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Project Stages Interface among Construction Professionals in Lagos State, Nigeria

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ABSTRACT

The study examined the interface problems in construction project stages among professionals in Lagos State, Nigeria. Primary information was obtained through structured questionnaire. The target population were construction professionals who had experienced interface problems at both the design and construction stages of projects in Lagos State. A total of two hundred and sixty (260) copies of completed questionnaire were retrieved through online and physical administration using snowball sampling technique for selection of respondents. Data were analyzed using exploratory factor analysis, confirmatory factor analysis and structural equation modelling. Findings revealed that the interface problems at the design stage are; inadequate specification of project data, problem of spotting component clashes at the beginning of design phase, difficulty in obtaining complete project documents leading to late issuance of some designs, design complexity, badly written contract documents, and too many adjustments whenever there is changes in designs while inadequate specialized quality-control team, serious doubting and ambiguity of interface conflicts, lack of system informing about new project data, bad value of construction, complicated construction process, incapability to forecast and bring resolution to challenges connected to new construction technological methods, financial and technical status of the constructor, poor communication among project team members and change based on instruction or command are the interface problems at the construction stage.

INTRODUCTION

Construction project is extremely a complex task that generate several issues in the areas of designs, production, components, planning, and the relationship among project members. Traditionally, the industry involved bringing together various project participants such as designers, constructors, subcontractors and material suppliers that frequently have interface problems, for instance inadequate cooperation and trust, and insufficient communication resulting to poor relationship (Moore, Mosley, and Slagle 1992). Interfaces take place when a project activity is separated into different numerous sub-project activities embraced by various firms. These interfaces can be soft (i.e., delicate) or hard, and external (outer) or internal (inner). Data substitutes between team members e.g., plan requirements, approval requirements, or utility requirements among construction teams or a delivery team and external members are illustrations of soft interface deliverables. Hard interfaces interoperated physical links between two or more elements or framework, for example, basic structural steel connections, pipe terminations, or link association.

Project interface challenges are connected to bad coordination of task and the team interface problems originated in poor information exchange are measured by having great potential effect on construction projects (Sweis et al. 2008). Interface problems, such as insufficient detailed plans, rework and clashes that usually occur between project team members due to poor data exchange and coordination of works, needed to be tracked, comprehended and solved (Fu et al. 2006). Since construction industry avoids efficient integration of all team members at various phases of the building development process, there is a need for professionals to convey, trade information and break down potential effects of the undertakings. Interface issues lead to low productivity, poor quality, waste, delays, claims, and cost overruns, these issues have significantly lowered overall project performance and implicitly hindered industrialization of construction. (Sugumaran. B and Lavanya M. R 2013). Other interfaces snags recognised by (Siao, Shu, and Lin 2011) are; design mistakes, part discrepancy, system performance flaws, coordination problems, and construction conflicts.

Okebugwu (2014), submitted some indicators of interface challenges in Nigeria such as delaying of work commencement, lack of understanding and inadequate cooperation, team members having diverse expectations from negotiated contracts, non-compliance of material usage combination in construction projects, frequent reworks, and misunderstanding of working drawings. Throughout project duration, each member of the project team must work together and rely upon one another for thriving project completion which requires the need to interface among one another (Okebugwu and Omajeh 2015; Daniels, Farnsworth, and Weidman 2014). Some of these interface issues occur as a result of inadequate integration among the architect, services engineers, civil engineers, and the contractors. Constant trade clashes between the mechanical, electrical, architectural and structural designs have been observed such that sewage pipes hitting or going through some of these structural components which are frequently discovered during the production process of a building (Dim, Ezeabasili, and Okoro 2015). However, several studies have been conducted on interface issues and management, but researches have not provided information on interface problems among construction professionals in Nigerian construction industry. Therefore, this study will focus on interface problems at both design and construction stages among construction professionals in Lagos State, Nigeria.

Tinjauan Pustaka

Definitions of Interface

(Shokri et al. 2012) described interface as the point of meeting between partners, stakeholders, equipment, industry, systems, production elements and people. Interface is recognised utilising drawing packages, contract records, work breakdown structure, project requirement, etc. (Chua and Godinot 2006). Interface definition is important in design and construction, (Krueger 2002) call attention that the planning of interface among two schemes relies on the ways at which the framework is comprehended and portrayed between the designers. Practically, the definition of interface is sufficiently defined in construction project. Project Interface refers as the contact point or communication among project team members or components (Okebugwu and Omajeh 2015). (Al-Masalha 2004) characterises interface as related production procedures, the procedures are just a single part of interface definition. Interface in an organisation is described as the communication among different stakeholders concerned with the project (Pavitt and Gibb 2003).

