THE PROSPECT OF MINIMISING PRODUCTION FLOW WASTE ON CONSTRUCTION SITES IN NIGERIA THROUGH THE LAST PLANNER® SYSTEM

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ABSTRACT

Poor performance of construction projects is a re-occurring problem in Nigeria. Production flow waste (ranging from waiting time, material handling and over-production, among others) may be partly responsible for this problem. Meanwhile, very little is known about the role of the Last Planner System (LPS) in minimising production flow waste in Nigeria. The current study examines the manifestation of production flow wastes on Nigerian construction sites, identifies current construction practices that bear resemblance to the LPS, and finally, examines the prospects of the LPS concepts in minimising production flow waste in the corresponding construction projects. A mixed research design that uses a quantitative cross-sectional survey and qualitative-exploratory approach was used in collecting data from construction professionals based in Nigeria. Fifty-one survey responses were received and 10 interviews were conducted. The study reveals various incidences and contributory factors to production flow waste, with the long approval process being the most prevalent. It also identifies current practices that are similar to the LPS practices. The prospect of the LPS in production flow waste management for improved productivity is also explored. The study concludes that the LPS concept has the potential for minimising production flow waste in the construction process and improving productivity in the Nigeria construction industry.

Keywords: construction sites, Last Planner System, production flow waste, non-value adding activities, Nigeria

INTRODUCTION

The construction industry has been identified as one of the industries that generate a high level of waste during their operations. Hindrances to continuous production flow (non-value adding activities) in the construction process such as waiting time, material handling, over-production, inventories, rework, redundant activities and labour movement all constitute waste. According to Koskela (2000), this amounts to about 30% of construction costs. These non-value adding activities are referred to as production flow waste in this study. Nigeria has an active

construction industry. However, its contribution to the nation's gross domestic product (GDP) has not been consistent (NBS report, 2015). For instance, in 2010 the share contribution of the construction sector to the GDP was 2.88% (NBS report, 2015); in 2011, it was 4.1% (Oluwasekeyi, 2011). However, in 2012, there was a decline of 14.86%, making the share of construction contribution to the GDP to stand at 3.05%. The National Bureau of Statistics (NBS) of Nigeria reported that the real growth in the construction section in the first quarter of 2016 stood at a negative 5.37% (NBS report, 2016).

This decline has been attributed in part to numerous ills faced by the industry, which include project management deficiencies, such as cost and time overruns; rework; poor work quality; high life cycle maintenance cost; as well as inadequate attention to safety, health, and environmental issues, among others. To improve the performance of the construction industry, Koskela (2000) suggested that advanced construction should be explored. This refers to production management that encourages improved coordination of the construction flow process, analyses and minimises waste (non-value adding activities), while also maximising value for the end users such as in lean construction.

The LPS developed by Ballard and Howell is a lean construction approach that focuses on reducing workflow uncertainty which was identified as a missing component in the traditional project management kit (Ballard and Howell, 2003). In practice, the LPS stabilises the production (construction) process on a project by identifying relationships, matching them with plans and balancing resources (Mossman, 2014; Ballard and Howell, 2003). The LPS establishes relationships between people, tasks, locations, materials, drawings, time, information, and resources so as to develop a common understanding of the project goals among stakeholders (Pasquire, 2012; Koskela, 2000). This supports the smooth flow of work, collaboration, and commitment from all project participants, thus delivering value for all the stakeholders of the project (Koskela and Ballard, 2006). This implies that the LPS could minimise production flow waste.

The implementation of the LPS has gained prominence in the construction industry and its influence on the production system seems to be rapid and significant (LCI, 2015; Daniel et al., 2015). However, its implementation in the construction industry in Nigeria is still low (Ahiakwo, et al., 2013; Adamu and Howell et al., 2012). There is a dearth in empirical study to understand the prospect of the LPS in minimising production flow waste. It is believed that production flow waste (non-value adding activities) is prevalent on construction projects (Emuze et al., 2014). However, previous studies on construction waste in Nigeria seems to focus more on physical waste on site (Ameh and Daniel, 2013; Ajayi et al., 2011; Wahab and Lawal, 2011), rather than production flow waste.

Furthermore, it is still not clear whether there are current construction practices that show resemblance to the LPS in Nigeria. This could support the future implementation of the LPS in Nigeria. However, previous studies on the LPS in Nigeria were based on a case study, are organisational specific (Adamu and Howell 2012), and are unable to capture current construction practice across the industry that shows a resemblance to the LPS. However, the study reported here cut across the major professionals in the construction industry in Nigeria so as to identify current

practices that show resemblance to the LPS and explore the prospect of the LPS in minimising production flow waste on construction sites. The research question therefore is: How does production flow waste manifest on construction sites in Nigeria? What is the prospect of minimising it using the LPS concept?

This study provides new insights into how production flow waste manifests on construction sites in Nigeria, and shows the potential of the LPS in minimising its occurrence in construction sites for improved productivity. Furthermore, the clear identification of some the current construction practices that show a resemblance to the LPS in Nigeria contributes to future implementation of the LPS in the construction industry in Nigeria.

