Non-Technical Components of Software Development and their Influence on Success and Failure of Software Development

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Abstract **- Knowledge and understanding of success and failure factors, as well as how to measure them and the interactions between these factors have great importance for project management effectiveness. Project success and failure is a question of perception and the criteria could vary from project to project A project that has been perceived to be a failure by one stakeholder may be perceived as a success by another. Therefore a study was conducted in India among the industries that are into in-house software development, to investigate the influence of the non-technical components of the software development process, on success and failure of software development. This study reveals that practitioners consider the level of customer/user involvement, software process management, and estimation & schedule to contribute most to project success and failure and from the organizational perspective the level of customer/user involvement, project manager/staff and software process management contribute most to project success and failure.**

Keywords**- Success, Failure, Non-technical components, in-house, Software development.**

I. INTRODUCTION

To have a successful software project, it is essential to identify what constitutes success. Projects succeed when enough factors go well to allow a project's objectives to be satisfied. Project success and failure can rarely be described in absolute terms. If failure is no accident then success is no accident. Failure and success provide different perspectives on improvement: failure tells what not to do in future, where as success shows what should be done again.

A review of extant literature shows that studies on success factors have been predominantly conducted in the Western settings [1], [3], [7], [8], [9], [10]. Literature reveals that decades of individual and collective efforts by project management researchers since the 1960s, have not led to discovery of definite set of factors leading to project success [1], [10]. The reasons could be attributed to methodical differences, the culture, and factors pertaining to the work role. Nevertheless, studies on project success factors in India are at a primitive stage. In recent years, researchers in project management have become increasingly interested in success and failure factors [1], [3], [7], [8], [10]. Knowledge and understanding of success and failure factors, as well as how to measure them and the interactions between these factors have great importance for project management effectiveness. "Beauty is in the eye of the beholder", Where beauty to one is a complete turnoff to another (Project success is no different). There are different perspectives and to mention a few - developer's perspective, end users' perspective, management/ organization perspective, and so forth [5]. There is a vast difference in developers' perceptions of project success factors, and their perception of how management personnel view project success and failure. Developers take a mainly inward-looking view of project success concentrating on the things that affect them and their ability to do their job properly. The management viewpoint appears to be more politically oriented - to keep customers and users happy rather than the developers.

The success or failure of Software Project management consists of two components, namely the technical and non-technical components of software development. The technical issues of software development include those directly related to hardware and software. Non-technical issues relate to people and process-related components of the development process. Non-technical related components of software development process tend to be under managed. The cause of most project failure has little to do with technological issues, despite the tendency among project managers to focus on technical issues involved in software development [5], [6]. There is a lack of quantitative research into the non-technical components of software development projects, specifically from the perspective of software practitioners [5]. Further research on success and failure of software projects developed in-house are sparse [4], [5], [6].

Therefore a study was conducted in India among the industries that are into in-house software development to investigate the software development success and failure. This study investigated the influence of the non-technical factors of software development process, on success and failure of software development from the perspective of software practitioners. Previous software engineering studies have suggested a number of non-technical components that contribute to the eventual success and failure of software development, however, the joint occurrence are captured only with three factors [5].

The non-technical components/factors can be broadly categorized as:

1. Sponsor/management support and participation (MS)
2. Customer/user support and participation (CS)
3. Requirement management (RM)
4. Estimation and schedule (ES)
5. Project manager and relationship with development staff (PM)
6. Software process management (SP) and
7. Software development personnel (Per).

Research on the joint occurrence of all the non-technical components of project management is sparse. This research investigated the above stated list of non-technical components of software development process and the joint effect of the chosen non-technical components that determines the success and failure of software development.

