Towards a Prototype Development for Construction Material Procurement using SharePoint

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Abstract— One of the main problematical operational issues in construction projects is the co-ordination of building materials to arrive on site at the right time, in the right quantities, and at an acceptable quality level. The number and details of the steps involved in the material lifecycle indicate the complex nature of the process and the potential for problems in the process for even a relatively small project. This heightens the need for more flexible and sophisticated project management tools to support collaborative geographically dispersed participants in the simultaneous planning and scheduling of tasks, and their execution, and they must highlight the critical technical and business risks that challenge successful material procurement. This work illustrates the use of a SharePoint environment to tackle problems in the interesting field of material supply chain, from the point of view that collaborative working is necessary in the materials supply chain environment. Hence, it justifies the use of techniques such as Just-In-Time decision support for material procurement processes. This paper is based on a case study which describes and discusses current and future approaches to material procurement, which can enhance the project team’s activities. Ultimately, improvements in material procurement as a result of effective and efficient communication and document management approach can reduce construction times, information overload, and costs. Indeed, looking at these issues in isolation is a problem in itself; as a consequence, research has started to look at how such processes can be undertaken automatically through ‘work flow’ style practices [1].

This paper builds on documented efforts to automate business tasks through process modelling (for example [2]; [3]; [4]; [5]) and applying the outcomes in a collaborative technological environment (16); [7]; [11]). This work provides an overview on the development of a SharePoint environment to tackle problems of the material supply chain. This work views this problem from the point of view that collaborative working is necessary in the materials supply chain environment. This work argues for the use of techniques such as Just-In-Time decision support for material procurement processes (see, e.g. [8]; [9]; [10]) through the use of information technology and information systems support [11]. This work describes the development of a demonstration innovation (virtual laboratory) facility for prototyping and showcasing generic business process models and collaborative workflow applications involving a site manager and warehouse personnel in a material procurement for a house builder in the North East of England.

II. MATERIAL MANAGEMENT

A. Material management in the construction industry

Managing material resources is imperative for the survival of organisations involved in project procurement. Maintaining an efficient and effective material procurement approach and being able to get materials at the right price, quality, quantity, and time are paramount for any construction organisations in order to survive in a competitive environment. The process of procuring materials is an area that witnesses a large number of changes throughout a project lifecycle. The number and details of the steps involved in the material lifecycle indicate the complex nature of the process and the potential for problems for even a moderate construction project. The series of approvals that must be obtained on a set time schedule, the lead time necessary to meet these set dates, and the range of items that run through the lifecycle process are all factors which must be incorporated during procurement. This argument may be compelling but it is not new. Ref [1] explored a task-based modelling in an attempt to apply it to construction.
business process modelling. The problem was identified as being one where the industry as a whole utilises many non-standard approaches.

B. Technological support in coordinating business activities

The growing complexities of the procurement of the materials have heightened the need for more flexible and sophisticated project management tools. These tools must support collaborative, geographically dispersed participants in a simultaneous planning, scheduling, and execution of the tasks, and they must highlight the critical technical and business risks that challenge successful material procurement. Effective communication is vital for proper functioning of construction projects, and failing to communicate will result in low quality and productivity. This has been highlighted by influential governmental reports ([12]; [13]; [14]; [15]) which accentuate the lack of effective co-ordination and communication and the need for integration.

Information technology is a powerful tool that can aid geographically dispersed participants as well as allow the organisation to monitor and support projects more effectively. Whilst the industry utilises a variety of software applications for project scheduling, there is less obvious use of technology for co-ordination of other project issues such as materials procurement and material ‘call-off’. Where these processes take place, they are undertaken using methods such as telephone and email. The main problem with this is not so much with the process that is followed but that the process is carried out in isolation from other stakeholders involved in the project. As a consequence, key information may be missed or poorly managed, causing a project to fall behind schedule, leading to the budget being exceeded. When cost margins are very tight, a more suitable co-ordination strategy clearly needs to be sought.

