INVESTIGATING THE POTENTIAL OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY FOR ORDER PROCESSING LOGISTICS IN THE CONSTRUCTION INDUSTRY

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Abstract
The dearth of modern technology and automation in construction logistics in Nigeria has affected the performance of construction sector. This research investigated the potential of Radio Frequency Identification (RFID) Technology used for order processing in the manufacturing and retailing sector which could be utilized in the construction order processing logistics. Lagos State and The Federal Capital Territory (FCT). Abuja, Nigeria were the selected geographical scope of the study, from which 5 manufacturing company, 5 retailing companies and 5 construction projects were purposely selected. Mixed methods research strategy was used. The research instruments included an observation guide (quantitative) and semi-structured interviews (qualitative). The collected quantitative data were analysed using descriptive analytical tools, including, frequencies and percentiles. The qualitative data was analysed, using thematic method. The result revealed that 100% and 80% of the manufacturing and retailing sectors respectively, observed, adopted RFID technology for order processing operations. Only 20% of the observed construction project adopted RFID technology for order processing in the following: out of which 0.6% was used for receiving process, 0.9% for put-away process, 0.6% for dispatching process, 0.6% for replenishment process, and 0.6% for tracking inventory (stock tracking). It was also revealed that utilization of the RFID technology could lead to increased speed of work in the construction industry; improvement in the quality of documents; decrease in documentation errors; allows for contactless identification with little or no manpower. It is recommended that the Nigerian construction industry should leverage on this in order to create the best ways of handling the RFID technology to improve the order processing logistics systems of construction process.

Keywords: Construction, Logistics, Order Processing, Radio Frequency Identification, , Technology

Introduction

The construction industry is often criticised for delivering projects behind schedules and over budgets, due to its over-reliance on manual modes of operations (Gadde & Dubois, 2010; Tseng, Wu & Nguyen, 2011). Almohsen and Ruwanpura (2011) opined that logistics management in the manufacturing and retailing industries and its contribution to construction productivity in the use of advanced technologies have been investigated insufficiently. Thus, the dearth in modern technology and automation in the Nigerian construction industry lead to increased project cost, tedious work processes and low efficiencies (Equere & Tang, 2010: 106). Ibrahim, Mohammed and Varouqa (2020) added that, Traditional methods of order processing are still in used in the world of material management, although they are neither adequately to meet site needs nor suits the overall management process. While there are some large companies around the world that apply modern systems, the majority of companies do not pay much attention to this matter (Ibrahim, *et al.*, 2020).

Moreover, tracking technologies, such as Radio Frequency Identification (RFID) is not adequately employed in construction project sites (Sarac, Absi, & Dauzère-Pérès, 2010). There is also insufficient support for tracking and management of materials for operational efficiency in

inventory management on site. Thus, Liwan, Kasim & Zainal (2013) suggested that construction industry must be up-to-date in implementing emerging logistics technologies like the RFID technology, in order to facilitate quick monitoring, better labour output, better replenishment process, and improved materials tracking processes.

Research evidence by some authors like Equere and Tang (2010); Dube, Muyengwa, & Battle, (2012**);** Nasr, Shehab & Vlad, (2013**);** Samuel & Ondiek, (2014) has shown that previous studies on construction logistics from different part of Nigeria have focused on transportation, forecasting, effectiveness or efficiency in logistics supply chain and so forth, however, very little is focused on logistics technology, especially the use of RFID technology for order processing to improve construction logistic processes. Therefore a huge wide gap has been identified in the Nigeria construction logistics processes (Fatnani & Malik, 2015; Braun, Tuttas, Borrmann, & Stilla, 2015). However, the technological aspect of construction logistics, most especially the order processing is over looked, and little is understood in the Nigerian construction industry. This problem has led to delay in speed of work, lack of improvement in quality of document and increase in documentation process (Equere and Tang 2010). It is, therefore, important to examine order processing related tasks in the manufacturing, retailing and construction industries; the percentage level of usage of RFID logistics technologies in the execution of these tasks, and the accruable benefits to construction from the utilisation of the order processing (RFID) technology in the industries. The article assesses the level of utilisation of order processing technology using RFID technology in the manufacturing and retailing industries, and how it could improve the order processing process of the Nigerian construction logistics.

