

A RESOURCE-BASED QUALITY CONTROL e-MODEL FOR CONSTRUCTION PROJECTS

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Abstract: In recent years, increasingly more construction companies have adopted the Enterprise Resource Planning (ERP) system in some form for increasing productivity and work efficiency. However, the current practice on construction Quality Control (QC) still centers on quality control of work items associated with construction activities. This makes it difficult to integrate or collaborate with the ERP system that centers on management of resource items of activities. To facilitate the integration of QC and ERP, this research proposes a resource-based QC model that extends the existing construction QC models from work-item based to resource-based. Also, the proposed model is an e-model that takes into account the need of computerization and digitalization for QC tasks and supports richer quantitative analysis for better construction quality assessment and QC information feedback. Because the proposed resource-based QC e-model is still being developed in an ongoing research project, the discussions in this paper focus on the analysis and design of the e-model.

Keywords: Construction ERP, Quality Control (QC), Quality Control Breakdown Structure (QCBS), Quality control index

1. INTRODUCTION

In many industries, especially manufacturing industry, Enterprise Resource Planning (ERP) system has emerged as a popular but fundamental tool for an enterprise to engage in e-business. It integrates business-related workflows and resources within the entire enterprise and provides a set of standardized business procedures (or processes) for enterprise management, and promotes these procedures to effectively improve business performance [1]. ERP systems also take advantage of information technologies to provide in-time and correct information about all of the enterprise's business operations, increase the efficiency of management communications, and shorten the time for strategic decisions (e.g., response to market changes) [2].

Because the complexity and characteristics of construction industry are quite different from those of manufacturing industry, it is until recently that increasingly more enterprises in construction industry have tried to adopt and take advantage of some forms of ERP systems for increasing productivity and work efficiency. Unlike the general ERP systems that are designed mainly from the viewpoint of enterprise management, the ERP systems adopted by the construction industry emphasize more from the viewpoint of construction project management. Therefore, the resources required for the successful completion of a construction project, such as labors, materials, equipments (including machineries), workmanship, etc., become the focus of management in these ERP systems.

Along with cost and schedule management, quality management plays a very important role for the success of a construction project. To achieve the objective of quality management, i.e., assurance of good construction quality, some standard Quality Control (QC) methods have been developed and employed in practice. In these QC methods of current practice, quality control is mainly carried out at the level of work items associated with construction activities. Because ERP systems focus mainly on management of resource items (instead of work items) of activities, the integration or collaboration between these QC methods and ERP systems becomes very difficult, if not impossible.

To facilitate the integration of QC and ERP for better project management, this research proposes a resource-based QC e-model that enables QC at the level of resource items of construction activities and promotes electronic QC tasks and processes. Furthermore, unlike the current QC methods that usually give just qualitative QC results (e.g., either 'passed' or 'failed') on the work items and limited quantitative analysis for the project, the proposed e-model is designed to support richer quantitative analysis from the resource level to the project level for better construction quality assessment and QC information feedback.

The remaining of this paper is organized as follows. Section 2 discusses the requirement analysis of the proposed resource-based QC e-model from the viewpoints of resource management in ERP, construction project lifecycles, and project management for construction. Section 3 presents the

design of the proposed e-model that consists of a set of QC objects and procedures as well as their relationships (or interactions). In Section 4, some conclusions are drawn for the work presented.

2. ANALYSIS OF THE QC e-MODEL

The requirements for the proposed resource-based QC e-model are analyzed in this work from the viewpoints of resource management in ERP, construction project lifecycles, and project management for construction.

From the viewpoint of resource management in ERP, QC should be also centered on the resource items needed for successful completion of a construction project. Therefore, all of the work items in a construction project should be further divided into resources items as shown in Figure 1 and the QC for the resources items should assure the QC for their parent work item.

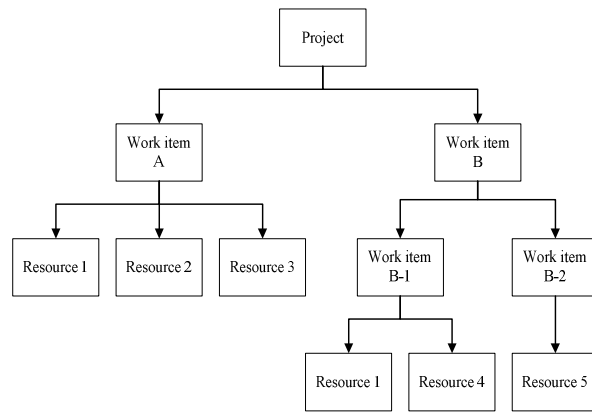


Figure 1 Hierarchical relationship for project, work items, and resources

For the QC purposes, the resource items are categorized into the following five types in this work:

- Labor resources: The QC focus is on the education, technical qualification, and work experience of workers.
- Machinery resources: The QC focus is on the operation management, usage records, and maintenance management of construction machineries.
- Material resources: The QC focus is on results from the standard quality tests of construction materials.
- Equipment resources: The QC focus is on the installation and attestation of equipments.
- Workmanship (or service) resources: The QC focus is on the construction specifications, quantity and quality of services (including package services).

