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CRITIAL SUCCESS FACTORS FOR PROJECT MANAGEMENT INFORMATION SYSTEM IN CONSTRUCTION

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ABSTRACT: With a focus on different aspects of PMIS in construction projects, various sets of critical success factors (CSFs) have been suggested in the literature such as IS Success Model by various researchers. It is crucial to explore the relative importance and groupings of these factors. This paper aims to identify CSFs associated with Project Management Information System (PMIS) in construction projects, and explore their ranking and underlying relationship.
CSFs for PMIS identified through a literature review, and consolidated by interviews and pilot studies with professionals in construction industry. A questionnaire instrument was sent out to experienced users (Construction Manager and Constructor) in Korea, and 253 completed questionnaires were retrieved. To increase the generalizability of the results, the respondents were spread across construction site.
Using factor analysis and considering the high importance of the factor, CSFs were grouped into three dimensions. All these three groupings and their relationship were included in a framework for successful PMIS in construction projects. These findings help to clarify what the high prioritized factors are, and could also be used as an assessment tool to evaluate the performance of PMIS and thus help to identify areas for improvement.

Keywords: Critical Success Factors (CSFs), IS Success Model, Project Management Information System (PMIS), Construction projects

1. INTRODUCTION

The importance of information technology (IT/IS) in the architectural/engineering/construction (A/E/C) industry has grown exponentially over the past decades [1]. As one of the key IT applications, project management information system (PMIS) has played significant role in construction management processes. The reason for this is that PMIS is an information system to gather, integrate, and disseminate the output of project management processes among project participants, which is used to support all aspects of a project from initiating through closing.

In order to continuously increase the efficacy of PMIS, we need to know the critical success factors (CSFs) for PMIS. That means, what users feel of importance should be identified and managed more significantly. In a similar context, there have been lots of researches on general information systems (IS) success factors and success models. However, there have been neither significant researches on CSFs for PMIS [2], nor studies on the actual use and impacts of these systems [3].

In general, there are two types of PMISs in construction: One is those which developed and used by individual construction companies. The other is ASP(Application Service Provider)-based PMIS that are developed for general construction projects but can be customized for a specific construction projects. The former can be considered as one of the information systems (eg., MIS and ERP systems, etc.) used in a company exclusively. Thus the CSFs for this type of PMIS are similar to those of general information systems of the company. However, the latter are generally used by various project participants such as clients, architects, constructors, sub-contractors and construction managers, their quality is much more dependent to the capability of service providers.

This research aims to identify the CSFs for ASP-based PMIS, so that we can understand what important items to the users are. This paper initially reviews the previous researches on information systems' success factors and models. A set of potential CSFs was established based on the previous researches. In order to assess their importance, a questionnaire was completed by PMIS users. Relying on the questionnaire results, factor analysis was conducted so that we could determine the final CSFs and from their meaningful groups. The CSFs will provide PMIS developers or application service providers with guidelines for PMIS evaluation and upgrades. For the users of PMIS, the CSFs will be selection guidelines among various service providers.

2. THEORETICAL BACKGROUND

2.1 Is Success Model

After reviewing over 180 papers on IT investment assessment factors in the 1870s and 1980s, DeLone & McLean [4] presented an IS Success Model with six factors related to the success of information systems: System Quality, Information Quality, User Satisfaction, System Use, Individual Impact, and Organizational Impact.

While the model integrates the comprehensive dependent variables used by IS researchers, there exist several criticisms. First IS Use in the DeLone & McLean model contains too many meanings to be appropriately examined. IS Use is also argued to play a problematic and controverisal role in modeling system success. Second, because User Satisfaction represents individual impacts of IS in an organizational setting, investigating the cause path from User Satisfaction to individual impacts is fruitless. Finally and most importantly, the model does not explain clearly and fully the relationship between User Satisfaction and Individual/Oraganizational impacts [5].

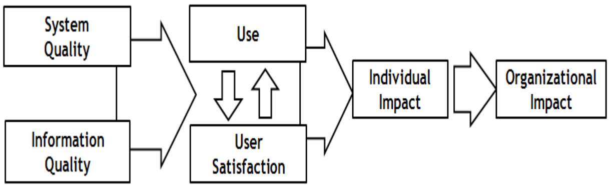

Figure 1. IS Success Model [4]

Ten years later, DeLone & McLean [6] presented an updated model reflecting criticisms by other researchers and the situation at the time. As the service concept was added to IT with the use of the Internet, they increased the number of information system success factors to seven, including Service Quality, and analyzed the interdependence and correlation of these seven factors.

The difference between the existing models is as follows. First, the addition of service quality to reflect the importance of service and support in successful IS systems. Second, the collapsing of individual impacts and organizational impacts into more parsimonious net benefit constructs.