Category of Interface

The multifaceted source of interfaces, numerous production team, and insufficient details of project documents does not allow each member of the project team (e.g. designers and constructors) from precisely characterising a wide range of interfaces. The basic challenges are inadequate standardisation interface classification and definition for a range of interface that required being defined (Al-Masalha 2004). (Chua and Godinot 2006) described project interface in various categories which are as follows; a) Time interface are the interface which impact any progress from a particular sort of action to another, b) geographical interface is the one that divide on-site activities from off-site activities, c) technical interface is the type that create restrictions of subcomponents arrangement, and d) organisational interface are those interface that preserve the gathering of individual separately. In interface management, it can be group into various categories, for instance time interface, relational interface, data interface, and environmental interface. Time interface is described as interface among various phases of construction project for examples, pre-advancement stage, preliminary stage, development and usage, operation and maintenance stage. Relational or social interface alludes to interface among various project participants. Social interface alludes be either legally binding or unauthoritative interface. Data interface alludes to interface created through the data trades among various division and workers. Environmental interface described as data exchange and the vitality among the project and the atmosphere (Tian 2013).

Organisational interface is either inner or outer. These interfaces are divided into three stages which are intra-project, inter-project, and extra-project. Inter-project interface happens among numerous team members directly concerned with project arrangement and implementation. Intra-project interface happens in association of individual self-determining party, concerned with the project. Extra-project interface arises among team members or other members and organisations that are indirectly concerned with the project (Shokri et al. 2012). Interfaces can be soft (i.e. delicate) or hard, and external (outer) or internal (inner). Data substitutes between team members e.g. plan requirement, approval requirements, or utility requirements among engineering teams or a delivery team and external members are illustrations of soft interface deliverables. Hard interfaces interoperated physical links between two or more elements or framework, for example, basic structural steel connections, pipe terminations, or link association. An interface in one single contract or work scope would be an inner interface, while if happens between contracts or scopes of work, then it will be an external interface (Shokri 2014).

Interface Issues among Construction Professionals

Construction industries have experienced various interface that occurs among many constructors, clients, engineers, as well as material producers, and sub-contractors (Mortaheb, Rahimi, and Zardynezhad 2010). Lack of teamwork, inadequate trust, and insufficient communication, result to poor relationship between the stakeholders in the projects. This type of relationship causes delaying in projects, challenges in settlement of entitlements, cost overruns, litigations, and compromising the quality of projects (Moore, Mosley, and Slagle 1992). In such conditions, professionals could manage to deal with them based on their own perception rather than the standards and therefore individual cannot be provided with a comprehensive picture of

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the interface issues. Therefore, these interface challenges required to be solved cautiously and promptly, mainly through appropriate harmonisation, collaboration, and communication among the project team members (Huang et al. 2008). In production phase of building projects, team members of the project need to ensure cooperation, collaboration and effective communication, and coordination of work from the commencement of the contract work to the successful complete phase. These crews comprise of designers, clients, contractors, contractors, and also the maintenance contractors (Wang 2000). Construction project activities are distinguishing by extreme multifaceted and non-standardisation of production, which are designed and carried out to satisfy clients' requirements.

Interface and Integration Among Construction Professionals

Integration is the coming together or merging of various construction professionals or organisations to interface among themselves with diverse objectives, goals, requirements and norms into a unified and commonly supporting system (Austin, Baldwin, and Steele 2002; Jaafari and Manivong 1999). The method requires that individual from numerous establishments requires collective efforts to accomplish the same possible goals of contract work through data sharing (Baiden, Price, and Dainty 2006). However, efficient interface data distribution permits construction professionals to recognise existing interface and provide solution to interface challenges. Physical consultations, phone conversations, virtual design and construction (VDC) are common and real approaches for team members to share interface data throughout the construction activities. Throughout construction stage, project team members classically carry out their personal duties and hardly share interface data with their colleagues on the project (Lin 2015). Interface data concerning the requirements and development status of each construction professional is frequently not traded efficiently among the team members. (Al-Hammad 1993) observed that interface among contractors and sub-contractors have great influences on contract work in construction industries.