LITERATURE REVIEW

Previous studies on waste in the Nigeria construction industry

Various studies in the past have examined waste in the Nigeria construction industry. Ajayi et al. (2008) examined waste management practice on construction sites in Lagos, Metropolis and the study found that the increase in waste generation on construction sites is ofgreat environmental concern. Similarly, a study by Oladiran (2009) explored the extent of the use of the Waste Management Plan (WMP) in minimising construction waste in the construction industry in Nigeria. The study reveals that the use of the WMP on construction projects in Nigeria is average. This could mean that not every construction project has a clear WMP in place. Ameh and Daniel (2013) analysed the most commonly used construction operations and material at construction sites. The study found that the most wasteful building material during the execution of construction activities on the site is mortar from plastering and rendering. The study further revealed that building material wastage contributes between 21% and 30% to project cost overrun. However, the study is based on the perception of construction professionals rather that quantitative measurement. Nevertheless, this evidence shows that construction waste occurs in the construction process in Nigeria. A further confirmation of this was a study by Adewuyi and Odesola (2015) who examined the contributory factors to material wastage in the construction industry in Nigeria. The study found that uneconomical cutting of shapes is one of the highest contributing factors to material wastage. It is clear from the review that the focus of previous studies was on physical waste. While it is important to examine physical waste, waste in construction is not limited to physical waste alone. There are other types of waste such as production flow waste, also known as non-value adding activities. According to Koskela (2000), any activities that consume resources and material but do not create value amount to waste. In view of this gap, the current study focused on production flow waste.

Construction production flow waste

There are different views as to what constitutes waste. However, in lean production all non-value adding activities in the production process are termed as waste. Zhao and Chua (2003) identified two major activities that occur in the production flow, namely non-value adding activities and value-adding activities.

According to Koskela (2000), non-value adding activities (waste) "…are those activities that take time, resources or space, but do not add value", while value-adding activities are those activities that convert material and information towards that which is required by the customer.

The Nigerian construction industry is characterised by the growing rate of construction, production flow waste occasioned by delays in project delivery, and rework, among others. Delay occurs when the contractor and the project owner jointly or severally contribute to the non-completion of the project within the agreed contract period. Important causes of delays in Nigeria building projects include the financing of and payment for completed works, poor contract management, design changes, and shortages in resources, among others (Aibinua and Jagboro, 2002; Oyewobi and Ogunsemi, 2010). In a study of 102 building projects in Nigeria, Aibinu and Jagboro (2002) found that the average time overrun associated with delay factors was 92.64% of the estimated project duration for projects below 10 million Naira ($65,000) and 59.23% for projects above this. This is perhaps one of the highest in the world.

On the other hand, Oyewobi and Ogunsemi (2010) assert that 70% of construction projects in Nigeria involve rework, leading to about a 3% to 15% variation of project cost, 40 to 60% labour productivity loss and 10% wastage of materials. In a study of 25 completed projects in Nigeria, the average estimated cost of rework was 3.47%. When broken down, this amounted to 5.06% for a new building, while that of a refurbished building was found to be 3.23% (Oyewobi et al., 2011). This gives an indication of the prevalence of production flow waste on construction sites in Nigeria. In a related study, Oyewobi et al. (2011) observed that finishes are more prone to rework which results in a 19.09% cost and time overrun.

Based on the foregoing, it is evident that production flow waste coupled with corruption and unethical practices (Oyewobi et al., 2011; Olusegun et al., 2011) makes the cost of construction in Nigeria one of the most expensive in sub-Saharan Africa. According to Thomas et al. (2002), the essence of eliminating or minimising non-value activities from the production process is to create better value for the consumer. Several sources of non-value adding activities have been identified in the literature (Alwi et al., 2002; Zhao and Chua, 2003; Ralph and Iyagba, 2012). Some of these could manifest in the form of waiting time for instruction, unclear shop drawings, poor quality site documentation, poor design, design changes, slow drawing revision, unclear specification, poor coordination among project participants, poor planning and scheduling, unreliable equipment, late delivery of material to the site, and weather conditions.

Koskela (2000) classified these non-value activities based on their root causes into the following three groups: the structure of the production system, the way production is controlled, and the inherent nature of the production. Figure 1 presents production flow waste as identified in the literature.

Table 1: Production flow waste

Production flow waste	Reference
Long approval process	Alwi (2002); Zhao and Chua (2003); Al-Aomar (2012)
Inadequate project planning	Daniel et al. (2014); Koskola, (2000); Alwi et al. (2002); Aiyetan and Das (2015).
Equipment breakdown	Alwi et al. (2002); Ralph and Iyagba (2012)
Design changes	Ralph and Iyagba (2012)
Waiting for inspection	Aiyetan and Das (2015); Ralph and Iyagba (2012)
Congestion on site	Zhao and Chua (2003)
Waiting for another crew to complete their work	Awi et al. (2002)
Delay from suppliers	Awi et al. (2002)
Excessive transport of material	Zhao and Chua (2003);
Construction error	Aiyetan and Das (2015)
Rework	Aiyetan and Das,(2015); Zhao and Chua (2003);
Waiting for instruction	Zhao and Chua (2003)
Excessive labour movement	Ralph and Iyagba (2012); Awi et al. (2002)
Waiting for equipment	Zhao and Chua (2003)
Dispute and disagreement on site	Awi et al. (2002)

