INFLUENCE OF VISUAL MANAGEMENT PRACTICES ON SAFETY PERFORMANCE ON CONSTRUCTION SITES IN ABUJA

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MTECH/SET/2019/9673

DEPARTMENT OF BUILDING

FEDERAL UNIVERSITY OF TECHNOLOGY

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER-STATE, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (MTech) IN CONSTRUCTION MANAGEMENT

JUNE, 2023

DECLARATION

I hereby declare that the thesis titled **"Influence of Visual Management Practices on Safety Performance on Construction Sites in Abuja"** is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

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CERTIFICATION

The thesis titled **"Influence of Visual Management Practices on Safety Performance on Construction Sites in Abuja**" by ADIO, Kehinde Victor (MTECH/SET/2019/) meets the regulation governing the award of the degree of Master of Technology in Construction Management of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to THE GOD ALMIGHTY GOD, who made Heaven and the Earth, the one who was, who is and who is to come. He gave me the grace to be among the living. May His name be praised forever.

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Glory be to God for the great things he has done, the one who was, who is and who is to come. He gave me the grace to be among the living. May His name be praised forever. He bestowed His mercies on me in countless ways and saw me through the successful completion of this programme. To him I shall forever be grateful.

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ABSTRACT

Effective Visual Management (VM) practices play great role in ensuring safety on construction sites. However, there are some challenges in the implementation of VM in construction industry which include: diversity and complexity of the job, temporary and transitory nature of construction workplaces and the construction itself might become a visual barrier. The study aimed to assess the influence of VM practices on safety performance on construction sites in Abuja with a view to improve site management. The study employed mixed methods methodology for data collection using well-structured questionnaire and non-participant observation as primary sources of data collection. 50 construction sites environment were carefully observed to check the extent at which visual aid is utilized on construction sites. Out of the 12 visual aids checked list, site layout, workplace organization, spray making and project performance board are the most adopted visual aids on construction sites. Also, 102 questionnaires were shared among the participants of which 86 were retrieved and 73 were deemed fit for analyses using mean item scores, correlation and regression analysis. The result showed the frequently high utilised VM practices in the construction sites are VM in workplace organization (4.24), VM practices by removing visual barriers (4.23), VM practice of standardized identification (4.13), VM practice of distributing system (3.94) and VM in prototyping and sampling (3.71) and the most effective VM practice that improves safety performance on construction sites are workplace organization (4.01), visual management by removing barriers (3.92), VM for standardized identification (3.91), VM in distributing system (3.80) and VM in safety management (3.71). The major barriers to VM implementation on construction sites are safety culture (3.63), lack of government support (3.61) and technical barriers (3.60) while, attitude (4.16), training and coaching (3.95) and management support (3.91) are the major drivers to VM implementation. Major determinants of safety performance measures on construction sites are workplace organization (4.01), management involvement (4.0) and workers involvement (3.93). The findings also reveal the relationship between the extent of usage VM practices and safety performance at ($r = 0.662$ and p value $0.014 < 0.05$), effectiveness of VM practices and safety performance at ($r = 0.698$ and p value $0.08 < 0.05$.), drivers of VM practices and safety performance at ($r = 0.658$ and p value $0.039 < 0.05$.) which all indicate a positive relationship. Only the relationship between the barriers of VM practice and safety performance indicated a negative relationship at ($r = 0.461$ and p value $0.212 < 0.05$). The study therefore recommended that positive attitude should be imbibed by firms so that safety culture can be engendered over time.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The construction industry is an important industry envisioned as one of the major drivers of the economy of developing countries (Olanrewaju *et al.,* 2018). It was revealed by the National Bureau of Statistics that the construction industry contributed about 3.23% to the Gross Domestic Products (GDP) of Nigeria's economy in the second quarter of 2020; lower than its contribution of 4.45% in the same quarter of the preceding year, and lower than in the immediate past quarter where it contributed 4.08%. However, the advent of Corona Virus disease and the consequent lockdown of construction activities further exacerbated the crisis resulting to its low contribution (Musa *et al.,* 2020). Despite the contribution of the industry, construction accidents remained an ongoing concern in developing countries despite the level of awareness in promoting health and safety over the years (Adebayo and Emoh, 2019).

