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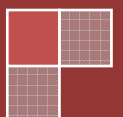
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Teaching Lead Time Reduction in Material Inventory Planning in the Construction Education

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ABSTRACT

The ineffective and effective management of construction materials affects construction stakeholders, the construction industry and its environment. Time is a crucial concept, which the construction student must learn to exploit in order to efficiently plan, procure and utilize materials on construction projects. Inadequate inventory should not catch construction students unawares especially when they become construction professionals. The study aimed to examine the teaching of lead time reduction in material inventory planning in the construction education. The study utilized an in-depth literature review and the conceptualization of frameworks on lead time reduction in material inventory planning in the construction education. The study revealed that lead time reduction in inventory planning of construction materials takes into account factors such as ICT, Supplier, Project details, Construction professional, Environment and Construction company factors in helping the construction student effectively understanding construction material management. In conclusion, the study would help to enrich the construction education curriculum by building the knowledge base of construction students in order to be systematic in planning, procuring and control of construction materials leading to a better construction industry and environment.

Keywords: Construction Education, Construction Materials, Lead time, Planning, Procurement

INTRODUCTION

The bible ably recorded in Luke 14 verse 28 and 29 (King James Version), where Jesus noted that “for which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it? Lest haply, after he hath laid the foundation, and is not able to finish it, all that behold it begin to mock him”. These verses broadly defined the importance of planning in setting up any form of building. Whether it be cost, materials, time, manpower etc. there is the utmost importance to plan. There is no reason insufficient construction materials should catch construction professionals on site if they actually engage in effective and efficient material inventory planning. The failure to effectively plan is evident in the Nigerian construction industry with diverse impediments which have stalled it in achieving successful project outcome at various levels. Pourrostan and Ismail (2011), Mohammed and Isah (2012), Oshodi and Iyagba (2012) stated that problems associated with planning and timing of project has been a major bane causing several challenges on projects in the construction industry. Planning resources essentially in the construction industry ranges from planning for construction resources such as materials, machine, men, money, time, etc. The influence of materials in the building and construction industry is paramount and cannot be over emphasized.

Studies from Formoso and Revelo (1999) and Dey (2001) indicated that in developing countries, material costs can make up as much as 60–65% of the total working capital of any industrial organization or construction project.

According to Che Wan Putra, Ahmad, Abd Majid and Kasim (1999); Dey (2000); Chan (2002); Kasim, Anumba and Dainty (2005), the critical nature of construction materials during handling and management is crucial in that it can influence the total project cost, time and the quality. Therefore, contractors or construction companies that aim to profit or succeed in the construction business need to foster a good understanding of material inventory planning. The Nigerian building and construction industry is becoming highly competitive. Many clients desire that their construction projects are finished as fast as possible in order to reap their investments (Kaelbe 2001; Kasim *et al.*, 2005). Also, contractors and clients are avoiding any extra cost which may mean huge losses and higher expenses respectively (Aina and Wahab, 2011). In order to meet these goals, contractors are focusing on materials by lowering total costs in supply chain, shorten throughput times, drastically reducing inventories, expanding product choice, providing more reliable delivery dates and better customer service, improving quality, and efficiently coordinating global demand, supply, and production (Shankarnarayanan, 2003). This means that efforts must be put to offer more advanced and quality products, fulfillment of consumer needs and faster delivery times through efficient controls and planning; an aspect of material management, ensuring that productivity is maintained, stocks are minimized and resources are optimized.

Obtaining the right quantity and quality of construction materials means that good sourcing decisions must be made. Although, the factors affecting the sourcing decisions may vary from project to project. The basis is the introduction of a lead time that could either be longer or reduced depending on the prevalent conditions. Using lead time is not a new concept but it is hardly taught in the four walls of the classroom. Also, lead time mostly been utilized in the manufacturing sector rather than on construction projects where it actually should be consciously used. In today's business world, the competitive nature requires that students are enriched with the requisite knowledge to make them the competitive edge that companies require. Understanding the management and use of a reduced lead time on construction projects gives that edge. The study intends to examine factors that would engender lead time reduction in the inventory planning of construction materials in order to teach construction students for an effective management of construction projects.

