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A Conceptual Framework to Study the Effectiveness of Interface Management in Construction Projects

K. KEERTHANAA[1] and S. SHANMUGAPRIYA[2]

[1]Post Graduate Student, Department of Civil Engineering, Coimbatore Institute of Technology, Coimbatore -641014, India, E-mail: keerthanaak93@gmail.com (*corresponding author)

[2]Assistant Professor, Department of Civil Engineering, Coimbatore Institute of Technology, Coimbatore - 641014, India, E-mail: sunmu20@gmail.com

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ABSTRACT

The management of mega construction projects which incorporate a large number of stakeholders, technologies, data, work culture etc., is cumbersome. The experts in the construction arena advocate that interface management serves as a precise tool in resolving these conflict points due to the intricate nature of the construction projects. Interface management is a current trending management practice in the construction industry which is also a beneficiary to mega/fast track projects in enhancing the project performance. The main objective of this study is to validate a model for assessing the relationships among interface management, IT applications, project performance & project benefits. The mediating effect of interface management in relationship between project performance & interfacial factors was also investigated. The research model was validated using PLS-SEM (Partial Least Square-Structural Equation Modelling) approach. Data were collected from clients, contractors, consultants in large scale projects through questionnaire survey and smart-PLS software was used to analyse the conceptual model. The research model comprises eleven hypothesis and the significance of these hypothesis were tested using T- statistics values. The research implies that people/participants factor is greatly influenced by interface management with the path coefficient of 0.608 and also enhancement of project's schedule performance due to the interface management is strongly appealing (Path coefficient = 0.711). The results also reveal IT application is significantly associated with interface management practice (Path coefficient =0.723) and also the effect of IT application on project performance (schedule, cost, quality & safety) is successfully mediated through interface management practice. The practical application of this validated model was done through case study. The case study aims at measuring the impact of interface management on interfacial factors and role of interface management in improving the project performance in the construction organisations.

Keywords: Interface management, IT application, Project performance, Project benefits, Partial least square

INTRODUCTION

A project is a cluster of large number of organisations, stakeholders, data/information, technology and other attributes. Each stakeholder/organisations have different objective and interest in viewing the project from their perspective. This difference in opinion gives rise to interfacial conflicts. The poorly managed conflicts weaken the project performance. Thus interface management holds a strategic importance in managing construction projects.

The interface management is the management of common boundaries between people, systems, equipment, or concepts [1]. The management of interfaces can be either internal or external. The management of communication, co-ordination, and responsibility across a common boundary between two organisations, phases, or physical entities which are interdependent is external interface management and internal interface management is managing the problems that often occur among the people, departments, and disciplines rather than within the project team itself [2].

The complex nature of large scale projects makes it monotonous to carry out interface management manually. It requires the support of advanced IT (Information Technology) applications to improve the efficiency of interface management. The emerging IT applications in the construction industry serve to enhance the project performance. The interface management can be enriched by the development of interface management tools with the aid of IT applications.

While many studies have focused on the factors influencing interfacial issues and only a few published studies focused on direct impact on interface management on performance of construction projects. Additionally, prior studies on impact of interface management have not examined the relationship of IT application with interface management in construction and their influence on project performance. The key focus of this research is three fold. The first objective is to develop a framework which gives the quantitative measurement of effectiveness of a project in terms of schedule, cost, quality and safety performance due to implementation of interface management. The second objective is to evaluate the mediating role of interface management in relationship between IT application and project performance. The third objective is to examine the impact of implementation of interface management on interfacial issues influencing factors, namely people/participants, methods/process, resources, documentation, project management & environment.

The analysis of interface management and IT application and their relationships with project performance are based on the survey of construction firms with interface management. A data collection tool was developed to examine the levels of interface management and IT adoption levels in construction firms.

DEVELOPMENT OF CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESIS

A desirable research has been conducted on the adoption of interface management in the construction industry. The prior literatures focused mainly on the factors influencing the interfacial issues, frameworks and methods for implementation of interface management in an organisation. The prior studies indicated the advancement in information and communication technologies should be accompanied with the management process [3].

WBS matrix concept breakdown a project into activity and product oriented structure to identify the interfaces .The interfaces were classified as organisational, technical, geographical, and time interfaces. In the case study of mass rapid transit system, WBS matrix was developed by generating work package sheets and work package reports for each trades like power supply, track works, etc. using excel and the entire interface in each trade was identified to improve the interface management [4].

Integration opportunity assessment tool (IOP Tool) was based on the drivers and hindrance factors for information integration. The benefit and hindrance drivers were classified as "Market/Legal", "Organisational/process", "People/Roles/Training". IOP tool consists of seven worksheets which helps to identify the level of information integration in the project. With the help of these worksheets, the level of information integration in the case studies was measured. If information integration was at low level, the hindrance mitigation plan was proposed [5].

Interface management was categorized as Time interface, Relational interface, Information interface and Environmental interface. Factors influencing these interfaces such as "engineering design and schedule control", "communication", "information sharing platform", "profit", "law & policy", "IT ability to apply", "natural climate", "contracting strategy" are identified. Using DEMATEL model, design, communication skills, IT ability to apply, information sharing platform & profit were shown to be the most important factors for interface management [6].

A case study was done on the use of the interface management software n-pulse. n-pulse integrates schedule, resources, inventory, BOQ, drawing data and provides proactive information about the schedule delays, cost overruns. The roles of stakeholders like client, PMC, general contractors and subcontractors, consultants in the case study were studied [7].

A model for assessing the relationships among IT application, KM practice adoption and project success was framed. Mediating role of KM practice adoption in relationship between IT application and project performance is studied and also the effect of project type on project success and knowledge management is also studied. This model served as a basic framework for the development of preliminary framework for this research [8].

From the extensive literature reviews it was found that no conceptual model was proposed to measure the influence of interface management on project performance indicators such as cost, schedule, quality and safety and also interrelationships among IT application, interface management, project performance and project benefits was not studied. This study aims at fulfilling these knowledge gaps.