The Last Planner System of production control

The Last Planner System is a production planning and control technique developed in the 1990s for the construction industry. It supports the development of collaborative relationships among those doing the work (Daniel et al., 2017; Ballard, 2000). According to Daniel et al. (2017) and Papke and Dove (2013), the LPS is a production planning and management methodology for construction. In the LPS approach of managing project production, "planning" and "control" are integrated: however, in the traditional approach of managing project production, "planning" is separated from "control" (Ballard and Howell, 2003; Ballard, 1997).

The LPS supports collaborative planning among construction stakeholders.

The influence of the LPS in managing the production process in construction has been retrospectively rationalised through theories relating to decision-making and uncertainty in the production process (Ballard et al., 2009). Notable among these theories are the Transformation-Flow-Value theory (Koskela, 1992; Koskela and Ballard, 2006); and the language/action perspectives (Flores, 1982; Hayek, 1945) which posited that the knowledge needed for planning is dispersed among individuals. More importantly, the underlying theories of the LPS revolve around planning, execution, and control. According to Ballard and Howell (2003), the LPS focuses on planning and production control which is opposed to monitoring in the traditional project management approach. The five key principles of the LPS (Ballard et al., 2009) are (1) ensuring tasks are planned in increasing detail the closer the task approaches the execution phase even before the task commences; (2) ensuring tasks are planned with those who are to execute them; (3) identifying constraints on planned task which should be removed by the team beforehand; (4) ensuring promises are secure and reliable; and (5) continuous learning from failures that occur when executing tasks to prevent future reoccurrence. These five initial principles have been extended to twelve in the recently published *Current Process Benchmark for the LPS* (Ballard and Tommelein, 2016).

The LPS comprises five basic elements: (1) the master programming, (2) phase scheduling/collaborative programming, (3) the look-ahead planning, (4) a weekly work planning (WWP) meeting, and (5) measurement and learning (Mossman, 2014; Ballard, 2000). It has been observed that the implementation of these elements could minimise production flow waste and improve project performance. For instance, measurement of Percent Planned Complete (PPC) which is one of the metrics of the LPS enables the project team to identify the reliability of their plan over time. According to Lim et al. (2006), measuring PPC is the performance management system for the LPS. Ballard (1997) asserts that PPC measurement supports continuous improvement as it allows the team to learn from the reason for non-completion postulated at the WWP meetings which are part of the PPC measurement process. This implies that the PPC measurement does not show plan reliability alone, but also other project performance indicators. For instance, Koskela et al. (2010) and Liu and Ballard (2008) observed that PPC measurement and the LPS generally improve productivity and thus cost reduction. This suggests that the implementation of the LPS in the building industry in Nigeria would improve the productivity of the sector.

The Last Planner(s) "…is the person or group that makes assignments to direct workers" (Ballard, 2000, G-14). Last Planners do not only do the work, but are also actively involved in developing the programme of work and ensuring work is made ready before being sent to the work phase (Mossman, 2014; Adamu and Howell, 2012). The duties of Last Planners, therefore, are to ensure that work is planned efficiently to create flow in the construction process and to ensure such work is executed at the optimal level. The Last Planner System process is based on five major processes and these have been explained in previous publications (Ballard and Tommelein, 2016; Mossman, 2014; Ballard, 2000).

Some practices associated with the LPS include weekly work coordination

meetings; weekly workload allocation; weekly review meeting with subcontractors (Daniel et al. 2017; Mossman, 2014 Ballard, 2000); investigating why what has been planned is not completed; a system to monitor improvement in the work executed; accepting suggestions from subcontractors; devising a back-up plan; having a collaborative meeting that allows the client, main contractor and subcontractor to communicate effectively; and team-based planning that uses reverse phase scheduling (Daniel et al., 2017; Ballard and Tommelein, 2016; Mossman, 2014; Ballard and Howell, 2004; Ballard, 2000).

The Last Planner System in Nigeria

Recent research has revealed that the LPS has been implemented in over 16 countries, including Nigeria (Daniel et al., (2015). The earliest study on the LPS in Nigeria was a research study that reported the implementation of the LPS in a public housing project (Adamu and Howell, 2012). The study found that the introduction of the LPS methodology led to faster delivery of more housing units within the given time compared to the housing units where the LPS approach had not been used. This shows that the LPS supports faster project delivery in Nigeria. However, the study reveals that the study participants were not familiar with the LPS. Similarly, Ahiakwo implemented the LPS on a road construction project in Nigeria (Ahiakwo, et al., 2015). The study found that the implementation of LPS contributed to production stabilisation and improvement in programme reliability.

