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Quantifying the Impact of Work Environment Factors on the Variability of Labour Productivity in Wall Plastering

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Abstract: Variability in labour productivity is a performance inhibitor and a determinant of effective and ineffective projects. It has hampered the intercomparison of construction projects and the accurate forecasting of project duration and cost. This study chose wall plastering activities as a case study. This study aims to quantify the impact of work environment factors on the variability of labour productivity. Data were collected using direct site observations and structured questionnaires. The results revealed that "Waiting for materials" (62.4%), "Being on the job but not working" (52.6%) and "Work area congestion" (52.5%) all had negative effects on labour productivity variance. Other negative factors include "Rework" (51.7%), "Waiting for tools/equipment" (51.1%), "Waiting for information" (47.2%) and "Weather changes". The overall average daily productivity was 1.268 whr/m^2, baseline productivity = 0.993 whr/m^2 and variation in daily productivity = 22.08%; where whr refers to work hours. The findings identified significant work environment factors and quantified their impacts on labour productivity variability in plastering activity. The results indicate that work environment factors during work in progress significantly impact the variability of labour productivity in plastering work and ample consideration should be given to its effects.

Keywords: Labour productivity, Variability, Work environment factors, Masonry construction, Plastering work

INTRODUCTION

In a competitive business environment such as the construction industry, improving the labour productivity of the construction workforce is crucial to the survival of any construction firm, as labour costs typically account for 30% to 50% of the project's total cost (Jakas and Bita, 2012).

Labour productivity is often estimated and priced based on the time required to accomplish each project component. During on-site production, work environment factors come into the picture, interfering with or disrupting work progress. As a result, fluctuations in daily labour productivity occurs. Labour productivity variability is the difference in daily, weekly or monthly labour output within and among gangs (Thomas and Sudhakumar, 2013). It is an inhibitor of performance and it determines effective and ineffective projects. Variability induces impact and unexpected conditions, making project goals unstable and obscuring the means of achieving them (Gerek et al., 2016).

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Previous studies have identified several significant factors affecting the construction workforce's labour productivity variability, including a lack of materials, incompetent supervisors, inadequate tools and equipment, construction rework and confusing instructions (Makulsawatudom, Emsely and Sinthawanarong, 2004; Odesola, Okolie and Nnametu, 2015; Gopal and Murali, 2015; Rao and Sudhanva, 2017). These studies show considerable differences in labour productivity in operations such as block/brickwork, concrete placement and wall plastering.

Few studies have investigated the effects of the foregoing factors on labour productivity variability in specific work environments, trades/crafts and projects. However, most of these research adopted questionnaires and activity sampling methods to collect data, but they lacked information on the craftsmen's productive time (Shashank, Hazra and Nathpal, 2014; Talhouni, 1990). Thus, this study seeks to identify work environment factors causing variability of labour productivity in wall plastering, measure labour productivity output using time study and qualify the impact of the work environment factors identified.

LITERATURE REVIEW

Labour Productivity

Previous studies have established that no universally accepted definition of productivity exists (Hanna et al., 2007; Swapnil and Biswas, 2015; Gerek et al., 2016; Rao and Sudhanva, 2017). Various definitions have been proposed based on the measurement method, the measurement or study's objective and the end-users of the data collected from the measurement (Agbo, 2014).

In these definitions, productivity is viewed as a measure of the outputs obtained due to the combination of inputs (Rao and Sudhanva, 2017; Agbo and Izam, 2019). Based on this standpoint, two general measures of productivity were considered: total factor productivity (TFP) and partial factor productivity (PFP) (Gerek et al., 2016). TFP is the productivity calculated when all inputs are accounted for, whether tangible or intangible (Sweis et al., 2009). The TFP is used to optimise the resource inputs required to produce the desired outcome. The TFP is calculated as follows:

TFP = Total outputs/Total input resources Eq. 1

PFP or unit rate productivity, on the other hand, is frequently referred to as labour productivity. It aims to build a connection between outputs and a subset of inputs. When focusing on the effectiveness and efficiency of a small number of input resources, the PFP becomes the most suitable method for measuring productivity (Russel and Taylor, 2009).