METHODS

This study utilized primary data generated through structured questionnaire. A total of thirty-three (33) completed questionnaire were obtained through physical contacts and two hundred and twenty-seven (227) through google format online questionnaire giving a total of two hundred and sixty (260) completed data. The first few construction professionals sampled for this study were chosen via snowball sampling technique. Respondents were asked if they knew professionals who had the same knowledge or who had experienced interface problems in construction projects. The questionnaire was designed to collect information on interface challenges among construction professionals at both the design and production stages of the projects. Data were analysed using frequency, percentages, exploratory factor analysis, confirmatory factor analysis and structural equation modelling. Frequency and percentage were adopted to analyse respondents' profile such as nature of firm, professional background, position, years of experience and academic qualification while exploratory and confirmatory factor analysis, and structural equation modelling were obtained to analyse interface problems at both design and construction stages. The model for the goodness of fit was determined by means of absolute fit, parsimonious and incremental fits. These indices and the recommended values are presented in table 1.

Table 1. Goodness of Fit Indices for Structural Equation Modelling.

Goodness of fit measure	Recommended Value	Reference
Absolute fit indices		
Normed Chi Square (x^2/df)	<5	(Sahoo 2019)
Goodness of Fit Index (GFI)	>0.9	(Hu and Bentler 1999)
Adjusted Goodness of Fit Index (AGFI)	>0.8	(Hu and Bentler 1999)
Non-centrality-based indices		
Comparative Fit Index (CFI)	>0.9	(Sahoo 2019)
Root Mean Square Error of Approximation (RMSEA)	<1	(Schermelleh-Engel, Moosbrugger, and Müller 2003)
Relative fit index		
Tucker-Lewis Index (TLI)	0<TLI<1	(Schermelleh-Engel, Moosbrugger, and Müller 2003)
Normed Fit Index (NFI)	>0.8	(Hu and Bentler 1999)

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Demographic Characteristics of Respondents

The socio-demographic characteristics of respondents were analysed and the results are listed in table 2. The characteristics analysed were professionals' nature of work undertaken by organisations, position occupied, working experience, academic qualification and professional qualification. The result of the nature of work undertaken by organisations showed that 26.5% of the respondents were in consultancy or design firms, 40.4% were general contractors, 23.5% were constructors; 1.2% were in non-governmental organisations and 8.5% were with the federal or state ministries. The result shows that the responses for the study were sourced from all relevant work categories. The result of the position occupied by respondents showed that 23.8% of the respondents were designers, 22.3% - supervisors, 24.6% - site engineers, 22.3% - project manager while other positions constituted 6.9%. The outcome of professionals' years of working experience revealed that 26.2% had 1-5 years working experience, 34.2% had 6-10 years, 23.8% had 11-15 years, and 13.1% had 16-20 working experience while 2.7% had over 20 years working experience. The outcome disclosed that professionals had adequate working experience required to supply the required data for the study. As regards the academic qualification of professionals, 36.2% holds HND degree, 40%

were B.Sc. degree holder, 23.8% of the respondents had M.Sc. degree. The result of the respondents' profession indicated that 31.5% were Architects, 12.7% - Builders, 14.2% Quantity Surveyor, 21.5% Civil/Structural Engineers while 20% were Mechanical or Electrical Engineers. The results imply that the respondents were academically and professionally qualified to give the information required for this research.

Table 2. Socio-Demographic Characteristics of Respondents

Nature of Work	Frequency (n)	Percentage (%)
Design/Consultancy	69	26.5
General Contractor	105	40.4
Constructor	61	23.5
Federal/State Ministry	22	8.4
NGO	3	1.2
Total	**260**	**100.0**
Position Occupied		
Designer	62	23.9
Supervisor	58	22.3
Site Engineer	64	24.6
Project Manager	58	22.3
Others	18	6.9
Total	**260**	**100.0**
Years of Experience		
1-5 years	68	26.2
6-10 years	89	34.2
11-15 years	62	23.8
16-20 years	34	13.1
Above 20 years	7	2.7
Total	**260**	**100.0**
Academic Qualification		
HND	94	36.2
B.Sc.	104	40.0
M.Sc.	62	23.8
Total	**260**	**100.0**
Professional Qualification		
Architect	82	31.5
Builder	33	12.8
Quantity Surveyor	37	14.2
Civil/Structural Engineer	56	21.5
Mechanical/Electrical Engineer	52	20.0
Total	**260**	**100.0**

Interface Problems in Construction Project Among Professionals

In order to ascertain interface problems in construction projects among professionals, exploratory factor analysis and confirmatory factor analysis were employed to analyse the problems encountered by the professionals at the design and production phases of the construction projects.