Literature Review

Construction logistics technology

Technologies can trigger change and provide the means for moving out of the past toward a more efficient and powerful future (Büyüközkan, Arsenyan and Ruan, 2012)**.** In modern construction industries, the tasks of logistics technology is to provide appropriate and efficient logistics systems that will guarantee the right goods to be delivered to the right customers, at the right time, at the right place, and in the most economical way (Farahani, Shabnam & Laleh, 2011)**.** Hence, Nasr *et al.*, (2013) noted that technology utilisation in the construction industry could significantly improve daily performance and project logistics management activities.

Furthermore, Equere and Tang (2010) assert that automation and related technology are not only lack in the Nigerian construction industry, but there seems to be very little interest in exploring their benefits, this is because there is lack of awareness, low level of technology and fear of innovation. Also, the logistic technology developed to support the management of the Nigerian construction industry in the area of forecasting, order entry, order processing, requirement planning, invoicing, warehouse operations, transportation, among others is outdated, ineffectual, and often over-looked, due to its weak contributions to project performance (Langeley, *et al.*, 2009).

RFID Technology as an order processing logistics tool in the construction industry

The RFID is commonly known as electronic tag, which is a non-contact automatic identification technology that automatically recognizes target objects and acquires relevant data through radio frequency signals, this identification capability can identify moving objects and recognize multiple objects at the same time without manual intervention (Wang, Jing and Kan, 2020). The technology has the ability to respond to radio waves transmitted from the RFID reader in order to send, process and store information (Jafari and Sadeghi-Niaraki, 2013)**.** The RFID technology can be stuck on

products including: Materials, apparel and baggage; vehicles; equipment; staff and laborers; and computers (Kim, Kim, Ryu & Kim, 2011; Ibrahim *et al.*, 2020). This RFID logistic technology for overcoming human errors in the areas of tracking and better management of materials especial during order processing process are lacking in the Nigerian construction industry when compare to manufacturing and retailing industries

Thus, completing a construction project within budget and in a timely manner with their numerous constraints requires skillful integration of logistics like RFID (Yahaya, 2020). Fatnani & Malik (2015) concluded that the trial of RFID technology in construction industry makes the processing of materials fast from the supplier to delivery on site and increase picking accuracy to almost 99.6 percent, it also increases the speed and certainty when validating the location of delivered goods in construction. This technology provide the following benefits: it reduced communication and transaction time, and provide greater information accuracy (Yahaya, *et al.*, 2020). Ibrahim *et al.* (2020) added that, using a very accurate system like RFID for managing materials on construction sites is essential to prevent problems that could affect the management process.

Manufacturing and Retailing Industries' Experiences of RFID Logistics Technology

The manufacturing and retailing industries has gain enough in term of development and usage with the use of RFIDs in receiving process, put away process, shipping process, dispatching process, replenishment process most of specially the tracking tires for stock management purposes save labor cost (Xiang, 2019; Goh & Aslam, 2020).

The RFID technology has been applied to many industries such as supermarkets, logistics, railway transportation and Manufacturing industries and automate facility management, improve management efficiency, and increase the speed of information flow (Wang, Jing and Kan, 2020).

Research methodology

This study uses a mixed methods approach where both quantitative and qualitative data are collected in parallel, analysed separately, and then merged. In this study, the quantitative semi-structured questionnaire survey was investigated by observations of the task performance of RFID technology from the manufacturing, retailing and construction sectors. The qualitative interviews explored the benefits of implementing RFID technologies in the construction sector.