The initial conceptual framework is developed with the aid of literatures on interface management. The initial PLS model comprises 51 attributes for 12 constructs as shown in Figure I The following are the hypothesis set up in PLS path model.

Interfacial Factors

Based on the relevant literatures, following hypotheses are postulated.

H1.Interface management positively influences people/participants in the project

H2.Interface management positively influences the methods /process involved in the project

H3.Interface management has positively influences resources assigned to the project

H4.Interface management has a positive influence on documentation

H5.Interface management has a positive impact on project management

H6.Interface management has a positive effect on environment

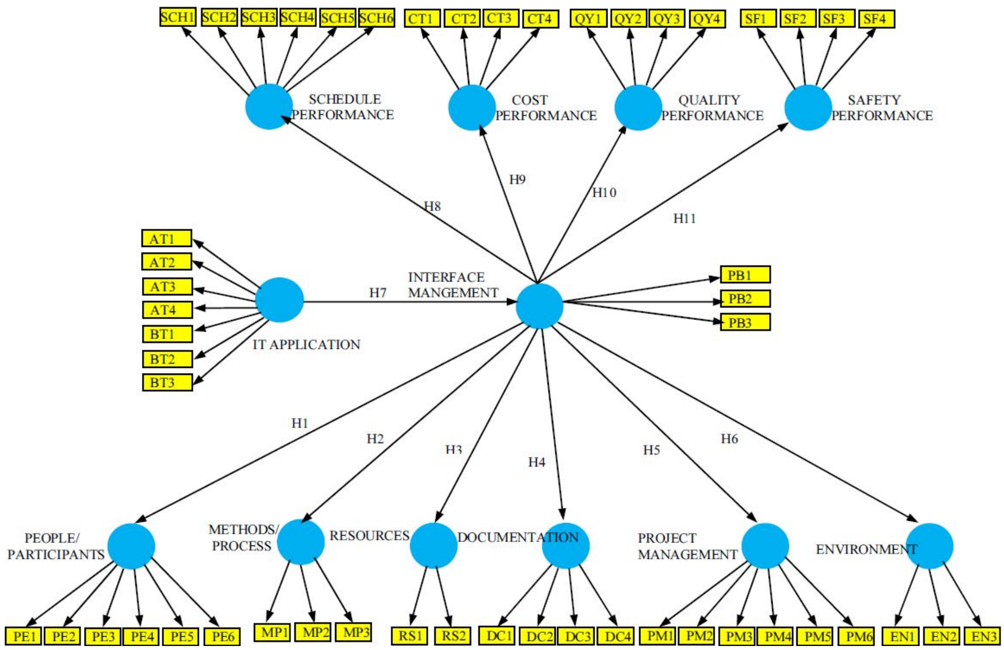

FIGURE I. INITIAL CONCEPTUAL PLS SEM MODEL FOR INTERFACE MANAGEMENT

People/participants are considered to be influenced by interface management. The individuals in the organisations perform certain activities which are interrelated and they have to be properly monitored to avoid conflicts and poor project performance. From this perspective people/participants are segmented as communication, coordination, trust, organizational structure, decision making, and financial issues among participants.

The multidisciplinary teams involved in the construction projects implement their own methods/process to attain their objective. The methods/process of individual teams has to be communicated and co-ordinated for the successful outcome of a work. Methods/process focuses on organisation's potential to choose appropriate construction methods, to resolve the issues in implementing new technologies & methods and ability to resolve construction and assembly problems due to inferior work sequence & handling methods.

Documentation of project information such as shop drawings, change orders, specifications, contracts, etc. is vital to avoid misinterpretations among the stakeholders. Documentation of interface information such as interface registers, interface O&M documents etc. through interface database proves to be crucial for the identification of the characteristics of interfaces and responsibilities of parties involved in the project.

Labor, equipment and material are the conventional resources to support the construction projects. Interface management includes space and information also as resources. The availability of labor, cross functional trained teams, materials, equipment proves to be a difficult task. Inadequate space among labor undertaking concurrent activities, storage of materials, movement of equipment are due to poor interface management.

Interface management is one of the aspects of project management. Inferior interface management affects contractor performance, resource allocation, planning and scheduling, quality performance etc. which are the other aspects of project management. Ignoring interface relationship among the sub-contractors, improper project decomposition, organisation structure, schedule shortening in fast track projects, lack of timely project update are major project management issues due to lack of interface management.

Environment here refers to of construction project. It includes geological, climate and weather conditions, building codes, local laws and regulations, cultural diversity of participants and also integrated work environment.

IT Application

In summary the literatures support the adoption of IT to enhance interface management. This study further extends the previous research by analysing the impact of IT tools on interface management. The following research hypotheses are set up based on the relevant literatures:

H7.IT application positively influences the project's level of interface management.

DEMATEL (Decision Making Trial and Evaluation Laboratory) model which shows IT ability to apply is the most important factor in interface management of the project [6].

Project Performance

In prior studies the relationship between adoption of systematic Interface management and project performance is investigated and concluded that interface management will positively affect project performance [9, 10]. Interface management process allows early identification of critical interfaces through a structured process which leading to early definitions of cost & schedule issues [11, 12]. Interface management optimizes the design in terms of quality to meet the customer needs [11]. The following hypotheses were proposed based on previous research and the project performance is measured in term of schedule, cost, quality, safety.

H8.Interface management has a positive impact on project's schedule performance

H9.Interface management has a positive impact on project's cost performance

H10.Interface management has a positive impact on project's quality performance

H11.Interface management has a positive impact on project's safety performance

The above hypotheses and conceptual framework were developed with the help of relevant literatures. The Figure I represents the variables and theoretical framework that links the constructs. This framework validates the association among IT application, interface management, project performance in term of schedule, cost, quality, safety.

RESEARCH METHODOLOGY

The research was carried out in 3 phases. In the first phase with the help of relevant literatures, factors for interfacial issues were identified and grouped under relevant constructs. The conceptual model for the study was framed with constructs and interfacial attributes.

