Measuring Success of Water Reservoir Project by Using Delphi and Priority Evaluation Method

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Abstract. Traditionally project success has been defined in terms of the time, cost and quality. Extending the traditional triangle to include other factor of stakeholders and end-user provide a more complete view of project success. The aim of the study is to determine the factors that can be used to assess water reservoir project success. The factors for project success in from previous study have been identified and then, narrowly to determine the critical success factors by evaluating the appropriateness of the factors. Delphi method has been applied and a one day seminar has been conducted with a group of expert who involved in construction of water reservoir project in a water company agency. An initial questionnaire has been asked during the seminar through brainstorming and discussion session to identify potential success factors. Following from the seminar, a questionnaire survey was distributed to the participant for the purpose to establish the level of important of the factors. From the feedback of thirty (30) expert opinion and fourteen (14) returned expert surveys, refined seven (7) clusters of project success factors were identified: Clear Realistic Objectives; Quality Factor; Time Factor; Cost Factor; Deliverable; Legacy System; and Safety, Health and Environment. A template for measuring project success has been produced base on Prioritization Evaluation Method. At the end, five (5) actual projects in the water company agency have been used to show the application of the measuring project success template specifically for the water reservoir project. It has been used to determine the successfulness of each project. It shows that the main factor of an unsuccessful water reservoir project in this case are because of unclear realistic objectives, deliverable issue and time factor.

1. Introduction
In order for a construction project to succeed, each phase of the project should be managed efficiently and effectively. The critical success factors of a construction project should be prioritized so that management efforts can be exerted in the most balanced way. Research has previously been carried out on methods for prioritizing project critical success factors. However, these approaches lack consideration of the degree of satisfaction specifically for water reservoir construction project. Satisfaction values should be considered equally with importance values. The aim of the study is to determine the critical factors that can be used to evaluate the success of water reservoir project. The objectives of the study are: (i) to identify project success factors in general; (ii) to determine critical project success factors for water reservoir project, and (iii) to develop a template for measuring success of water reservoir project in a water company. The template for measuring project success produced suitable to be used for the project in that agency only. The water company is a water provider and can contribute to achieve the UN Sustainable Development Goals (SDG) 6: Ensure availability and sustainable management of water and sanitation for all.
2. Methodology

Basically, descriptive measures have been used in this research methodology. Descriptive measures include two components: (1) a person competent to judge the work performed and (2) a list of factors by which the quality of the work can be judged. The methodology in this study can briefly explain as funnel concept of identifying success in factors. All the project success factors from previous study will be narrowly down for measuring project success. While these factors may not be quantifiable—that is, measurable in numbers—they should be verifiable. Verifiable measures provide a way to measure those aspects of performance for which number do not work well (Crawford and Cabanis-Brewin, 2006).

2.1 Objective 1: To identify project success factors in general

There are about 21 journals & articles related to project success have been reviewed. They are from Project Management Journal, IEEE, Journal of Management in Engineering, International Journal of Project Management, Journal of Construction Engineering Management and different types of books and thesis relating to measuring project success. All of the success factors are from the different type of projects are listed (Cook-Davies, 2002, Chan et al., 2002, Chan, 2001). Out from the 21 journals, only 6 are related to construction projects. There are hundreds factors that have been identified and listed.

2.2 Objective 2: To determine critical project success factors for water reservoir project

The Delphi method is an interactive process to collect and distil the anonymous judgments of experts using a series of data collection and analysis techniques interspersed with feedback (Skulmoski et al., 2007, Linstone et al., 2002). The Delphi process in this research was initially planned to include surveys by questionnaire. The process was planned to end when a certain agreement was reached among the members of the Delphi panel.

This study adopted the brainstorming and discussion of potential success factor from a group of expert in a one day seminar and workshop to identifying the potential critical success factors of construction projects and Delphi method to confirm the identified critical success factors. A one day seminar and workshop on Project Auditing for Measuring Project Performance and Delivery have been organised by the agency and been attended by a group of expert in construction project (Figure 1, & 2). All the data collected are within the scope of a group of personnel of the agency only which situated at Johor, Malaysia. The correspondent background are a group of expert included Senior Officer, Project Manager and Engineers, and mostly involved in the construction project in the agency. There are thirty (30) of them who attend the one day seminar and acted as respondents in the survey.