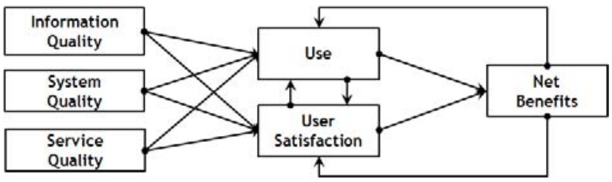

Figure 2. IS Success Model [6]

2.2 PMIS Quality

Even though existing studies have added or removed a few quality factors, we already conducted a prior study based on the three factors of system quality, information quality and service quality as proposed by DeLone & McLean [4,6], since they are the most important factors.

1) System Quality

System quality means the performance of the information processing system itself. As an essential quality element in the processing of tasks through computer-based information systems, it has been established as a critical factor for the success of information systems. Detailed assessment items for System Quality include accessibility, usability, efficiency and accuracy.

Table 1. System Quality in literature review

Item	Author
Ease of use, usability, esthetics, functionality, certainty, answerability, accessability, stability, convenience, and sympathy	[7]
Convenience / simplicity, accuracy / reliability, accessability, speed, availability, stability, compatibility	[8]
Speed, reliability, availability	[9]
Speed, stability, obstacle	[10]
Convenience, reliability	[11]
Simplicity of use, skill, accessability, accuracy, flexibility, reliability, efficiency	[12]
Accuracy, Flexibility, Reliability, Sophistication, Efficiency, Ease of use, Convenience of access	[4,6]
Flexibility, Interoperability, Functionality	[13]
Rapid access, Quick error recovery, Security, Correct operation & Computation, Coordination Balanced payment,	[14]

2) Information Quality

Information systems are created to provide useful decision making information to individuals and groups by storing, keeping, processing and managing information resources. Their values are realized when the information provided is applied to operations. Swanson [15] claimed that information quality is a critical factor that determines the success of information systems, and defined detailed factors for assessing information quality such as the rapidity of information resource acquisition and the usefulness of information resources. Meanwhile, Zmud [16] insisted that accuracy and timeliness are the critical factors which determine information quality after he developed and empirically analyzed various information quality assessment factors.

Table 2. Information Quality in literature review

Item	Author
Accuracy, Ability of Understanding, Availability, Precise, Currency, Conciseness, Consistency, Interpretation, fidelity.	[7]
Accuracy/ reliability, conformance/ correlation, timeliness, completeness, significance	[8]
Accuracy, component type, completeness, timeliness	[9]
Accuracy, screen configuration adequacy, offering information diversity, timeliness	[10]
Timeliness, accuracy	[11]
Accuracy, immediate, reliability, completeness, adequacy of format, ability of Understanding	[12]
Usefulness, Readability, Clarity, Format, Appearance, accuracy, Currency, Completeness, Timeless, comparability, Usableness	[4,6]
Integrated and better quality of information	[13]
Business profitability, Improved decision quality and performance, perceived benefits	[14]

Accuracy, Completeness, Consistency, Timeless	[17]

3) Service Quality

ASP-based PMIS is a type of outsourcing service for information systems which provides various services for products, hardware and software installation, maintenance and A/S services. Thus, service quality is an important success factor for information systems and must be assessed. Information system service quality is actively researched in marketing and business administration areas. Widely used Service Quality assessment tools include SERVQUAL developed by Parasuraman A., Zeithaml, V. A. and Berry, L. L.[18] and SERVPERF which was derived from a criticism of SERVQUAL.

Table 3. Service Quality in literature review

Item	Author
Diversity, accessability, correspondence, speed, reliability, kindness, reactivity, convenience, and supportability	[7]
Response at once, reliability, confidence, sympathy	[9]
Service speed, comply with hours of employee, Speciality of the service provider, sympathy about the client company	[10]
Operation of the information center, education and support for user et al.	[11]
Reliability, Assurance, Tangibles, Empathy, Responsiveness	[18]
Quick, Responsiveness, Assurance, Reliability, Empathy	[4,6]
System reliability, Availability of service	[13]

Through this prior study on quality assessment and a successful information system model, we collected detailed information about the factors to be used in this study. Based on this, duplicate items with similar meanings or that measured specific information systems were deleted, while items reflecting the construction industry and construction information management were added to assess the quality of PMIS construction. In order to ascertain the validity of these assessment items, we interviewed PMIS construction developers and reviewed duplications and the appropriateness of the survey items.