The geographical study areas for this study included the manufacturing, retailing and construction sectors in Lagos State and Abuja, the Federal Capital Territory (FCT) of Nigeria. These geographical study areas were selected, because they both have many manufacturing and retailing companies and many construction projects. Moreover, these two cities are among the metropolitan cities in Nigeria with the highest population of professionals within the built environment with many ongoing construction projects. For the quantitative semi-structured questionnaire survey, purposive sampling was used to select a sample of 15 companies (including five manufacturing, five retailing and five construction companies) with projects of 2.8 billion Naira and above, as at 28 August 2017. Purposive sampling allows for the selection of individuals or organisations, based on their experiences, to yield adequate information about the topic under investigation. For this study, companies with projects to the capital base/value of 2.8 billion Naira and above are deemed mature enough and presumed to have advanced technologies such as RFID. For qualitative data collection, purposive sampling was used to sample 15 participants (workers each from the different sectors visited who were stationed to work on the technology) who simultaneously participated in the interviews.

An observation guide and semi-structured interviews were used to observe only the RFID technology utilized, including five RFID technology from manufacturing companies; eight RFID

technology from retailing companies, and one from construction projects. The observation guide included seven main order processing tasks for the manufacturing and retailing companies, namely: receiving process, put away process, hipping process, dispatching process, replenishment process, tracking inventory and holding inventory as well as seven main tasks for construction companies, namely: receiving process, put-away process, stock control, dispatching process, replenishment process, stock tracking and stock holding.

The observations were carried out with the aid of the workers in the sectors (manufacturing, retailing, and construction) who were stationed to work on the technologies. The observations were done by taking the researcher around the RFID technology available. Questions were asked on the task performed by the technology in the industry and the related tasks and subtasks that the same technology could perform in the construction industry. The observations were only based on the RFID as order processing logistics technologies available (see Tables 1).

The respondents of the semi-structured interviews were one worker each from the different sectors visited who was stationed to work on the technology. This included five from manufacturing companies, four respondents from retailing companies and one respondent and from a construction sector, making a total of ten respondents from the companies. The semi-structured interview guide contains only one major question: How can the benefits of utilising this RFID logistics technology be accruable to the logistics order processing of the construction industry? (See the last column of Tables 1).

Data Analysis and Interpretation

The collected quantitative data (observations) for this study were analysed, using descriptive analytical tools that included frequencies and percentiles. The tabulated results from the instruments were divided into two parts. The first part consisted of the related tasks in the manufacturing and retailing industries, and the second part consisted of tasks and subtasks in the construction industry. In the first part, the technologies were identified in five manufacturing and five retailing companies, thus a total of ten companies.

The identification in each of these companies represented 20% of the 100% for the five manufacturing and the five retailing companies, respectively. In addition, the tasks in the five manufacturing and retailing companies were identified, with each occupying 20% of the 100%. For example, put away process in Table 1 was used by 3 manufacturing companies out the five (5) manufacturing companies, each company occupying 20%. This means 20% multiply by 3 industries, equals to 60% of the 100% of the five manufacturing companies. The same process applies to the five (5) retailing companies. Moreover, for identification of the technologies in the 5-construction projects, each occupied 20% of 100%.

The tasks that correspond to the manufacturing and retailing companies were also identified, each occupying 20% of 100% for the five (5) projects in the construction industry. The tasks under the construction project were sub-divided in to sub-tasks, for which 20% occupied by each project was further sub-divided into the sub-tasks under the projects in the construction projects. This means, put away process only occupied 20% which will be divided among the number of sub-tasks that appear under put away process. For example, the corresponding task to put away process in construction is put away process in Table 1. Therefore, put away process as a main task, each occupying 20% to make 100%, the 20% under 'put away process'' was further divided into 2 different sub-tasks in put away process (inter site material transfer and return of material to manufacturer) that is, 20% divided by 2 equals to 10% for each sub-task.