Interface problems at design stage in construction project among professionals

To determine the interface problems among professionals at the design stage, 20 factors were analysed. A Kaiser-Meyer-Olkin of 0.855 showed that the study sample is adequate. The result of the Bartlett's Test of Sphericity ($\chi2$= 1661.852, p = 0.000) showed that the correlation of variables is not an identity matrix. The result of the communalities of interface problems (design issues) faced by professionals are presented in table 3. All communalities of variables were greater than 0.4 implying that the underlying factors are measured by the interface problems. Table 4 shows the extraction of the principal components. The components have eigen values which were not less than 1 and rotation sum of square loadings which fell between the range of 1.786 and 3.017. This shows that five factors could be extracted from the variables. The principal one accounted for 30.914% of the observed variance with eigen value of 3.017; component 2 accounted for 7.904% with eigen value 2.459; component 3 accounted for 7.128% with eigen value of 2.262; component 4 accounted for 6.270% with eigen value of 2.027 and component 5 accounted for 5.535% with eigen value of 1.786.

Table 3. Interface problems at design stage in construction project stages among professionals

Interface Problems at the Design Stage	Code	Initial	Extraction
Design omissions	C1	1.000	0.418
Errors and inconsistencies in design documents	C2	1.000	0.543
Insufficient comprehension of design documents	C3	1.000	0.666
Inadequate specification of project data	C4	1.000	0.609
Unclear, deficient drawings and specifications	C5	1.000	0.573
Inadequate coordination between several design team	C6	1.000	0.513
Incomplete working drawing details	C7	1.000	0.523
Insufficient pre-construction study and review of design documents	C8	1.000	0.585
Design complexity	C9	1.000	0.593
Inadequate of design value and assurance practices	C10	1.000	0.578
Difficulty in obtaining complete project documents leading to late issuance of some designs	C11	1.000	0.578
Limitation of time in design stage	C12	1.000	0.504
Lack of integration among the design players	C13	1.000	0.670
Problem of spotting component clashes at the beginning of design phase	C14	1.000	0.614
Badly written contract documents	C15	1.000	0.656
Too many adjustments whenever there are changes in designs	C16	1.000	0.698
Collaboration challenges among professionals at the design stage	C17	1.000	0.489
Unsynchronised designs and mismatch in project documents	C18	1.000	0.601
Lack of interoperability in design phase	C19	1.000	0.593
Erroneous estimate of contract work element, costs and quantities	C20	1.000	0.546

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Table 4. Total Variance Explained of the Interface problems related to design in construction project stages among professionals

Variance Explained									
Comp.	Initial Eigen value			Extraction sums of square loadings			Rotation sums of squared loadings		
SN	Total	% of variance	Cumul. (%)	Total	% of variance	Cumul (%)	Total variance	% of	Cumul. (%)
1	6.183	30.914	30.914	6.183	30.914	30.914	3.017	15.086	15.086
2	1.581	7.904	38.819	1.581	7.904	38.819	2.459	12.293	27.378
3	1.426	7.128	45.947	1.426	7.128	45.947	2.262	11.308	38.687
4	1.254	6.270	52.217	1.254	6.270	52.217	2.027	10.134	48.821
5	1.107	5.535	57.752	1.107	5.535	57.752	1.786	8.931	57.752
6	0.946	4.732	62.484						
7	0.918	4.591	67.075						
8	0.763	3.817	70.891						
9	0.700	3.498	74.390						
10	0.640	3.198	77.587						
11	0.618	3.089	80.677						
12	0.593	2.963	83.639						
13	0.571	2.853	86.493						
1	0.488	2.440	88.932						
2	0.445	2.223	91.155						
3	0.416	2.078	93.233						
4	0.397	1.984	95.216						
5	0.374	1.871	97.087						
6	0.318	1.592	98.679						
7	0.264	1.321	100.000						

Table 5 shows how the items in the components loaded after rotation. The rotated component matrix shows the factor loadings for each component. The factors in component 1 which include C2, C6, C13, C1 and C3 were labeled Design Interface Problems 1 (DIP1), components 2 comprising C14, C19, C18 and C17- ((DIP2), component 3 comprising C11, C12, C10 and C8 – (DIP3), component 4 comprising C9, C20 and C5 - (DIP4) and component comprising C15 and C16 - (DIP 5) loaded above 0.50 which is adequate. Factors that loaded very strongly were highlighted in the table and selected as major interface problems faced by construction professionals at the design stage. These factors have loadings of at least 0.700.