PFP = Output (m^2)/ Input (h) Eq. 2

PFP= Man hour (h)/ Output (m^2) Eq. 3

Most contractors prefer to use Equation 3, which is the inverse of Equation 2. The reason is that most contractors are more concerned with the number of hours a worker works every day because they pay their workers by the hour (Gopal and Murali, 2015; Odesola et al., 2015). Hence, this study adopts Equation 3 because

65% of construction firms pay their workers by calculating the number of hours worked out of eight working hours per day.

Productivity Measurement

Productivity measurement is a performance indicator that measures the efficiency of a construction firm to current input resources such as labour, materials, and equipment, among others (Ali, Smith and Choon, 2010; Chan and Kaka, 2010). Several techniques of productivity measurement are available. The choice of method(s) depends on the purpose of the research, the type of data required and the resources available (Swpnil and Biswas, 2015).

Noor (1992) grouped these methods into continuous observation and intermittent observation. One way to minimise the influence of factors affecting labour productivity output on construction sites is by obtaining quantitative site data on factors affecting labour productivity using appropriate productivity measurement methods on site. The data gathered via accurate on-site measuring methods can be utilised to model productivity loss and its impact (Chan and Kaka (2010).

Olomolaiye, Wahab and Price (1989) evaluated the productivity of building artisans in wall plastering in Lagos, measured their labour output through work sampling and reported that the average daily productivity was 9.3 m^2, based on eight work hours per day. However, the author's findings did not indicate any variability.

Similarly, Odesola et al. (2015) investigated labour productivity in wall plastering in six states in southern Nigeria, using direct continuous observation on the site. According to the study's findings, the average daily labour productivity was 2.68 m^2/h. Additionally, significant variation exists within and among gangs and the various projects studied. Similarly, Udegbe (2005) examined labour force output in the plastering industry in Edo State, Nigeria and discovered an average daily labour output of 16.65 m^2.

Labour Productivity Variability

Labour productivity variability is the differences in daily, weekly, or monthly labour output or labour productivity within and among gangs (Swapnil and Biswas, 2015). It is a well-established fact that labour productivity fluctuates throughout an activity (Thomas and Sudhakumar, 2013). The variance results from the existence of work environment factors during the execution of the activity, which can be classified as management factors such as a lack of material, overcrowding in workspaces, rework and gang composition. Additionally, technical factors such as incomplete design, inexperience, supervisor incompetence and individual factors such as skill level differences, fatigue and other behavioural factors that influence workers' performance, also contribute to the output rate variation observed in practice (El-Rays and Moselhi, 2001; Abdel-Razek, Elshakour and Abdel-Hamid, 2006).

Factors affecting productivity vary from gang to gang, site to site, project to project and from day to day (Talhouni, 1990; Rao and Sudhanva, 2017). According to Idiake (2014), artisans' output variations on construction sites are caused by a lack of experience, competence and overtime work lasting more than 30 min. He calculated that wall plastering generated a variance of 39.56%.

Song and Abou-Rizk (2008) stated that design, management, working hours, congestion and weather would increase variability in performance and make productivity comparison almost impossible. The cumulative effect of these various factors causes random and systematic disturbances to performance in performance-intensive operations (Mohammed and Mosehi, 2005). If the effect of these factors is discounted from the actual performance, there will be a smooth and non-variable performance curve.

According to Ofori-Kuragu, Baiden and Edum-Fotwe (2010), productivity variation among individual artisans was 4.1% (60%) on selected housing sites with a similar design. Similarly, Talhouni (1990) discovered that the variability in bricklaying and plastering production was 2:3.1 (+ 39%) and that a bricklayer gang could produce twice the average output. However, the investigation took no consideration of design differences and interference factors. The author noted considerable variability on-site, particularly on construction sites where gangs worked.