From the viewpoint of construction project lifecycles, the QC lifecycle is located at the bottom level of the hierarchical lifecycle tree, which consists of the project lifecycle at the top level and the work item lifecycle at the middle level, as shown in Figure 2. The construction project lifecycle goes through feasibility study, planning, preliminary design, detailed design, construction, operation and maintenance phases. Every work item derived from any of the above phases has its own PDCA (Plan-Do-Check-Action) cycle [3]. The “Check” phase of the work item’s PDCA cycle performs the QC tasks and runs through the QC PDCA cycle [4]. Therefore, the QC tasks should be planned based on different types of work items derived from different phases of a construction project and the results of the QC should feed back to the “Action” phase of each corresponding work item. In this work, the focus is on the QC processes for the work items in the construction phase of a construction project, as indicated in the gray area of Figure 2.

From the viewpoint of project management, QC is mainly associated with the work items in the Work Breakdown Structure (WBS) defined for project management. The PMBOK (Project Management Body of Knowledge) [5] developed by PMI (Project Management Institute) categorizes project management into nine major fields: Project Integration Management, Project Scope Management, Project Time Management, Project Cost Management, Project Quality Management, Project Human Resource Management, Project Communications Management, Project Risk Management, and Project Procurement Management. WBS is employed repeatedly in many of these fields and is an important basis for deriving other breakdown structures, e.g., Cost Breakdown Structure (CBS) and Resource Breakdown Structure (RBS). For performing QC at the resource level, a QC Breakdown Structure (QCBS or QBS) is developed in this work based on the WBS and RBS as well as related construction specifications. Each resource in the RBS hierarchical structure is mapped to appropriate QC items in the QCBS hierarchical structure (unless its QC is not needed) to ensure that all resources as well as the whole project is under QC.