Furthermore, the total of this percentages from the manufacturing, retailing and constructional industries were utilized to produce the percentage level of usage of the task and sub-task in the three industries. For example, using this formula: L=U/T x 100%. Where, U= Unit percentage of one task of the three industries; T=Total percentage of manufacturing, retailing and construction industries; and L=Percentage level of usage of each unit percentage task, moreover, the total percentage and percentage proportion of tasks in the three (3) industries were used to develop the Figure 1 for RFID technology. Using thematic data analysis, a nuanced account of the data could be presented by transcribing, coding and setting themes from the responses of the focus-group interviews.

Results and Discussion

Level of Usage of RFID Technology

A total of 100%, 80% and 20% of the manufacturing, retailing and construction industries respectively observed, adopted RFID technology for order processing purposes, from which the manufacturing and retailing industries used 100% and 80% respectively for the receiving process, each occupying percentage proportions of 9,3% and 7.5% respectively. The construction industry occupied a total proportion of 0.6% for the receiving process, with 6.7% for processing receipt of plants considering another related RFID task. These results support the findings of Ibrahim *et al.* (2020) who opine that RFID is mostly used in the manufacturing industry when compared to other industries.

Moreover, 60% of the manufacturing and retailing industries used RFID technology for the put-away process, both occupying proportions of 5.6% A total of 10% of the construction industry used RFID technology for returning goods to the manufacturer, occupying a proportion of 0,9% Similarly, 100% and 60% were used for the shipping process in the manufacturing and retailing industries respectively, occupying a proportion of 9.3% and 5.6% each. These results confirm the findings of Jafari and Sadeghi-Niaraki (2013) that RFID allowed for very fast and easy shipping of materials.

Moreover, 80% and 40% of the dispatching process was used by the manufacturing and retailing industries respectively, each occupying a proportion of 7.5% and 3.7%, even though 6.7% was used in the construction industry occupying a proportion of 0,6% for material issued considering other related RFID tasks.

Furthermore, in terms of the replenishment process, 60% and 80% of the manufacturing and retailing industries respectively used RFID technology for the replenishment process, occupying proportions of 5.6% and 7,5% respectively. However, 100% and 80% of the manufacturing and retailing industries respectively used RFID technology to track the inventory process, occupying proportions of 9.3% and 7.5% each. However, 6.7% of the construction industry used RFID to track inventory under material tracking. This occupied a proportion of 0.6% considering other related RFID technology tasks. These results are in line with the conclusions of Kim *et al.* (2011) and Lee & Lee (2015), who stated that RFID allowed for replenishment with little or no manpower. Additionally, 9.3%, 7.5% and 6.7% of the manufacturing, retailing and construction industries respectively, are the percentage proportions occupied for tracking inventory. This also corroborates the finding of Lee & Lee (2015) on tracking inventory.

It was therefore revealed that though, the RFID technology was not fully utilised by the respondents, but could be utilised to improve the following area of construction logistics tasks: Receiving process: processing receipt of material, processing receipt of plant and processing receipt of equipment; Put away process: inter site material transfer and returns of material to the manufacturer; Stock control: inter site material transfer and returns of material to the manufacturer; Dispatching process: plant issued, material issued, and equipment issued; replenishment process: Material replenishment, plant replenishment and equipment replenishment; Stock tracking: material tracking, equipment tracking and plant tracking; Stock holding: material on site.

The general benefits of RFID technology to construction

The table 1 above shows that the interviewed respondents deemed that the following benefits could be accrued to construction industry if the RFID technology is utilised in the construction industry for order processing processes of logistics management, these include: increased speed of work in the construction industries; provision of improvement in the quality of documents in the construction industries; provision of a decrease in documentation errors in the construction industries; make the shipping process fast and easy on the construction site; allows for contactless identification with little or no manpower in the construction industries; reduction in inventory losses in the construction industries; provision of an increase of efficiency and speed of data processing in the construction industries; increased improvement of information accuracy; and make it possible to read data from multiple tags at one time.

These results corroborate the finding of Ibrahim *et al.* (2020) who stated that the integration of the RFID would aid the construction companies' performance by allowing real-time monitoring and documenting of construction activities. These are also in line with Valero and Adán (2016) who stated that RFID has an advantage over barcoding. The also, results validate the finding of Sarac *et al.* (2010) on the increase of efficiency, flow of information, speed of processes and reading of multiple tags. This also supports the findings of Kim *et al.* (2011) that RFID identifies objects and stores information.