Causes of Labour Productivity Variability

Faridi and El-Sayegh (2006) developed a framework for a labour-intensive forecasting model on construction sites. They outlined factors causing variation in productivity into project-specific, project-dependent and region-dependent. These factors can be classified as physical and non-physical characteristics of projects that affect construction labour productivity. Project size, location, building height and the degree to which engineering overlaps construction and project administration by a strong project management team are the physical and non-physical characteristics described by Enshassi et al. (2007). In a similar vein, Thomas and Horman (2006) listed the significant causes of variability in brick/block layers' productivity as site delays, variation in the length of working days and gang composition.

Frimpong, Oluwoye and Crawford (2003) defined site delay as a situation where the workforce is either stopped from working or is functioning inefficiently. This situation usually arises during a project's construction phase. Delays have a substantial impact on construction employees' productivity. Their effect varies depending on the type of construction delay(s) that occur (Hegab and Smith, 2007).

Construction site delays have been described in a variety of ways by different researchers. Hegab and Smith (2007), for example, distinguished between intrinsic and extrinsic delays. Intrinsic delays occur due to a trade's operational characteristics or the features of a particular construction site. Examples include waiting for the scaffolding installation and delivering materials from the stockpile to the construction site. On the other hand, extrinsic delays are induced by nature and over which management has no control, such as inclement weather and natural disasters. Thomas and Horman (2006) classified the significant causes of construction site delay as weather, material, plant/tools, sequence, rework and instructions.

Hanna, Taylor and Sullivan (2005) examined the effects of longer working hours on workers' output. They concluded that increasing the number of hours worked per day per week would decrease productivity.

According to Goodrum, Zhai and Yasin (2009), increasing the length of the working day to 12 hours or more each week will result in a 55% decrease in production. Naturally, when workers are required to work longer than their regular working hours per day or week, fatigue sets in, resulting in a diminishing return on their output (i.e., decreased production).

Hanna et al. (2007) examined the man-hours necessary to construct individual housing units in Ireland. While appraising the block laying process, they discovered that the optimal gang size for man-hours required per individual block was two block layers and one labourer. Their investigation revealed that the larger the gang size, the more man-hours per house are required. However, it is crucial to note that Hanna et al. (2007) recommend a gang size of 2:1 (block layer to the worker) for walls less than 1.4 m in height.

RESEARCH METHOD

This study employed a mixed strategy to collect data in order to meet the research objectives. This technique involved two types of data: quantitative data collected using a structured questionnaire and qualitative data obtained by direct continuous site observation on-site.

Population and Population Sampling

The study population is any group of persons, objects, or institutions that exhibit one or more of the research characteristics (Bernold and Lee, 2010). The study population consists of all registered Estate Developers in Abuja who currently have on-site projects. The Federal Capital Development Authority (FCDA) provided a list of registered estate developers, which shows only 27 registered contractors with ongoing projects in Abuja. These 27 contractors comprised the study population, from which the sample size was calculated. The following formula was used to determine the sample size for this study:

$$M = \frac{Z^2 \times P^* \times (1 - P^*)}{\varepsilon^2} \quad \text{Eq. 4}$$

$$M = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.05^2} = 385$$

$$N = \frac{M}{1 + \frac{M - 1}{N}}$$

$$N = \frac{385}{1 + \frac{385 - 1}{27}} = 25 \quad \text{Eq. 5}$$

where,
M = Sample size of the unlimited population,
N = Sample size of the limited population,
n = Sample population to be studied and
Z = maximum error of the point estimate = 0.05.

DATA COLLECTION AND ANALYSIS

A time study was used to collect data using questionnaires and direct site observation. Utilising these two methods became necessary because the data collected by questionnaire was intended to supplement the data gathered through direct site observation. A structured questionnaire was designed to elicit information about the factors affecting plasterers' labour productivity from project managers, engineers, supervisors and plaster masons. Eight questionnaires were distributed at some sites, while seven were administered at others, depending on the number of respondents willing to reply to the questions. In total, 190 questionnaires were distributed, with 152 duly completed and returned. The information from the questionnaires was analysed using the relative importance index (RII).

$$RII = 5n_5 + 4n_4 + 3n_3 + 2n_2 + n_1/5(n_1 + n_2 + n_3 + n_4 + n_5) \times 100 \qquad \text{Eq. 6}$$

