any problems in the buildings affect the learning process, in Kurdistan according to the latest status about 60% of schools need maintenance and renovations and these data's needs to manage properly. Information management involves the design of a system in which data is collected and processed into management information, Missing building information or outdated lead to ineffective project management. In this research a web-based model namely BMIMS (Building Maintenance Information Management System) is developed to record, kept, manage and share all information between technical staff in directories. The Model presented to the technical staffs in MOE (Ministry of Education), perform a survey using the special questionaries' form. The results show that the system has an impact on maintenance process and information management in MOE, the system outcome effect on three themes which are information, communication and cost. The model lead to increase collaboration, communication and productivity, and reducing request for information, losing data, time, rework and administration cost. BMIMS also improves data gathering, information management, better design and construction decisions, knowledge transfer, and staffs technical skills. The research indicates the factors which lead to implement in MOE, training staff is the first one after that the hardware and IT issue after that adoption by top managers. This model is most suitable for other ministries carrying out maintenance.

1. INTRODUCTION

Building maintenance (BM) considered as a part of the construction sector, is seen as an activity in the larger ambiance of facilities management (FM) [1] [2]. BM purpose to remain building services at acceptable level of standard to enable its functions in results of keeping, holding, sustaining or preserving [3]. It is a process of reservation and restoration activity of the structure and components of a building. It covers the whole building which includes toilets, rooms, walls, roofs, drains, doors, windows, floors and also fix furniture. School maintenance is a continuous process to keep the school buildings, furniture's, and equipment's in the best form for regular use [4]. Educational buildings and schools are one of the important facilities in community directly related to all families and any problems in the buildings affect the learning process. Some studies found that students are likely to do better in newer or newly built buildings than in older ones. [5]. So, maintenance in school buildings are also required to serve staff and students to continue education sector and providing better quality of education.

It is clear that without improved communication and efficient means of exchanging information the integration of the design and construction processes alone cannot improve productivity and performance [6]. In a study conducted in 1979 the Project Information Group of the NCC Standing Committee highlighted the effect of inadequate project information on many areas like time-waste on technical problem solving [7] [8]. Missing building information or outdated lead to ineffective project management, time loss, undefined process results, const increase in maintenance, retrofit and repudiation processes [9]. Singh and etc. stated that organizations according to their structures and projects necessities will need to improve and develop data management processes. [10]. A set of information held in one place and used mainly for the maintenance and management of a building [11]. Information management related to design of a system which processed the collected data into management information. [12]. According to [6] construction information can be grouped into three groups:

- General information.
- Organization specific information.
- Project-specific information.

The general information group defines available information concerning construction products, regulations, standard procedure, etc. publicly or commercially. Interested organizations generally have such required information. Organization-specific information categorized all information available to a specific organization such as standard solutions for design construction problems that often appear in the form of the library from previously completed projects which are used as reference cases within the organization. This information kept or stored in a digital environment and used any time needed. The project specific information is tie to one specific construction project or other project type.

2. LITERATURE REVIEW

2.1 Previous Works

The requirement for integration of the construction processes with information has been widely recognized for decades. Ioannou and Liu (1993) mentioned that construction technology is a computerized database for the classification, documentation, storage, and retrieval of information about emerging construction technologies [13]. Document management systems are constructing an essential step towards computer-integrated construction [14].

Internet-based web-mediated collaboration tool kit were developed in 1999 by Fruchter as a tool for remote offices. The tool kit is aimed to assist team members and owners to capture and share knowledge and information about the project, navigate through the archived information and evaluate performance [15] [16].

IT-based tool for document management as a first phase used by Dawood [6]. It developed an automated integrated solution for the communication, collection, storage and delivery of project documents among the project team, the system designed under the name AutCom by using Microsoft Access and web programming to an interface. The system capability is to view drawings in the system of CAD. The program also offers time-and expense savings. [6].

A Buildpass model is the web-based application designed at that level all users can use it engineers and others also, it has a capability to share the experience and knowledge of experts in the system, also linkage their knowledge with the technical standards [17].