III. METHODOLOGY

The aim of this project was to develop an innovation facility (a virtual laboratory) that would demonstrate a prototype technology for the procurement of the materials needed for a project. A two-phased research methodological approach was used. The first phase involved an action research approach, as the project involved applying IT solutions to existing (though not necessarily effective) information and management systems. Earlier authors (for example [16]; [17]) have specifically identified information systems as suitable for an action research approach. This method allowed us to work with a building organisation to map their current materials procurement and management processes. From the identification of the current processes, it was possible to identify any duplication of work, communication bottleneck issues, and processes undertaken in isolation. The outcomes of ‘action research loop’ process (i.e. Diagnosing, Action Planning, Action Taking, Evaluating, and Specifying) led to the second phase of laboratory experimentation, where a collaborative prototype was developed in a SharePoint environment. Based on the findings of the action research (i.e. the outcomes of the investigation into the current materials management process, and the identification of where improvements could be made), a prototype was developed that aimed to allow more effective collaboration between individuals in the organisation. The prototype was then tested on a single-case project which involved a site manager and a warehouse man who was responsible for scheduling and co-ordinating kitchen deliveries to site. The application and testing is described in the following case study.

A. Case study

The research was undertaken with a building firm located in the North East of England. The organisation is a strategic business unit, which forms part of a larger building organisation. The strategic business unit planned to design and roll out a prototype technology to help with their materials management process and to evaluate the results. If the project proved successful, the business unit planned to promote the solution to other members of their business group. The main objective, according to senior management, was to implement a materials management system that would eliminate current waste and inefficiencies that had been identified throughout the business unit.

Using the action research strategy to structure the investigation, the proposed project set out to investigate the ‘ideal’ materials management process. The project identified what documents should feed into each process, where they should be located, and who was to be responsible for them. Once this was completed, supporting processes such as technologies and forms to be completed were to be identified. By analysing the current approach, limitations could be identified and refined to design the ‘new system’. This ‘new system’ would utilise a collaborative prototype technology that would then be trialled within the organisation, with the results being compared to the current system. If the piloted system and its collaboration technology proved successful, an extension to the project would be planned to up-scale and roll out the new system across the organisation. The key objectives of the project were identified as follows:

- Introduce a standardised system across the business,
- Streamlining Quality Management System (QMS) processes,
- Produce electronic Quality Assistance (QA) forms,
- Eliminate duplication of roles,
- Control materials on site,
- Save time by eliminating the time taken to physically write out paper forms,
- Increase accuracy of documented reports by minimising data input.

The objectives would be measured quantitatively (e.g., measuring cost savings) and/or qualitatively (e.g., increased employee satisfaction).

B. Project justification and early analysis

Utilising the action research stages of diagnosing and action planning suggested by Ref [18], the project was identified as necessary as the current system had become too complex and misunderstood. The firm’s buying
department had been disbanded some years before and as a result, operatives were unsure as to whom they should contact about problems relating to materials management. In an attempt to reduce the number of addendum orders, suppliers were being issued with an upper value that project teams could ‘call off’ materials against. Whilst the number of addendums was reduced, other problems surfaced: materials were being called-off from one supplier when they should be called–off against another, suppliers were supplying materials over and above the given value, and the materials specified were not always being used.

C. Area of change

The delegation of responsibilities relating to materials management was unclear. Many documents detailing how a process should be undertaken refer to ‘the nominated person’. However, the nominated person can be very different depending on the personnel involved on the project and the business stream (e.g., new build or refurbishment building projects). Since the disbanding of the buying department, the contact person for materials queries has become confusing, and this confusion and query chasing takes time away from other activities. To further add to this problem, because employees were confused about whom to contact, individuals were ‘bending’ processes in an attempt to get the job done. Whilst this ‘bending’ is not malicious, it can cause problems within the current materials management process. Due to a lack of knowledge of the procurement technology package throughout the organisation, it is viewed as a difficult package to operate and is not being used to its full potential. This project will benefit most of the business unit as well as support functions (e.g., the accounts department).