In direct continuous observation, the first step was to identify 25 ongoing public building projects in the study area which use a standard sandcrete block of 225 mm × 225 mm × 450 mm, a prototype and all plastering work were on the ground floor. The researcher and his observers were then granted free access to the site after receiving official clearance from the client and contractors. Before the commencement of the study, the workers to be observed were assembled on-site and the purpose of the observation was explained to them to avoid the "Hawthorn" effect, that is, workers working diligently because they are being observed. To avoid bias, when a specific gang is selected, it is kept hidden that they are being watched while on-site research assistants make observations. An average of 28 observations was made on each of the sites during the 30 days observation period.

Each day, the research assistants arrived 20 min before the start of work. They maintained a safe distance from the monitored gang to avoid distraction and observe instances of late starts and time errors. At each site, a gang of two individuals—a mason and a labourer—was observed. The site observation period began on 1st January 2020 and ended on 1st February 2020. All observations were made most directly feasible. This method entailed taking brief notes on rough paper where necessary and later transcribing them on the appropriate data collection sheets.

To make the approach less tedious, observers were instructed to report only unproductive time (time not spent on direct work or contributory work by labourers). Each time a record of unproductive time is made, the factors that contributed to the disruption or interruption are noted, along with the duration it persists. The total time for each workday was calculated by inquiring about the foreman's daily hours of operation. At the end of each workday, daily labour output, daily productivity and variability were calculated using a direct physical measurement of work completed after the day's work using a productivity formula. The research assistants repeated the technique of observing and calculating labour output and daily productivity.

$$\text{Labour productivity} = \text{Input hours}/\text{Output} \qquad \text{Eq. 7}$$

$$\text{Coefficient of productivity variation (CPV)} = P_V \times 100/\text{Baseline productivity} \qquad \text{Eq. 8}$$

RESULTS AND DISCUSSION

Productivities and Output Quantities in Wall Plastering

Table 1 shows the results of productivity measurement in wall plastering in Abuja, Nigeria. The expected average daily output quantities and daily productivity as shown in the table represent the minimum standard of daily output quantities and daily productivity in wall plastering for a gang of two members: a mason and a labourer, respectively, 22 m^2 and 0.727 whr/m^2; where whr refers to work hour. This information was gathered from site engineers, supervisors and foremen who were directly responsible for monitoring the day-to-day labour output and productivity of construction craftsmen on site, particularly those on the monthly payroll of the contracting company.

Table 1. Average productivity and output quantities for wall plastering activity

Project No.	Expected Average Quantities (m^2)	Actual Average Daily Quantities (whr/m^2)	Expected Average Daily Productivity (whr/m^2)	Actual Average Daily productivity (whr/m^2)	Cumulative Productivity (whr/m^2)	Baseline Productivity (whr/m^2)
1	22	18.067	0.727	0.885	0.823	0.797
2	22	17.536	0.727	0.912	0.892	0.849
3	22	17.500	0.727	0.914	0.886	0.861
4	22	13.700	0.727	1.168	1.120	0.967
5	22	14.928	0.727	1.148	1.034	0.935
6	22	15.100	0.727	1.059	0.960	0.883
7	22	14.429	0.727	1.109	1.005	0.900
8	22	14.214	0.727	1.125	1.063	0.920
9	22	19.040	0.727	0.695	0.634	0.538
10	22	18.145	0.727	0.882	0.816	0.779
11	22	17.340	0.727	0.922	0.881	0.789
12	22	15.810	0.727	1.012	0.973	0.830
13	22	14.660	0.727	1.091	0.984	0.827
14	22	17.181	0.727	0.931	0.895	0.745
15	22	19.250	0.727	0.831	0.790	0.698
16	22	15.770	0.727	1.014	0.930	0.815
17	22	16.121	0.727	0.992	0.940	0.812
18	22	22.600	0.727	0.707	0.680	0.595
19	22	30.500	0.727	0.503	0.500	0.410
20	22	23.000	0.727	0.695	0.634	0.590

(*Continued on next page*)