The second phase comprises the development of the questionnaire with the aid of identified factors and model. Initially for pilot study the questionnaire was distributed to 10 experts in the construction industry. The response from the pilot study validated the effectiveness of the questionnaire. Subsequently necessary update was made in the questionnaire. The construction organisations where a large number of stakeholders, tools, phases involved were spotted, so that it may be ideal to identify the companies with interface management. The questionnaire was then distributed to the targeted organisations.

In the third phase, the data collected from the industry wide survey were filtered for analysis and the data was analysed using PLS-SEM (Partial Least Square- Structural Equation Modelling) technique. The flowchart of reserch methodology is presented in Figure II.

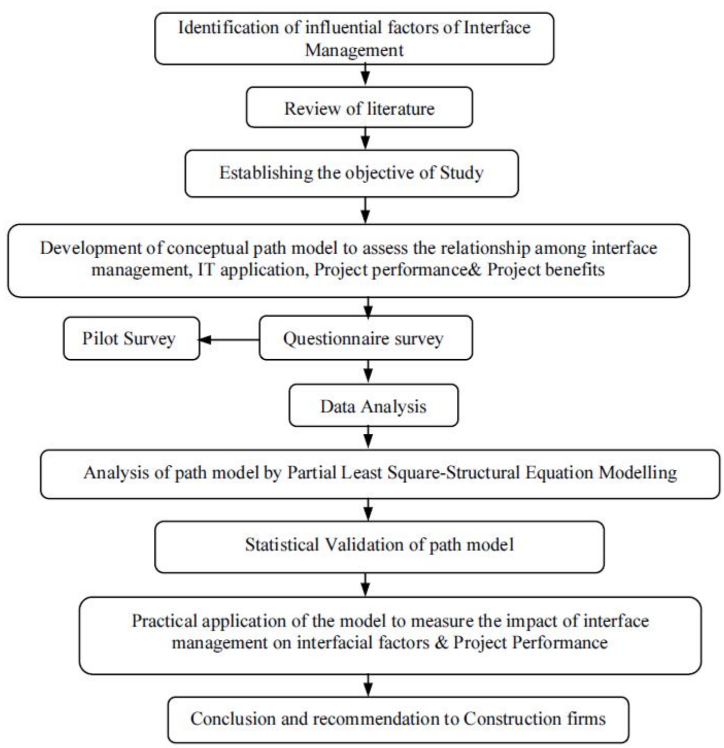

FIGURE II. FLOW CHART OF RESEARCH METHODOLOGY

Demographic Information

The industry wide survey was conducted among top 50 organisations. The questionnaire was distributed to 200 managers in leading multinational companies, who seemed to be more relevant to our research. At the end 101 questionnaires were completely filled. The data were collected through direct interviews and also through online – basis. A data collection tool was developed for this purpose. Thus the final response rate is 51%.

Among the respondents the positions hold by them were, 62% of Engineers (quality, safety, procurement, structural, etc.), 23% of Project Managers, 8% of Construction manager, 3% of Architects, 3% of Contract administrators and 1% of Interface co-ordinators. 67% of respondents holds bachelor degree, 22% having Masters degree, 7% having graduate diploma and 4% having a doctorate degree.

The type of organisations the questionnaire distributed were, 77% of Construction contractors/subcontractors, 9 % of Project management consultants, 7% of Owner/Clients, 6% of Structural consultants, 1% of Architectural consultants. In the pool of organisation responded, 45% of organisations are involved with more than 100 projects, 23% between 51 to 75 projects, 21% less than 50 projects, 11 % between 76 to 100 projects. Some of the organisations are aware of interface management tools. A few interface management tools suggested by the respondents which are used in their organisations are Aconex, CIMS, R construct, Rhythm.

Data Analysis using PLS-SEM Approach

Structural Equation Modeling is a multivariate analysis technique used to examine the interrelationship between multiple variables simultaneously. SEM is the combination of factor analysis and multiple regression analysis to study the relationship between measured variables and latent constructs. SEM is extremely beneficial in investigating the relationship among the significant variables and to solve complex construction problems [13]. SEM serves as appealing tool in the field of construction engineering and management [14]. The SEM analysis can be either covariance based structural analysis or component based structural analysis using Partial Least Square (PLS-SEM). In this research PLS-SEM technique is used for analysis.

The two main components included in the PLS-SEM are: measurement model or outer model and structural model or inner model. The measurement model gives the relationship between latent construct and its indicators and the potential casual dependencies between the endogenous and exogenous constructs is given by structural model. The structural model gives the direct effects (path coefficients) connecting the endogenous and exogenous constructs.

Assessment of Measurement Model

The indicator reliability, convergent validity, discriminant validity are the criteria used for assessing whether the measurement model has acceptable measurement properties [15].The initial model with 51 observed variables is tested using PLS. The indicator reliability is evaluated by examining the outer loadings of the items. Table I shows the final loadings of indicators with value greater than 0.6.

The convergent validity is estimated to measure the extent to which a latent variable shares its indicator variance. It involves measuring the cronbach's alpha, composite reliability and average variance extracted (AVE). Cronbach's alpha is a measure of internal consistency and reliability. The internal consistency is found to be good when alpha ranges from 0.7 to 0.9 [16]. The composite reliability is same as cronbach's alpha except that it takes into account that indicators have different loadings. The cutoff value of composite reliability is 0.6 [17]. Table II shows that all indicators possess Cronbach's alpha greater than 0.7 and composite reliability greater than 0.6. AVE is the criterion for convergent validity and its cut off value is suggested to be greater than 0.5 (i.e., at least 50% of