These factors were inadequate specification of project data (C4), problem of spotting component clashes at the beginning of design phase (C14), difficulty in obtaining complete project documents leading to late issuance of some designs (C11), design complexity (C9), badly written contract documents (C15) and too many adjustments whenever there are changes in designs (C16). Poorly written contract was the strongest factor among the components of DIP which is in line with the studies of Al-Mousli and El-Sayegh (2016); Arain and Assaf (2007) that poorly written contract and time limitation in the design stage, design complexity was part of the major causes that led to design-construction interface problems among contracting parties. Lack of stipulated data also found as a major factor influencing interface problems at design stage which is also in consistence with the results of (Sugumaran. B and Lavanya M. R 2013) that insufficient working drawing details was part of the most significant causes of design-construction interface challenges in construction firms. This is contrary to the findings of Lin and Jeng (2017) that poor design, poor coordination and communication between the designers, owners and construction actors were the key features of interface problems.

Interface problems faced by professionals at construction stage

To determine the interface problems faced by professionals at the construction stage, 20 factors were analysed. A Kaiser-Meyer-Olkin of 0.901 showed that the study sample is adequate. The result of the Bartlett's Test of Sphericity ($\chi 2$= 2483.779, p = 0.000) showed that the correlation of variables is not an identity matrix. The result of the communalities of interface problems faced by professionals at the construction stage is presented in Table 6. All communalities of variables were greater than 0.4 implying that the underlying factors are measured by the interface problems. Table 7 shows the extraction of the principal components. The components have eigen values which were not less than 1 and rotation sum of square loadings which fell between the range of 3.764 and 1.636. This shows that four factors could be extracted from the variables. The principal one accounted for 40.068% of the observed variance with eigen value of 3.764; component 2 accounted for 7.862% with eigen value 3.518; component 3 accounted for 7.153% with eigen value of 3.142 and component 4 accounted for 5.220% with eigen value of 1.636.

Table 8 shows how the items in the components loaded after rotation. The rotated component matrix shows the factor loadings for each component. The factors in component 1which include C31, C32 and C33, C30 and C27 were labeled Construction Interface Problems 1 (CIP1), components 2 comprising C21, C22, C26, C36 and C23 (CIP2), component 3 comprising C38, C37, C39 C40 and C34 – (CIP3), component 4 comprising C29 and C35 - (CIP4) all loaded above 0.50 which is adequate.

Table 5. Component Matrix of the Correlations between Components and Interface problems related to design in construction project stages among professionals

	DIP (1-5)				
Interface Problem at the Design Stage	**1**	**2**	**3**	**4**	**5**
C4	0.744				
C2	0.676				
C6	0.580		0.310		
C13	0.565	0.502			
C1	0.553				
C3	0.531	0.315	-0.309	0.302	0.313
C7	0.435		0.394		0.405
C14		0.708			
C19		0.686			
C18		0.663		0.313	
C17		0.534			
C11			0.708		
C12			0.644		
C10		0.378	0.624		
C8	0.301		0.501	0.401	
C9				0.743	
C20				0.652	
C5	0.474			0.554	
C15					0.794
C16					0.745

Factors that loaded very strongly were highlighted in the table and selected as major interface problems faced by construction professionals at the construction stage. These factors have loadings of at least 0.700. These factors were inadequate specialised quality-control team (C31), serious doubting and ambiguity of interface conflicts (C32), lack of system informing about new project data (C33) bad value of construction (C21), complicated construction process (C22) incapability to forecast and bring resolution to challenges connected to new construction technological methods (C38), financial and technical status of the constructor (C37), poor communication among project team members (C39) and change based on instruction or command (C29). Change order and poor quality of construction were the strongest factors in this study among the top factors that cause construction interface problems (CIP) among professionals. In Saudi Arabia, Al-Hammad (2000) found that poor quality of work was ranked as one of the highest severities of construction interface problem between various construction parties. This suggests that poor quality of construction work is the major factor of construction interface problem (CIP) among professionals in Nigerian construction industry.