Table 4. Factor of PMIS Quality

Q1	PMIS should be compatible with Software such as Excel, P3, CAD
Q2	PMIS should connect to IT tool such as PDA, RFID, USN
Q3	System functions and configuration should be construct that easy to use user
Q4	System screen configuration (a button, symbol, letter/ Image size) or document formats should be suitable
Q5	Input/Output data should be easy(up/download, printing)
Q6	Access to system should be not difficult
Q7	System should maintain the steady state
Q8	Search of information should be easy
Q9	PMIS should offer Information to users on real time (human resource/ material/ approval information)
Q10	Registered information in system should be proper
Q11	Registered information in system should be used without correction
Q12	Registered information in system should be sufficient
Q13	Registered information in system should be related to user's task.
Q14	Reaction of PMIS service provider should be quick in the situation
Q15	Technical support of PMIS service provider for maintenance and repair should be quick.
Q16	Functions of PMIS should be useful according to the project characteristic and user's role
Q17	Options should be various depending on the user's task
Q18	Education for PMIS user should be provided
Q19	User's manual and advice should be provided during usage
Q20	PMIS service provider should possess knowledge of construction field
Q21	User should feel security about data
Q22	User should trust capability of PMIS service provider
Q23	PMIS service provider should faithful

3. RESEARCH METHODOLOGY

The data used to test the research model were obtained from a sample of experienced users (Construction Manager and Constructor) of PMIS. To increase the generalizability of the results, the respondents were spread across construction site. Each of items was measured on a seven-point scale varying. Likert scales (1-7), with anchors ranging from "strongly disagree" to "strongly agree" were used for all questions. The questionnaire was sent by e-mail and mail,

A total of 253 usable responses were obtained. Detailed descriptive statistics relating to the respondents' characteristics are shown in table

Table 5. Characteristics of the respondents (n=253)

Measure		Frequency	%
Project Characteristic	Public Project	113	44.7%
	Private Project	140	55.3%
Sector of the respondent' Organization	Construction Management	113	44.7%
	Construction	140	55.3%
Experience	Less than 2 years	44	17.39%
	3~5years	32	17%
	5~10years	50	19.76%
	10~15years	24	9.49%
	More than 15years	92	36.36%

4. DATA ANALYSIS AND FINDING

4.1 Factor analysis of the CSFs

Analysis is used to identify a relatively small number of factor groups that can be used to represent relationships among sets of many inter-related variables". In this survey, this method was used to determine the groupings of the 23 CSFs.

According to Pallant[19], 2 main issues have to be considered in determining whether a data set is suitable for factor analysis: sample size and the strength of the relationship among the factors. In terms of sample size, According to Hair et al.[20] at least 4-5 times the number of variables is appropriate. At least 4-5 times the number of variables is appropriate. Also Nunnalyy[21] is suggested that the sample size should be at least 10 times. However the sample size should usually suggest at least 5 times. There were 23 factors in this survey, so according to Nunnalyy[21] recommendation, 230 respondents should be obtained in this study. Therefore the sample size was enough for factor analysis. In terms of the strength of relationship among the factors, the correlation matrix[22], the Bartlett's test of sphericity [23] and the kaiser-Myer-Olkin(KMO)[24] were recommended.

Most values in the correlation matrix are larger than 0.3, the Bartlett's test of sphericity is significant($p<0.05$), and the value of the KMO index is above 0.6, suggesting the data set is suitable for factor analysis. In this survey, all of the correlation coefficients were above 0.3, the Bartlett's test of sphericity was significant ($p<0.05$) (Table 6), and the value of the KMO index was 0.950(above 0.6). The results of these tests confirmed that the data were appropriate for factor analysis.

A 3-component was produced based on varimax rotation of principal component analysis (Table 6). There three factor groupings with Eigen value greater than 1.0 explain 66.191% of the variance. Each of the CSFs belonged to only one of the groupings, with the value of factor loading exceeding 0.5 [25].

Q3 ' System functions and configuration should be constructed easy to use user ‘is loaded in the Component 1 and 3, but did not delete. Because the item is higher than the mean average of the total item and not interfere with the unidimensionality. Q3 is more related to Component1 in terms of content. So it is considered component 1.

The following table shows the results of factor analysis.

Table 6. Result of reliability and validity test

Component	Items	Factor Loading	Eigen value	Cumulative %	Cronbach'α
1	Q12	0.783	12.684	55.149	0.941
	Q11	0.776			
	Q10	0.709			
	Q13	0.704			
	Q9	0.668			
	Q3	0.650			
	Q16	0.643			
	Q4	0.632			
	Q8	0.625			
	Q17	0.544			
2	Q19	0.816	1.550	61.890	0.926
	Q20	0.752			
	Q18	0.750			
	Q23	0.726			
	Q22	0.711			
	Q21	0.647			
	Q14	0.596			
	Q15	0.558			
3	Q2	0.697	1.019	66.322	0.835
	Q1	0.694			
	Q7	0.609			
	Q6	0.607			
	Q5	0.603			

Kaiser-Meyer-Olkin measure of sampling adequacy		0.950
Bartlett's test of Sphericity	Approx. Chi-Square	4632.666
	df.	253
	Sig.	0.000

1) Component 1: Information Quality

This component, which accounted for 55.149% (Table 6) of the total variances between CSFs, was relatively more important than the other two components. It indicated that experienced users (Construction Manager and Constructor) in Korea consider PMIS information quality during construction. Therefore, this component, which is related to information quality, could be illustrated by Q12, Q11, Q10, Q13, Q9, Q3, Q16, Q4, Q8 and Q17.