MATERIAL INVENTORY PLANNING

Bell and Stukhart (1986) in Kasim *et al.* (2005) defined materials management functions which include planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution. In three major functions, materials management is related to planning, procuring and storing in such a way that provides the appropriate material of right quality, right quantity at right place in right time. No organization should shove aside issues of material management due to its importance. Ogbadu (2009); Keitany, Wanyoike and Richu (2014) opined that materials management is a tool that should be used effectively by organizations to promote profit maximization and optimize customer service requirements by making the best use of available resources. Materials are vital in the activities of any industry since unavailability of materials can impede production. Unavailability of materials is not the only phase that can cause problems. Excessive quantities of materials could also make serious problems to managers. Unnecessary storage of materials can raise the costs of production and the overall cost of any project. Equere and Tang (2010) stated that stockpiling time of materials cause extended tied down capital that would otherwise have been better invested, requiring extensive storage facilities and space. An important aspect of material management that takes place on building construction sites is material inventory planning. Planning is said to be the formalization of what is intended to happen at some time in the future. Although, a plan does not guarantee that an event will actually happen, therefore the need for controls to help cope with the changes that may occur. Materials inventory planning in a construction process involves the process of quantifying, ordering and scheduling of materials. Payne *et al.* (1996) added that material inventory planning process is incomplete until a proper record is setup and maintained while determining target inventory levels and delivery frequency. Fundamentally, a critical purpose of materials inventory planning is to procure the materials for the dates when they are needed. Islam *et al.* (2013); Mehr and Omran (2013) stated that two crucial things lacking in material inventory planning on construction sites are that construction professionals hardly keep proper records and most construction sites experience material delay. Essentially, contractors and construction professionals depend on material schedules in order to know what materials are needed and when they should be on site. In addition to acting as a guide for ordering materials, the schedule also serves as a checklist of materials needed for the project. But, most of these schedules used either paper based or computer based hardly incorporate lead time management. They are most focused on the start and finish dates of the activities. The question is, what happens before the start date?

LEAD TIME MANAGEMENT

Laufer and Tucker (1987) argued that uncertainty and complexity cannot be eliminated from construction projects and that there is an increasing demand of speed. These uncertainties and complexities results in the need to introduce lead time in the acquisition of construction materials. Silver et al. (1998) defined lead time as the time spent that elapses between the placement of an order and the receipt of the order into inventory. According to Afzal and Vivek (2014), lead time is composed of setup time, processing time, move time and waiting time and there are different tools reducing the lead time of the different component as shown in Figure 2. Elfving (1999) explained that lead time is sometimes confused with cycle time whereas cycle time is the time it actually takes for a job to go from the start to the end of the process. Afzad and Vivek (2014) opined that lead time reduction does not mean working harder, faster or with reduced quality, but it means working smarter. Overall, lead time can be introduced at each stage of the construction project life cycle. By this, it is possible to separately allocate significant lead time to each of the “functional” lead times. For example, design lead time is the time that is reserved for defining and specifying product characteristics. Procurement lead time is the time that is reserved for product acquisition. Whereas, the inventory planning lead time consist of placing a purchase order, order entry and processing, supplier manufacturing/warehouse work lead time, transportation length, order received and different waiting periods between processes. Figure 1 showed the breakdown of a typical inventory lead time. The figure revealed that before the start of the activity, the inventory lead time had taken into account certain activities to ensure the prompt delivery and availability of the construction material. Therefore, it is possible to attach lead times to every inventory to be used in carrying out an activity. In construction projects, long lead times of product delivery often dictate the pace of the construction project. This necessitates that lead times are adequately reduced.