At present, the paperwork relating to materials management is quite high, with individuals utilising their own working practices to collect and compile data. These data collection processes are disjointed and fragmented throughout the organisation. Any reporting, therefore, takes time to prompt individuals to supply the necessary data. The project folders available across the computer network are used to store project information but different people put different documents in different places, also making the identification of the exact data difficult. To add to this problem, a large volume of these documents are printed off and held as hard copies in site offices.

D. Presentation of findings

It was important to communicate the findings to the project team. This enabled an open discussion on the problem areas, the potential improvements that could be made, and the collaborative prototype that could be developed. A report was prepared that detailed the current materials management process using rich pictures [19], IDEF3 functional models [3] and swim lane models. The key points of the report are summarised in Table I below, which is divided into three problem-areas, namely: general material management problems, problems associated with the refurbishment area of the business, and problems associated with the new build part of the business.

### Table I. Summarised Findings from the Material Management Investigation

<table>
<thead>
<tr>
<th>General Issues</th>
<th>Refurbishment</th>
<th>New Build</th>
</tr>
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<tbody>
<tr>
<td>Placing values on orders (as opposed to quantities) and ‘calling-off’ materials may still not be fully understood throughout the production side of the organisation. Could cause problems for Site Managers as they have to find out the measures beforehand as opposed to just looking at the orders.</td>
<td>The refurbishment area of the business incorporates a warehousing function to help with the materials handling process.</td>
<td>Brick orders can be problematic due to the design of houses (e.g., particular brick types) and the agreement with suppliers on minimum order levels.</td>
</tr>
<tr>
<td>Some of the processes may need to be more detailed in their application as they can be open to interpretation.</td>
<td>The role of the Warehouse Man seems to be misunderstood and viewed differently depending on who is occupying the role and what ‘systems’ have been put in place.</td>
<td></td>
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<tr>
<td>The current processes utilise a lot of paper based working practices either through a requirement of the job role (e.g., measuring architectural plans) or through style of working (e.g., making notes of material call offs).</td>
<td>Some Warehouse Men have tried to design some stand-alone spread sheets to help manage the materials process for their sites, as they can be held responsible if sites breech the limits on materials orders, or cannot provide materials for a site when required.</td>
<td></td>
</tr>
<tr>
<td>As all electronic records are not linked together, each project folder can contain different file structures and have similar documents stored in different places. Identifying particular documents can take time as well as some documents not being the most up-to-date.</td>
<td>The relationship between the Site Manager and the Warehouse Man is overlooked. It is hypothesised that less problems and areas of concern arise when a Site Manager and Warehouse Man meet at least once a week to review the programme and scopes of work documents.</td>
<td></td>
</tr>
<tr>
<td>A lot of electronic versions of documents are printed off and held in paper form in files on sites.</td>
<td>All materials ordered are supposed to be sent to the warehouse to be accounted for before being sent to the site. This does not always happen with materials being sent directly to site. The Warehouse Men are still expected to be accountable for these materials.</td>
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<td></td>
<td>Individuals may turn up and try and requisition materials they have not ordered.</td>
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<td></td>
<td>Senior individuals emphasise the importance of getting kitchen deliveries right due to the ‘just-in-time’ approach adopted in the ordering and delivery of the units. Changes to the site schedule are not always communicated to Warehouse Man.</td>
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</tr>
</tbody>
</table>
The outcomes listed in Table I were all directly or indirectly related to materials management, but from the detailed report that was produced, it was clear that a great number of these issues were the result of ineffective collaboration and poor communication. As a consequence, through discussion with the project team, this area became the focus for the design of the SharePoint prototype.