Information quality factors can be largely divided into three groups ; Simplicity of information acquisition (Q3, Q4, Q8, Q9), Quality of provided information (Q10, Q11, Q12) and Relevance of provided information (Q13,Q16, Q17).

‘The Relevance of provided information’: As one of the expected effects of ASP-based PMIS, customization should be evaluated. Items related to the relevance of provided information consist of Q13, Q16, Q17.

‘Registered information in the system should be used without correction’: If separate work is required for PMIS input and output information, it can cause duplications. Thus, it must be ascertained whether the PMIS input and output information can be used as is, without any modification.

2) Component 2: Service Quality

This component ranked second among the three components. As shown in Table 6, service quality factors can be largely divided into three groups; Reactivity (Q14, Q15), Support (Q18, Q19, Q20) and Reliability (Q21, Q22, Q23).

‘The PMIS service provider should possess knowledge of the construction field’: If the system is developed with no regard to user operations, it will cause inefficient operations. Thus, the developer’s possession of expert knowledge of the construction industry will affect the quality of PMIS.

‘User should feel security about data’: It is one of the factors that inhibits the activation of ASP-based PMIS. Thus, continuous improvement is needed through evaluation.

3) Component 3: System Quality

Though this component is the lowest ranked among the three components (Table 6), it is indispensable for PMIS's CSFs. System quality is the performance of the information processing system and how it works when systems are related. Service quality factors can be largely divided into two groups; Connectivity (Q1, Q2), Usefulness (Q5, Q6, Q7)

'Connectivity': The construction industry developed PMIS as a support tool to help solve the inefficient exchange of information between workers due to the use of different information formats in each work step. To meet this PMIS requirement, it is necessary to assess the connectivity between the software and IT tools used for each operation and the PMIS.

4.2 Validation of the CSFs

1) Testing for reliability

α value higher than 0.7 is considered a relatively higher reliable. In the survey, result of reliability test is 0.835 to 0.941. Therefore, this provides evidence that all the factors have a high internal consistency and reliable.

2) Testing for content validity

To ensure the content validity of our survey was established from the existing literature, and our measures were constructed by adopting constructs validated by other researchers, as a result of the pretesting, we conducted with experts in the field of PMIS in construction. After the pretesting of the measures these items were modified to fit the construction context studied.

3) Testing for construct validity

Construct validity was used to check for unidimensionality. Unidimensionality means that a single factor is extracted for each test. Each factor grouping was evaluated by factor analysis for construct validity. table presents results of the unidimensional test. Since all of the KMO value were greater than 0.5, and the percentage of variance explained by each component was more than %, all 3 components were demonstrated to be unidimentional.

Table 7. Result of unidimensionality Test

Component	KMO value	Factor Loading	Eigen value	Percentage variance explained
1	0.921	0.747-0.856	6.549	65.492
2	0.896	0.753-0.861	5.292	66.152
3	0.789	0.679-0.835	3.054	61.084

5. DISCUSSION AND CONCLUSION

The importance of information technology (IT/IS) in architectural/engineering/construction (A/E/C) industries has grown exponentially in the past decades. As one of the key IT applications, PMIS has played a significant role in construction management processes.

The main contribution of this study is identifying an ordered and grouped set of CSFs for PMIS quality in the Korean construction industry. 23 CSFs were identified through a literature review such as Delone & McLean's "Is Success Model" and face-to-face interviews. Using factor analysis, the 23 CSFs were grouped into three dimensions: System Quality, Information Quality, Service Quality.

Factor analysis results are as follows. First, Information Quality (10 Items; Simplicity of information acquisition (Q3, Q4, Q8, Q9), Quality of provided information (Q10, Q11, Q12) and Relevance of provided information (Q16, Q17)).

Second, Service Quality (8 Items; Reactivity (Q14, Q15), Support (Q18, Q19, Q20), Reliability (Q21, Q22, Q23))

Finally, System Quality (5 Items; Connection (Q1, Q2), Usefulness (Q5, Q6, Q7)).

In order to improve the ability to describe the relationships between the critical success factors of construction PMIS (which were derived in this study), the success model for ASP-based PMIS needs to be verified by applying additional parameters such as intended use and user satisfaction that have been presented in existing information system success models.

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