Table 1. *Continued*

Project No.	Expected Average Quantities (m^2)	Actual Average Daily Quantities (whr/m^2)	Expected Average Daily Productivity (whr/m^2)	Actual Average Daily productivity (whr/m^2)	Cumulative Productivity (whr/m^2)	Baseline Productivity (whr/m^2)
21	22	17.311	0.727	0.924	0.901	0.800
22	22	18.400	0.727	0.869	0.812	0.735
23	22	17.950	0.727	0.890	0.825	0.820
24	22	21.551	0.727	0.732	0.6	0.585
25	22	18.650	0.727	0.857	0.803	0.770
Overall average		17.33		0.916	0.808	0.712

The average daily labour output and productivity, according to this study, were 17.33m^2 and 0.916whr/m^2, respectively. These results were slightly less than the minimal level established in Abuja for wall plastering. On the contrary, the results indicated that a few individual projects' average daily labour output and labour productivity (Projects 18, 19, 20 and 24) exceeded the Abuja minimum standard for wall plastering. This analysis suggests that the project managers of better-performing projects had better managerial abilities than the poorly performing projects. When a project is appropriately managed, it results in increased labour production, improved performance and low variability; when managed poorly, it results in decreased labour output, poor performance and high variability (Gerek et al., 2016).

According to this study, Project 19 was the best managed and performed due to its low variability and higher labour productivity. Similarly, this research revealed that Project 4 was the worst-performing and managed project due to its high variability and low labour production. The overall and baseline productivity averages were 0.808 whr/m^2 and 0.712 whr/m^2, respectively. The trends of these productivities follow average daily productivity and daily labour output. The labour productivity and baseline productivity trend are depicted in Figures 1 and 2 for Projects 19 and 4. The baseline productivity was computed using the following formula:

Baseline productivity = Summation of work hours/output quantity in n workdays

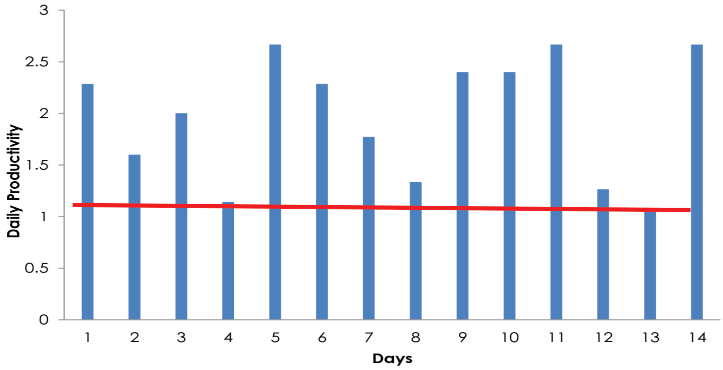

Figure 1. The best-performing and best-managed project (Project 19)

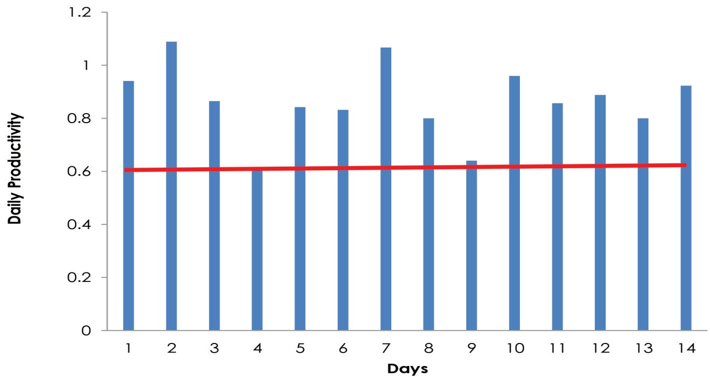

Figure 2. The worst performing and worst managed project (Project 4)

Idiake (2014) conducted a similar analysis on wall plastering in Abuja and discovered that the average daily productivity of masons varies between 0.753 whr/m^2 and 1.415 whr/m^2. Similarly, Swapnil and Biswas (2015) examined labour productivity in wall plastering and discovered an average daily output of 1.31 m^2/hr.