Other benefits realized from the LPS on the above project include a reduction in bad news, on-time completion of the project, a predictable and workable work plan, improved logistics, and a reduced management workload, amongst others. The above findings show that the benefits of LPS implementation in Nigeria are similar to those reported in other parts of the world (Fernando-Solis et al., 2012; Mossman, 2014; Alsehaimi et al., 2009). According to Mossman (2014), bad news early is good news in the LPS approach of managing construction project. This is so because it allows the team to plan and address bad news early. Even with these benefits, there are challenges facing LPS implementation in Nigeria. These include cultural issues and resistance to change, lengthy approval processes, and issues with subcontractors, amongst others (Ahiakwo et al., 2015).

RESEARCH METHODOLOGY

A mixed research design that employed a quantitative cross-sectional survey and qualitative-exploratory approach was used in collecting data from Nigerian construction professionals dispersed across the country. The use of the mixed approach in construction management research has been widely reported in literature (Dainty, 2008). In this study interviews and a survey approach were used to complement each other. The survey instrument was divided into four major sections. The first section sought to know the respondents' background information to validate the reliability of the responses. Section two sought to determine the frequency of occurrence of 15 sources of production flow waste identified from the literature review (Aiyetan and Das, 2015; Emuze et al., 2014; Ralph and Iyagba, 2012; Alwi et al., 2002; Zhao and Chua, 2003). The respondents were also asked to rank some encountered construction practices associated with the LPS as identified from

literature (Daniel et al., 2017; Ballard and Tommelein, 2016; Ballard et al., 2009; Chee et al., 2009; Ballard, 2000). However, these practices were rephrased to facilitate the respondents' understanding. This was done since most of the respondents are not familiar with the technical terms associated with the LPS principles and concepts. The five-point Likert scale was used, with five (5) being the highest and one (1) the least on the scale.

The questionnaires were administered via email to construction professionals in Nigeria who are registered with their professional bodies and have valid email addresses in the online database system. These professional bodies include the Nigerian Institute of Quantity Surveyors, the Nigerian Institute of Civil Engineers, the Nigerian Institute of Architects and the Nigerian Institute of Building. The respondents hold various positions such as construction managers, project managers, quantity surveyors, site managers, project architects, and structural engineers, among others, and they are based in different parts of the country. Construction professionals from academia also participated in the study.

A total of 110 questionnaires were distributed and only 51 responses were received. This represents an aggregate response rate of 46%. Ten (10) respondents participated in the open-ended semi-structured interviews. They comprise five main contractors, three consultants and two academics (See Table 2 for the profile of the interviewees). The open-ended interview questions allowed the respondents to speak their mind on the subject under investigation. The interviews were recorded and transcribed. The results from the surveys and interviews are presented in the next section.

Table 2: Interviewees' profiles

Respondents	**Position**	**Years of experience in Nigerian construction**
Main contractor 01	Project coordinator/Researcher	15
Main contractor 02	Project engineer	20
Main contractor 03	Site engineer	10
Main contractor 04	Construction manager	12
Main contractor 05	Senior project manager	25
Consultant 02	Senior engineer	20
Consultant 03	Project engineer	15
Consultant 04	Resident engineer	22
Academia 01	Senior lecturer	23
Academia 02	Lecturer	10

FINDINGS AND DISCUSSION

Respondents' organisation background

The details of the respondents indicate that 62.5% are from contracting organisations, 20% from consulting and 17.5% are from academia. This shows the responses were not limited to the construction site professionals alone, but also included the consultants and those in academia. This means the study benefits from the current academic knowledge of researchers on non-value adding activities and Last Planner practices. Furthermore, since the majority of the respondents are from contracting organisations, they should be able to provide reliable data for the study considering that non-value adding activities and any means to minimise these will be of interest to them. In terms of respondents' experience in the Nigerian construction industry, the result showed that 70% had over five years of experience. This implies that the respondents have sufficient construction experience in Nigeria, thus information obtained on production flow waste can be adequately relied upon.

Analysis of production flow waste in Nigeria

The study sought to determine the frequency of occurrence of some identified sources of production flow waste from the literature. The factors were measured on a five-point Likert scale ranging from 'very frequently' to 'not all'. Figure 1 shows the results of the analysis of production flow waste in Nigeria.