Safety is an important aspect of everyday life especially for an employee domiciled in the construction industry. Unfortunately, many construction firms ignore and do not take serious action on safety issues (Sarkam *et al.*, 2018). Globally, workers suffer from workplace illness and accidents leading to serious injuries and death every day as they go about their jobs (Ahmed *et al.,* 2018). According to Walter (2018), the death and injury rate from construction is very high, alarmingly and continues to rise, hence, the construction industry has been considered as one of the most hazardous industries in many parts of the world (Nadhim *et al.,* 2016) and there is a negative stereotype concerning safety in the construction industry (Nawi *et al.,* 2016).

The industry has faced a wide range of challenges especially due to the occurrences of hazards on construction sites (Sarkam *et al.*, 2018). The main cause of accidents is poor safety performance of the workers from a combination of contributing causes (Nawi *et al.*, 2016). Therefore, a safety measure is needed to ensure and encourage better safety performance on construction sites. Safety programmes are key for avoiding work-related accidents and injuries on construction sites (Sarkam *et al.*, 2018). According to Nawi *et al.* (2016), there are four categories of factors affecting safety performance that should be focused on, which are: management of health and safety, safety culture, behaviour, and awareness. Therefore, the need to incorporate and maintain safety standards and practices is both the duty of the employer and employee.

Lean constructions techniques are new way to manage construction. Lean practice is the dominating theory that helps explore and examine how accidents can be mitigated through a clear identification of the root causes (Tezel *et al.*, 2015; Bajjou *et al.*, 2017). Visual Management (VM) is one of the lean tools used to increase process transparency (Tezel *et al.*, 2016). According to Abdelkhalek *et al.* (2019), VM is a way of communicating information using the right visual tools at the right time for the right situation in all construction projects. It is crucial as it improves efficiency, ensures transparency, establishes better communication and reduces safety risks.

VM practices are set of techniques for creating a place embracing visual communication and control throughout the environment (Grief, 1991) The main objective behind VM is to effectively communicate information using visuals, which may include signs and labels (Abdelkhalek *et al.*, 2019). The increase in information availability and different sensory aids improve the health and safety performance on construction sites (Awada *et al.*, 2016). Safety visual will communicate vital information to construction challenges to the successful implementation of VM practices.

1.2 Statement of the Research Problem

VM is especially important to support continuous improvement and it relies workers with low levels of knowledge and poor site awareness which could reduce the likelihood of accidents occurrence. It will also reduce the chances of errors and mistakes which could lead to accidents (Sarhan *et al.*, 2017). The application of VM practice at construction site will greatly improve safety performance, However, there are some challenges in the implementation of VM in construction industry which include: diversity and complexity of the job, temporary and transitory nature of construction workplaces and the construction itself might become a visual barrier (Fernanda *et al.*, 2018). Effective VM practice on construction site can produce significant benefit and impact the overall project performance. Moreover, the application of VM practices on construction sites is still relatively limited (Fernanda *et al.*, 2018). The application of VM on construction sites has shown promising result which has improved safety performance on construction sites. Abdelkhalek *et al.* (2019) reveal that there was safety improvement on construction sites that slightly used safety visual on construction sites in Lebanon where accident was limited and not fatal and stressed the need for further improvement on VM application. Sarhan *et al.* (2017) also acknowledg that VM application has positive improvement on safety at construction sites in Saudi Arabia. Furthermore, Petal *et al.* (2018) also reveal that VM and its application on Indian construction industry have shown promising result. However, there are peculiarities in different countries and the level of adoption differ.

In Nigeria, health and safety has not been given the required attention to reduce or prevent hazards and accidents on construction sites, thereby posing a serious threat to workers and non- workers creating the need for a quick solution for the issue to be addressed (Abass *et al.,* 2019). One of the major causes of accident on construction sites in Nigeria is the inability to identify or recognise hazards/unsafe conditions on construction sites before the start of tasks (Egbele-Okoro, 2020). Abass *et al.* *(*2019) also posited that inadequate provision of safety devices to appropriate places around the construction sites result in most of the accidents on construction sites. Isah (2019) asserts that construction contractors are not implementing safety visual on construction sites leaving construction sites unsafe for workers. Therefore, the need to improve safety visualization on construction sites cannot be overemphasized. Hence, it is of paramount importance to explore how VM practices can be used to mitigate accident on constructions sites in Abuja.