Table 1: Radio Frequency Identification (RFID) technology

Manufacturing and retailing industries						Construction industries				
		Manufacturing		Retailing		Construction				
Percentage Identification		100%		80%		20%				
Tasks in Manufacturing and Retailing		100%	% Level of usage	100%	% Level of usage	100%	% Level of usage	Tasks in Construction		Benefits accrued
								Sub tasks	Main tasks	
1	Receiving process	100	9.3	80	7.5	6.7		Processing receipt of material	Receiving process	Increased speed of work, allowance for contactless identification, increased efficiency and speed of data processing; and makes it possible to read data from multiple tag
							0.6	Processing receipt of plant		
								Processing receipt of equipment		
2	Put away process	60	5.6	60	5.6			Inter site material transfer	Put-away process	Increased efficiency and speed of data processing
						10	0.9	Return of material to manufacturer		
3	Shipping process	100	9.3	60	5.6			Inter site material transfer	Stock control	Makes the shipping process fast and easy and increased speed of work
								Return of material to manufacturer		
4	Dispatching process	80	7.5	40	3.7			Plant issued	Dispatching process	Increased speed of work provides a decrease in documentation errors and increased improvement of information accuracy
						6.7	0.6	Material issued		
								Equipment issued		
5	Replenishment process	60	5.6	80	7.5			Material replenishment	Replenishment process	Increased speed of work reduces inventory losses and are successfully used for improving the flow of information
								Plant replenishment		
								Equipment replenishment		
6	Tracking inventory	100	9.3	80	7.5	6.7		Material tracking	Stock tracking	Identified object and store information without seeing the tag and allows for contactless identification
							0.6	Equipment tracking		
								Plant tracking		

Manufacturing and retailing industries						Construction industries				
		Manufacturing		Retailing		Construction				
7	Holding inventory	60	5.6	80	7.5			Material on site	Stock holding	Improvement in the quality of documents and decrease in documentation errors;
TOTAL		560	52.3	480	44.9	30.1	2.7			

Source: Researcher's analysis of data, 2018.

Conclusion

This research assessed potential of RFID technology, for improving the order processing and construction logistics. The research found that 100% and 80% of the manufacturing and retailing industries respectively, observed, adopted RFID technology for order processing purposes (for receiving process, put away process, shipping process, dispatching process, replenishment process, tracking inventory and holding inventory). Only 42% of the observed construction project adopted RFID technology for order processing in the following: 0.6% for receiving process, 0.9% for put-away process, 0.6% for dispatching process, 0.6% for replenishment process, and 0.6% for tracking inventory (stock tracking). Based on these findings, it can be concluded that RFID technologies was not fully utilise in the construction projects when compared to the manufacturing and retailing industries.

Conclusively, the RFID technology, could be utilised to improve the following tasks in the construction industry: Demand control: material, labour and equipment and plant demand on site; stock control: material on site, order management, and material to be used; production output control: labour output and plant output; and procurement process: bidding process, invitation to tender, submission of tender, tender evaluation and report. Receiving process: Processing receipt of material, processing receipt of plant and processing receipt of equipment; Put away process: inter site material transfer and returns of material to the manufacturer; Stock control: inter site material transfer and returns of material to the manufacturer; dispatching process: plant issued, material issued, and equipment issued; replenishment process: material replenishment, plant replenishment and equipment replenishment; stock tracking: Material tracking, equipment tracking and plant tracking; and stock holding: material on site. It is also concluded that the ultimate benefit that could accrue to the construction industry for the utilization of the RFID technology for order processing purposes is achievement of full order processing efficiency gains in construction. To this end, the Nigerian construction industry should leverage on this in order to create the best ways of handling the RFID technology to improve the order processing logistics systems of the construction process.

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