Although the average daily labour output and daily productivity determined in this study were less than the minimum standard, they were comparable to those found in previous studies. Hence, the daily average labour output of 17.33 m^2 and daily productivity of 0.916 whr/m^2 could be used to estimate wall plastering in Abuja.

Labour Productivity Variability in Wall Plastering

Table 2 shows the result of the variability of labour productivity. The coefficient of productivity variation (CPV) was computed for all the projects investigated using the following formula:

$$CPV = P_V \times 100/\text{Baseline productivity}$$

Table 2. Productivity and coefficient of variation in plastering activity

Project No.	Actual Average Daily Productivity (whr/m^2)	Baseline Productivity (whr/m^2)	Coefficient of Productivity Variation (%)
1	0.885	0.797	35.6
2	0.912	0.849	16.7
3	0.914	0.861	23.9
4	1.168	0.967	63.3
5	1.148	0.935	25.4
6	1.059	0.883	30.0
7	1.109	0.900	36.1
8	1.125	0.920	43.3
9	0.695	0.538	21.6
10	0.882	0.779	25.6
11	0.922	0.789	23.0
12	1.012	0.830	15.0
13	1.091	0.827	13.6
14	0.931	0.745	17.6
15	0.831	0.698	9.6
16	1.014	0.815	15.6
17	0.992	0.812	26.2
18	0.707	0.595	17.5
19	0.503	0.500	8.76
20	0.695	0.590	10.1
21	0.924	0.800	23.3
22	0.869	0.735	8.9
23	0.890	0.820	11.4
24	0.732	0.585	13.9
25	0.857	0.770	20.6
Overall average	1.268	0.963	22.08

The CPV results revealed that the rate of labour productivity variability in wall plastering ranges from 8.76% to 63.3%, with Project 4 having the highest percentage of variability of 63.3% and Project 19 having the lowest percentage of variability of 8.76%. The overall average variability was 22.08%.

According to Thomas and Sudhakumar (2013), a higher value of labour productivity variability is a sign of poor performance, which is a pointer to poor management of such projects. On the other hand, a lower value of variability of labour productivity is a sign of better performance and better management of such projects.

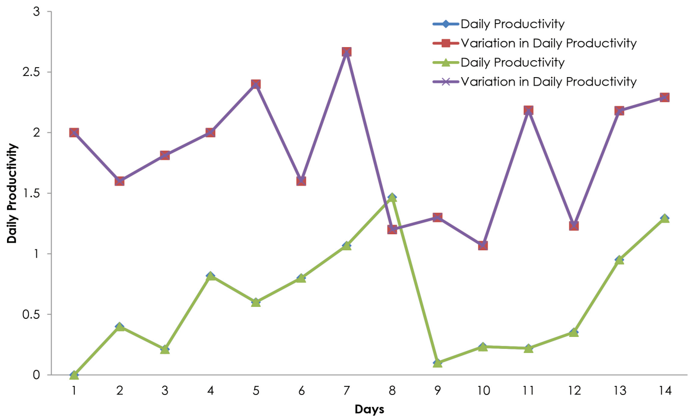

Figure 3. The best-performing and best-managed project (Project 19)

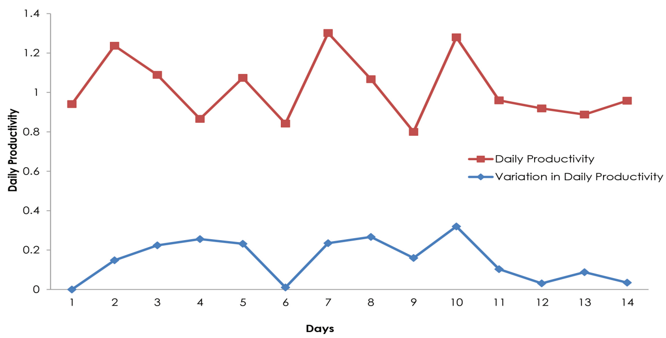

Figure 4. The worst performing and worst managed project (Project 4)

The findings of this study on average daily labour productivity variability were similar to those of previous studies. For instance, Swapnil and Biswas (2015) reported that the coefficient of labour productivity variability in wall plastering ranges from 35 to 147.5%. Furthermore, Idiake (2015) reported that the coefficient of labour variability in wall plastering in Abuja was 28.26%. He equally observed that the significant causes of variability of labour productivity of craftsmen on construction sites are interruption (a delay that lasted not more than two hours) and disruption (a delay that lasted above two hours). Figures 3 and 4 illustrate the trend of labour productivity variability for Projects 19 and 4, respectively. The movement of the trend reveals a rise and fall pattern.