The information gathered by the system would be useful for future maintenance management such as decision making, cost monitoring, optimizing the re-use of information and future planned maintenance according to Ali [18]. He has developed a prototype system under name MoPMIT, has identified some problems under three categories which associated with reactive maintenance which are Knowledge Management, Procedures and Overall System.

Using ITools and techniques to capture and update a knowledge base that includes a central repository and reuse in later also helps to improve communication and information flow. The web-based systems are controlled accessibility. This means all parties involved in the work can access the system from any remote workplace with their access permissions according to their job responcibilities. [18].

To avoid wasting time, cost and energy with reducing unnecessary paperwork and rework the building maintenance process needs effective management [3]. Knowledge sharing between the facility management and design professionals has become possible [19] and enhance the use of project information throughout project's life cycle [20].

According to (Becerik-Gerber etal.) project information needs to be incorporated or compliant with FM information systems such as computerized maintenance management (CMMS), electronic record management (EDMS) systems [20].

Using a web-based system to using BIM models information and storing the knowledge to reuse for any maintenance operation, in 2013 (Motawa and etl.) investigated cases in ten organization in Kuwait to integrate public sector organization with a developed system to store and retrieve all relevant maintenance information, as an approach to establish the transformation from BIM to Building Knowledge Modelling (BKM).

The system stored maintenance operation history, before each new task maintenance team can use it as a guide and learn from previous experience and trace the history of effected element [2].

The BIM-server to serve as a collaboration platform, it's organization has features and technical requirements for model management and organization includes (model repository: a server should have a centralized repository to store models, hierarchical model structure, ability to store and present objects of the model as text-based information in repositories, public and private model spaces [10].

Effective maintenance management requires knowledge of the building inventory (sizes, types, and association of elements), physical condition (a measure of individual components and building as a whole), component performance (condition over time), and the impact of component performance on overall building performance [21].

2.2 Ministry of Education's Current Situation

Education is an essential part of any country as well as it is one of the most challenging sectors to any government to deal with its problems. Like any other places, at least a family member of the majority of the Kurdistan Region of Iraq's (KRI) households are reaching schools on a daily bases. According to statistics released in 2018 by KRG-MoE, the total students officially studying in the primary and high schools are 1731629, which the number is nearly a quarter of KRI's residents. In addition to that, MoE manages 6563 schools, 127560 teachers, and 33040 staffs which are distributed among the four KRI governorates. The organizational structure of MoE is like the following. The ministry itself located in Erbil, the KRI capital, and six general directorates in the cities of (Erbil, Sulaimaniyah, Duhok, Halabja, Kirkuk and Garmiyan administration), each of which contains sub-directories in the districts accordingly, such as in Sulaimaniyah the General Directorate of Education (SGDE) has eleven sub-directories. One of these sub-directorates is the general department for rehabilitation and maintenance of the buildings.

2.3 Current Building Maintenance Management System

Normally, the maintenance process in the SGDE-MoE can be divided into three majors stages. All three stages are explained below:

- Stage A: Request for Maintenance and Inspection.

In this stage, the process starts with submitting the requested document from the school administration or educational supervisory department to the general director of education. The inspection team according to the nature of work and the school requirements vary from one to another in regards to the number of engineers and technicians. Also, another committee in the SGDE is responsible for checking and approving the estimated cost of the works and items. Finally, the drawings and Bill of Quantity submitted to Head of the Building Department to be prepared for the next stage.

- Stage B : Decision Stage.

In the second stage, the building department and finance department ask for a budget for the maintenance. In case if the budget was available, the execution team will be assigned. From there, the second stage will be completed. If not the head of departments informs the head General Director.

- Stage C : Excusion stage.

the last stage of school maintenance, the executive committee will receive an advance in the finance department. Then, preparation for labour and materials just begin. Also, investigate any variation in the cost and scope of the work. After finishing works and final measurement the handover team will check all works according to drawings and the BQ if there is any difference should be repaired after that the project closure and archive the documents.

3. METHODS AND MATERIALS

The research designed and conducted in three stages; gap assessment using qualitative methods, creating the model, and evaluation the model by quantitative research methods.

3.1 Gap assessment

The gap assessment is intended to understand the gaps that now exist in the maintenance process. This is done through a qualitative analysis approach using semi-structured interviews with six senior construction engineers who currently managers of building departments in the SGDE and education departments in Sulaimaniyah districts.