1.3 Research Questions

i. What is the extent of usage of VM practices on construction sites in Abuja?

ii. How effective is VM practices in improving safety performance on construction sites in Abuja?

iii. What are the factors influencing the implementation of VM practices on construction sites?

iv. How can safety performance on construction sites be measured?

v. What is the relationship between VM practices and safety performance on construction sites?

1.4 Aim and Objectives

The aim of the study is to assess the influence of VM practices on safety performance on construction sites in Abuja with a view to improve site management.

Specific objectives are to:

i. Determine the extent of usage of VM practices on construction sites in Abuja.

ii. Assess the effectiveness of VM practices in improving safety performance on construction sites in Abuja.

iii. Examine factors influencing the implementation of VM practices on construction sites.

iv. Determine safety performance on construction sites in Abuja.

v. Establish the relationship between VM practices and safety performance on construction sites.

1.5 Justification for the Study

VM is an essential element of, and one of the functional blocks of lean production philosophy (Tezel *et al.,* 2015). It is a system that provides real-time information on workplace status by a combination of simple, effective visual information aids, which allows employees to understand their influence on the organisation overall performance hence allowing the employees to improve their performance. Several studies have been conducted on the application of VM practices in the construction industry. Abdelkhalek *et al.* (2019) conducted an analysis of VM practice in Lebanon for construction safety and advised construction firms to make use of visual tools on their sites to educate workers on safety and to direct workers actions and behaviour. Awada *et al.* (2016) emphasized that the use of visual tools for communication of important safety instructions on sites is the major key for maintaining safe construction environment. Tezel and Aziz (2017) investigated the VM practice in highways construction projects in England. The study concluded that the implementation of VM, particularly in English highways construction is limited. Murata *et al.* (2017) explored VM in construction through a block diagram used in control theory. Two VM tools for construction teams from construction companies in the UK and Japan were analysed in detail, findings revealed that VM can and must cover various communication levels in construction organisations in order to break the barriers for information flows and to share valuable and newest knowledge. Patel *et al.* (2018) revealed that VM tools have potential to increase value in the construction phase of Indian construction projects.

Many scholars concluded that VM is an under-studied phenomenon in lean management literature (Beynon-Davies and Lederman, 2017; Koskela *et al* 2018., Tezel *et al.,* 2016). The few studies that examined VM as a management strategy focus on theoretical foundations (Beynon-Davies and Lederman, 2017), board design and development (Bateman *et al.*, 2016), benefits and functions (Bititci *et al.,* 2016, Tezel *et al.,* 2016), actual usage in business practice (Jaca *et al.,* 2014), adoption in the healthcare sector (Verbano *et al.,* 2017).

Fernanda *et al*. (2018) analysed some VM practices that supported production management that have been successfully implemented by lean construction best-practising companies in Brazil. Findings revealed that none of the most advanced practices were developed or implemented with a strong participation of the operational teams at the construction sites. Hence, there is the need for greater involvement of the workforce and operational management in VM, which can be initiated through training and collaborative activities.

Therefore, the study recommended continuously improvement in practices, as this is important to address some existing communication problems, the information needs of the target audience, and the way the device can be integrated into construction companies' routines. Studies such as Egbele-Okoro (2020) has shown that there is a relationship between VM and safety performance, however, due to implementation barriers such as resistance to change, cultural issues, lack of training, limited knowledge, lack of commitment and government issues may hamper the relationship in different climes. Hence, more efforts are needed in research to expand the horizon of the personnel that will adopt VM as a tool in health and safety on construction sites with a view to improving site management practices.