IV. PROTOTYPE DEVELOPMENT

A. Virtual Laboratory for Prototyping

Through this investigation of the existing materials management process, it was decided that an initial prototype should be developed to look at the co-ordination of kitchen deliveries from a warehouse to a site, as kitchens are a key area for materials in a refurbishment project. It was also evident that the communication between the site manager and the warehouse man needed to be improved. The purpose of this prototype, therefore, was to help improve and structure this communication. This aspect of the project was deemed to sit within the ‘action taking’ stage of the action research cycle [18].

To start with, a hosted SharePoint site and its individual accounts were created. Figure 1 (below) shows the interaction within the SharePoint system. The figure depicts how supply chain team members in a project can communicate and manage documents within the SharePoint environment. SharePoint is operated through a user interface which can be accessed via the internet domain address. By entering the correct username and authorised password, the user can access the various modules within the SharePoint environment. A typical material management as shown in the figure below consists of the following stages:

1. A user’s web browser issues an HTTP request for a particular web page.
2. The SharePoint server receives the request, retrieves the files, and passes it to the XML/HTML engine for processing.
3. The XML/HTML engine begins the analyses of the script. Inside the script is a command to connect to the database and execute a query. XML/HTML opens a connection to the MySQL server and sends on the appropriate query.
4. The MySQL server receives the database query, processes it, and sends the results back to the XML/HTML engine.
5. The XML/HTML engine finishes running the script, which usually involves formatting the query results in HTML. It then returns the resulting HTML to the web server.
6. The SharePoint server passes the HTML back to the browser, where the user can see the output requested.

To understand how this works, the authors of this paper have used a flow chart approach (figure 2 below) to discuss the implementation. The next section will present the prototype implementation, stating how material procurement can be managed.

B. Prototype Development

The prototype is operated through a user (site manager or warehouse personnel) interface, which can be accessed via the internet domain address. Figure 2 (below) depicts the user navigational process within the prototype. It shows that the start of the material procurement process begins from the default page (login page). Once the authentication is verified, the user is allowed access into the main page (index page). The ‘index page’ is the main page and hosts all components and main functions of the system such as the ‘search tool’ and other tools. The search section can be used to search for material orders that have been entered and stored in the database. Figure 2 also shows that a user will be able to add material orders, view added material orders by all the users, and also update their own material orders. There are other functionalities as depicted in Figure 2, for example notifying users when material orders are added and shows when material orders are entered/retrieved/changed from the database, but these are not apparent in the workflow. When material orders are entered in the system, the sequences of interactions are initiated by the users through the web browser and this is numbered 1-6 in Figure 2. These sequences are described below:

1. When a user initially accesses the website, the first page that they see is the ‘login page’ with a registration link.
2. Before the user can use the site, they have to register their details first. Once the system receives the details of the user, it will send out an email confirmation, which will activate the user authentication. There are two levels of authentication: the user and administration level, the latter having authorisation to add and update project details. The system also uploads the details of users in the database (2c).
3. Equipped with the log-in details, the user can now log into the prototype system. The next page after the ‘login page’ is the ‘index page’, which shows and links to all the material orders that have been entered. However, at the _initialisation stage_, the index page section is blank, and only the added material orders and logout links are visible. Once the user enters a material order using the template, it will then appear on the index page.
4. The ‘add material orders’ page is a template used to enter the different types of orders (i.e. kitchen unit). Once the template has been filled in and submitted,
the system stores the material order in the database and immediately generates a fresh index page that contains the entered order. The next process at this stage is for the system to send out an email to every user, informing them that a new material order has been entered (4c).

5. The ‘view material orders page’ is used by users to view various material orders entered. The distinguishing factor of this page is that users can open various entered orders, but the system will not allow them to edit the entered orders unless it was entered by that particular user. To view material orders, the system interacts with the server to generate stored knowledge.