II. Purpose and Significance of the Study

Over-management of technical issues and under-management of non-technical people related issues is the problem that software development is facing. Managing technical issues tends to be more straightforward than managing non-technical, people, who come with their unique personalities, strengths, weakness and opinions. Therefore managing non-technical, people-related components tend to be difficult. As a result non-technical issues more often plague software development than technical problems. Moreover in-house developed software tend to get deviated from estimates and schedule due to various reasons like; more attention for maintenance and support for already implemented projects, lack of resources, lack of required participation of stakeholders due to their day to day activities and other priorities.

This study will help to fill the current quantitative, survey-based research gap on the non-technical components of the software development process specifically from the perspective of software practitioners of India. This study is also intended to enlighten project managers with regard to the importance of practitioners' overall perception of project success. Therefore an understanding of the importance of software development success and failure will have significant implication for the organization and the software practitioners.

III. Research Methodology

A. *Research Focus*

The research focus is to study software development success and failure of in-house developed software projects in India. The research focus is also to study the level of non-technical components and to predict the success and failure of software development by the selected non-technical components from the perspective of software practitioners' and organizations' (Practitioner's view).

B. *Objectives of this study*

1) To measure the percentage of software development success and failure from the perspective of software practitioners and from the organizations' perspective (practitioners' view).
2) To test whether there is any significant association on software development success and failure between the software practitioners' perspective and the organizations' perspective.
3) To predict the software development success and failure by the selected non-technical components from the software practitioners' perspective.
4) To predict the software development success and failure by the selected non-technical components from the organizational perspective.

C. *Research Model*

In this context the researcher has developed a model to be tested. The model treats the chosen non-technical components as predictors or independent variables and success and failure of the software development as the dependent variable or the grouping variable. This is a predictive model where the chosen non-technical components are tested for prediction of success and failure of software development.

D. Methodology

The major purpose of this investigation is to capture the factors that predict the success and failure of software development. It was decided that a descriptive study using primary data would be appropriate to investigate the objectives. The instrument used to collect the data was a questionnaire.

1) Instrumentation

For the purpose of studying the objectives, a questionnaire has been used as an instrument to collect the data. The questionnaire has two parts; the first part measures the short profile of the respondents and the second part measures the study variables. The variables chosen for this study are Management support, customer/user, requirement, estimation and schedule, project manager/staff, software process management and personnel. The items capturing each factor have been adopted from earlier research [4]. The items that constituted adequate coverage of the factors under study were decided and agreed upon by the researcher.

The second part of the instrument captured the study variables and the items of the study variables, which were adopted from [4], management support scale consisted of 7 items, customer/user consisted of 8 items, requirement consisted of 8 items, estimation and schedule consisted of 11 items, project manager/staff consisted of 16 items, software process management consisted of 22 items, and personnel consisted of 18 items.

2) Validity test

The questionnaire was subjected to face and content validity whose determination was judgmental. The face and content validity of the items were conducted with 8 experts. The content validity ratio (CVR) was applied to each item. Content Validity Ratio = (Ne-N/2) / (N/2), where Ne = number of panelists indicating "essential" and N = total number of panelists.

All items scored less than 0.50 on the content validity ratio have been removed from the study. Based on the face validity and content validity ratio, the final number of items in each of the factors taking part in this study was decided.

3) Sampling frame

The geographical area of Coimbatore city (India) was chosen as the Universe. The main reason for choosing Coimbatore city is that the investigator is located here and is familiar with the place. Familiarity is found to be essential for gaining accessibility to the respondents as well to solicit genuine participation by the respondents.

a) Administration and justification of the sample

A list of companies having an in-house software development department was prepared. 58 companies were chosen. From this list, only those companies which had at least a project leader to lead a project had been selected; the project managers/project leaders should have undertaken led and completed at least one software project. A total of 41 companies were identified. After identifying the companies, snowball sampling technique was used to select the respondents. Accordingly, 141 software practitioners were identified.