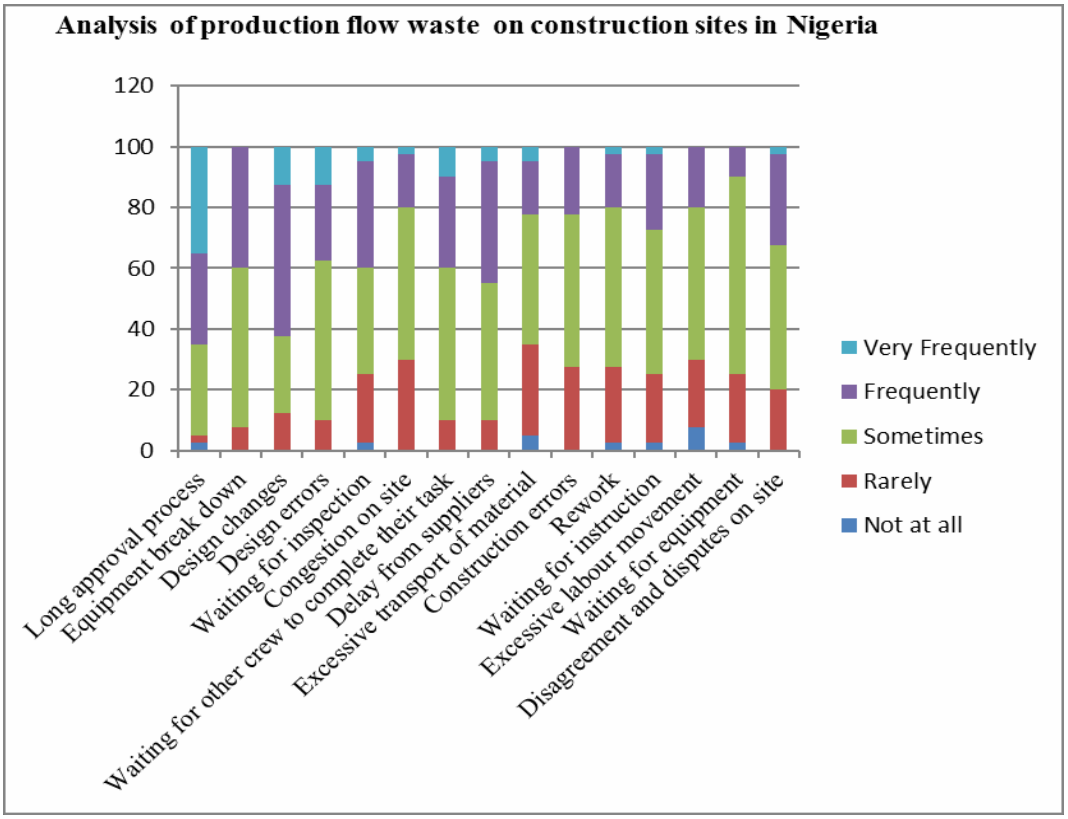

Figure 1: Analysis of production flow waste on construction sites in Nigeria

As shown in Figure 1, it is evident that production flow waste is a common occurrence on construction sites in Nigeria. The result revealed four significant sources of ? production flow waste that occur most frequently in the construction process on sites in Nigeria. They include a long approval process, design changes, design errors, and waiting for another crew to complete their task. Earlier studies such as those by Alwi (2002), Zhao and Chua (2003) and Ralph and Iyagba (2012) also identified waiting for instructions, design changes, design errors, and waiting for other crews to complete their work to be among the factors that affect production workflow on site. This study found that the long approval process is the most frequent cause of production flow waste in the Nigerian construction industry. This finding is consistent with similar findings in a study in Abu Dhabi by Al-Aomar (2012) in which long approval processes ranked second among the top ten waste types in the Abu Dhabi construction industry. Aiyetan and Das (2015) also found that design-related issues contribute to production flow waste on projects in Nigeria. Again, the frequent occurrence of long approval processes in the Nigerian construction industry could be attributed to bureaucratic bottlenecks, especially with public projects; the demand for 'kick backs (bribery); and the lack of transparency and trust in the procurement process (Olusegun et al., 2011; Oyewobi et al., 2011). According to Olusegun et al. (2011), the absence of a clearly defined project scope and the underpayment of consultants in Nigeria contribute to kick back practices. Oyewobi et al. (2011) found that corruption in Nigeria contributes to delays in project approval. This could mean those in the approval process could contribute to this as well since it takes people to cause delays.

To further support this view, the ongoing debate within the International Group for Lean Construction research community put forward a proposal to view bribery and corruption as waste in the construction industry (Stifi et al., 2014). The study suggests that the LPS could be a means of overcoming bribery and corruption in the construction industry because of its potential to support transparency and the development of collaborative relationships among construction stakeholders.

Furthermore, the frequent design changes could be attributed to inadequate project scope definition, the procurement option adopted and constant interference from the client. In Nigeria the most frequently used procurement route is the traditional approach (Ojo et al., 2006). However, drawings are never completed before the commencement of work on site and even when drawings are completed, scope creep and variations due to site challenges may necessitate changes. Morledge et al. (2006) argue that clients are largely responsible for most of the changes that occur to satisfy their needs during construction on sites.. Zhao and Chua (2003) found that project-related factors such as external factors, project features, design features, organisational factors, and management factors influence the occurrence of production flow waste on site.

The impact of these five main causes of production flow waste on productivity and performance improvement in the Nigeria building construction industry cannot be underestimated. There is a need to minimise production flow waste in construction, which can be achieved by adopting lean techniques such as the LPS (Adamu and Howell, 2012). In reality, production flow waste does not only

contribute to cost and time overrun, but also leads to accidents on the site and the underutilisation of human resources on the site (Ralph and Iyagba, 2012). Currently, the productivity loss in the Nigerian construction industry is high. According to Oyewobi and Ogunsemi (2010), loss in labour productivity in Nigeria is in the range of 40% to60%. However, Alarcon et al. (2005) assert that the application of the LPS on some case study projects resulted in an 86% improvement in productivity.