TABLE I. CONSTRUCTS AND INDICATORS OF INTERFACE MANAGEMENT

Construct	Indicators	Description of indicators	Outer loadings
IT APPLICATION	AT1	BIM is used to support IM practice.	0.773
	AT2	Information sharing platform Tools used to support IM practice.	0.791
	AT3	Interface database management system used to support IM practice.	0.750
	AT4	Video conference used to support IM practice.	0.709
	BT1	Email is used to support IM practice	0.719
	BT2	AutoCAD is used to support IM practice	0.653
PEOPLE/ PARTICIPANTS	PE2	Lack of negotiation, communication & coordination among relevant stakeholders involved in the project.	0.699
	PE3	Lack of personal experience of project teams.	0.761
	PE4	Financial issues like Delayed payments, cost disputes, low budget.	0.713
	PE5	Lack of trust among project parties	0.738
	PE6	Organisation structure	0.633
METHODS/ PROCESS	MP1	Ability to predict and resolve problem related to new technology and materials	0.862
	MP2	Extent of Mechanisation in the project	0.802
	MP3	Ability to design from constructability point.	0.698
RESOURCES	RS1	Space conflicts among labor, equipment & materials.	0.808
	RS2	Unexpected changes in material, equipment, labor availability & cost.	0.924
DOCUMENTATION	DC1	Inadequate specifications and drawings.	0.725
	DC2	Level of documentation of interface information.	0.803
	DC3	Lack of proper planning and scheduling details.	0.865
	DC4	Lack of documentation of change orders, shop drawings.	0.851
PROJECT MANAGEMENT	PM1	Lack of proper subcontractor and work packaging system.	0.782
	PM2	Responsibilities of interfaces not clearly defined in the contract.	0.750
	PM3	Type of contracting strategy adopted doesn't match the project.	0.743
	PM4	Insufficient and lack of alignment of work breakdown structure (WBS), Contracting work breakdown structure (CWBS), Cost breakdown structure (CBS), organisation breakdown Structure (OBS).	0.707
	PM5	Unclear company standard operating procedures.	0.618
	PM6	Multidisciplinary teams are involved	0.649
ENVIRONMENT	EN1	Inexperience with local laws and other government regulations and modifications in laws & regulations.	0.771
	EN2	Inexperience with building codes, by laws, statutes and other government regulations	0.824
	EN3	Unfamiliarity with site geographical and weather conditions.	0.715
SCHEDULE PERFORMANCE	SCH1	Each milestone of the project reached as per planned.	0.747
	SCH2	Project completed ahead of schedule.	0.75
	SCH3	Reduction of stress among the team members.	0.769
	SCH4	Disputes among the team members reduced.	0.819
	SCH5	Positive impact on social status of our organisation.	0.742
	SCH6	Quality of work in the projects has improved.	0.747

TABLE I. CONSTRUCTS AND INDICATORS OF INTERFACE MANAGEMENT (CONTINUED)

Construct	Indicators	Description of indicators	Outer loadings
COST PERFORMANCE	CT1	The cost objectives of the project met.	0.775
	CT2	The actual budget of the project is as per planned.	0.798
	CT3	Estimated cost has improved the quality of work in our organisation.	0.822
	CT4	Economic risks have reduced.	0.83
QUALITY PERFORMANCE	QY1	The project quality complied with the owner requirements.	0.841
	QY2	Cost due to rework has been reduced.	0.711
	QY3	Status and image of organisation have improved.	0.865
SAFETY PERFORMANCE	SF1	The project construction and operation complied with all EHS laws and regulations.	0.791
	SF2	The recorded accident rate in organisation is low.	0.851
	SF3	The recorded injury rate in organisation is low.	0.775
	SF4	Safety commitment improved the project key performance indicators like quality, schedule& cost.	0.849
INTERFACE MANAGEMENT-PROJECT BENEFITS	PB1	Relationship among the project stakeholders have improved.	0.849
	PB2	Project's overall benefit's exceeded the owner's expectation.	0.877
	PB3	The project achieved the successful outcome.	0.840

TABLE II. ANALYSIS OF MEASUREMENT MODEL

Constructs	Cronbach's Alpha	CR	AVE
IT application	0.83	0.88	0.54
People/participants	0.75	0.84	0.50
Methods/process	0.71	0.83	0.63
Resources	0.70	0.86	0.75
Documentation	0.83	0.89	0.66
Pro management	0.80	0.86	0.51
Environment	0.70	0.81	0.60
Schedule performance	0.86	0.89	0.58
Cost performance	0.82	0.88	0.65
Quality performance	0.74	0.85	0.65
Safety performance	0.83	0.89	0.67
Interface management-project benefits	0.82	0.89	0.73

variances captured by latent variables) [18]. In the initial model, constructs IT application and People/Participants showed AVE less than 0.5. The observed variables with least loadings BT3 and PE1 are dropped to improve the AVE by performing the elimination in two iterations. Table II shows the cronbach's alpha, composite reliability, AVE value of final path model constructs.

The discriminant validity indicates the extent to which each construct is different from other construct in the model. The discriminant validity is examined by Fornell and Larcker criterion and Cross loadings [19]. AVE is found for each latent variable. Square roots of AVE are then compared against the correlations among the latent variables. Square roots of AVE are shown in the main diagonal elements in Table III. The correlations among the latent constructs are shown in the off-diagonal elements in Table III. To satisfy the discriminant validity the square root of AVE should be greater than the off-diagonal elements in the corresponding rows and columns. Thus Table III indicates Fornell and Larcker criterion is met to satisfy the discriminant validity. The results of cross loading show that indicator loading on its own construct is higher than all of its cross loadings with other construct.

TABLE III. CORRELATION AMONG THE CONSTRUCTS

Constructs	CT	DC	EN	IM	IT APP	MP	PE	PM	QY	RS	SF	SCH
CT	0.80											
DC	0.40	0.81										
EN	0.37	0.54	0.77									
IM	0.65	0.49	0.52	0.86								
IT APP	0.67	0.51	0.47	0.72	0.73							
MP	0.54	0.71	0.61	0.57	0.61	0.79						
PE	0.59	0.64	0.51	0.61	0.66	0.73	0.71					
PM	0.50	0.67	0.64	0.53	0.48	0.66	0.62	0.71				
QY	0.64	0.51	0.43	0.70	0.62	0.58	0.48	0.54	0.81			
RS	0.46	0.58	0.49	0.49	0.40	0.64	0.73	0.61	0.30	0.87		
SF	0.53	0.52	0.51	0.69	0.66	0.59	0.50	0.56	0.77	0.33	0.82	
SCH	0.73	0.44	0.46	0.71	0.62	0.56	0.59	0.61	0.71	0.39	0.61	0.76