The issues of safety in the Nigerian construction industry have drawn a lot of attention in various studies over the years and continuous efforts have been made through research in promoting safety performance on construction sites. The influence of VM practice in improving safety performance on construction sites cannot be overlooked, as results from other climes in the industry that implemented these practices have been encouraging and promising, yet continuous effort in the practice remained imperative. Assessing the influence of VM practices on safety performance on construction sites in Abuja is imperative to determine if the practices are well known and being implemented in the industry and whether the improvement in safety performance derived from other climes is achievable in Abuja. In the end, effort will be made to determine strategies that could promote the implementation of VM practices in Nigeria, using constructions firms in Abuja as the study area, as this is the assertion of Abdelkhalek *et al.* (2019) so that efforts put in will bring in results that are effective and efficient. Egbele Okoro (2020) focus and small and medium size construction company in Lagos state and employ a qualitative research method (interviewed). This study targets medium and large-size construction firm Abuja also, a mixed research method was adopted.

The outcome of this research work is expected to aid professionals and construction firms in Nigeria to shift their attention towards implementing effective VM practices in order improve safety performance on construction sites and also to support in disseminating the concept in Nigerian construction industry. The findings will guide the construction practitioners to the main barriers and the measures to be taken to successfully implement VM practices in safety improvement in construction projects.

1.6 Research Scope and Limitation

The study focused on the influence of VM practices on safety performance on construction sites in Abuja with a view of establishing relationship between VM practices and safety performance on construction sites. The choice of Abuja is premised on the fact that it is the capital of Nigeria, and both the public and private sector entities are undertaking a lot of new buildings and infrastructural projects regularly. Construction firms and specialist contractors, building and real estate investors, construction professionals and experts, and skilled and unskilled workers, would naturally be attracted to areas or regions with high job opportunities (Eze *et al.,* 2020). A combination of questionnaire survey and observation methods were adopted in this study. Active constructions sites were sampled. The study is limited active construction sites in Abuja

1.7 Definition of Terms

i. **Lean Construction**: A combination of original research and practical development in design and construction with an adaption of lean manufacturing principles and practices to the end-to-end design and construction process (Pradeepkumar and Loganathan 2015).

ii. **Visual Management:** VM in construction is adopting different visual tools and orders in construction buildings to enhance safety and reduce wastes. (Grief, 1991).

iii. **Visual Management Practices:** VM practices is a set of techniques for creating a place embracing visual communication and control throughout the environment. (Grief, 1991).

iv. **Safety:** An absence of danger (Suresh *et al.,* 2017).

v. **Hazard:** The potential to cause harm, including ill health and injury; damage to property, plant, products or the environment, production losses or increased liabilities (Ahmed *et al* 2018)

CHAPTER TWO
LITERATURE REVIEW

2.1 Construction Industry in Developing and Developed Countries

The construction industry forms an integral part of developing any nation's economy as other sectors rely heavily on the construction industry to execute their daily or routine activities and operations (Olanrewaju *et al.,* 2018). The exclusive nature of activities involved in the construction industry and its complexity increased the chances of accidents occurring on construction sites worldwide (Awaad *et al.,* 2016). Hence, the construction industry is viewed worldwide as an accident-prone industry (Suresh *et al.,* 2017, Pestana and Gambatese, 2016, Awada *et al.,* 2016). The construction industry is challenged with health and safety issues year in, year out. However, the influence of these issues on the construction industry is largely dependent on how individual countries lay importance to safety issues and what regulations and initiatives are put in place to address these issues by government and organizations across the level of risk involved in construction, makes it a difficult industry to work in (Egele-Okoro, 2020). Significant efforts have been made to improve safety in the construction industry (Wong *et al.,* 2016) as a result, construction accident rates in many countries have been significantly reduced. In spite of this progress, construction remains to face more occupational injuries and fatalities compared with the other industries (Suresh *et al.,* 2017, Kukoyi and Smallwood, 2017).