Current planning practices in Nigeria that resemble LPS

The study investigated current site practices that indicate Last Planner practices. The respondents were required to indicate how often they adopted or observed some identified practice that shows a resemblance to the LPS practice by responding to the five-point Likert scale, ranging from 'not at all' to 'very frequently'. The results of the analysis are presented in Figure 2.

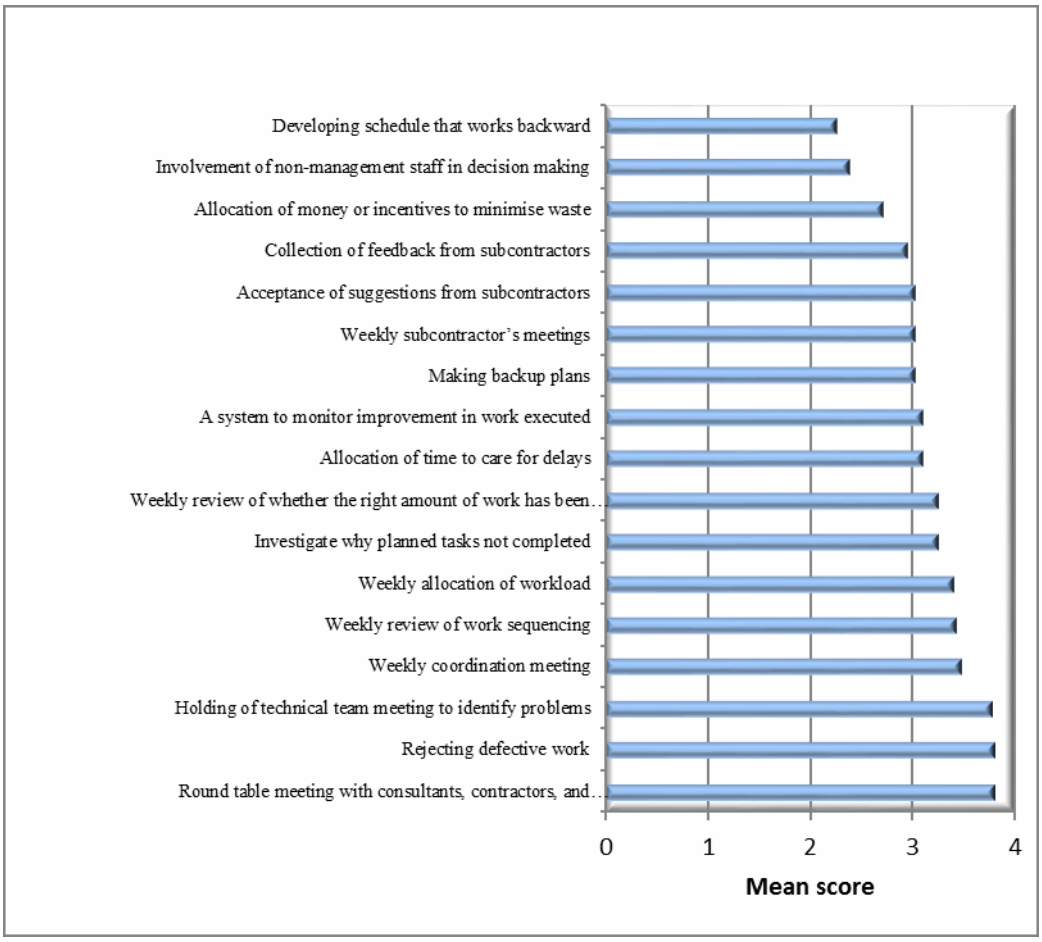

Figure 2: Current planning practices in Nigeria that resemble LPS

The study reveals two frequently used practices that resemble the Last Planner practices indicated in the literature. They include round table meetings with clients,

consultants, contractors and subcontractors and the holding of weekly technical meetings. Having round table meetings with the key stakeholders could be linked to the phase planning or collaborative programming meetings in the LPS (Ballard and Howell, 2003; Ballard, 2000). In the LPS, the phase planning session enables key project participants to agree on the interphase between each activity in the master programme, known as the milestone programme in the LPS, and to agree collaboratively on activity durations. Additionally, the technical meetings frequently held for resolving problems could serve as a platform for carrying out the "five whys" analysis in the LPS process to resolve problems in the production process (Ballard and Howell, 2003).

Since the majority of the respondents claimed to have frequent meetings with clients, consultants, contractors and subcontractors, this could help in encouraging collaboration among the project participants, thus creating a better platform for the implementation of the entire Last Planner System on the project for better outcomes. Researchers have shown that the Last Planner System even helps in managing complex relationships among project team members at all levels for the optimal delivery of the project outcomes (Daniel et al., 2017; Mossman, 2014; Ballard and Howell, 2003). More importantly, when the complex relationship that exists among construction stakeholders is properly managed, this will further reduce production flow waste that might arise during the construction process on site, thus improving productivity and performance. Research has shown that the LPS approach can be used to reduce uncertainty and to create flow in the production process since it has the potential of relating project scheduling with planning, thus enhancing good workflow and reducing variability in the production system (Fernandez-Solis et al., 2012; Ballard and Howell, 2004; Salem et al., 2006).