Assessment of Structural Model

The structural model is assessed for path coefficients (β value), significance of R^2, effect of size of f^2, predictive relevance and mediating effects. The validation of structural model is done by calculating Global fit index and power analysis for the adequacy of sample size.

i) Path coefficient (β value) and T- statistics value:

The path coefficients in the structural model are the hypothesized relationship among the constructs. The t- value is found by bootstrapping procedure and is tested at 5% level of significance i.e., 1.98. The analysis of path coefficient shows that interface management has positive significant effect on schedule, cost, quality & safety performance, people/participants, methods/process, resources, documentation, project management and environment with β values as in Table IV and Figure III The IT application has significant influence on interface management with β value of 0.723 and also the β value of 0.711 implies that interface management strongly influences schedule performance of the project. All other inferences for the path coefficients are given in the Table IV.

Concerning the hypothesized relationship, all hypothesis from H1 to H11 are supports with t-values greater than 1.96 for the significance level of 5% as shown in the Table IV.

TABLE IV. PATH COEFFICIENTS AND T STATISTICS

Code	Hypothesis	Path Coefficients	T values	Inference
H1	Interface Management - People/Participants	0.61	10.13	Significant
H2	Interface Management - Methods/Process	0.57	10.56	Significant
H3	Interface Management - Resources	0.49	5.86	Significant
H4	Interface Management - Documentation	0.49	5.26	Significant
H5	Interface Management - Project Management	0.53	8.05	Significant
H6	Interface Management - Environment	0.52	6.59	Significant
H7	IT Application - Interface Management	0.72	9.66	Significant
H8	Interface Management - Schedule Performance	0.71	8.06	Significant
H9	Interface Management - Cost Performance	0.65	7.05	Significant
H10	Interface Management - Quality Performance	0.70	7.51	Significant
H11	Interface Management - Safety Performance	0.69	7.59	Significant

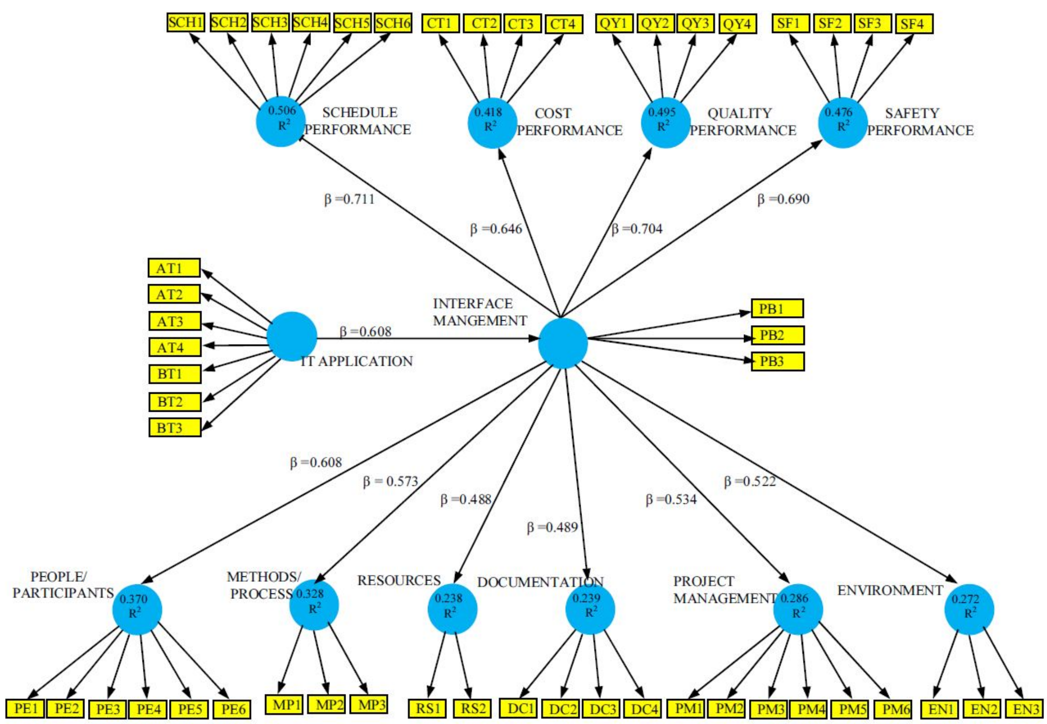

FIGURE III. FINAL PLS SEM MODEL FOR INTERFACE MANAGEMENT

ii) Measuring the value of R^2

The explained variance is assessed using R^2 of the endogenous latent variable. The R^2 indicates the change in the endogenous construct, when there is a change in the predictor construct. R^2 of endogenous construct can be assessed as substantial when the value is 0.26, moderate when the value is 0.13 and weak at the value of 0.02 [20]. The R^2 value of each endogenous construct is shown in Figure IV.

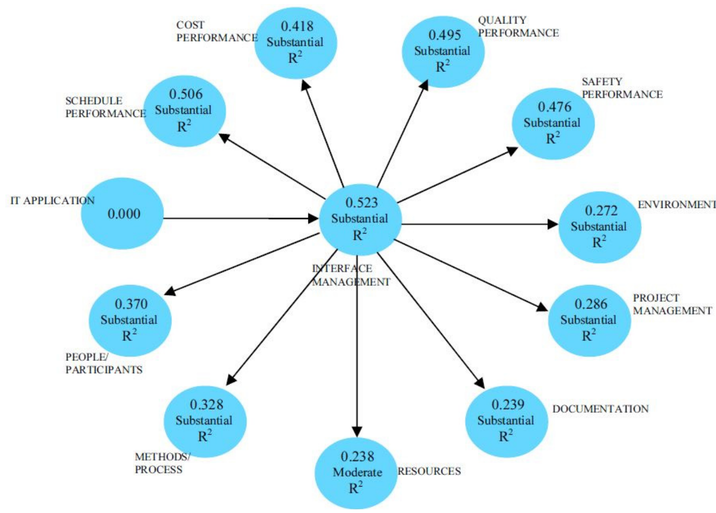

FIGURE IV. MEASURING THE VALUE OF R^2

iii) Effective size f^2

The impact of each predictor construct or exogenous construct on the dependant or endogenous construct is measured by means of effective size. When a predictor construct is eliminated from the PLS model, it measures the changes in the value of R^2 and determines whether the eliminated predictor construct has a significant effect on the value of dependant construct. The effective size f^2 is calculated using the following formula given by [21].

$$f^2 = \frac{R^2 included - R^2 excluded}{1 - R^2 included} \qquad \text{Eq. (1)}$$

The effect of predictor construct is large if f^2 is 0.35 and it is medium if f^2 is 0.15 and less if f^2 is 0.02 [6] and the results and inference for this model are given in Table V.