A thorough follow-up was done in person and over telephone to expedite the process of filling up the questionnaire. Yet few questionnaires were not returned and few were unusable and incomplete, yielding a response rate of 71.42% (100 usable questionnaires). Filled-in questionnaires from 34 companies alone were returned. The final sample size is of considerable size when compared to some relevant prior studies [2], [3], [5]. The industry sectors of respondents' organizations are manufacturing sector, Textile & Sugar mills and hospitals.

b) Techniques used for analysis

Discriminant analysis was used to predict the success and failure of software development by the study variables from the perception of practitioners and organization (practitioners' view).

IV. ANALYSIS AND INTERPRETATION

The data collected from the respondents was tabulated and analyzed using appropriate statistical techniques mentioned in the research methodology.

A. Testing the objectives

This section contains tabulation of techniques used to study the objectives mentioned above.

Objective 1: To measure the percentage of software development success and failure from the perspective of software practitioners and from the organizations' perspective (practitioners' view).

To study this objective percentage analysis was done. The results are as shown in Table 1.

TABLE 1: CROSS TABULATION BETWEEN SUCCESS(S) AND FAILURE(F) OF PROJECTS FROM ORGANIZATIONAL AND PROJECT MANAGER'S PERSPECTIVE.

		S & F from Organization perspective		Total
		F	S	
S & F from individual perspective	F	24	0	24
	S	12	64	76
Total		36	64	100

X2 (Chi-square) = 56.14; p = 0.00

Objective 2: To test whether there is any significant association on software development success and failure between the software practitioners' perspective and the organizations' perspective.

Chi-square was conducted to find the association between the individual's perspective and the organizational perspective. The above Table 1 shows that 24 project managers who say that the software projects are a failure from their perspective equally say that the project has failed from the organizational perspective. No project manager who says that the project is a failure from the individual's perspective says the project is a success from the organizational perspective. Similarly, 12 project managers who say that the project is a success from the individual's perspective say that the project has failed from the organizational perspective. Similarly, 64 project managers have the same opinion on the success of the project from the individual as well as the organizational perspective. It has been found that there is significant difference between the individual and the organizational perspective.

Objective 3: To predict the software development success and failure by the selected non-technical components from the software practitioners' perspective.

Stepwise Discriminant Analysis (DA) is performed to predict the success and failure of software development by the study variables from the perspective software practitioners. The stepwise DA resulted in a 3 – step discriminant model. It was found that the significance levels of the individual variables reveal that on a univariate basis, Customer/User, Requirement, Estimation and schedule, Project manager/staff, and Software process management and Personnel, display significant differences between the group means. Management support is not significant across success and failure of software development. Visual examination of the group means provide information about the differences between the groups, however, the statistical significance of any specific comparison is not known. This is important in discriminant analysis, though only two groups are involved in this model.

TABLE 2: STUDY VARIABLES IN THE ANALYSIS

Step	Study Variables	Tolerance	F to Remove	Min. D Squared	Between Groups
1	CS	1.00	49.632		
2	CS	.938	57.239	1.557	S & F
	SP	.938	35.066	2.721	S & F
3	CS	.936	54.941	2.031	S & F
	SP	.920	26.337	3.763	S & F
	ES	.973	5.418	5.647	S & F

Table 2 presents the three steps of the stepwise discriminant model. In the first step, the variable Customer/user entered the model. In the second step Customer/user entered discriminating between the success and failure along with Software process management. In the third step Customer/User entered discriminating between success and failure along with Software process management and estimation and schedule.

Since stepwise discriminant analysis is performed, Mahalanobis D^2 (Min D^2) is used to evaluate the statistical significance of the discriminatory power of the discriminant function(s) and to determine the variable with the greatest power of discrimination. This is used over Rao's V because it is based on generalized squared Euclidean distance that makes adjustments for unequal variances. It is also preferred because the researcher is interested in the maximal use of the available information and also of its computation in the original space of the predictor variable rather than a collapsed version as used in other measures.

