USING FACTOR ANALYSIS TO ASSESS THE KEY FACTORS INFLUENCING THE SUCCESS COMPLETION OF A PUBLIC SCHOOL PROJECT IN MALAYSIA

Siti Rashidah Mohd Nasir[1] and Muhd Zaimi Abd.Majid[2]

Faculty of Civil Engineering,
University Technology Malaysia, 81310-Skudai, Johor, Malaysia.

Corresponding Author: sitir015@uitm.salam.edu.my

Abstract: *The study of project success is considered to be a means to improve the effectiveness of project. Generally, successful project can be defined as the overall achievement of project goals and expectations. This goal and expectation relate to a variety of elements including technical, financial, educational, social and professional issues. This study reports a factor analysis of seventeen (17) major factors influencing the successful completion of construction project that were determined in an assessment of 141 respondent. The respondent are from the Public Work Department (PWD), Education Work Branch (EWB) of PWD and the Contractors who has completed the public school project for PWD. A principal axes method of factor analysis with orthogonal rotation revealed five (5) significant factors representing underlying structure for the success of project completion. Factor 1 accounts for 16.591% of variance compared to Factor 2 accounts for 16.386% of variance, Factor 3 accounts for 13.711%, Factor 4 accounts for 13.657% and Factor 5 accounts for 13.098% of variance. Oblique rotation was also carried out and interrelationships between the factors were determined and discussed.*

Keywords: Construction project, influence factors, project success , factor analysis.

Introduction

Measuring project success is a complex task since success is tangible and can hardly be agreed upon. The general concept of project success remains ambiguously defined because of varying perception. Usually, project success is defined as the overall achievement of project goals and expectations. These goals and expectations relate to a variety of elements including technical, financial, educational, social, and professional issues (Parfitt et al., 1993). Determination of which factors are critical or having controlling impact on the final success of a project is also difficult to define or identify.

A project is considered successful if the project is delivered on time, on schedule and acceptable quality. Hence, there is still a need to consider other factors that influence the success project completion. This paper aims to determine the correlation between the variables and to determine the interrelationship correlation of these factors which influence the successful completion of a project.

Literature Review

There has been many efforts of research in determining factors that influence project success where, Ashley et al.(1987) and Pinto and Slevin (1988) are some of the major contributors in identification and examination of critical success factor empirically in the 1980s. Sandivo et al. (1992) examined the contribution of factors such as project team experiences, contracts, resources, and information available to project success. Mohsini and Davidson (1992) tested the influence of a number of conflict-inducing organizational variables on performance of project using traditional procurement method. Tiong (1996) identified six critical success factors for build-operate-transfer projects. Pocock et al. (1997) examined the impact of improved project interaction on performance. Konchar and Sanvido (1998) conducted an empirical study that examined nearly 100 explanatory and interacting variables to explain project cost, schedule, and quality performance of three procurement systems (construction management risks, design and build, and design/bid/build).

Mohsinni and Davidson (1992) indicated that attributes of project team cannot be overlooked. Project team refers to the key players, namely, the project manager, client, contractor, consultants, subcontractors, and suppliers and manufacturers. The involvement and commitment of project team is also crucial for project success. The active participation and cooperation of the other key players depend significantly on the capability of the key personnel and the overall competency of the team assigned to the project. Furthermore, the level of support from top management (Pinto and Slevin 1987) in their respective organizations is a factor that can determine the ease and the will to resolve difficulties that arise. Hasssan (1995) indicates that a construction project requires team spirit; therefore team building is important among different parties. Team effort by all parties to a contract is a crucial ingredient for the success completion of a project.

Maloney (1990) conducted a study on evaluation of project performance in terms of time, cost and quality in determining whether project objectives are met. However, achieving success in completing a project should be something much more important than simply meeting cost, schedule and performance specifications. Freeman and Beale (1992) and Riggs et al. (1992) suggested that project success criteria should also be recognized from respective viewpoints of different project participants.

This study reports the findings from the survey conducted with PWD and contractors in Malaysia. Seventeen (17) most influence factors of project completion is identified and subjected to factor analysis for better interpret, understand and to model the structure matrix that relevant to factors influence the project completion.

Methodology

In this study, PWD's projects particularly school project were researched. The questionnaire survey was conducted throughout Penisular Malaysia, Sabah and Sarawak. The questionnaires were sent through postal to PWD states and district compromise of 9 states and 78 districts and to 150 contractor organization. The questionnaires were addressed to the Director and Assistant Director of the PWD states; the District Engineer of the PWD districts; and the director of the contractor organization. All of the respondents have had experience in public school projects.