TABLE V. EFFECTIVE SIZE f^2

Independent Construct	Dependent Construct	f^2	Inference
Interface Management	People/Participants	0.59	Large
Interface Management	Methods/Process	0.49	Large
Interface Management	Resources	0.31	Medium
Interface Management	Documentation	0.31	Medium
Interface Management	Project Management	0.40	Large
Interface Management	Environment	0.37	Large
Interface Management	Schedule Performance	1.03	Large
Interface Management	Cost Performance	0.72	Large
Interface Management	Quality Performance	0.98	Large
Interface Management	Safety Performance	0.91	Large
IT Application	Interface Management	1.09	Large

MEDIATING EFFECT OF INTERFACE MANAGEMENT

The indirect effects are studied to determine whether interface management mediates the relationship between IT application and Project performance in term of schedule, cost, quality and safety. The IT application possesses significant β coefficients and t- value as shown in Table VI This suggests interface management fully mediates the effect of IT application on project performance.

TABLE VI. MEDIATING EFFECT

Construct	Mediating construct	Direct Effect	Indirect Effect	Total Effects	T-Value	Inference
IT Application -Cost Performance	Interface management	0	0.467	0.467	4.435	Significant
IT Application -Documentation	Interface management	0	0.353	0.353	4.787	Significant
IT Application - Environment	Interface management	0	0.377	0.377	5.969	Significant
IT Application - Methods/Process	Interface management	0	0.414	0.414	6.111	Significant
IT Application - People/Participants	Interface management	0	0.440	0.440	6.377	Significant
IT Application - Project Management	Interface management	0	0.386	0.386	5.493	Significant
IT Application - Quality Performance	Interface management	0	0.509	0.509	4.747	Significant
IT Application - Resources	Interface management	0	0.353	0.353	5.749	Significant
IT Application - Safety Performance	Interface management	0	0.499	0.499	4.686	Significant
IT Application - Schedule Performance	Interface management	0	0.514	0.514	4.838	Significant

GLOBAL FIT INDEX OF THE MODEL

GoF(Global Fit measure) is calculated for PLS path modelling, which is defined as geometric mean of average communality and average R^2.GoF is used to assess the model fitness and explaining power of model. The results of global fit index of the model is presented in Table VII The cut-off values of GoF small=0.1, medium = 0.25, large = 0.36. GoF value for PLS model is estimated using the following equation [22].

$$\text{Goodness of fit} = \sqrt{\text{Average communality x Average } R^2} \quad \text{Eq. (2)}$$

$$\text{Average Communality} = 0.622 \quad \text{Eq. (3)}$$

$$\text{Average } R^2 = 0.377 \quad \text{Eq. (4)}$$

$$\text{Goodness of fit} = 0.48 \quad \text{Eq. (5)}$$

In this study, GoF value is 0.48, which indicates the model has 48% explaining power on interface management.

TABLE VII. GLOBAL FIT INDEX FOR THE MODEL

Constructs	R^2	Communality
Cost performance	0.418	0.651
Documentation	0.239	0.660
Environment	0.272	0.595
Interface management	0.523	0.732
IT Application	0	0.539
Methods/Process	0.328	0.625
People/Participants	0.370	0.504
Project management	0.286	0.505
Quality performance	0.495	0.654
Resources	0.238	0.754
Safety performance	0.476	0.667
Schedule performance	0.506	0.582
Average	0.377	0.622

POWER ANALYSIS

The stability of model's parameter with the sample size is tested using power analysis [21]. The parameters required for power analysis are significance level (α) of the test, sample size (N) of the study and effect size (ES) of the population. The power of the model is calculated using G power 3.1 software, The input parameter for this model are significance level =5%, sample size N (101), and the effective size ES is calculated using the following equation [23].

$$\text{Effective size} = \frac{R^2}{1-R^2} = \frac{0.377^2}{1-0.377^2} = 0.61 \quad \text{Eq. (6)}$$

Figure V indicates the power of the overall model increases as the number of sample size increases. With the

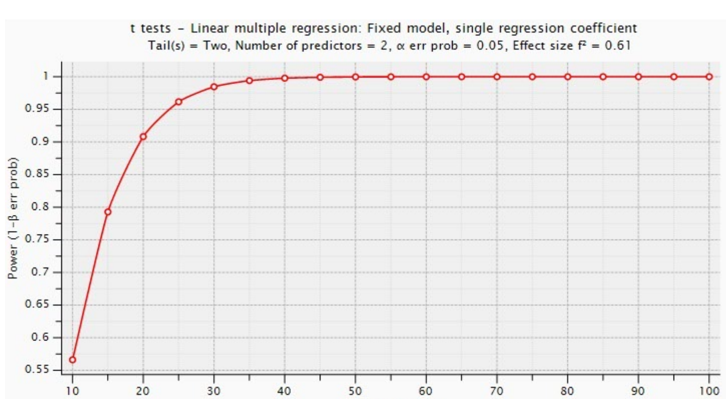

FIGURE V. POWER ANALYSIS

sample size of 40, the power of 100% is achieved.The sample taken up for this research is 101. Therefore the sample size used for this study is adequate for achieving substantial power.