Table 6. Interface problems faced by professionals at construction stage

Interface Problems	Code	Initial	Extraction
Bad value of construction	C21	1.000	0.668
Complicated construction process	C22	1.000	0.631
Constructability problems	C23	1.000	0.621
Challenges of project data resulting to rework and variation order	C24	1.000	0.511
Construction flaws and bad work on site	C25	1.000	0.413
Poor site organisation and maintenance	C26	1.000	0.520
Coordination difficulties and construction conflicts	C27	1.000	0.530
Poor decision making in selecting construction method and components	C28	1.000	0.601
Change based on instruction or command	C29	1.000	0.753
Insufficient comprehension of design documents	C30	1.000	0.480
Inadequate specialised quality-control team	C31	1.000	0.700
Serious doubting and ambiguity of interface conflicts	C32	1.000	0.690
Lack of system informing about new project data	C33	1.000	0.662
Poor study of tender documents to detect discrepancies	C34	1.000	0.503
Regular changes of subcontractors on project works	C35	1.000	0.593
Inaccurate estimation of construction costs	C36	1.000	0.517
Financial and technical status of the constructor	C37	1.000	0.630
Incapability to forecast and bring resolution to challenges connected to	C38	1.000	0.692

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Interface Problems	Code	Initial	Extraction
new construction technological methods			
Poor communication among project team members	C39	1.000	0.674
Lack of cooperation and team spirit	C40	1.000	0.670

Confirmatory factor analysis of the interface problems in construction project stages

To validate the result of the Exploratory Factor Analysis (EFA) previously conducted, Confirmatory Factor Analysis (CFA) was performed on the output of the EFA of the interface problems faced by professionals at the design and the construction stages. The results of the standardized regression coefficients above the 0.5 indicate a good convergent validity of the scale.

Table 7. Total Variance Explained of the Interface problems faced by professionals at construction stage

Variance Explained									
Comp.	Initial Eigen value			Extraction sums of square loadings			Rotation sums of squared loadings		
SN	Total	% of variance	Cumul. (%)	Total	% of variance	Cumul (%)	Total	% of variance	Cumul. (%)
1	8.014	40.068	40.068	8.014	40.068	40.068	3.764	18.822	18.822
2	1.572	7.862	47.930	1.572	7.862	47.930	3.518	17.588	36.411
3	1.431	7.153	55.082	1.431	7.153	55.082	3.142	15.711	52.122
4	1.044	5.220	60.302	1.044	5.220	60.302	1.636	8.179	60.302
5	0.938	4.692	64.994						
6	0.916	4.579	69.572						
7	0.754	3.770	73.342						
8	0.728	3.639	76.982						
9	0.594	2.969	79.951						
10	0.520	2.601	82.552						
11	0.486	2.430	84.982						
12	0.477	2.383	87.366						
13	0.397	1.983	89.349						

Variance Explained									
Comp.	Initial Eigen value			Extraction sums of square loadings			Rotation sums of squared loadings		
SN	Total	% of variance	Cumul. (%)	Total	% of variance	Cumul (%)	Total variance	% of	Cumul. (%)
1	0.386	1.931	91.280						
2	0.378	1.890	93.170						
3	0.346	1.730	94.900						
4	0.298	1.489	96.388						
5	0.286	1.431	97.819						
6	0.230	1.151	98.970						
7	0.206	1.030	100.000						

Table 8. Component Matrix of the Correlations between Components and Interface problems faced by professionals at the construction stage

Interface Problem (Construction stage)	CIP (1-4)			
	1	2	3	4
C31	0.798			
C32	0.791			
C33	0.736		0.316	
C30	0.569			
C27	0.502	0.403		
C28	0.495	0.454		0.326
C24	0.468	0.405		0.338
C21		0.797		
C22		0.730		
C26	0.305	0.609		
C36		0.571	0.409	
C23		0.544		0.486
C25	0.399	0.464		
C38			0.757	
C37			0.750	

Interface Problem (Construction stage)	CIP (1-4)			
	1	2	3	4
C39	0.311		0.707	
C40	0.422		0.667	
C34		0.431	0.515	
C29				0.810
C35		0.399	0.438	0.444

The result of the parameter estimates presented in table 9 reveals a direct positive significant relationship between all the five dimensions of the Design Interface Problems (DIPs 1-5) and the latent variable DIP; and also reveals a direct positive significant relationship between all the four dimensions of the Construction Interface Problems (CIP 1-4) and the latent variable CIP (Anvuur and Kumaraswamy 2012). These results further indicate a convergent validity of the scale of measurement of the interface problems earlier adopted for the EFA.