3.1.1 Gap analysis

Qualitative Data from the interviews were transcribed, translated and thematic analysis was conducted. This involved coding all the data before identifying and reviewing five key themes. Each theme was examined to gain an understanding of participants' perceptions and motivations.

3.2 Proposing Model

In this phase, a computer model was developed named “Building Maintenance Information Management System - BMIMS”. This system was designed to fill the gaps in information management and some extra features to cover other demands and challenges faced during the administration of building maintenance and moderation.

3.3 Evaluation of the Model

The last phase consisted of the validation of the model by designing a questionnaire. This was presented to the SGDE engineers, technicians and administrative staff. After that, they filled the survey questionaries which consisted of 29 questions standard five-degree Likert scale distributed in four sections:

The first section was the demographics of the participants and backgrounds collected profile information about years of experience, the specialist, academic qualification, area of their directories works, roles, responsibility and total years in MoE, in eight questions (Q1 – Q9).

In the second section, ten questions (Q10 – Q19) was set to evaluate the model effect on maintenance management process and information management (Collaboration, Communication, Data gathering and Data Management, Request for Information RFI, Losing Data, Time & Rework, Administration Cost, Productivity, Decision Making, Knowledge exchange).

The third section (Q20 – Q23) investigate the models main part features and how to fit the purpose and suitable for the procedures and maintenance process and covers the gaps which exist, the main parts are (reporting, BoQ, inspections and projects).

In the last section, the six criteria presented (Q24-Q29) to know the priorities to implement the proposed model, the factors are (Legal, Adoption in top management, IT and hardware installation, Resistance to change, Training of staffs, Changing work process).

3.4 Data Analysis

Model designed in Drupal; Drupal is a content management software. It is used to make many of the websites and applications used every day.

Quantitative data are collected from 41 participants and Minitab program are used to analyze them. For ensuring internal consistency of the questions testing validity and reliability, the Cronbach alpha test was performed. Cronbach’s alpha is a statistic that measures the internal consistency among a set of survey items, ranges between 0 and 1. The greater the value of alpha, the more the scale is coherent and thus reliable. (Lavrakas, 2008) have proposed a critical value for the alpha of 0.70.

The frequency table for respondents with percent and cumulative percent’s and descriptive statistics (mean, standard deviation and coefficient of variance (CV)) has been prepared for all sections.

The spearman rho correlation test was used to determine the nature of correlation between factors.

4. BMIMS MODEL

The proposed system for KRG-MoE- SGDE, uses to enhance and further learn from the maintenance and building mechanisms to reach the best and optimum solutions for the future education projects in the mentioned governorate as a sample. The system designed in Drupal; Drupal is content management software. It is used to make many of the websites and applications which they are used every day. In the BMIMS model, each employee includes engineers, technicians and administrative staff, have own account can log in the system according to their granted access and privilege in the MOE, the system can install remotely and controlled anywhere and input the required data and use the information, as shown in Fig. (1).