Work Environment Factors Responsible for Labour Productivity Variability in Wall Plastering

A checklist of 25 work environment factors drawn from previous studies was presented to respondents who worked as plasterers on the construction sites sampled. They were instructed to tick, appropriately, the factors that affect their labour output and labour productivity.

On average, 15 factors were ticked as factors affecting their labour output and labour productivity. These variables were similar to those identified in prior research (Thomas et al., 2002; Thomas and Horman, 2006; Vaishant and Kansal, 2014). The ranking of the variables according to their severity revealed that waiting for materials came in first place on the ranking scale, with a 60.6 importance index. This figure was followed by waiting for instruction and rework, both of which had an important index of 57.24 and 56.69. Accident was ranked as the least influential factor by the plasterers. These findings corroborate those of Udegbe (2005).

Table 3. Plasterers' perception of work environment factors' effects on productivity

Factors	1	2	3	4	5	Total No.	Index	Ranking
Waiting for materials	28	22	20	30	20	120	60.69	1
Waiting for instruction from foreman/engineer	37	18	19	28	18	120	57.24	2
Work redone	41	17	18	27	17	120	56.69	3
Incompetent supervisor	43	17	17	26	17	120	54.83	4
Inefficient/breakdown of equipment	47	15	16	26	16	120	53.45	5
Late and un-cleared information from the foreman/engineer	51	14	15	25	15	120	51.90	6
Waiting for other crew	55	13	14	24	14	120	50.17	7
Unexplained movement of gang members	59	16	15	20	10	120	45.86	8
Inefficient/shortage of tools	63	15	14	19	9	120	44.13	9
Gang ratio	69	14	12	18	7	120	41.38	10
Weather changes	73	13	11	17	6	120	39.66	11
On the job but not working	82	12	8	14	4	120	35.52	12
Interference from other crew	86	11	7	13	3	120	33.79	13
Congestion of work area	95	8	5	11	1	120	30.17	14
Accident	102	7	3	8	0	120	27.71	15

Quantifying the Impact of Work Environment Factors on Labour Productivity Variability in Plastering Activity

In order to quantify the impact of work environment factors on labour productivity variability in wall plastering activity, a multiple regression model was developed. Multiple regression allows a researcher to predict *Y* scores based on several *X* scores. Hence, the multiple regression model was used to predict the relationship (impact) between work environment factors and labour output in wall plastering. In other words, the effect of X_1, X_2, X_3 … and X_{15} on the variability of *Y* was predicted using *Y*'s scores.

The model is in the following structure:

$$Pav - Pbl = Var - Pbl + PL_1X_1 + PL_2X_2 + PL_3X_3 + PL_{15}X_{15}$$

where,

Pav	=	Average daily productivity,
PbL	=	Baseline productivity,
Var	=	Average variation in daily productivity,
PL_1 PL_2 PL_3	=	Loss of productivity due to X_1 X_2 X_3 and
$X_1X_2X_3$	=	Work environment factors cited during the workday.

To determine the model's fitness, the preceding model was subjected to a statistical test. As indicated in Table 4, the coefficient of determination was $R^2 = 0.636$, $F(15, 137) = 6.201$ and DW = 1.346 (5% level of significance). This demonstrates that the model can account for 63.6 % of labour productivity variability for wall plastering and other masonry trades. The model's *F*-statistic (ANOVA) indicated a high degree of fit, indicating that the model is statistically significant at the 5% ($p = 0.05$) level of significance. The Durbin-Watson value of 1.346 suggests that the autocorrelation between the variables is statistically significant.