In addition, the analysis reveals twelve other current practices that resemble the Last Planner System practices and that are sometimes adopted by the respondents. Although these practices are not observed or adopted regularly on construction sites now, the study has shown that such practices already exist in the construction process on sites in Nigeria. This could serve as a good platform for the full implementation of the Last Planner System on construction sites in Nigeria. For instance, Hamzeh and Bergstrom (2010) suggest that for better implementation of the Last Planner System, a framework that encourages teamwork and continuous improvement should be developed by the organisation. Fuemana (2013) asserts that when the LPS is properly implemented, it improves project performance and also increases productivity. However, LPS implementation is still low in the Nigerian construction industry, as only two studies have reported its implementation on case study projects (Adamu and Howell, 2012; Aihaikwo et al., 2013). This implies that for the Nigeria construction industry to benefit from the productivity improvement achievable through the LPS, industry-wide adoption is essential. It is worth noting that even in developed countries industry-wide adoption of the LPS does not exist yet (JØrgensen et al., 2004; Mossman, 2009; Johansen and Walter, 2007).

On the other hand, the study reveals two Last Planner practices that were seldom used in the current practice in the Nigeria construction industry. They include developing schedules that work backwards and involving non-management staff in decision-making. The implication of this is that construction managers, project

managers, site engineers, and site managers may not involve site operatives such as foremen in their planning and decision-making processes on site. This could lead to the generation of more production flow waste on site, since the common understanding needed to create flow in the construction process is absent (Pasquire, 2012). Pasquire (2012) proposed the eighth flow, known as the "common understanding", as one of the pre-conditions that need to be met for smooth work flow in the production process. The danger of not involving all the required stakeholders in the planning process is that it would be difficult to gain their input and commitment to the plan. This will always occur when the plan is thrown at them to perform it. Ballard (2000) argued that in order for site operatives to make reliable promises and be committed to carrying them out, they must be involved in the planning and decision-making process.

The manifestation of production flow waste on construction sites - interview results and discussion

The respondents interviewed were asked to identify how production flow waste manifests on construction sites and the factors that contribute to it. One of the interviewees identified the inconsistent use of site operatives that results in error and rework, and bringing equipment to site when not needed due to the over-ambition of contractors' project managers. The frequent change of site operatives could be due to the nature of construction projects. Over the years the construction industry has been identified as one of the sectors that keeps hiring and firing its workforce, thus resulting in low employee retention (Aguenza et al., 2012). However, research by the Construction Industry Institute has shown that contractors with an employee retention of rate of 80% complete projects on time and record better project performance (Ramos, 2014). This could be due to the common understanding the workers or site operatives develop from working with one another over a period of time. Similarly, another research participant stated that:

> "*In Nigeria we disagree to agree dispute and disagreement on site, delay in transporting material to site and waiting for equipment are among the most common incidences of production waste flow on site*" [Resident engineer].

The delay in waiting for material and equipment could be due to a lack of adequate planning of the production process. For example, in the LPS this problem can easily be addressed in the lookahead planning and in the make work ready meetings, where provisions are made for tasks to be properly screened before moving into the work phase (Ballard and Tommlein, 2016; Ballard and Howell, 2003). Furthermore, a construction manager working for a contracting organisation observed that long approval processes and the excessive use of inexperienced workers contribute to production flow waste on construction sites in Nigeria. The interview results affirmed the findings of the questionnaire survey on the manifestation of production flow waste on construction sites in Nigeria. Other factors identified as contributory factors to production flow waste by the interviewees include a lack of adequate planning, a lack of team work, disturbance from the local community, and not allowing enough time for planning before the commencement of work on site, among others.

The study reveals that all the respondents agreed that the lack of adequate planning and the use of inexperienced workers contribute to the incidence of production flow waste on site. It is worth noting that the occurrence of any of this waste has a cumulative effect on the production process. When one operation is delayed, it will affect the entire production or construction process, thus leading to a lack of flow in the entire process and an increase of production flow waste (Koskela, 1999; Ballard, 2000). The occurrence of these causes of production flow waste on site will no doubt negatively affect the productivity and performance improvement on site in Nigeria. However, these can be addressed through proper planning based on the LPS principles. Research has shown that value can be created through proper planning and defining what every tradesman or operative on site is required to achieve using the LPS principles (Ballard and Tommelein, 2016; AlSehaimi et al., 2014; Ballard, 2000). This could help in eliminating rework and error, among others, thus improving productivity on site.

Current planning and control practice and the LPS practice-interview results and discussion

The interviewees were asked to describe the current planning and control practice on their projects. One of the study participants, a project engineer, stated that:

> *"Currently we adopt the following planning and control measures on our projects; material delivery schedules, planning work weekly, checking of the quality of work done and motivation of workers*".