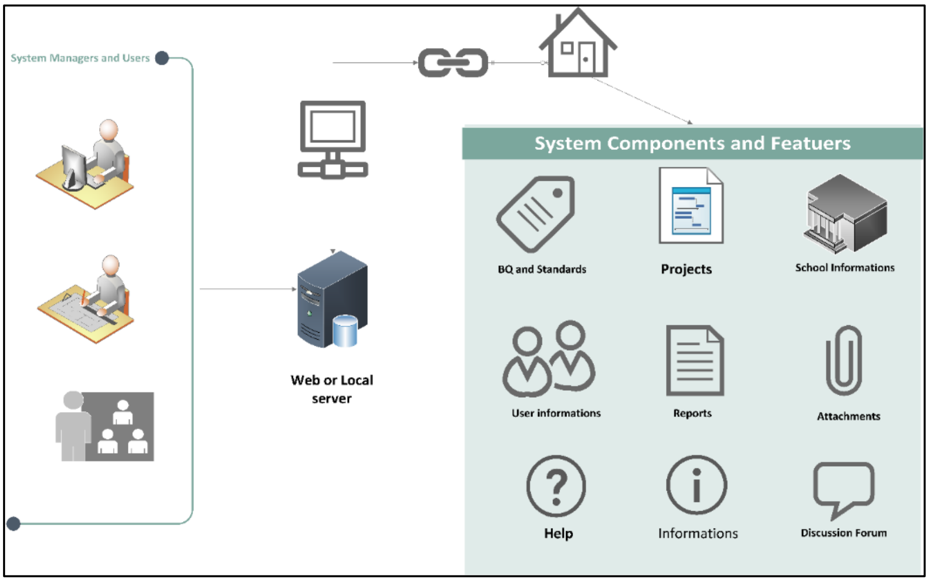

Figure 1: Map diagram for the proposed moodel

The main system parts and sections are:

- **Projects**: users store all information related to the maintenance project, also the summarized previous projects shown in the table.
- **Inspections**: All inspection requests information records also according to the follow-up process the status of the request changes and notify, also the users can see the status and summary of all requests in the table format can sort according to type, date and status. The inspection documents attached to the inspection requests.
- **Bill of Quantitates:** The purpose of this section is to provide the suitable easy useable central standardized tool to prepare BoQ in the MOE, users can easily search for any item want according to the type of item or using in the building parts, only the BoQ committee can enter the information all engineers can use data if they have any comments can send and improve that item, also shown the summarized data in the table and can see categorial view of any item and any use in the part.
- **Reports:** Reporting is an important stage and essential work of any mangers to moderate and check the performance and evaluation of progress, in the report section in BMIMS can easily add, read, edit, modify any type of reports you have, also view summarized table for entire reports also can categories according to types).
- **Documents**: Can keep all types of documents they have the documents summarized in the table can sort according to type, date and name, also can view according to categories.
- **Forums:** Forum section provide a medium for conversation and knowledge sharing between engineers, technicians and staffs, also can share experts between them and expand knowledge about the topics.
- **Search:** The search section is a helpful tool to reach and find any data anywhere any time recorded you want, just by writing the keyword. After that, you get the result by type and show the location.