Table 4. Model summary of regression model

R^2	*F* Change	df1	df2	Sig. *F* Change	Durbin-Watson
0.636	6.201	15	137	0.0005	1.346b

Multiple regression analysis was performed on the average variation of daily productivity of the plasterers and the work environment factors using the regression model developed in this study.

The analysis revealed that waiting for material accounted for 62.4% of the variability in labour productivity changes in plastering work ($t = 2.857$, $p = 0.006$), while being on the job but not working accounted for 52.6% of the variability in labour productivity changes in plastering activity ($t = 2.836$, $p = 0.010$). Following that, congestion of the work area accounted for 52.5% of labour productivity change in plastering work ($t = 2.180$, $p = 0.011$), followed by work re-done with 51.7% labour productivity variability and waiting for tools and equipment at 51.1% ($t = 2.660$, $p = 0.150$).

Other variables included waiting for information, which accounted for 47.2% of the variability change ($t = 2.337$, $p = 0.031$), weather, which also accounted for 42.1% of the variability change ($t = 2.869$, $p = 0.034$), interference with 37.2% of the variability change ($t = 2.162$, $p = 0.046$), unexplained movement, which accounted for 32.0 % (t = 2.266, p = 0.050) and gang size composition that accounted for 31.0% variability in plastering work.

During the workday, other work environment factors cited included supervision, which accounted for 23.1% of the variability in labour productivity, waiting for other crew members, which accounted for 5%; accidents, which accounted for 11%, plant/equipment breakdown, which accounted for 21.0 % and waiting for instruction, which accounted for 21.6%. The effect of these factors on variability was statistically insignificant and thus negligible. This means that while these factors have a minimal effect on the variability of labour productivity in wall plastering in this study, they may considerably affect other masonry construction activities such as blockwork and concrete work.

Table 5. Multiple regression analysis of work environmental factors on plasterers' productivity

Environmental Factors	Unstandardised Coefficients		Standardised Coefficients	*T*	Sig	Remarks
	B	Std. Error	Beta			
Waiting for materials	2.399	2.992	0.624	2.857	0.006	Significant
Unexplained movement	–0.264	2.191	0.320	2.266	0.050	Significant
Supervision	1.376	1.096	0.231	1.256	0.220	Not significant
Weather	1.170	1.346	0.421	2.869	0.034	Significant
Waiting for tools.	2.498	1.339	0.511	2.660	0.015	Significant
Work redone	1.726	1.292	0.517	2.739	0.013	Significant
Waiting for other crew	0.317	1.361	0.052	0.233	0.818	Not significant
Interference	0.483	1.531	0.372	2.160	0.046	Significant
Waiting for information	3.593	1.538	0.472	2.337	0.031	Significant
Congestion	0.756	1.460	0.525	2.18	0.011	Significant
Accident	0.733	1.376	0.117	0.532	0.600	Not significant
Gang size/ composition	1.649	0.781	0.310	2.112	0.041	Significant
Plant/equipment breakdown	0.003	0.001	0.210	2.142	0.052	Not significant
Waiting for instruction	1.468	1.199	0.216	1.225	0.233	Not significant
Staying on the job but not working	3.591	1.266	0.526	2.836	0.010	Significant

CONCLUSION

This study investigated the impact of work environment factors on labour productivity variability in wall plastering. It was concluded that there is significant labour productivity variability in plastering activity for projects surveyed. The causes of variability were ascribed to the presence of certain work environment variables that interrupt (cause a delay of between one hour to two hours) and disrupt (cause a delay of more than two hours) work progress. It was also observed that factors such as "Being on the job but not working" (62.4%), "Congestion of work areas" (52.6%), "Waiting for materials" (52.5%), "Rework" (51.7%) and "Waiting for tools" (51.1%) accounted variability changes in labour productivity. The regression model developed was statistically validated and shown to be fit to hold the variability of labour productivity at 63.6 %.

The findings from the study contributed to the body of knowledge theoretically and practically by identifying critical work environment factors, measuring daily labour output and daily labour variability and quantifying the impact of individual work environment factors on labour productivity variability.

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