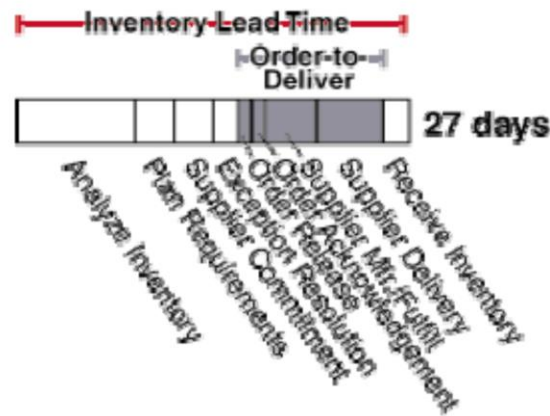


Figure 1. Breakdown of a typical inventory lead time

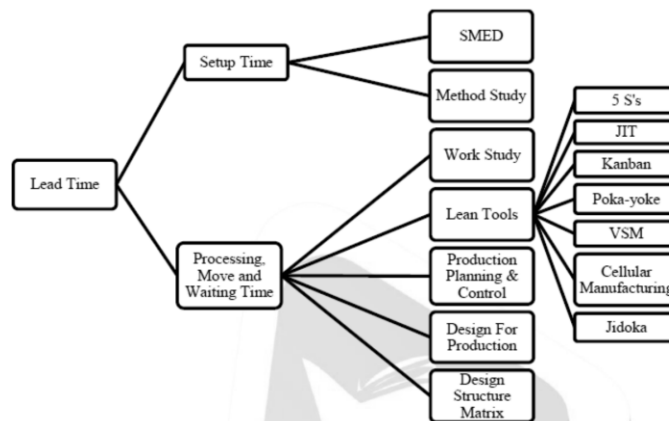


Figure 2. Summary of tools and techniques for Lead Time reduction

Source: Afzal and Vivek (2014)

The benefits of using lead time and making sure that it reduced are numerous. Afzal and Vivek (2014) identified benefits such as reduce work in progress, reduce safety stock, reduce costs, improved product quality, faster

response to customer need, increased flexibility, reduce time to market and increase profitability. In addition, Treville et al. (2014) noted that short lead times can be a source of competitiveness.

METHODOLOGY

The focus of this study is to examine the teaching of lead time reduction in material inventory planning in the construction education. The study is theoretical in nature. The study gave a theoretical background to material inventory planning and lead time management and their benefits. In the discussion, reducing lead time for material inventory planning require that construction students and construction professionals take note of possible factors that could be considered when deciding the lead time for material inventory planning on construction projects. The study considered all construction materials has a basis of the inventory. As these factors affects inventory of construction materials in one way or the other.

DISCUSSION

In order to ensure that adequate construction materials are available before a construction activity is carried out, construction professionals may decide to stockpile the construction materials on site. Maintaining stock of building materials on site can be attributed to availability of funds, market condition, site location, climatic condition and project cost (Arunprakash and Nandhini, 2013). This has the disadvantage of tying down valuable capital that could have been used for other activities on the construction project. Mehr and Omran (2013) stated that there are problems that are related to materials management during construction. These problems can be resolved largely by introducing lead times to construction activities and materials needed to carry them out. The lead time can be put in days, weeks or years. In spite of the project management or lean tools for reducing lead time on material inventory planning, there is need for the consideration of certain factors affecting the availability of the construction materials when it is needed, in the right quantity and quality. Figure 3 showed the framework of factors that could reduce lead time in material inventory planning.