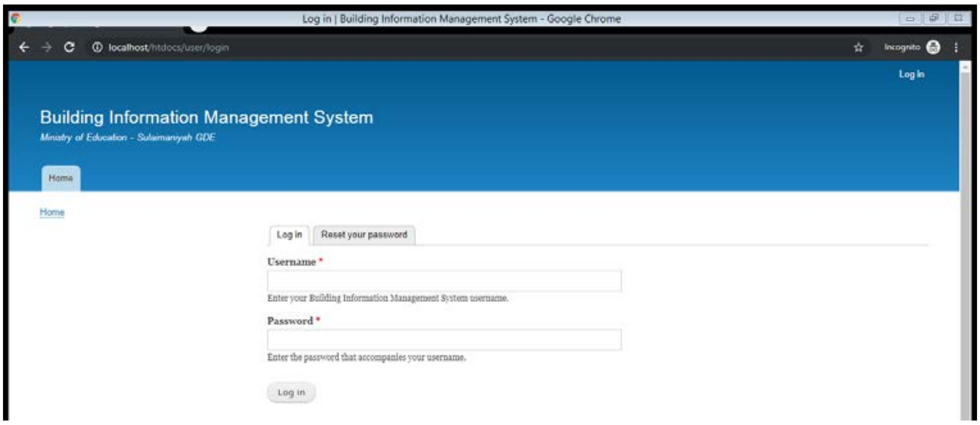

Figure 2: interface for BMIMS

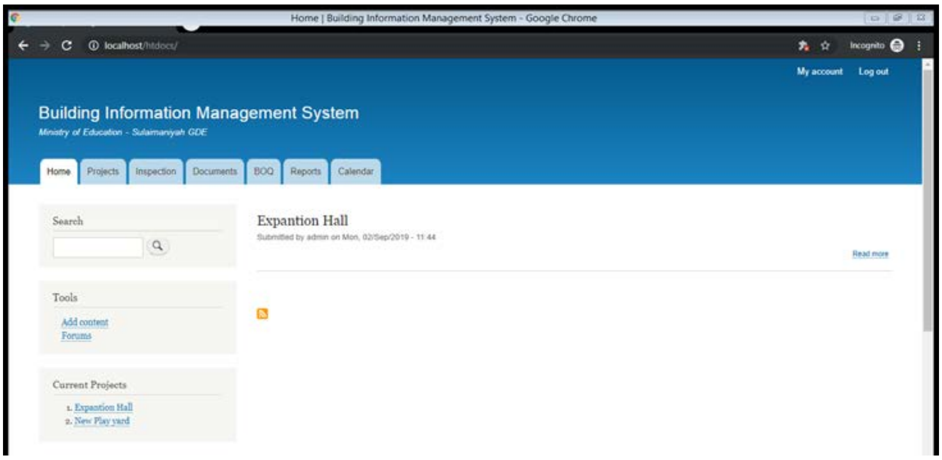

Figure 3: General interface for the user

5. RESULTS AND DISCUSSION

All data collected from questionnaires are analyzed and presented in four sections. The sections are (1) the descriptive statistics for demographics of respondents, (2) evaluation of the system features, (3) the model components, and (4) application criteria. The data are collected from 41 participants and using Minitab program to analyze the data. Also, for ensuring the internal consistency of the questions, testing validity, reliability, Cronbach alpha tests were performed and the alpha equal (0.821), which mean high reliability.

5.1 Demographics of participants

The first section demographics of the participants are summarized in Table 1, which are 70.73 % are engineers, 26.83 % are technician, and 2.44 % are administrative staff. Furthermore, 58.54 % of them have experience more than 10 years, and 46.34 % of them employed in the MoE more than 10 years, the ration of male and females are closer which are 51.22% males and 48.78% female, the qualification and education background majority of them have bachelor in engineering which equal to 65.85 %, only 2.44 % of them have higher than BSc. Diploma 29.27 %, also 53.66 % of the employees have than one more task in their department and their roles distribution shown in Fig. 4.

Table 1: Demographic of responders

	Item	Frequency	Percent	Cum. %
1	**Specialist**			
	Civil	22	53.66	53.66
	Electrical	5	12.20	65.85
	Mechanical	2	4.88	70.73
	Technician	11	26.83	97.56
	Others	1	2.44	100.00
2	**Education Level**			
	Bachelor	27	65.85	65.85
	Master	1	2.44	68.29
	Diploma	12	29.27	97.56
	Others	1	2.44	100.00
3	**Gender**			
	Male	21	51.22	51.22
	Female	20	48.78	100.00
4	**Experience in their fields**			
	5 - 1 0	17	41.46	41.46
	10 - 1 5	15	36.59	78.05
	15 - 2 0	4	9.76	87.80
	> 20	5	12.20	100.00
5	**Employed in MOE**			
	< 5	1	2.44	2.44
	5 - 1 0	21	51.22	53.66
	10 - 1 5	12	29.27	82.93
	15 - 2 0	5	12.20	95.12
	> 20	2	4.88	100.00

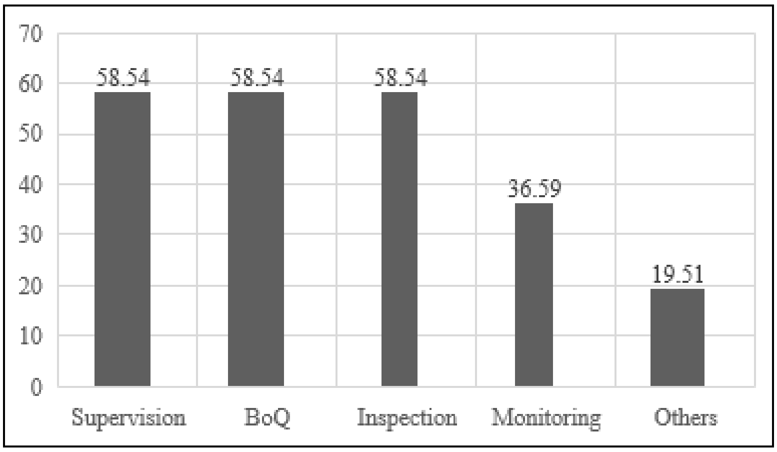

Figure 4: Roles of the Responsibilities of Responders

5.2 Evaluation effects of the model

In the second section, ten questions were set to evaluate the systems effect on maintenance management process and information management. The results were summarized in Table 3. The results show that the BMIMS helps the MOE building department to increase collaboration, communication and productivity, and reducing request for information, losing data, time, rework and administration cost. Also, the BMIMS improves data gathering, information management, better design and construction decisions, knowledge transfer and staffs technical skills.