The list of factors that led to poor performance of project was identified from literature review that conducted through various management journals. These factors were developed and adopted as a framework in this study. In designing the questionnaires, the work of Belout et al. (2003), Ling (2004) and Ling et al. (2004) were drawn, in terms of developing appropriate survey instruments for measuring factors that influence project success. This framework is adapted in this study to enable to measure the degree of opinion focusing on client, consultant and contractor. The first section asked respondents to indicate their background e.g. role in current job, years of experience, organization they are working with i.e. PWD or Contractor and the Contractor's grade. The remaining ten (10) sections of the questionnaires, respondent were asked to indicate their perception of the factors that comprises of project related factors, PWD related factors, design related factors by EWB, contractor related factors, material, labour, plant & equipment, external factors, contractual and project participant commitment factors. The level of focus associated with each item was measured using a 5-point Likert scale. (No Influence at all, Low Influence, Average Influence, High Influence, Very High Influence). The validity of the data was examined using Cronbach's alpha test. This measure of internal consistency is recommended for the analysis of an appreciation scale such as Likert (Kaplan et al., 1993). In this study, the alpha coefficients were 0.9848, suggesting that the questionnaire is a valid measure.

Pilot study of the questionnaires is conducted in the ten (10) different organizations consist of 2 nos. of PWD as client, 4nos. of EWB as consultant and 4 nos., of contractors. Several comments made by the experts on the questionnaires during the pilot study and have been taken into consideration. In the main survey a total of 354 nos. of questionnaires were distributed to PWD states (18 nos.), PWD Districts (156 nos.), PWD EWB (30 nos.) and contractors (150 nos.) The contractors were selected randomly from the list of PWD who has completed the school projects.

Results And Discussion

In total, one hundred fourty one (141) respondents returned the completed questionnaires. This represents a reasonable response rate of 40%. Figure 1 shows the distribution of respondents based type of organization where respondents from PWD, EWB and contractors organization are 44%, 19% and 37% respectively. The data collected was analysed using factor analysis of Statistical Package for Social Sciences (SPSS) version 12.0.

Selection Of Factors

Initially there were 104 variables that influence the completion of school project. Mean rank was performed to produce the top 30 most influence variables from the survey conducted. In order to validate the results, interview with 10 different contractors were conducted where the final 17 variables were then selected and shown in Table 1.

Figure 1. Distribution of respondent by organisation

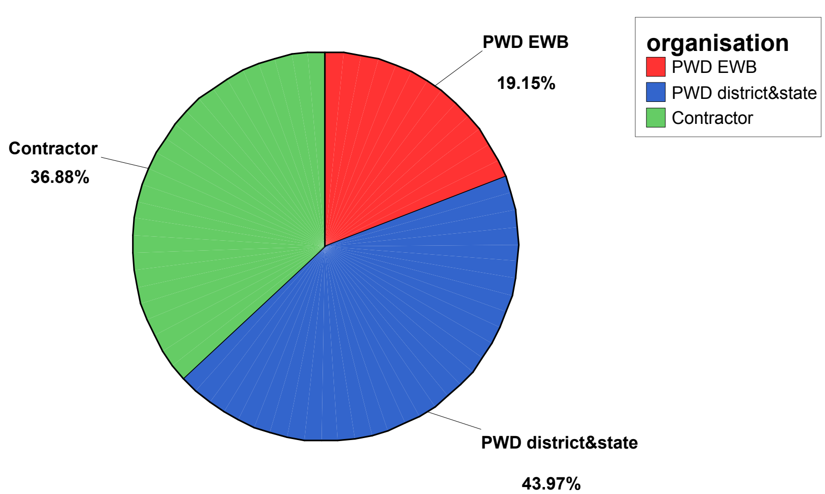


Table 1: Mean Rank

Descriptive Statistics

	Mean
Contractor's deficiencies in planning and scheduling at pre-construction stage	4.0303
Contractor's bad cash flow during construction	4.4255
Contractor's financial difficulties	4.4493
Lack of control over site resources allocation by contractor	3.8298
Contractor's poor site management and supervision	4.1631
Inadequate of contractor's managerial and supervisory personnel	3.7660
Inadequate contractor experience	3.8489
Delays in subcontractor's work	3.9078
Problem with M&E subcontractors	3.8085
Late delivery of imported materials.	3.8087
Late delivery of materials and equipment	3.9786
Poor procurement programming of materials	3.8085
Low labour productivity	3.8440
Equipment/machineries availability	3.6218
Frequent breakdowns of construction plant and equipment	3.6000
Shortage of labour	4.1702
Main Contractor's lack of control of subcontractors works	3.7445

FACTOR ANALYSIS

Factor Analysis were performed on the 17 selected variables and from the correlation matrix table, determinant of R matrix is 0.00002931 which is> 0.00001. This indicates that the data has no problem with multicollinearity. In summary, all questions in questionnaires are correlate fairly with all others. Therefore there is no need to consider eliminating any variables.

