Introducing Business Process Reengineering Concepts In Construction Education

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Abstract
To be winning competitors in a global economy, many major construction and engineering companies are utilizing business process reengineering (BPR) techniques to change their internal corporate structure and business processes. The objective of BPR is to improve the efficiency of administrative procedures, reduce errors and facilitate the internal and external integration of project information among engineers, contractors, owners, subcontractors, vendors and others. Realizing the importance of BPR, a course module has been developed at the University of Cincinnati to introduce senior students to business process reengineering concepts. This paper discusses the importance of BPR in construction and describes the course module mentioned above. A case study on analyzing and improving the materials management process in the construction industry is presented.

1. Introduction

The construction of a facility typically requires the application of many business processes. Business processes are a set of activities that transform a set of inputs into a set of outputs (goods or services) for another person or process using people and tools. Examples of construction processes include architectural design, mechanical design, structural design, material procurement, subcontractor procurement, construction and startup. Each of these processes is usually performed by a different discipline/organization, which has to work closely with other disciplines/organizations for the successful completion of the construction project.

In the past, each discipline has attempted to optimize its own process without paying much attention to other processes. This has created what has been referred to as “islands of automation”. An example from the construction industry deals with the separation of the design and procurement departments. The procurement department orders materials that are specified by the designers. Usually the computer systems supporting both departments are separated. As a result of this separation, if the design is changed and the procurement agents are not promptly notified, materials that may no longer be needed might still be ordered. This results in material surplus and increases the overall project cost.

Over the last 10 years several factors have accelerated the need to improve business processes. The most important is technology. New technologies (like the Internet) are rapidly bringing new capabilities to businesses. Another factor is the opening of world markets and increased free trade. Such changes bring more companies into the marketplace, and competing becomes harder and harder. As a result, companies have sought out techniques for rapid business process improvement. One approach for rapid change and dramatic improvement that has emerged is Business Process Reengineering (BPR). BPR requires complete analysis and design of information-flows and processes within and between departments and/or organizations. Before re-engineering a process, a model for the business should be developed. The model specifies how business is conducted before being re-engineered.

At the University of Cincinnati, a course module has been developed to introduce senior students to business process reengineering concepts. The objective of this module is to teach students how to model existing processes, identify their problems and develop strategies to improve them using available information technologies. A case study on analyzing and improving the materials management process in the construction industry is presented as part of the module to enable students to apply the BPR techniques they have learned. Student teams are then asked to choose another construction process, analyze it and recommend strategies for improving it. Students are required to present their findings at a technical exposition held yearly at the University of Cincinnati.

The remainder of this paper will describe the different topics covered in the course module as they relate to materials management in the construction industry. These topics start with a description and an analysis of the materials management process. An enabling technology is then evaluated and recommended to improve the process. The enabling technology in this case is an integrated database management system. The author has developed a materials management database tutorial to illustrate the
The capabilities of the enabling technology. Factors required for successful implementation of the technology are also discussed. The paper ends with a discussion of future work that can improve the materials management process even further.

2. Materials Management Process

Materials management is the process of planning and controlling all necessary efforts to make certain that the right quantity and quality of materials and equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available when needed [1]. The materials management process is comprised of different functions that are usually performed by different departments within a company. These functions include quantity takeoff, requisition, purchasing, expediting, transportation, field material control and warehousing.

Plemmons and Bell 1995, have developed a generic process model for the materials management process in the construction industry. As shown in Figure 1, the model illustrates the flow of data, information, and documents between primary and secondary suppliers and customers. The diagrams also illustrate and communicate the functional boundaries of the process. The activities of the materials management process are as follows:

2.1. Planning

The purpose of planning is to identify who is responsible for materials management and to develop the various MM strategies. Basic input from the project team is required before the planning goes underway. Input usually includes description of the facilities, project location, job site conditions, local climate, and existing facilities. A result of the planning process is the materials management project book, which describes the various MM strategies agreed upon.

2.2. Material takeoff and engineering interface

The purpose of takeoff is to define and quantify all materials for the project. Initial takeoffs may be executed from plot plans or flow sheets so bulk material orders can be placed as soon as possible. The material takeoff process may be repeated as more definitive design information becomes available.

2.3. Vendor inquiry and evaluation

The purpose of this activity is to evaluate potential vendors. Both technical and commercial evaluations of vendor proposals are performed. The vendor should be evaluated in a number of key areas, such as capability, price, quality, delivery and service. The relative importance or weight of these factors will vary among companies and between projects.

2.4. Purchasing

The duties of purchasing are to identify potential suppliers, issue request for bids, prepare commercial evaluations, negotiate, develop terms and conditions for PO, commit project funds for the supply of goods and services and administer the purchase order or contract.

2.5. Expediting

The purpose of expediting is to provide timely information regarding anticipated materials deliveries to all concerned project personnel. The level of expediting required will depend on market economic conditions and shop loads. To maximize expediting efficiency, the project expeditors should receive information pertaining to projected or actual material shortages in some order of priority. This priority can be conveyed from a trial allocation report.

2.6. Shipping

The purpose of shipping is to establish material shipping plans early in the project. Alternate transportation methods are investigated and routes inspected for potential obstructions. Transportation planning becomes especially critical when materials are being shipped overseas.

2.7. Warehousing, Receiving and Material Distribution

The purposes of these activities are to receive material on site, inspect them for quality, store them adequately and distribute them to the crafts. When material is received at the warehouse, it is inspected and a formal material-receiving report is completed. Non-conforming materials are photographed upon receipt to document back-charge claims. The status of received material is communicated to other interested parties as soon as possible.
3. Process Improvement Using Integrated Database Technology

Many construction firms have invested in the development of computer-based integrated materials management systems (MMS). Integration of materials management (MM) activities using a relational database improves the accuracy and speed of the MM process. Integration simplifies the process of summarizing takeoff sheets into purchase requisitions, which is probably the most time-consuming effort in the materials management cycle. With an integrated system, engineering requisitions can be easily downloaded by the purchasing agents to facilitate the generation of purchase orders.