Table 3 gives a summary of the 3 steps involved in the discriminant analysis. The variables customer/user, software process management, and estimation and schedule enter the discriminant function. Discrimination increased with the addition of each variable, achieving by the third step a substantial ability to discriminate between the groups. This is indicated by the Mahalanobis D^2 value which is significant. As the variables enter in each step from 1 to 3, the respective stepwise models are significant indicated by the significance of the F – value, shown in Table 3. The overall results are also found to be statistically significant and continue to improve in discrimination as evidenced by the decrease in Wilks' Lambda value (from 0.664 to 0.462).

Table 3 describes the 3 variables that were significant discriminators based on their Wilks' lambda and minimum Mahalanobis D^2.

TABLE 3: SUMMARY OF STUDY VARIABLES ENTERED/REMOVED

Step	Study Variables Entered	Wilk's Lamda	Min. D Squared					
			Statistic	Between Groups	Exact F		
					df1	df2	Statistic
1	CS	.664	2.72*	F & S	1	98	49.63*
2	SP	.488	5.65*	F & S	2	97	50.98*
3	ES	.462	6.30*	F & S	3	96	37.34*

** significant at 0.05 level*

To assess the contributions of the seven predictors, the researcher has examined the structure matrix, which is indicative of each variable's discriminating power (shown in Table 4). It is found that Customer / User have the largest discriminating power with coefficient 0.66 followed by Software process management 0.49, and Estimation and schedule 0.35.

The predictive accuracy of the discriminant function is assessed using the classification matrix. Table 5 shows that the discriminant function in combination achieves a higher degree of classification accuracy. The hit ratio for the analysis is 92.0%. The final measure of classification accuracy is Press' Q calculated to test the statistical significance that the classification accuracy is better than chance. Press' Q = $[N – (nK)]^2 / [N (K-1)] = [100 – (92*2)]^2 / [100 (1)] = 70.56$.

The Press' Q statistic calculated is compared to the critical value based on Chi-square distribution. The calculated value is more than the critical value at a significance level of 0.05. Therefore, the classification results are significantly better than that which would be expected by chance.

TABLE 4: STRUCTURE MATRIX

Study Variables	Canonical Discriminant Function
CS	0.659*
SP	0.498*
ES	0.350*
RM**	0.286
PM**	0.166
Per**	0.059
MS**	0.070

** Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions variables ordered by absolute size of correlation within function. ** This variable not used in the analysis.*

TABLE 5: CLASSIFICATION RESULTS

Success and Failure from practitioners' perspective		Predicted Group Membership		Total
	Success or failure	Failure	Success	
Count	Failure	23	1	24
	Success	7	69	76
%	Failure	95.8	4.2	100
	Success	9.2	90.8	100

A 92.0% of original grouped cases correctly classified.

Objective 4: To predict the software development success and failure by the selected non-technical components from the organizational perspective (practitioners' view).

Stepwise Discriminant Analysis is performed to predict the success and failure of software development by the study variables from the organization's perspective. The stepwise DA resulted in a 3 – step discriminant model. It was found that the significance levels of the individual variables reveal that on a univariate basis, Customer/User, requirement, estimation and schedule, project manager/staff, software process management and personnel display significant differences between the group means. Management support is not significant across success and failure of software development. Visual examination of the group means provide information about the differences between the groups, however, the statistical significance of any specific comparison is not known. This is important in discriminant analysis.

Table 6 presents the three steps of the stepwise discriminant model. In the first step, the variable Customer/User entered the model. In the second step customer/user entered discriminating model along with Project manager/staff. In the third step, Customer/user entered the model along with Project manager/staff and Software process management. Since stepwise discriminant analysis is performed, Mahalanobis D^2 (Min D^2) is used to evaluate the statistical significance of the discriminatory power of the discriminant function(s) and to determine the variable with the greatest power of discrimination.