Figure 1. & 2. Process of adding and eliminating potential project success factors during one day seminar and workshop

Initial Questionnaire Survey is purposely to identify the potential critical success factors of construction projects suitable in their agency. From the perspective of the expert, short listed of factors are captured. Factors that are considered as not important will be eliminated from the list by consensus opinion in the workshop. Moreover, a subjective question was included in the discussion to describe any factors other than initially listed. If any new factors emerged, they were to be added to the subsequent surveys. The process was continued until they met an agreed project success factors for evaluation of project in their agency. Below is a list of project success factors in construction project resulted from the workshop. At this stage, the factors are grouped into ten (10) clusters.

Follow up Questionnaire Survey aims to establish the level of satisfaction for each of the criteria presented as an element that can influence the success factor evaluation for construction projects. This
methodology is a follow up from the previous one day seminar and workshop with a group of expert in construction of an agency. All the factors presented in this questionnaire survey have been agreed by the seminar participants as ‘important’. However, the level of their importance is needed to be established as factors that can be used to evaluate project success so that a fair contribution of weightage can be established. The questionnaire survey was sent by email and fourteen (14) respondents’ feedbacks have been returned by post. Details results of important level of each factor in the clusters can be seen in Table 1.

Table 1. Ten (10) clusters and Level of important of each Project Success Factors

| PROJECT SUCCESS FACTORS | Average | Relative Important Index (RII) |
|-------------------------|---------|------------------------------|
| Cluster 1               |         |                              |
| Clear Realistic Objectives | 5.1     | 0.85                         |
|                                 | End product benefits met | 5.4 | 0.91 |
|                                 | Design must meet requirements | 6.3 | 0.90 |
|                                 | Realistic time allocated for the project | 5.8 | 0.83 |
|                                 | Risk addresses Preventive Measures | 5.8 | 0.83 |
|                                 | Project scope | 5.6 | 0.80 |
| Cluster 2 Quality Factor | 5.9     | 0.85                         |
| Material quality | 6.6 | 0.95 |
| Workmanship | 6.6 | 0.95 |
| Design accuracy | 6.1 | 0.88 |
| User-select specifications and standards | 6.1 | 0.87 |
| Adequate quality control mechanism | 5.9 | 0.84 |
| All defect and problems immediately addressed | 5.9 | 0.84 |
| Relevant specifications and standards | 5.6 | 0.81 |
| Competent quality control personnel | 5.6 | 0.80 |
| Standard quality program | 5.5 | 0.79 |
| Management is responsible for the creation of the quality environment | 5.3 | 0.76 |
| Cluster 3 Time Factor | 5.8 | 0.83 |
| Complete within contractual period | 6.5 | 0.93 |
| Adherence to schedule | 5.9 | 0.84 |
| Measurable accomplishments | 5.6 | 0.80 |
| Minimizing the duration | 5.2 | 0.74 |
| Cluster 4 Cost Factor | 5.8 | 0.83 |
| Completed within budget allocated | 6.3 | 0.88 |
| Optimum usage of resources | 5.9 | 0.84 |
| Variations order well justified | 5.8 | 0.83 |
| Effort to minimize cost | 5.7 | 0.82 |
| Pay as per work done | 5.7 | 0.82 |
| Cluster 5 Focus on Customer Requirements | 5.7 | 0.82 |
| Fulfil serviceability for the future requirements | 6.4 | 0.92 |
| Value of the product to customer | 6.0 | 0.86 |
| Served the intended purpose | 5.9 | 0.84 |
| Better customer service | 5.9 | 0.84 |
| Customer satisfaction | 5.8 | 0.83 |
| Accuracy of progress report | 5.7 | 0.82 |
| Customer acceptance | 5.4 | 0.79 |
| Consideration of customer requirements in the design process | 5.4 | 0.78 |
| Listening to customer | 5.2 | 0.72 |
| Cluster 6 Optimisation of legal and administrative services | 5.6 | 0.80 |
| Good project leadership | 6.3 | 0.88 |
| Compliance to regulatory requirements | 6.0 | 0.86 |
| Design must be finalized before tendering | 5.9 | 0.85 |
| Save active involves contractors who do not perform | 5.8 | 0.85 |
| Good project communication system | 5.5 | 0.79 |
| Distance of collaborative team environment | 5.5 | 0.79 |
| Clear project organizational structure | 5.4 | 0.79 |
| Standardisation of decision making system | 5.4 | 0.78 |
| Application of innovative management approach | 5.4 | 0.73 |
| Conflict resolution system | 5.6 | 0.91 |
| Cluster 7 Project Planning System | 5.6 | 0.80 |
| Clear project resource allocation | 5.9 | 0.84 |
| Monitoring the integrity of the performance measurement baseline | 5.8 | 0.83 |
| Established project schedule | 5.9 | 0.84 |
| Communication during planning stage clearly defined | 5.4 | 0.77 |
| Cluster 8 Effective project control system | 5.4 | 0.77 |
| Clear Work breakdown structure system | 5.6 | 0.80 |
| Effective project management action | 5.6 | 0.80 |
| Design problem reduced at design stage | 5.6 | 0.80 |
| All relevant documents supplied to the contractor and supervision team | 5.6 | 0.80 |
| Monitoring the integrity of performance measurement baseline | 5.5 | 0.79 |
| Project resource adequately assigned | 5.4 | 0.78 |
| Used of software based schedule | 4.9 | 0.70 |
| Cluster 9 Performance | 5.3 | 0.75 |
| Safety and health and environment | 5.5 | 0.79 |
| Sustainability issue addressed | 5.6 | 0.71 |
| Cluster 10 Legacy system | 5.2 | 0.74 |
| Database system to capture project as build record | 5.8 | 0.83 |
| Lessons learned to be examples of future projects | 5.5 | 0.76 |
| Adequacy of documentation of organizational responsibilities on the project | 5.1 | 0.72 |
| Learning process from project performance | 4.9 | 0.70 |
3. Data Analysis