Table 2. KMO and Bartlett's test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.780
Bartlett's Test of Sphericity	Approx. Chi-Square	881.978
	df	136
	Sig.	.000

Table 2 shows that Kaiser-Meyer-Olkin (KMO) values are 0.780 which is more than 0.5. Kaiser (1970) stated that KMO static varies between 0 and 1. A value close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. He also recommends accepting values between 0.8-0.9 are consider in the great range. The diagonal elements values of the anti-image correlation matrix are all above 0.5. Therefore there is no need to exclude any variables from the analysis. The off diagonal elements for these data the value are consider small. Table 2 also shows that Bartlett's test significant value is 0.000($p<0.001$). This indicates that for these data Bartlett's test is highly significant, and therefore factor analysis is appropriate. It also suggesting that R matrix is not an identity matrix; therefore it can be expected that there are some relationship between the variables.

Table 3 shows that the analysis has produced 5 latent factors with eigen value >1. Factor 1 accounted for 39.633%, which considerably more variance than the remaining four. Factor 2 accounted for 10.835%, Factor 3 accounted for 9.204%, Factor 4 accounted for 7.567% and Factor 5 accounted for 6.204%. However after extraction Factor 1 accounts for only 16.591% of variance (compared to 16.386%, 13.711%, 13.657% and 13.098% respectively).

Table 3. Total Variance Explained

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.738	39.633	39.633	6.738	39.633	39.633	2.821	16.591	16.591
2	1.842	10.835	50.468	1.842	10.835	50.468	2.786	16.386	32.977
3	1.565	9.204	59.672	1.565	9.204	59.672	2.331	13.711	46.689
4	1.286	7.567	67.239	1.286	7.567	67.239	2.322	13.657	60.345
5	1.055	6.204	73.443	1.055	6.204	73.443	2.227	13.098	73.443
6	.699	4.112	77.555						
7	.642	3.774	81.330						
8	.555	3.263	84.593						
9	.503	2.956	87.549						
10	.454	2.672	90.221						
11	.437	2.572	92.793						
12	.326	1.917	94.710						
13	.307	1.808	96.517						
14	.197	1.158	97.675						
15	.144	.845	98.520						
16	.128	.752	99.272						
17	.124	.728	100.000						

Extraction Method: Principal Component Analysis.

Kaiser's criterion (eigen value >1) suggested that 5 latent factors should be extracted as shown in Table 3. Kaiser's criterion can be adopted since the number of sample is small with 17 variables and the average communality is 0.7345(>0.6). MacCallum et al (1999) suggested that with communalities above 0.6 as in table 4, relatively small samples (less than 100) maybe perfectly adequate. Therefore for this research, 141 number of samples was deemed adequate for factor analysis. As a final check in selecting the numbers of latent factors, Scree plot as shown in Figure 2 is used. It shows that the curve begins to tail off after three factors before a stable plateau is reached. This indicates that Scree plot and eigen values > 1 retain same number of factors. Therefore, it is probably justify retaining 5 factors.

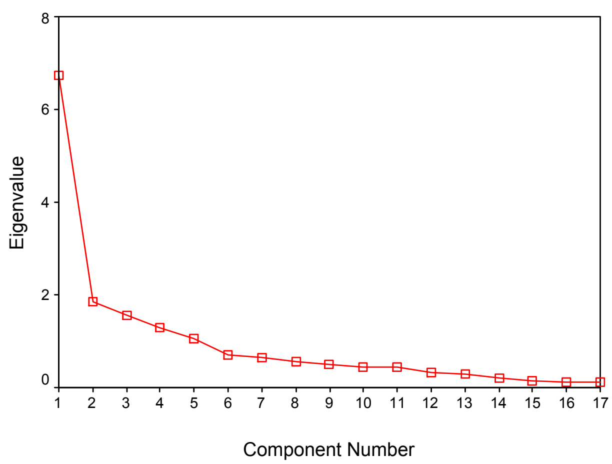
Table 4. Communalities

Communalities

	Initial	Extraction
Lack of control over site resources allocation by contractor	1.000	.784
Contractor's poor site management and supervision	1.000	.797
Contractor's deficiencies in planning and scheduling at pre-construction stage	1.000	.672
Inadequate of contractor's managerial and supervisory personnel	1.000	.738
Problem with M&E subcontractors	1.000	.724
Main Contractor's lack of control of subcontractors works	1.000	.659
Contractor's financial difficulties	1.000	.786
Contractor's bad cash flow during construction	1.000	.830
Frequent breakdowns of construction plant and equipment	1.000	.766
Equipment/machineries availability	1.000	.697
Late delivery of imported materials.	1.000	.741
Poor procurement programming of materials	1.000	.781
Late delivery of materials and equipment	1.000	.819
Shortage of labour	1.000	.696
Delays in subcontractor's work	1.000	.719
Low labour productivity	1.000	.609
Inadequate contractor experience	1.000	.668

Extraction Method: Principal Component Analysis.