The result of the measurement model is depicted in table 10. A chi-square/df ratio of 1.508 which is within the acceptable threshold of < 5.0 confirms that the overall fitness of the measurement equation model. The result of the Root Mean Square Error of Approximation (RMSEA) value of 0.044 is within the acceptable threshold of < 0.1 indicating a good fit. The results of the GFI value of 0.969 and CFI value of 0.913 are within the acceptable limit of > 0.8 and > 0.9 respectively. This similarly proved that the model is fit. The results of the AGFI value 0.946, GFI value of 0.969 and TLI value of 0.880 fell within the acceptable thresholds of ≥ 0.8, >0.8 and 0<TLI<1 respectively.

Table 9. Parameter Estimate for Structural Model of the Interface Problems in construction project stages

Causal relationship			Maximum Likelihood Estimate	Standard error	Critical value	P
DIP1	<---	DIP	1.000			0.000***
DIP2	<---	DIP	1.006	0.226	4.445	0.000***
DIP3	<---	DIP	0.808	0.198	4.071	0.000***
DIP4	<---	DIP	0.790	0.196	4.028	0.002
DIP5	<---	DIP	0.513	0.163	3.149	
CIP1	<---	CIP	1.000			0.000***
CIP2	<---	CIP	1.066	0.219	4.875	0.000***
CIP3	<---	CIP	0.657	0.165	3.987	0.000***
CIP4	<---	CIP	0.524	0.150	3.493	0.000***

*Regression coefficient significant at $p < 0.05$ or < 0.01.

Table 10. Fit Indices of the Interface Problems in construction project stages

Model	Df	χ2	χ2/df	RMSEA	GFI	CFI	TLI	AGFI
FR-WV	26	39.197	1.508	0.044	0.969	0.913	0.880	0.946
Independent	36	187.815	5.217	0.128	0.885	0.000	0.000	0.857
Recommended Value			<5	<0.1	>0.8	>0.9	0<TLI<1	≥ 0.8

The result of the Confirmatory Factor Analysis validates the findings from the exploratory factor analysis. Hence, major design interface issues encountered among professionals are lack of project-stipulated data, difficulty in detecting trade clashes at earliest design stage, difficulty in obtaining complete project documents leading to late issuance of some designs, design complexity, poorly written contract and excessive amendments when changes occur in designs; while the major construction issues are inadequate specialised quality-control team, increase in the uncertainty and ambiguity of interface conflicts, lack of system updating new information, poor quality of construction, complicated construction process, incapability to forecast and bring resolution to challenges connected to new construction technological methods, financial and technical status of the constructor, poor communication among project team members and change order. The Final CFA model is depicted in figure 1.

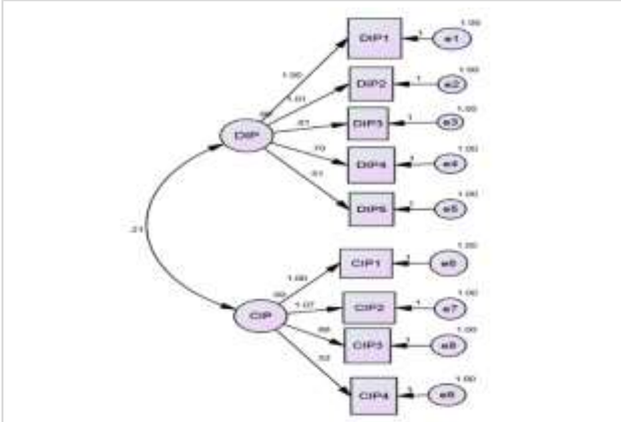

Figure 1. Structural Equation Modelling for the Confirmatory Factor Analysis of the Interface Problems in construction project stages among professionals.

CONCLUSION

The findings of this research concluded that most frequent interface problems at the design stage among construction professionals are; inadequate specification of project data, problem of spotting component clashes at the beginning of design phase, difficulty in obtaining complete project documents leading to late issuance of some designs, design complexity, badly written contract documents, and too many adjustments whenever there are changes in designs. However, major interface challenges at construction stage are; inadequate specialised quality-control team, serious doubting and ambiguity of interface conflicts, lack of system informing about new project data, bad value of construction, complicated construction process, incapability to forecast and bring resolution to challenges connected to new construction technological methods, financial and technical status of the constructor, poor communication among project team members and change based on instruction or command.

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