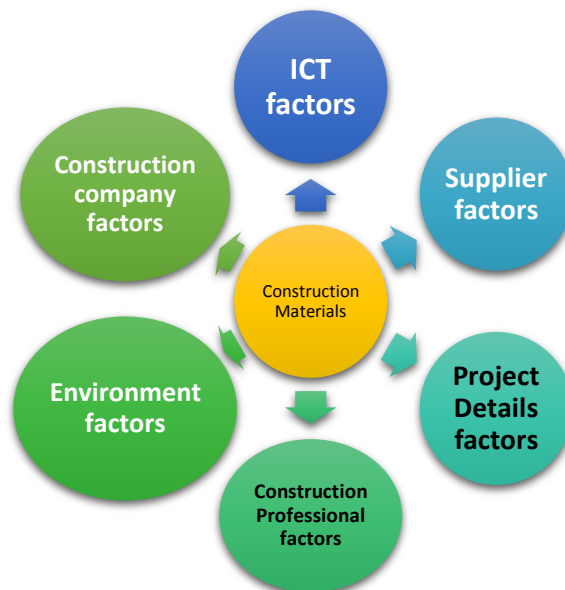


Figure 3. Factors affecting reduced lead time in material inventory planning

These factors are grouped into six (6) main factors which are the ICT factors: level of ICT usage, availability of ICT tools for material inventory planning and control; Supplier factors: relationship with supplier, supply and delivery of materials, price of building materials; Project details factors: site location, availability of storage space, availability of building materials, accuracy of project documents, variations, duration of project, sequence of activities; Construction professional factors: training of construction planner, experience, computer literacy, cooperation of team members, estimating skills of construction planner; Environment factors: market conditions, climatic condition; Construction company factors: availability of funds, communication between site and head office, policies of the construction firm. By identifying and understanding these factors it is possible to reduce or extend the

lead time of the availability of the construction materials required. When these factors are favourable to the construction project it will result in lead time reduction on the material inventory planning.

In teaching of lead time reduction in material inventory planning in the construction education, Figure 4 described the framework for teaching lead time reduction in material inventory planning in the construction education. Much consideration has been given to teaching construction students about start and finish date, evidently this study revealed that before the start date, a comprehensive lead time must be out in place. Apart from the project management and lean tools to reduce the lead time, factors affecting material inventory planning must be considered in order to have an effective and efficient reduced lead time. Construction students' knowledge of construction activities should be aligned with the use of reduced lead time for proper inventory planning of materials and other construction activities.

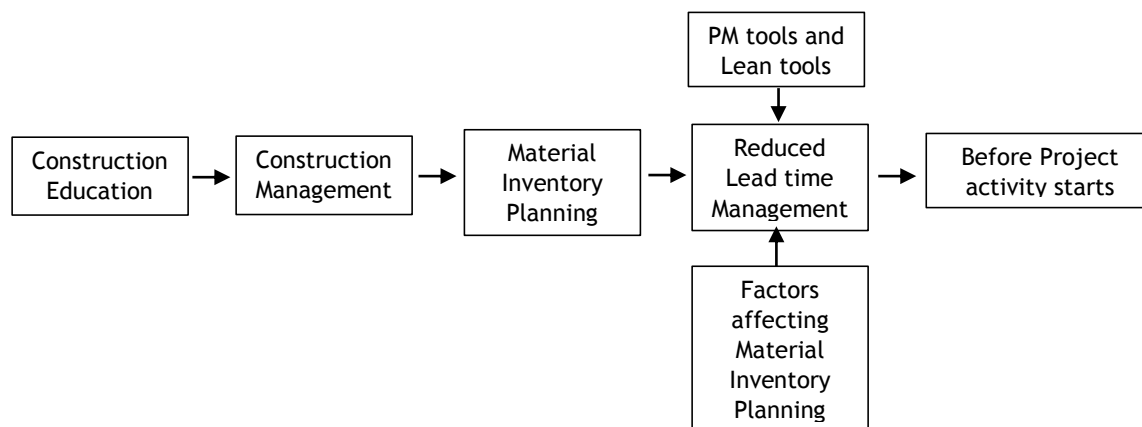


Figure 4. Framework for teaching lead time reduction in material inventory planning

Some of the material inventory planning variables are discussed below;

Availability of Storage Space

Material storage on site requires close attention in order to avoid waste, loss and any damage of materials which would affect the operation of the construction project. Previous studies have identified that construction materials often require a large storage capacity which is rarely available on site (Agapiou *et al.*, 1998). Lack of space is an inherent difficulty acknowledged throughout the industry, when constructing a development in an urban environment (Tindiwensi, 2000; Singer, 2002; Navon and Berkovich, 2006). However, Stukhart (1995) suggested that there are a few considerations to take in the planning of the storage space such as timing of the initial buy, and historical information and experience. Hisham and Khaled (2011) stated that storage on construction sites need to be properly planned and executed to avoid the negative impacts of material shortage or excessive material inventory on-site. Material inventory planning is essential to overcome this issue and management of the critical space.