Figure 2. Scree Plot



Rotated using Orthogonal rotation (Varimax) is performed because at this juncture, factors are expected to be independent. Table 5 shows the factors and its predictor variables after rotation. Having this results enable the researcher to identify common themes. Extreme negative values of the factor loading (close to -1) indicate factor essentially unaffected by the variable and the positive scores (close to +1) the factor most affected. Near zero scores indicate factor affected to an average degree by a variable. The questions that load highly on Factor 1 seem to all relate to contractor. There are contractor's poor site management and supervision; lack of control over site resources allocation by contractor; contractor's deficiencies in planning and scheduling at pre-construction stage; and inadequate of contractor's managerial and supervisory personnel. Therefore it is appropriate to label this factor as contractor's management problem. The questions that load highly on Factor 2 all seem to relate to subcontractor and contractor's experience. Factor 2 consists of problem with M&E subcontractors; delays in subcontractor's work; main contractor's lack of control of subcontractors works; and inadequate contractor experience. Therefore this factor can be labeled as subcontractor's problem & contractor's experience. Factor 3 consists of equipment/machineries availability; frequent breakdowns of construction plant and equipment; shortage of labour; and low labour productivity. Therefore, Factor 3 is label as machineries and labour problem. Factor 4 consists of contractor's financial difficulties and contractor's bad cash flow during construction; it is therefore label as contractor's financial problem. Finally, the questions that load highly on Factor 5 are all contain component of material. Factor 5 contains of late delivery of imported materials, late delivery of materials and equipment and poor procurement programming of materials; therefore it is label as material problem. This analysis seems to reveal that in reality, is composed of five sub-scales: contractor's management problem, subcontractor's problem and experience, machineries and labour problem, contractor's financial problem and material problem. These five constructs are sub-components of influential to project completion and this can be illustrated in Loading Plots, Figure 3.

Table 5. Rotated Component Matrix (after rotation)

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
Contractor's poor site management and supervision	.847				
Lack of control over site resources allocation by contractor	.796				
Contractor's deficiencies in planning and scheduling at pre-construction stage	.678				
Inadequate of contractor's managerial and supervisory personnel	.660	.509			
Problem with M&E subcontractors		.784			
Delays in subcontractor's work		.700			
Inadequate contractor experience		.674			
Main Contractor's lack of control of subcontractors works		.658			
Frequent breakdowns of construction plant and equipment			.845		
Equipment/machineries availability			.725		
Shortage of labour			.603		
Low labour productivity			.570		
Contractor's financial difficulties				.837	
Contractor's bad cash flow during construction				.804	
Late delivery of materials and equipment					.761
Late delivery of imported materials.					.731
Poor procurement programming of materials					.727

Extraction Method : Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalisation
a. Rotation converged in 7 iterations.

Figure 3. Loading Plot

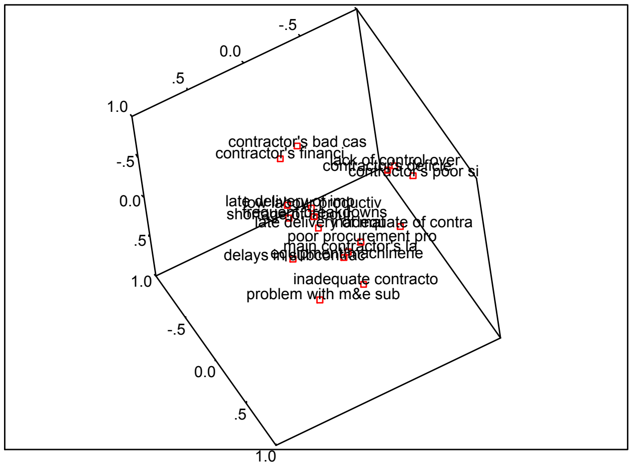


Table 6. Component Transformation Matrix

Component Transformation Matrix

Component	1	2	3	4	5
1	.497	.514	.411	.393	.407
2	-.286	.481	.570	-.447	-.403
3	-.755	.042	.154	.626	.109
4	-.150	-.450	.465	-.377	.646
5	.280	-.548	.516	.334	-.493