The results also showed that the factor about losing data in Q14 have the Coefficeint of Variance (CV) 14.12 %. The majority of the respondents think that the system will reduce losing data, also after that CV 14.20% for communication between employees, and the reducing time and rework with CV 14.30 %.

After performing the spearman rho correlation test to determine the nature of correlation between factors, the results show that all variables have a positive relations. The results were summarized in Table 2.

The correlation between Q13 (reducing request for information RFI) and Q18 (providing a good decision making) are very strong and equal 0.803, it means the system will provide all necessary information's this lead to good design and construction decision making. Correlation between Q12 (Data gathering and Data Management) and Q14 (reducing losing data) are (0.747) it mean there is a strong positive relationship.

The results also showed that there is a strong relationship between communication, reworking and reducing time, the spearman rho value is (0.709) between Q11(increasing communication) and Q15 (reducing time and rework).

Table 2: Correlation matrix between factors

	Q10	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**
Q11	0.612								
	0.000								
Q12	0.517	0.573							
	0.001	0.000							
Q13	0.330	0.434	0.545						
	0.035	0.005	0.000						
Q14	0.349	0.533	0.747	0.696					
	0.025	0.000	0.000	0.000					
Q15	0.583	0.709	0.759	0.744	0.724				
	0.000	0.000	0.000	0.000	0.000				
Q16	0.400	0.474	0.531	0.619	0.427	0.629			
	0.010	0.002	0.000	0.000	0.005	0.000			
Q17	0.432	0.500	0.491	0.669	0.609	0.607	0.694		
	0.005	0.001	0.001	0.000	0.000	0.000	0.000		
Q18	0.324	0.502	0.447	0.803	0.600	0.624	0.567	0.747	
	0.039	0.001	0.003	0.000	0.000	0.000	0.000	0.000	
Q19	0.480	0.554	0.601	0.609	0.551	0.687	0.486	0.601	0.622
	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000

Table 3: Frequency and Descriptive data for section two

Symbol	1	2	3	4	5	Mean	SE Mean	St. Dev	CV
Q10 / Frq.	0	0	4	18	19	4.366	0.103	0.662	15.160
Percent	0	0	9.76	43.9	46.34				
Cum. %.	0	0	9.76	53.66	100				
Q11	0	0	3	15	23	4.488	0.100	0.637	14.200
	0	0	7.32	36.59	56.1				
	0	0	7.32	43.9	100				
Q12	0	0	5	15	21	4.390	0.110	0.703	16.010
	0	0	12.2	36.59	51.22				
	0	0	12.2	48.78	100				
Q13	0	0	5	16	20	4.366	0.109	0.698	16.000
	0	0	12.2	39.02	48.78				
	0	0	12.2	51.22	100				
Q14	0	0	3	14	24	4.512	0.100	0.637	14.120
	0	0	7.32	34.15	58.54				
	0	0	7.32	41.46	100				
Q15	0	0	3	19	19	4.390	0.098	0.628	14.300
	0	0	7.32	46.34	46.34				
	0	0	7.32	53.66	100				
Q16	0	3	5	18	15	4.098	0.139	0.889	21.690
	0	7.32	12.2	43.9	36.59				
	0	7.32	19.51	63.41	100				
Q17	0	1	4	22	14	4.195	0.112	0.715	17.040
	0	2.44	9.76	53.66	34.15				
	0	2.44	12.2	65.85	100				
Q18	0	0	7	17	17	4.244	0.115	0.734	17.300
	0	0	17.07	41.46	41.46				
	0	0	17.07	58.54	100				
Q19	0	1	5	16	19	4.293	0.122	0.782	18.230
	0	2.44	12.2	39.02	46.34				
	0	2.44	14.63	53.66	100				

5.3 Evaluation of the Model's Features

The third section investigates the system's main features and how to fit the purpose and suitable for the procedures, maintenance process and covers the gaps which currently exist. The main parts are reporting, BoQ, inspections and projects as shown in Figure 5.