Training and Experience of Project Manager

According to Stukhart (2007), studies from the Construction Industry Cost Effectiveness Project (CICEP) concluded that senior management have not recognized the contribution of material management to cost issues in projects, that personnel involved in material management activities do not receive an adequate training, and that the computer systems used by companies are not good sources of information for materials control. Lack of material may be due to an unskilled project manager who gives insufficient precedence to material procurement and has insufficient knowledge of materials, including appropriate substitutes (Mehr and Omran, 2013). Mehr and Omran (2013) reported that most people in the construction industry cannot use computer in case of materials management so they prefer to use manual materials management techniques. Navon and Berkovich (2006) noted that the use of manual process is labor concentrated, risky and inaccurate which may lead to extra and unwanted materials, delay, output decrease, shortage of new and up to date data.

Construction company policies

According to Umble *et al.* (2003), an organization or company must create a clear, compelling vision of how the company should operate in order to satisfy customers, empower employees, and facilitate suppliers. These types of decisions are the policy decisions of the management. Sometimes, the head office is in charge of material evaluation, its availability, alternative materials selection, procurement and inventory control or the make and buy decisions, thereby making sure that the inventory planning and control of materials are hinged on the major decisions of the construction firm to provide the necessary resources needed. Mehr and Omran (2013) reported that shortage of building materials on construction sites and activity delays have been hinged on poor communication between sites and head office purchasing, planning and co-ordination. According to Nwakor *et al.* (2012), most construction professionals (89%) have to bypass the establishment of material/store department in the head offices in order to save operational costs on their construction sites. However, this practice introduces flaws such as connivance with suppliers to inflate prices.

Availability of materials

This is one of the main factors affecting material inventory planning on Nigerian construction sites. Most Nigerian construction sites have been found to suffer from unavailability of needed construction materials which adversely delays the project, reduces productivity of workers and consequently lead to increase in final construction cost (Adeyemi, 2000; Liberda, Ruwanpura and Jergeas, 2003; Fagbenle, Ogunde and Owolabi, 2011). Mishra (2009) stated that it is important to make sure the quantity of materials which is required are available and that there is no shortage. Adeagbo (2014) noted that the availability of building materials should also be adequate in quality as this is crucial for the activities in the building and construction sector. According to Mehr and Omran (2013), timely availability of materials are essential to successful construction. However, the situation is such that the materials are often not available in the required quantity and quality. This adversely affects cost of construction and quality of projects executed. Material inventory planning cannot be effective when materials are not available.

Available ICT tools

Mehr and Omran (2013) explained that nowadays, successful management of construction materials has to be based on thorough and updated information, and procedure of using well designed construction materials management software. This idea has driven the vast use of ICT to ensure that up-to-date information is made available when needed. Mishra (2009) posited that computerize and network information offer fast, accurate and maintenance of information. The availability of ICT tools would affect the type planning and controlling technique adopted by the professionals involved and also the type of information available to them. Oladokun and Olaitan (2012) opined that lack of affordable, efficient, and user friendly inventory management tools, for adequate planning has been identified as a major cause of the high inventory cost in many Nigerian manufacturing firms. Navon and Berkovich (2006) added that lack of capable personnel in using computer-based materials management systems are considered the main difficulty in using computer in construction materials management.