6. The ‘update material orders’ page is used to update or change orders that have been entered. This can only be done through the index page as shown in Figure 1. The system also prevents users from changing orders they have not added. Once orders have been updated or changed, the system stores them in the database (6b).

![Figure 2. Users Workflow Chart](image)

**V. DISCUSSION AND CONCLUSION**

This paper has set out an approach to materials management that reflects its human dimensions, particularly those involving communication, and proposes the use of an IT system that exploits the consistent benefits of technology. The paper has proposed ways in which SharePoint can promote, enhance, and support materials management. SharePoint capabilities are already delivering major economic benefits to businesses as diverse as computer manufacturing, retail, and construction. For such firms to fully exploit its benefits, well implemented strategies must be put in place across the entire enterprise or project, from initial conceptualisation and design all the way through to procurement and completion. In construction, it is likely that such automated approaches will become more pervasive in the coming years, especially as the full effect of the current economic crisis is felt within these organisations. It is argued that the use of SharePoint to manage communication and documents as discussed in this paper can enhance the project team’s activities by enabling them to leverage information and knowledge internally and externally through improved information and knowledge sharing among the project team. Ultimately, improvements in material procurement using SharePoint can reduce construction periods and reduce the cost of projects. Some of these improvements can be accomplished through better communication and document management. However, it is established that the construction industry still has a significant gap to bridge to reach best practice in its use of the associated IT tools.

In the case of materials management, the potential of SharePoint for enhancing communication and document management can be highly significant. For example, when project team members are faced with making quick decisions, the system can provide efficient and effective capabilities for management materials procurement (i.e. management information and knowledge). Using this information and knowledge, team members can easily rectify past mistakes with project development or determine the identity of the team member that enacted a particular change. This approach corresponds to the development of high and low-level functionalities that help a supply chain to deal with many activities within a project.

In the early part of this paper, the general concept of material management was emphasized. Comparative descriptions of existing limitations were presented and related works were also highlighted. The development of a new system that adopted an IT approach was described. The SharePoint prototype has demonstrated how a business process application can be used to partially automate the material procurement of kitchen units in a construction project. This is an important step towards the deployment of a fully commercial approach in the industry. It is evident that the industry could stand to reap many benefits from this approach to material management once a number of challenges have been overcome. Some of these benefits are as follows:

- The management of internal process relations so as to eliminate waste (lean thinking) produces a controlled flow of activity and ensures that continual improvement is endemic.
- The management of clear external relations so as to identify and integrate complementary core competencies and create mutual benefits throughout the supply chain.
- Attention to necessary accompanying shifts in attitude to ensure material supply chain management remains an activity and not merely an initiative.
- Achieving execution excellence by fully automating, optimising business practices and extending the enterprise to embrace all members of the supply chain.
• Integrating business systems with those of customers, suppliers, and partners to create a common information foundation and deploying real-time decision support to increase responsiveness.

• Investing in re-educating and re-orienting employees and other members of the supply chain in the practices needed to optimise business processes.

• Making a company-wide commitment to creating and managing a more complex organisation capable of tackling global business issues.

• Immediate benefits from the shared experiences that are captured as part of the learning on key events (e.g., problems, breakthroughs, change orders, etc.). In this way, project teams would be enabled to manage better the subsequent phases of a project (through the capture and transfer of learning from a previous phase).

• Longer term benefits accruing from the same shared experiences, as these will increase the capacity to plan future projects and the ability to collaborate. Furthermore, learning from past projects can be used to train new employees and project managers.

• Client organisations will benefit from enriched knowledge about the development and construction of their assets. This will contribute to the effective management of facilities and the commissioning of other projects. In the longer term, clients will benefit from the increased certainty with which construction firms can predict project outcomes.

To conclude, this paper has described and discussed ways in which material procurement can be improved in order to enhance the project team’s activities. Ultimately, improvements in the material procurement as a result of effective and efficient communication and document management approach can reduce construction periods and decrease the cost of projects.

REFERENCES