The results show that the most accepted part are BoQ (Q21) part more than 90% of participants agree and strongly agree about this section and have CV 17.47% also has higher percentage of acceptance.

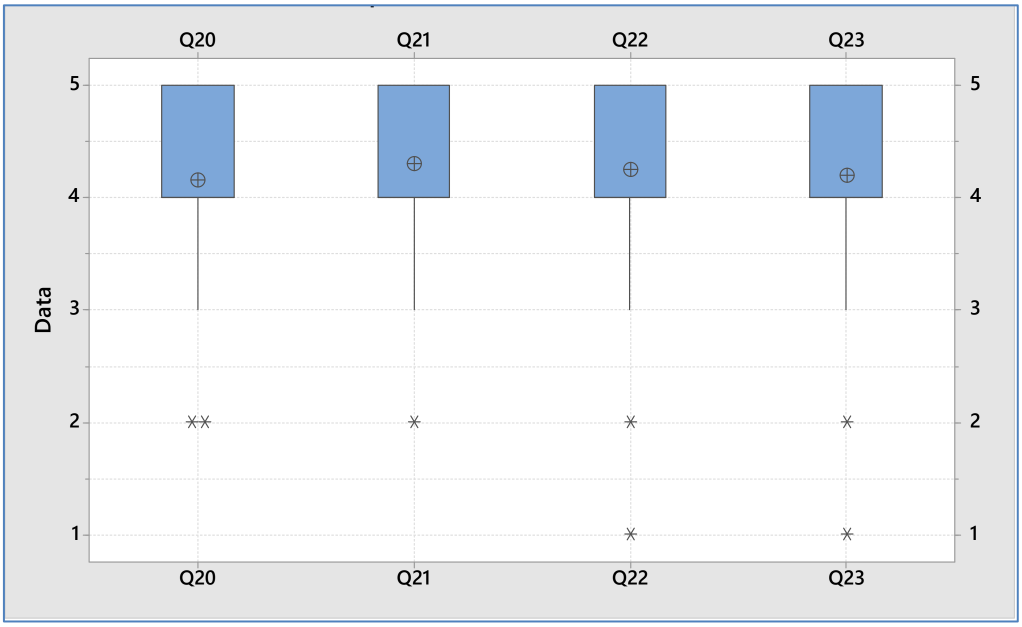

Figure 5: Box plot for responses in chapter three.

5.4 Implementation criteria factors

In the last section, the six criteria presented to know the priorities to implement the proposed system. The relative important index (RII) and CV were used to rank the factors, which results are summarized in Table 3.

As results showed that these three factors are most important rather than others:

1. Staff training.
2. Hardware and IT issues.
3. The adoption in top management.

Table 4: Implementation criteria questions

Variable	Criteria	Mean	SD	CV	RII	Ranking
Q24	Legal	3.146	1.333	42.38	0.629	4
Q25	Adoption in top management	3.878	1.208	31.15	0.776	3
Q26	IT and hardware installation	3.878	1.144	29.51	0.776	2
Q27	Resistance to change	3.268	1.432	43.82	0.654	5
Q28	Training of staffs	4.390	0.862	19.65	0.878	1
Q29	Changing work process	3.098	1.625	52.46	0.620	6

6. CONCLUSIONS AND RECOMMENDATIONS

The results show that BMIMS provide a virtual area to collaboration and knowledge share. In addition to that, it improves the quality of works and better technical standards especially in the areas of preparing BoQ, inspection, follow-up, monitoring process, project data management and reporting. The remotely controlled feature provides better communication between departments. It also helps the MOE building department to increase collaboration, communication and productivity, and reducing request for information, losing data, time, rework and administration costs. Also, BMIMS improves data gathering, information management.

The BMIMS model can be installed in web or local servers, and users can operate remotely. last part of the research survey indicated factors effect implementation of the model, which are training of staffs and adoption of the model from top managers.