The above statement shows that there are approaches used in the planning of construction activities on the site. However, the lists tend to show that the planning and control measures are more of a stand-alone process rather than an integrated approach. In the LPS planning and controlling of the production system is seen as an integrated process (Ballard and Howell, 1997). However, another main contractor, a project engineer and researcher who claimed to be knowledgeable in lean construction as a result of his research, stated that:

> *"We create time for various meetings such as 6 weeks lookahead planning with project team, constant planning and review of work with other stakeholders, and early meeting to address problems with the project. Through this planning approach we were able to reduce wasteful processes on the project.* "

When asked whether his knowledge of lean construction had in any way influenced the current practice, he said, "Definitely, yes! I didn't do this many years ago with my worker[s], but now enjoy doing it". Again, this shows the importance of having awareness and knowledge of lean construction principles and understanding its potential in reducing waste and improving productivity. However, the research shows that there is no formal procedure for doing this across the industry.. Furthermore, the interview results revealed that the planning strategies used reduced

wasteful processes on site. The respondent explained that the six weeks' lookahead planning and weekly work review with those doing the work enabled the team to deliver a task as planned. Koskela (1997, 2000) found that non-value adding activities could be minimised through effective planning and control of the construction process. This means effective planning and control would reduce production flow waste on site.

Prospect of minimising production flow waste through the LPS

The research participants were asked to identify how to minimise production flow waste on construction sites. A respondent, a senior lecturer, suggested that team work, early involvement of subcontractors, good project planning, good communication among the different operatives, discipline among site operatives, visual management and simulation using 3D, and stakeholder management would minimise production flow waste on site.

Similarly, another respondent, a construction manager, proposed that production flow waste can be minimised by "putting into practice what is planned", using trained and qualified site operatives, communicating and collaborating among workers on site, constantly monitoring and checkingplans, working in one room to reduce waiting time, and being disciplined in the use of the planning approach. Other measures for minimising production flow waste on site suggested by other respondents include encouraging team working among project teams, training and proper scheduling of work by professionals, constant reviewing work, and creating effective coordinating units in the organisation. All ten respondents interviewed firmly believed that effective planning, team work in planning, frequent reviewing work and planning ahead can minimise the incidence of production flow waste.

Some of the approaches suggested by the respondents as a means for minimising production flow waste can be matched with some LPS and lean construction principles. For instance, some of the respondents suggested effective planning and collaborative approach in planning, team working in planning, frequent reviewing the plan, constant monitoring, checking, using one single room, and communicating with other workers on the project, among others. Studies have found that production flow waste can be minimised through a systematic planning approach, such as allowing work to commence at optimal conditions, reducing task variability risk, emphasizing continuously improving task execution, avoiding loss of time in the production process and encouraging team work (Koskela, 1999; Howell and Ballard 1998).

This implies that LPS has the potential to minimise production flow waste in the construction process because of its ability to reduce uncertainty and risk inherent in the production process (Howell and Ballard, 1998). However, the traditional approach to planning based on the critical path method (CPM) lacks the capacity to manage the uncertainty inherent in the production process on site (Khanh and Kim, 2014). It has been observed that the inability of the traditional planning approach to manage the uncertainty in the production process on site is among the major contributory factors to production flow waste on site and the low predictability of engineering projects (Daniel et al., 2014; Khanh and Kim, 2014).

CONCLUSIONS AND RECOMMENDATIONS

The purpose of the current study was to determine how production flow waste manifests on construction sites and explore the prospect of minimising production flow waste and improving productivity on construction sites in Nigeria using the Last Planner System practice. The study has identified that production flow waste is prevalent in the construction process, based on the consensus of Nigerian construction industry professionals' perceptions. It manifests in various forms with long approval processes, design changes, design errors, and waiting for other crews to complete their task being the most prevalent. In addition, factors such as the use of inexperienced site operatives, lack of adequate planning, lack of team work, and frequent changing site operatives are among the factors that contribute to the occurrence of production flow waste on site.

The study found that there are practices in the Nigerian construction process that show resemblance with the Last Planner such as having frequent round table meetings between main contractors and subcontractors, holding frequent technical meetings to review problems, and having lookahead meetings and weekly review meetings with project team members. However, there is no formal procedure for doing this across the business and the meetings are also unsystematic. Nevertheless, the findings confirmed the presence of some elements of LPS practice adopted in the construction process which could be used as a basis for the implementation of the Last Planner System.

The study found that some of the measures suggested for minimising production flow waste on the construction site reflect some LPS principles. The measures suggested include adequate planning, team work in the planning of tasks, constantly reviewing work, communicating effectively among the different operatives, maintaining discipline among site operatives, and creating an effective coordinating unit. These suggestions demonstrate that the LPS has the potential to minimise production flow waste on construction sites in Nigeria, thus improving the sector performance and productivity.

The study concludes that the LPS has the potential to minimise production flow waste on construction sites in Nigeria and recommends that, since the structure for the LPS is on the ground, and its benefits have been reported, Nigerian construction professionals should embrace the full implementation of the LPS. A limitation of this study is that the majority of the evidence is based on the construction phase. A future study could explore the application of the LPS in the design and pre-construction stages.

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