Extraction Method : Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalisation

As shown in Table 6, the matrix is not symmetrical therefore orthogonal rotation was inappropriate. It is expected that there have a correlation between factors. Therefore, oblique rotation (Direct Oblimin) is required. For Pattern matrix as shown in Table 7, the same five factors seem to have emerged (although for some variables the factor loadings are too small to be displayed). From Table 7, Factor 1 seems to subcontractor's problem and contractor experience, Factor 2 represents contractor's financial problem, Factor 3 represents contractor's management problems, Factor 4 represents machineries and problems and Factor 5 represent material's problem.

In Table 9, Component Correlation Matrix shows that all factors are interrelated to some degree. However, Factor 1 seems to have a highest relationship with Factor 4 and Factor 3 where the correlation coefficients are slightly high compared to other factors. Table 8, Structure Matrix confirmed this results by showing the loading factors of Factor 1 distributed mainly on to Factor 3 and 4.

The fact that these correlations exist tells that the constructs measured can be interrelated; for these data it appears that we cannot assume independence.

Therefore, the results of the orthogonal rotation should not be trusted: the oblique rotated solution is probably more meaningful. On a theoretical level of the dependence between factors does cause concern; expected a fairly strong relationship between subcontractor's problems and experience; machineries and labour's problem; and contractor's management problem's.

Table 7. Pattern Matrix

Pattern Matrix[a]

	Component				
	1	2	3	4	5
Problem with M&E subcontractors	.837				
Delays in subcontractor's work	.709				
Inadequate contractor experience	.622				
Main Contractor's lack of control of subcontractors works	.582				
Contractor's financial difficulties		-.815			
Contractor's bad cash flow during construction		-.776			
Contractor's poor site management and supervision			-.875		
Lack of control over site resources allocation by contractor			-.818		
Inadequate of contractor's managerial and supervisory personnel			-.674		
Contractor's deficiencies in planning and scheduling at pre-construction stage			-.673		
Frequent breakdowns of construction plant and equipment				.903	
Equipment/machineries availability				.738	
Shortage of labour				.596	
Low labour productivity				.551	
Late delivery of materials and equipment					-.701
Late delivery of imported materials.					-.699
Poor procurement programming of materials					-.675

Extraction Method : Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalisation

a. Rotation converged in 20 iterations.

Conclusion

In summary, the results of this study suggest that the influence factors to project completion is more validly represented by the five factors of contractor's management problems; machineries and labour's problems; subcontractor's problem and experience; materials problems; and contractor's financial problems. It also seems as though an obliquely rotated solution was preferred due to the interrelationships between factors. Generally, increase problem in contractor's management may lead to the increase of subcontractor, labour, machineries and material problems. It can also be said that contractor with less experience will have difficulty in managing and financing the projects. The results of these studies will lead to a more comprehensive understanding of the components of influence factors to project completion and therefore, require further study on the five main factors. It will also provide a more accurate understanding of the extent of the site problem during construction i.e. material, labour and machineries in the area of project completion, and so too the nature of the problems which need to be targeted in the site meeting.

Table 8. Structure Matrix

Structure Matrix

	Component				
	1	2	3	4	5
Problem with M&E subcontractors	.820				
Delays in subcontractor's work	.771	-.497			
Main Contractor's lack of control of subcontractors works	.742		-.494	.468	
Inadequate contractor experience	.731		-.455	.482	
Contractor's financial difficulties		-.867			
Contractor's bad cash flow during construction		-.844	-.423		
Contractor's poor site management and supervision			-.891		
Lack of control over site resources allocation by contractor			-.856		
Inadequate of contractor's managerial and supervisory personnel	.578		-.735		
Contractor's deficiencies in planning and scheduling at pre-construction stage			-.728		-.505
Frequent breakdowns of construction plant and equipment				.858	
Equipment/machineries availability				.772	
Shortage of labour	.495	-.467		.690	
Low labour productivity	.460	-.436		.678	
Late delivery of materials and equipment				.502	-.801
Late delivery of imported materials.		-.503			-.768
Poor procurement programming of materials	.426		-.548		-.764

Extraction Method : Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalisation

Table 9. Component Correlation Matrix

Component Correlation Matrix

Component	1	2	3	4	5
1	1.000	-.213	-.321	.384	-.121
2	-.213	1.000	.171	-.160	.181
3	-.321	.171	1.000	-.280	.266
4	.384	-.160	-.280	1.000	-.169
5	-.121	.181	.266	-.169	1.000

Extraction Method : Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalisation

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