The model can be improved by integrating in smartphones application system, further improvements to input datas capacity by school managers can also be provided. The model capable to implete in other ministries which has the similar maintenance procedure.

REFERENCE

[1] P. Barrett and D. Baldry, *Facilities management: Towards best practice*. John Wiley & Sons, 2009.

[2] I. Motawa and A. Almarshad, "A knowledge-based BIM system for building maintenance," *Automation in construction,* vol. 29, pp. 173-182, 2013.

[3] S. Fong and K.-C. Wong, "Knowledge and experience sharing in projects-based building maintenance community of practice," *International Journal of Knowledge Management Studies,* 2009.

[4] Z. A. Akasah, S. H. Shamsuddin, I. A. Rahman, and M. Alias, "School Building Maintenance Strategy: a new management approach," in *Malaysian Technical Universities Conference on Engineering and Technology (MUCET 2009), Pahang, Universiti Malaysia Pahang,* 2009, pp. 1-5.

[5] S. Lavy and D. L. Bilbo, "Facilities maintenance management practices in large public schools, Texas," *Facilities,* vol. 27, no. 1/2, pp. 5-20, 2009.

[6] N. Dawood, A. Akinsola, and B. Hobbs, "Development of automated communication of system for managing site information using internet technology," *Automation in construction,* vol. 11, no. 5, pp. 557-572, 2002.

[7] M. Richards, *Building information management: A standard framework and guide to BS 1192*. BSI Standards, 2010.

[8] F. Khosrowshahi, "Building Information Modelling (BIM) a Paradigm Shift in Construction," in *Building Information Modelling, Building Performance, Design and Smart Construction*: Springer, 2017, pp. 47-64.

[9] R. Volk, J. Stengel, and F. Schultmann, "Building Information Modeling (BIM) for existing buildings—Literature review and future needs," *Automation in construction,* vol. 38, pp. 109-127, 2014.

[10] V. Singh, N. Gu, and X. Wang, "A theoretical framework of a BIM-based multi-disciplinary collaboration platform," *Automation in construction,* vol. 20, no. 2, pp. 134-144, 2011.

[11] J. Eynon, *Construction manager's BIM handbook*. John Wiley & Sons, 2016.

[12] B. Chanter and P. Swallow, *Building maintenance management*. John Wiley & Sons, 2008.

[13] P. Ioannou and L. Y. Liu, "Advanced construction technology system—ACTS," *Journal of Construction Engineering and Management,* vol. 119, no. 2, pp. 288-306, 1993.

[14] Z. Turk, "Construction design document management schema and prototype," *The International Journal of Construction Information Technology,* vol. 2, no. 4, pp. 63-80, 1994.

[15] R. Fruchter, "A/E/C teamwork: A collaborative design and learning space," *Journal of Computing in Civil Engineering,* vol. 13, no. 4, pp. 261-269, 1999.

[16] C. H. Caldas, L. Soibelman, and L. Gasser, "Methodology for the integration of project documents in model-based information systems," *Journal of Computing in Civil Engineering,* vol. 19, no. 1, pp. 25-33, 2005.

[17] D. Macek and J. Dobiáš, "Buildings renovation and maintenance in the public sector," *Procedia Engineering,* vol. 85, pp. 368-376, 2014.

[18] N. Ali, M. Sun, G. J. Petley, P. Barrett, and M. Kagioglou, "MoPMIT: a prototype system for reactive maintenance projects in The UK," *Jurnal Alam Bina,* vol. 6, no. 2, pp. 13-28, 2004.

[19] R. Liu and R. Issa, "Automatically updating maintenance information from a BIM database," in *Computing in Civil Engineering (2012),* 2012, pp. 373-380.

[20] B. Becerik-Gerber, F. Jazizadeh, N. Li, and G. Calis, "Application areas and data requirements for BIM-enabled facilities management," *Journal of construction engineering and management,* vol. 138, no. 3, pp. 431-442, 2011.

[21] D. E. Dickerson and P. J. Ackerman, "Risk-based maintenance management of US public school facilities," *Procedia Engineering,* vol. 145, pp. 685-692, 2016.

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