Data collected from the respondents were analysed using Microsoft Office Excel. An evaluation of the questions relative to other questions in the survey of Relative Importance Index (RII) was used in the analysis. The data will be translated into pictorial and graphically way for better understanding (Figure 3). It will explain more and the information can be seen as an overall view. Relative Importance Index (RII) is the evaluation of the questions relative to other questions in the survey. The weightage is based on the response of the questionnaire surveys. It is governed by the formula:

$$RII = \frac{\sum n_1 x_1 + n_2 x_2 + n_3 x_3 + n_4 x_4 + n_5 x_5 + n_6 x_6 + n_7 x_7}{\sum n_1}$$

where:
- $RII$ = Relative Importance Index
- $n_1, 2, 3, 4, 5, 6, 7$ = frequency of occurrence for Likert value 1
- $1, 2, 3, 4, 5, 6, 7$ = the Likert Scale chosen

The index value for any given factor is not more than 1. The higher the value of RII, the higher the importance of the factors compared to the others. These values were calculated using the Excel Spreadsheet.

![Project Success Factors](image)

*Figure 3. Level of important within ten (10) clusters of project success factors.*

3.1 Objective 3: To develop a template for measuring success of water reservoir project in a water company

Analysis of critical success factors (CSFs) will be using the *Priority Evaluation Model* that has been introduced by Yu and Kwon (2010) consisting of three steps, as shown in Figure 5. The Measuring Project Success Template was designed by using Priority Evaluation Model as mentioned. First template has been designed base on ten (10) clusters of levelled project success factors. The result from the template consist four level of achievement depends on the Priority Index (PI) calculation below. A “priority CSF” list consists of those CSFs that have statistically significant gaps between I and S values. This step determines the rank of the CSFs in the priority CSF list. The priority of CSFs is determined by a Priority Index (PI), calculated using the following equation:
\[ PI = (I-S) \times (I+S) \]

- \( PI <= 2 \) "Successful"
- \( 2 < PI <= 5 \) "Satisfactory"
- \( 5 < PI <= 12 \) "Unsatisfactory"
- \( 12 < PI \) "Failure"

**Figure 4.** Critical success factors priority evaluation model Yu and Kwon (2010).

### 3.2 Refined Measuring Project Success Template

Result from the questionnaire and first template were returned to the agency and reviewed by the top management personnel. They found that listed agreed factors were too many and still need to be refined and modified. As discussed, they were decided to simplify the template and compressed the project success factors into seven (7) clusters which contain fewer factors, namely: Clear Realistic Objectives; Quality Factor; Time Factor; Cost Factor; Deliverable; Legacy System; and Safety, Health and Environment. This refined template has been used to measure project performance in the agency. They also decided to put fixed level important of each factors with rating seven of extremely important. The template has been modified as in Table 2.