Accuracy of Project documents

According to Mishra (2009), the success of material management is highly dependent on accurate and correct generation and convey of information. During the procurement phase it is necessary to decide how much material is required and when materials should be delivered to site. Mehr and Omran (2013) stated that accurate value and amount of materials must be accessible when needed. The accuracy of the information needed for inventory planning of materials would depend on the accuracy of the project documents that have been supplied by the consultants for project execution. According to Williamson (1996) resource allocation for a project becomes impossible when information provided in the design systems are uncertain and the complexity of the design do not align. Iyagba (2005) opined that design is the pre-planning process requiring knowledge, ability and selection of materials and determining performance. A faulty design document is a faulty foundation to building planning and control systems. Aina and Wahab (2011) have traced a lot of buildability problems to the issues of defective and faulty working drawings by inexperienced designers. The use of defective and faulty working drawings have often led to rework, high construction cost, huge claims, delay and ultimately building collapse (Iyagba, 2005).

Supply and Delivery of materials

Inventory planning of materials would greatly be affected by the frequency of supply and delivery of building materials. The logistics of supply and delivery of building materials during the building process is very crucial. Bertelsen and Nielsen (1997) noted that most contractors operate the "Oops! Principle", that is, ordering and deliveries of building materials take place when the production comes to a halt due to lack of the materials required. This means, not only frequent delays and loss of time but also additional costs caused by express deliveries. Mehr

and Omran (2013) stated that many companies rely greatly on outside suppliers for the materials needed for production. Therefore, good relations and association with material suppliers might be decisive for a construction company to be in business. When a construction company has bad relation with their material suppliers it might be feasible that it experiences late deliveries or wrong materials delivered. This will have an impact on the total cost of the product, probably increasing the total costs, and delaying the end of the final product (Mehr and Omran, 2013).

Price of Building Materials

It is clear that materials should be obtained at the lowest cost possible to provide savings to the construction company (Damodara, 1999). Project delays and increase in project cost have been linked to increase in material prices and fluctuation in building material prices (Frimpong *et al.*, 2003). These changes in building material prices can be attributed to unavailability and shortage of materials in the country (Mehr and Omran, 2013). Eshofonie (2008) stated that price of material is highly dependent on supply and demand and are affected by many other things such as quality, quantity, time and place, currency exchange, material specification, inflation and availability of new materials. Changes in building material price can stall material planning and controlling systems of construction project leading to time overrun.

Cooperation of Team Members

According to Mehr and Omran (2013), material management is an appropriate use of services, goods and equipment before, during and at the completion of construction projects. So for successful material management, there is a need for participation of all persons and parties involve in the project. In such situation material management needs collaboration between architects and engineers to identify the accurate material to be supplied during pre-construction to prevent over stocking. Construction management team must buy accurate quantity of material at the right time to prevent future issues such as deterioration and storage problems. Umble *et al.* (2003) noted that the implementation team is important because it is responsible for creating the initial, detailed project plan or overall schedule for the entire project, assigning responsibilities for various activities and determining due dates. The team also makes sure that all necessary resources will be available as needed.

CONCLUSION AND RECOMMENDATION

Before the start of construction project activities, there is need for construction materials in order for the activity to take-off. Most times on construction projects, the lead time management to prepare for the acquisition of materials are usually done haphazardly by construction professionals. The study sought to integrate the teaching of lead time reduction in material inventory planning in the construction curriculum in order to aid construction students in effectively and efficiently planning for construction projects. The study revealed the breakdown of activities in inventory lead time management and considered six (6) main factors that can lead to a reduced lead time in material inventory planning. The study posits that construction students should painstakingly address these factors in order to reduce the lead time in material inventory planning. The identified factors include as ICT, Supplier, Project details, Construction professional, Environment and Construction company factors. A framework was developed which showed that reduced lead time management should be integrated in the construction management education.

The study recommended that by enriching the construction education, construction students are empowered with knowledge that helps in adequate material inventory planning. Effective and efficient lead time management can lead to reduced material delay, availability of construction materials when needed and improve construction project delivery parameters of time, cost and quality. There is conscious need to constantly review the curriculum to adapt to the current needs of the industry.

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