CASE STUDY

The validated model was applied in the construction firms through case studies. The results of the analysis were used to develop the template. The case study comprises two templates. The first template was to evaluate the impact on interface management factors in the particular organisation. The second template measures the improvement in project performance due to interface management.

Construction firms with interface management were identified and two organisations were selected for the case study namely company A and B. A questionnaire was framed and then distributed to the firms A and B. Questionnaire comprises three parts with the first part framed to gather information about the organisation and personal information of the respondent.

The second part consists of 22 statements to evaluate the impact on interfacial management factors in the firms A & B under six constructs namely people/participants, methods/process, documentation, project management, and environment. The third part is designed to measure the improvement in project performance due to interface management with 20 statements under 4 constructs i.e., schedule performance, cost performance, quality performance and safety performance.

Each statement was framed to obtain the organisations status on the various attributes in the context of interface management. The respondents were asked to rate their organisation’s level in percentage from 0 to 100(Strongly Agree-80-100%,Agree-60-79%, Neutral-40-59%, Disagree-20 -39%, Strongly Disagree-0-19%) for each statement in the questionnaire from the perspective of interface management in their organisation.

Development of Template

The first template is developed to measure the impact on interfacial management factors as shown in Table VIII. From the results given by the PLS-SEM, the outer weights of all attributes of constructs namely people/participants, methods/process, documentation, project management, and environment were used.

The importance percentage index of each construct and also importance percentage of each attributes to its corresponding constructs are calculated. The respondents give the impact of interface management factors in their organisation in terms of percentage. This percentage is multiplied with importance percentage index of each attributes to measure the contribution each attribute towards interface management.

The second template is used to measure the improvement in project performance of the firms due to interface management as indicated in Table IX. The outer weights of project performance indicators, namely schedule performance, cost performance, quality performance and safety performance are measured and the calculations are done similar to first template.

TABLE VIII. IMPORTANCE % INDEX FOR INTERFACE MANAGEMENT FACTORS

Constructs	Indicators	Outer Weights	Mean Weight	Importance percentage index of each construct	Contribution each attribute towards its corresponding construct	Importance percentage index of each attribute
People/Participants	PE2	0.276	0.282	12.61	0.196	0.0247
	PE3	0.289			0.205	0.0258
	PE4	0.283			0.201	0.0253
	PE5	0.289			0.205	0.0258
	PE6	0.273			0.194	0.0244
Methods/Process	MP1	0.554	0.415	18.54	0.445	0.0826
	MP2	0.389			0.313	0.0580
	MP3	0.301			0.242	0.0449
Resources	RS1	0.447	0.569	25.44	0.393	0.0999
	RS2	0.691			0.607	0.1544
Documentation	DC1	0.236	0.306	13.66	0.193	0.0264
	DC2	0.314			0.257	0.0351
	DC3	0.345			0.282	0.0386
	DC4	0.327			0.268	0.0365
Project Management	PM1	0.275	0.234	10.47	0.196	0.0205
	PM2	0.24			0.171	0.0179
	PM3	0.247			0.176	0.0184
	PM4	0.17			0.121	0.0127
	PM5	0.209			0.149	0.0156
	PM6	0.264			0.188	0.0197
Environment	EN1	0.407	0.432	19.31	0.314	0.0606
	EN2	0.471			0.363	0.0702
	EN3	0.418			0.323	0.0623

TABLE IX. IMPORTANCE % INDEX FOR PROJECT PERFORMANCE

Constructs	Indicators	Outer Weights	Mean Weight	Importance percentage index of each construct	Contribution each attribute towards its corresponding construct	Importance percentage index of each attribute
Schedule Performance	SCH1	0.207	0.218	17.57	0.158	0.0278
	SCH2	0.197			0.150	0.0264
	SCH3	0.246			0.188	0.0330
	SCH4	0.241			0.184	0.0323
	SCH5	0.202			0.154	0.0271
	SCH6	0.217			0.166	0.0291
Cost Performance	CT1	0.351	0.310	24.96	0.283	0.0706
	CT2	0.255			0.205	0.0513
	CT3	0.298			0.240	0.0599
	CT4	0.337			0.272	0.0678

TABLE IX. IMPORTANCE % INDEX FOR PROJECT PERFORMANCE (CONTINUED)

Constructs	Indicators	Outer Weights	Mean Weight	Importance percentage index of each construct	Contribution each attribute towards its corresponding construct	Importance percentage index of each attribute
Quality Performance	QY1	0.416	0.408	32.85	0.340	0.1116
	QY2	0.32			0.261	0.0858
	QY3	0.489			0.399	0.1311
Safety Performance	SF1	0.311	0.306	24.62	0.254	0.0626
	SF2	0.288			0.235	0.0579
	SF3	0.286			0.234	0.0575
	SF4	0.339			0.277	0.0682

Assessment Results of Firms A & Firm B

Company A is one of the largest construction contracting firms in India which has done more than 100 projects. The main industry the company working are Infrastructure, Oil & Gas, Commercial and Industrial Buildings. The

TABLE X. IMPACT ON INTERFACE MANAGEMENT FACTORS FOR FIRM A & B

Constructs	Indicators	Response from company A in %	Actual Level	Response from company B in %	Actual Level
People/Participants	PE2	80	1.974	75	1.851
	PE3	70	1.809	80	2.067
	PE4	90	2.277	85	2.151
	PE5	75	1.938	80	2.067
	PE6	90	2.197	75	1.831
Methods/Process	MP1	80	6.604	75	6.191
	MP2	80	4.637	80	4.637
	MP3	85	3.812	85	3.812
Resources	RS1	60	5.995	85	8.492
	RS2	65	10.039	50	7.722
Documentation	DC1	70	1.846	80	2.110
	DC2	75	2.632	85	2.983
	DC3	80	3.084	80	3.084
	DC4	85	3.106	80	2.924
Project Management	PM1	75	1.537	70	1.434
	PM2	80	1.430	75	1.341
	PM3	85	1.564	80	1.472
	PM4	90	1.140	85	1.077
	PM5	80	1.246	85	1.324
	PM6	80	1.574	90	1.770
Environment	EN1	85	5.155	85	5.155
	EN2	85	5.966	70	4.913
	EN3	70	4.360	80	4.983

company uses ERP to manage interface. Company B is also a large contracting firm with its headquarters in UAE. The company has done more than 50 Oil & Gas and Industrial projects. Aconex is the interface management tool used in the company B to handle the interfaces.