| Table 2 Refined Measuring Project Success Template (Example of Project 5 joint assessment result by 3 assessors) |
|---|---|---|---|---|---|---|
| PROJECT SUCCESS ASSESSMENT TEMPLATE | POST PROJECT |
| PROJECT SUCCESS FACTORS | Cluster’s weightage | Pre-defined Importance(I) 1 to 7 | Satisfaction (S) Rate 1 to 7 | Gap (I-S) | Priority Index (PI) | Achievements Level |
| 1. CLEAR REALISTIC OBJECTIVES | 35% | 7 | 6 | 1 | 42.00 | Failure | Failure |
| - Project economy (worthiness / keberbaloian) | 35% | 7 | 6 | 1 | 42.00 | Failure | Failure |
| - Design meets actual objectives | 35% | 7 | 3 | 4 | 9.33 | Unsuccessful | -15.8% |
| - Realistic time-allocated for the project | 10% | 7 | 2 | 5 | 17.50 | Failure | -21.1% |
| Sub-total | 33.83 | Failure | -14.8% |
| 2. QUALITY FACTORS | 12.5% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| - Material quality | 10% | 7 | 5 | 2 | 2.80 | Satisfactory | Satisfactory |
| - Workmanship | 12.5% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| - Relevant specifications and standards | 10% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| Sub-total | 1.98 | Satisfactory | 9.1% |
| 3. COST FACTOR | 12.5% | 7 | 3 | 4 | 9.33 | Unsuccessful | Unsuccessful |
| - Completed within budget allocated | 12.5% | 7 | 6 | 1 | 2.25 | Satisfactory | Successful |
| Sub-total | 9.33 | Unsuccessful | -14.9% |
| 4. TIME FACTOR | 12.5% | 7 | 2 | 5 | 17.50 | Failure | Failure |
| - Completed within contractual period | 12.5% | 7 | 2 | 5 | 17.50 | Failure | Failure |
| Sub-total | 17.50 | Failure | -14.9% |
| 5. DELIVERABLE | 20% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| - Internal Customer satisfaction | 20% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| - Served the intended purposes | 20% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| - Fulfill serviceability for the future requirements | 20% | 7 | 6 | 1 | 2.25 | Satisfactory | Satisfactory |
| Sub-total | 42.00 | Satisfactory | 24.32 |
| 6. LEGACY SYSTEM | 5% | 7 | 6 | 1 | 1.17 | Successful | Successful |
| - As-built drawing available | 5% | 7 | 6 | 1 | 1.17 | Successful | Successful |
| Sub-total | 1.17 | Successful | 4.7% |
| 7. SAFETY, HEALTH and ENVIRONMENT | 5% | 7 | 4 | 3 | 9.33 | Unsuccessful | Unsuccessful |
| - Risks and Prevention Measures | 5% | 7 | 4 | 3 | 9.33 | Unsuccessful | Unsuccessful |
| Sub-total | 9.33 | Unsuccessful | -20.0% |
| OVER ALL PROJECT PERFORMANCE | 24.32 | Failure | 100.0% |

**VERIFICATION:**

**NAME:**

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*Note: Some formatting elements like bullet points and numbered lists may not be fully captured in the text representation.*
4. Discussion

4.1 Application of the Measuring Project Success Template

At the end of the methodology, the template for Measuring Project Success produced have been used to evaluate five (5) construction water reservoir projects in the agency. The result of project performance will be generated automatically in the template. The measurement were conducted by the officer who involve in project auditing in the agency together with the researcher. The finalised Measuring Project Success template has been applied to measure project success by three assessors in the agency. Projects involved are construction of reservoir, ancillary works and pipelines located scattered around Johor, Malaysia. These five actual projects have different objectives, cost, contract period, scope and location. The projects that have been measured are as below. As results, Project 1, 2, 3 and 4 were found as Satisfactory, whereby Project 5 was a Failure (Table 3).

Table 3. The Priority Index (PI) and Achievement Level of five (5) water reservoir project.

| Project | Priority Index (PI) | Achievement Level |
|---------|---------------------|-------------------|
| 1       | 4.85                | Satisfactory      |
| 2       | 3.47                | Satisfactory      |
| 3       | 4.65                | Satisfactory      |
| 4       | 4.76                | Satisfactory      |
| 5       | 20.56               | Failure           |

Table 4. Water reservoir projects views and measurement analysis.
5. Conclusion
The main factors of unsuccessful water reservoir project in this case are because of: (i) unclear realistic objectives; (ii) deliverable issue; and (iii) time factor. At planning stage, the clear realistic objectives should be worth to project economy, end product that benefits well and design that meets actual objective. In term of deliverable issue, the unsuccessful project did not meet the customer satisfaction and acceptance. It does not served the intended purposes and give better customer service. It fail to fulfil the serviceability for the future requirements. The project also did not complete within the contractual period.

The finalised template that has been developed had helped has helped them as a tool to measure project success in their agency. They also decided to use the template for assessment of next fifteen (15) project. If there is a request for using this template in other agency, all over process of methodology need to be done to meet suitable project success factors. This study has met the objectives within the scope and limitation and successfully been applied by the agency.

6. References
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