Integration also provides the ability to exert maximum control over material acquisition and distribution. Effective material control is enabled by system integration in a number of ways:

- When the crafts request material that is not available for distribution, the system can rapidly determine the status of that material before a backorder is placed.
- An integrated system can produce a history of the unavailable material from material takeoff through purchasing, expediting, and shipping.
- An integrated system provides field controls for material issues by flagging instances when the crafts request materials that have already been issued and ensuring that materials is only issued to the designated subcontractor.
- An integrated system can rapidly determine required quantity, requisitioned quantity, purchased quantity, received quantity and issued quantity of any material for ultimate material control.
- An integrated system can rapidly perform a trial allocation report. A trial allocation report arranges drawings in some priority order and then allocates the materials on hand to the drawings with the highest priority. Materials not yet received are then assigned a priority in the order in which they will be needed.
- An integrated system can provide expeditors and purchasing agents with timely on-line information needed to effectively perform their work. This information includes the number of partial deliveries per purchase order and the number of late deliveries.

4. MMS tutorial

To demonstrate the integration capabilities, an Access tutorial has been developed by the author. The tutorial integrates the materials-related functions of quantity takeoff, requisition, purchasing, expediting, vendor performance, receiving, warehousing and labor planning. The main menu of the tutorial is shown in Figure 2.
Selected features included in the tutorial are discussed in the following sections.

4.1. Takeoff Module

As shown in Figure 3, the tutorial takeoff module equates required material quantities to a specific drawing number, process line number and construction category (e.g. underground electrical, lighting electrical, etc.). The information is attached separately to each line item in the bill of materials for maximum control. Once the takeoff is executed, materials requirement for any combination of code number, material category, need date, drawing number, subcontractor responsibility, work area, can be established as shown in Figure 4.

![Figure 3. Takeoff module screen](image)

4.2. Requisition Module

Once the takeoff data is stored in the takeoff file, the user can use the requisition screen (Figure 5) to consolidate takeoff data and generate a requisition. For example, assume there is 200 ft of 2 inch pipe on drawing 42, and 300 ft of 2 inch pipe on drawing 43 that has been entered into the takeoff file. The tutorial will combine the quantities and generate a requisition line item for 500 ft of 2 inch pipe. The “CONS_CODE” field displayed on the takeoff line item screen (Figure 3) denotes whether or not that takeoff entry has been consolidated and incorporated into a requisition.

![Figure 4. Sorting takeoff data by drawing number](image)

![Figure 5. Requisition Screen](image)

4.3. Purchasing

To help with the generation of the purchase orders, the tutorial can display requisitioned items that have not been ordered as shown in Figure 6. Purchase order quantities can be compared to requisitioned quantities as shown in Figure 7. When an approved requisition is converted into a purchase order, the purchase order information is entered into a separate computer file as shown in Figure 8. Information typically entered includes the PO number, the item stock number, item description, order quantity, received quantity, vendor name, need date, promised date, requisition number, the status with respect to partial delivery and expeditors remarks. Once the PO file is created, the status of any purchase order or group of purchase orders can be examined. Purchase orders can be summarized by vendor, by type of material, by status (whether the PO is open or closed) and by the material need date.
5. Key Factors for Successful Implementation of Technology

Based on previous research done on materials management, several important factors necessary for successful implementation of an integrated database system are identified and discussed with the students. These factors include:

- Performing a cost and benefit analysis to document the economic feasibility of the proposed technology and help getting top management support.
- Adequate training in all aspects of material classification, inspection and computer data entry.
- Flexibility: the system must be able to adapt to the specific data handling, material coding, and report generating requirements of different owners and engineers.
- Compatibility with other accounting, cost estimating, and project control computer systems.
- Security provisions for controlling access to information.

6. Future Improvements to the Materials Management Process

The course module ends with describing other integration models and technologies that can help improve the materials management process even further. These include:

6.1. Integrating MMS with Design and Schedule systems

Integration with design produces faster and more accurate takeoff and allows design changes to be directly communicated to the procurement department to stop ordering materials that are no longer required. Integration with scheduling notifies procurement with new need dates of material resulting from schedule changes. It also enables just-in-time (JIT) scheduling of procurement, which improves cash flow and eliminates double handling.

6.2. Using Expert Systems Technology

Expert systems technology can be used to automate the most labor intensive and knowledge intensive processes in the MM cycle. It can be used to generate commodity codes, compute material lead time, intelligently generate purchase order, select vendors, and automatically generate expediting reports.

6.3. External integration of information among all process participants

This model integrates all MM activities, not only within an organization, but among the various organizations involved in the process. The external integration can be achieved using technologies such as web-based e-commerce; electronic data interchange (EDI) and bar coding. Inter-organizational communication improves the timeliness and efficiency of information transfer, improves data accuracy and minimizes rework occurrences.

7. Conclusion
Understanding of business processes is extremely important in today’s market, where companies are constantly changing their processes to compete in a global marketplace. The paper presented a course module that introduces senior construction management students to business process reengineering. The main objective of the module is to make students aware that the construction of any facility involves a large number of business processes and that these processes need to be optimized and continuously improved. Several information technologies that have been associated with process improvement are discussed as part of the course module and a computer tutorial has been developed to demonstrate capabilities of these technologies.

8. References