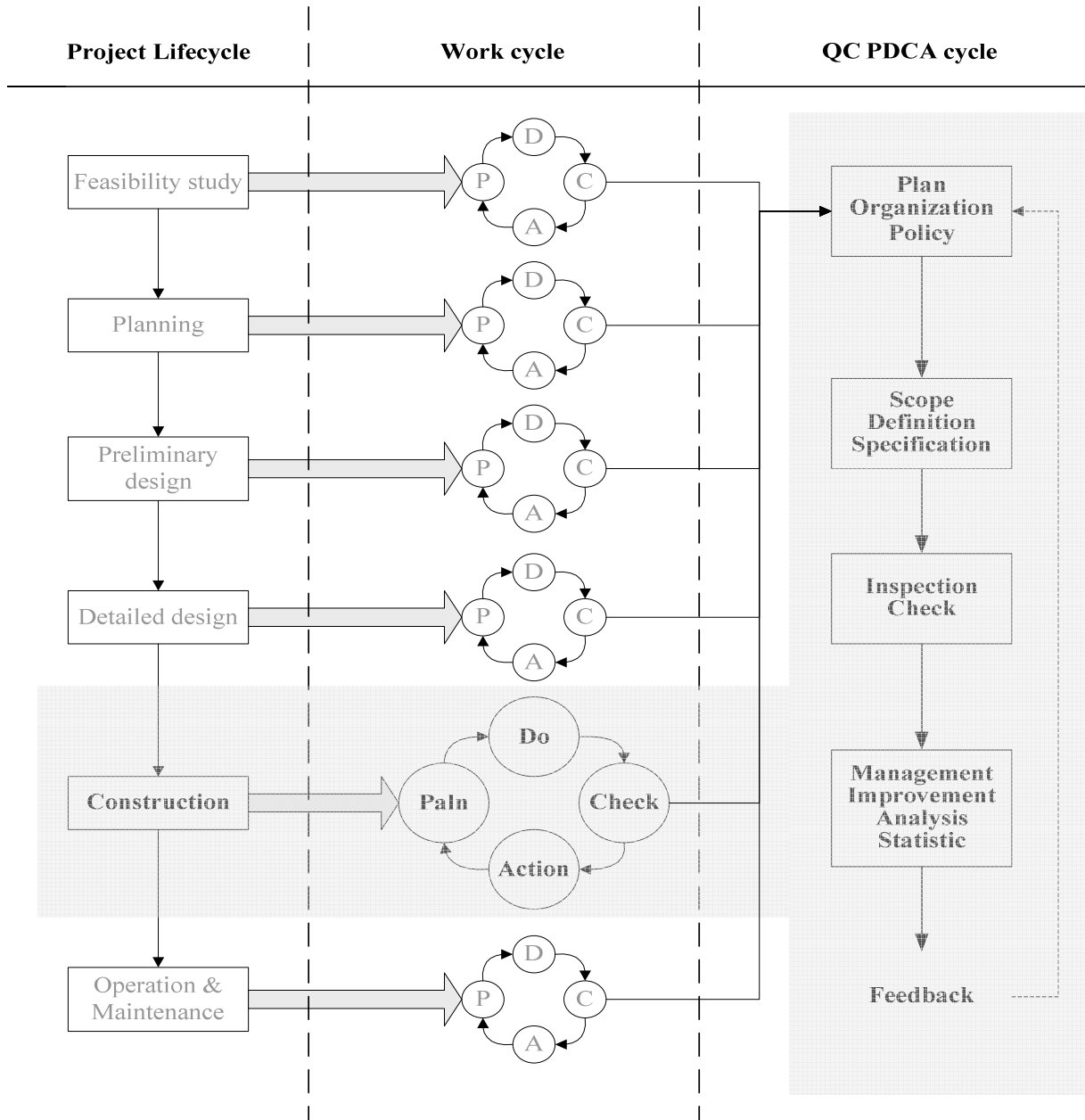


Figure 2 Lifecycles at different levels of a construction project

3. DESIGN OF THE QC e-MODEL

Based on the requirement analysis discussed in the previous section, the design of the proposed QC e-model is presented in the sub-sections here. The proposed e-model consists of a set of QC objects, processes, and their relationships (or interactions).

3.1 QC objects in the e-model

Figure 3 shows the QC objects and their relationships. On one hand, a construction project is decomposed into work

items (according to its WBS) and further into resource items (according to its RBS). On the other hand, it is decomposed into QC items according to its QCBS. A QC index table is established for mapping each resource item to appropriate QC items for required QC in a particular project.

Each QC index table consists of a list of items from construction quality specifications for QC of each resource item. It can be reused in other projects when the same QC requirement is needed for the same resource item. The QC index tables for all resources are defined in the “Plan” phase of the QC PDCA cycle to achieve the QC objective for a

particular project. In the “Do” phase of the QC PDCA cycle, the QC inspector will fill in the QC results for the items in the list. In this work, the design of the QC evaluation favors more for the numerical (or quantitative) scores than for the qualitative binary selection (e.g., “passed” or “failed”) or descriptive comments. In addition, there are two types of quantitative QC results. One is the measurement result directly copied from the test results in the laboratory or in the field; while the other is scored by the inspector based on some standard score specifications on the QC index. It is obvious that the former is objective while the latter is more subjective. Nevertheless, with the quantitative scoring scheme, more comprehensive statistic analysis and quality assessment can be performed and more useful feedback information about construction quality can be obtained. In addition, for quality assessment, a weighting value may be assigned to each of the QC items to reflect its influence to the overall construction quality.

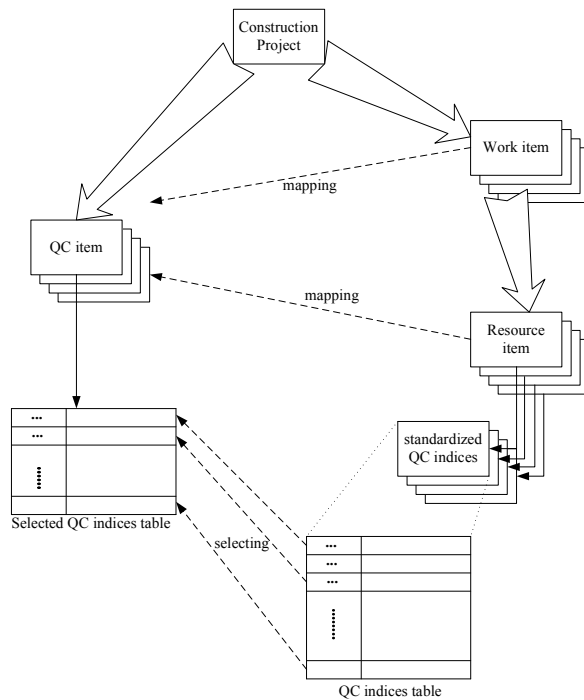


Figure 3 Object relationships in the proposed QC e-model

3.2 QC procedure in the e-model

Figure 4 shows the design of the QC procedures for the proposed e-model. The corresponding tasks (or processes) in different phases of the QC PDCA cycle are indicated for each step of the QC procedure and discussed briefly as follows:

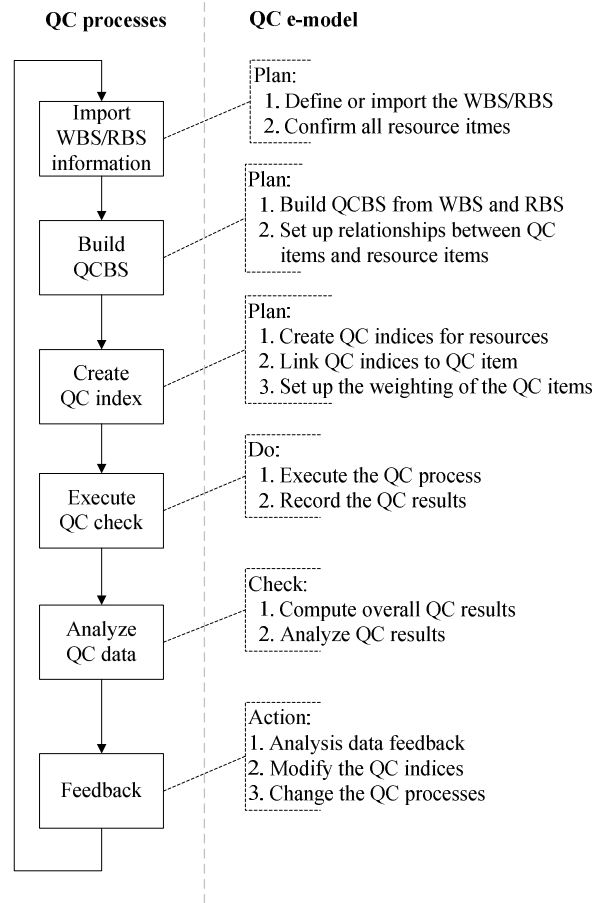


Figure 4 The QC procedures in the proposed QC e-model

- **Plan:** The major tasks in this phase include definition of WBS and RBS for the project, construction of the QCBS from the WBS and RBS, creation of standardized QC indices for each resource item, creation of the QC indices table for a particular QC item by selecting indices from the standardized QC indices of the corresponding resource item, and assignment of weighting values to the QC items and QC indices.
- **Do:** The major tasks in this phase include execution of QC tasks and recording and calculation of QC results.
- **Check:** The major tasks in this phase include validation of the QC results from the “Do” phase, computation of the overall QC result based on the QCBS, statistic analysis on QC results.
- **Action:** The major tasks in this phase include feedback of analyzed QC results, improvement (or adjustment) of the QC e-model, processes, QC indices, weighting of QC items, and the QC plan.

4. CONCLUSIONS

A resource-based QC e-model has been proposed in this paper to facilitate the integration or collaboration between QC and ERP for better project management. The analysis and design of the proposed e-model, consisting of a set QC objects and processes, are discussed to show how it can be employed to integrate with ERP at the resource level and to carry out QC tasks and processes in an electronic fashion. In addition, the design of the proposed e-model makes more comprehensive quantitative analysis on the QC results possible. Because the proposed e-model is still being developed in an ongoing research project, validation and application studies of the model are needed in the future.

REFERENCES

- [1] Vincent A. Mabert, Ashok Soni, and M. A. Venkataramanan, "Enterprise Resource Planning Survey of U.S. Manufacturing Firms," *Production and Inventory Management Journal*, Vol. 41, No. 2, pp. 52-58, 2000.
- [1] S. Keng and Y. Tian, "The Next Wave in ERP Implementation," *Managing Information Technology in Global Economy*, pp. 662-664, 2001.
- [3] H. S. Gitlow and S. J. Gitlow, *The Deming Guide to Quality and Competitive Position*, Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.
- [4] Office of Community-Based Education and Research, "The Clinician's Black Bag of Quality Improvement Tools: The PDCA Cycle," Dartmouth Medical School, "<http://www.dartmouth.edu/~ogehome/CQI/PDCA.html>".
- [5] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Third Edition*, Project Management Institute, 2006.