TABLE 6: STUDY VARIABLES IN THE ANALYSIS

Step	Study Variables	Tolerance	F to Remove	Min. D Squared	Between Groups
1	CS		81.78		
2	CS	.96	86.01	.75	S & F
	PM	.95	20.38	3.55	S & F
3	CS	.94	88.37	1.07	S & F
	PM	.93	13.34	4.72	S & F
	SP	.94	7.93	5.19	S & F

Table 7 gives a summary of the 3 steps involved in the two-group discriminant analysis. The variables customer/user, project manager/staff and software process management enter the discriminant function. Discrimination increased with the addition of each variable, achieving by the three step a substantial ability to discriminate between the groups. This is indicated by the Mahalanobis D^2 value which is significant. As the variables enter each step from 1 to 3, the respective stepwise models are significant, indicated by the significance of the F – value. This is shown in Table 7. The overall results are also found to be statistically significant and continue to improve in discrimination as evidenced by the decrease in Wilk's Lambda value (from 0.55 to 0.42). The above Table 7 describes the 3 variables that were significant discriminators based on their Wilk's lambda and minimum Mahalanobis D^2.

To assess the contributions of the seven predictors, the researcher has examined the structure matrix which is indicative of each variable's discriminating power (shown in Table 8). It is found that customer/user has the largest discriminating power with coefficient 0.77, followed by project manager/staff 0.355 and software process management 0.296.

TABLE 7: SUMMARY OF STUDY VARIABLES ENTERED/REMOVED

Step	Study Variables Entered	Wilk's Lamda	Min. D Squared		Exact F		
			Statistic	Between Groups	df1	df2	Statistic
1	CS	.55	3.55*	F & S	1	98	81.78*
2	PM	.45	5.19*	F & S	2	97	59.17*
3	SP	.42	5.97*	F & S	3	96	44.91*

** significant at 0.05 level*

TABLE 8: STRUCTURE MATRIX

Study Variables	Canonical Discriminant Function
CS	0.771*
PM	0.355*
SP	0.296*
MS**	0.153
Per*	0.103
RM**	0.090
ES**	0.053

** Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions variables ordered by absolute size of correlation within function. ** This variable not used in the analysis.*

The predictive accuracy of the discriminant function is assessed using the classification matrix. The Table 10 shows that the two discriminant functions in combination achieve a moderate degree of classification accuracy. The hit ratio for the analysis is 91%. The final measure of classification accuracy is Press' Q calculated to test the statistical significance that the classification accuracy is better than chance. Press' Q = $[100 – (91*2)]^2 / [100(1)] = 67.24$.

The Press Q statistic calculated is compared to the critical value based on Chi-square distribution. The calculated value is more than the critical value at a significance level of 0.05. Therefore, the classification results are significantly better than that which would be expected by chance.

TABLE 9: CLASSIFICATION RESULTS

Success and failure from organization perspective	Predicted Group Membership			Total
	Success or Failure	Failure	Success	
Count	Failure	31	5	36
	Success	4	60	64
%	Failure	86.1	13.9	100
	Success	6.2	93.8	100

A 91.0% of original grouped cases correctly classified.

V. FINDINGS AND DISCUSSION

One of the most interesting findings of this study is the perceptions that the software practitioners' have about management's view of project success and failure. There is a difference between practitioners' perception of project success and failure and their perceptions of how management views project success and failure. It is found that both practitioners' and organizations' consider the level of customer and user involvement contributes most to project success and failure. Practitioners perceive the next important factors to be software process management, and estimation and schedule. On the other hand, organizations perceive (practitioners' view) the next important factors to be project manager/staff and software process management.

VI. CONCLUSION

The success and failure of software project is not only a unique pattern in Western countries but also it pertains to countries like India too. Given the cultural differences in attitudes, values, and behaviors towards work, this study enables to see the pattern that is emerging in industrializing and economically progressing countries like India. The major contribution of this study is that it proposed a composite model establishing the relationship between the non-technical factors and success and failure using a non Western sample. The organization concerned with huge cost and harnessing software technology for competitive advantage painstakingly can use the findings of the study. To conclude, this study gives cue to organizations on the factors that determine the success and failure of software development.

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