The Tables X and XI gives the respondent's answer and the corresponding company's actual level of impact on interface management factors and project performance.

In this case study for company A, the first template reveals interface management has an impact of 10.19% on people/participants, 15.05% on methods/process, 16.03% on resources, 10.67% on documentation, 8.49% on project management, 15.48% on environment. The second template depicts 14.29% of schedule performance, 20.66% of cost performance, 28.48% of quality performance, 21.58% of safety performance have improved due to the interface management in the company A.

For company B interface management has an impact of 9.97% on people/participants, 14.64% on methods/process, 16.21% on resources, 11.10% on documentation, 8.42% on project management, and 15.05% on environment. In case of project performance 12.59% of schedule performance, 17.65% of cost performance, 27.70% of quality performance and 21.50% of safety performance are due to interface management in particular organisation.

TABLE XI. IMPROVEMENT IN PROJECT PERFORMANCE IN FIRM A & B

Constructs	Indicators	Response from company A in %	Actual Level	Response from company B in %	Actual Level
Schedule Performance	SCH1	80	2.220	60	1.665
	SCH2	85	2.245	80	2.113
	SCH3	80	2.639	75	2.474
	SCH4	75	2.424	70	2.262
	SCH5	90	2.438	70	1.896
	SCH6	80	2.328	75	2.182
Cost Performance	CT1	85	6.001	75	5.295
	CT2	80	4.103	60	3.077
	CT3	80	4.795	70	4.195
	CT4	85	5.761	75	5.083
Quality Performance	QY1	90	10.040	85	9.482
	QY2	85	7.294	90	7.723
	QY3	85	11.146	80	10.491
Safety Performance	SF1	90	5.630	85	5.317
	SF2	85	4.924	90	5.213
	SF3	85	4.889	90	5.177
	SF4	90	6.136	85	5.795

DISCUSSIONS AND PRACTICAL IMPLICATIONS

The number of research dealing with impact of IT tools and interface management on project performance is scarce. The first objective of this study is to validate a model for assessing the relationship among IT application, interface management and project performance. The PLS-SEM approach is used to validate the model. The findings suggest the IT tools are widely used to support the Interface management, which can be inferred from the hypothesis H7.The path coefficient of 0.723 indicates the influence of IT tools on interface management. The model suggests that IT tools like BIM, Information sharing platforms, Interface database management system, Video conference, E-mail, Auto-CAD are the effective tools that can be used to support the interface management system. The construction managers should be aware of these IT tools to enhance the Interface management. Though the previous studies shows that application of IT improves the interface management, no attempt is taken to develop a model for assessing the relationships among IT application and Interface management [6]. This study attempted to fill this knowledge gap in the literatures.

The hypothesized relationships H8-H11 are all positively significant which implies Interface management has a significant effect on project performance in term of schedule, cost, quality & safety. Interface management improves the communication chain among the stakeholders which helps in early detection of misinterpretations, disputes which indirectly reduces schedule, cost, quality and safety issues. The findings show interface management has more impact on schedule performance with a path coefficient of 0.711 in improving the project performance. The interface management improves the schedule performance by reducing the disputes, stress among the team and ensuring the timely completion of the project. The cost performance is enhanced by managing financial risks and meeting the cost objectives of the project with the aid of interface management. The Interface management helps in the reducing reworks by prior identification of flaws thus ensuring the quality performance. The accidents and injury rate are reduced, which contributes to the safety performance of the project. The results of this research show that project performance can be strengthened by identifying the interface points and effective interface management. These results are also in line with the previous studies which show that interface management practice act as an enabler for project performance [9, 10, 11, 12].

The second objective is to evaluate the mediating role of interface management in relationship between IT application and project performance. Prior research indicates that IT plays an important role in interface management [6]. The interface management is found to be associated with the project outcomes. However the previous studies have not provided any insights into the mediating role of interface management in relationship between IT application and project performance. By examining the indirect effects of IT application on project performance in terms of schedule, cost, quality, safety, the research confirms that use of IT tools influence the project performance via interface management.

The third objective is to examine the impact of interface management practice in solving the interfacial issues. The hypotheses H1-H6 are positively significant which portrays proper interface management will have a positive impact on people/participants, methods/process, documentation, project management and environment. The path coefficients of these factors suggest interface management has greater impact (0.608) on people/participants, which suggests interface management improves co-ordination, communication and trust among the project participants which is in line with the previous studies [24]. The findings suggested proper sharing of interface information will help to implement new technologies without any construction and assembly problems. The resource utilisation can be optimised by interface practice by spotting the resource conflict points in advance. The interface management practice uses interface management tools which make it easy for the construction practitioners to document the interface information, change orders, etc. The findings report enhancement of interface management will have a positive eye on project management practices. The Mega projects have cultural diversities due to the involvement of multidisciplinary teams. These interface points can be effectively managed or improved by proper interface management practice.

The case study reveals interface management has the greatest impact on resources in both organisations i.e., 16.03% & 16.21% respectively. In case of company A project performance has improved by 85.01% and for company B, 79.44% of project performance have enhanced due to interface management.

CONCLUSIONS

In summary, this research provided empirical evidence for gaining the project benefits with higher levels of interface management practice and IT application adoption. The research findings provide that ensuring the awareness of interface management, helps the project managers to identify the focus arena in a particular project to enhance the project performance. The result of this study aids the construction organisations to predict their level of interface management in their organisations and also to identify the factors to be focused to improve the interface management in the organisation. The interface management can be enriched by the usage of IT application which ultimately improves the project performance.

The major research limitation of this research is small sample size, although it is enough to carry out the analyses using PLS-SEM approach. Further parts of model can be investigated in detail by introducing further casual relationships among the constructs. The templates can be further developed to do study the impact of IT application on interface management in construction firms.

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