The difference between developed and developing countries in accident rates among construction industry is remarkable (Egele-Okoro, 2020). In developed economies there are regulations, initiatives and practices in place to protect the health and safety of the construction workers, however, unlike in the developed economies, the developing economies are still struggling in the areas of taking the health and safety of their citizens serious which is observed by studies that have shown that health and safety is not given a priority in the developing economies (Agbede *et al.*, 2016). Regulations are hardly complied to in developing countries thereby spiking an increase in health and safety related issues (Udo *et al.,* 2016). Therefore, fatalities in developing countries are three times more than it is in developed countries (Awada *et al.*, 2016)

2.2 Safety in the Construction Industry

Health and safety are unavoidable aspect of construction industry due to its nature of being made up of the conglomerations of people from diverse background and disciplines with each individual output determining the level of success to be recorded at each construction stages. The exclusive nature of activities involved in the construction industry and its complexity increased the chances of accidents occurrence on construction sites (Awaad *et al.,* 2016). Therefore, the construction industry is viewed worldwide as an accident-prone industry (Suresh *et al.,* 2017, Pestana and Gambatese, 2016, Awada *et al.*, 2016). Safety is defined as absence of danger (Suresh *et al.* 2017). Ahmad *et al.* (2016) defined safety as unique event that is paramount to continuous attainment of productivity. The construction industry is challenged with health and safety issues year in, year out. However, the influence of these issues on the construction industry is largely dependent on how individual countries lay importance to safety issues and what regulations and initiatives are put in place to address these issues by Government and organizations across the level of risk involved in construction, makes it a difficult industry to work in (Egele-Okoro, 2020). Significant efforts have been made to improve safety in the construction industry (Wong *et al.*, 2018) as a result, construction accident rates in many countries have been significantly reduced. In spite of this progress, construction remains to face more occupational injuries and fatalities compared with the other industries (Suresh *et al.*, 2017, Kukoyi and Smallwood, 2017).

2.3 State of Health and Safety Practices in the Nigerian Construction Industry

The construction industry in Nigeria has since been on a steady rise in recent years owing to the large expanse of undeveloped land required to provide shelter for the booming population. As a result, the population of construction workers has also increased (Oreoluwa and Olasunkanmi, 2018). Health and safety of construction workers on building construction sites in Nigeria have become necessary because of the hazardous nature of the practice. The industry has a long-standing poor performance record of health and safety. This has been blamed on the complexity, multiple stakeholders, dynamic operational environment, and organizational arrangements of construction projects, which have regularly resulted in accidents and injuries to workers (Chen *et al.,* 2020).

The health and safety performance of construction organizations in the construction industry of Nigeria is poor (Oreoluwa and Olasunkanmi, 2018). It was posited that in Nigeria, construction workers are still being exposed to injuries, disease, and fatalities. In-spite of the level of technological advancement and level of professionalism in the construction industries in this 21st century (Okoye, 2018). Similarly, Williams *et al.* (2019) confirmed that the spate of accidents and fatalities occurrences is still high in Nigeria. There are a lot of extant studies on health and safety on construction projects that sampled construction professionals, consultants, clients, or contractors (Abas *et al.* 2020; Agede *et al* 2016; Kukoyi and Smallwood 2017; Chen *et al.,* 2020; Adebayo and Emoh 2020; Williams *et al.*, 2019).

Agbede *et al.* (2016) examined health and safety management practices in the Nigerian construction industry particularly those operating in the South Western geopolitical zone. The study revealed that very few health and safety management practices are commonly implemented by contractors, particularly in the South Western zone, and recommend immediate action to be taken by contractors to enhance health and safety management in all the elements of health and safety management, and also call for the support of state institutions and other relevant professional bodies (e.g. through provision of training programmes and awareness raising initiatives, and tightening of health and safety regulation) would be helpful.

Okoye *et al.* (2016) examined building construction workers' health and safety knowledge and compliance on sites in Anambra State, Nigeria. The outcome of the research showed that, low health and safety awareness and compliance among the site's operatives, this resulted into low project performance. The study recommended that, knowledge and compliance with health and safety practices alone cannot achieve optimum project performance, it would require safety culture which encompassed other factors are as follows: management commitment, workers involvement and strict enforcement of safety regulation should be adopted.

Akinwale and Olasunbo (2016) examined implications of occupational health and safety intelligence in Nigeria via cross-sectional research design and risk society and sense-making theories, the study affirmed that managers and employees are the major target of occupational health hazards, such as loss of man-hours, productivity, and job security. High level of awareness on the importance of occupational safety was recorded but inadequate investment in the capacity building on safety' programmes in the organization. The study therefore recommended good policy on occupational health with adequate investment in precautions and safety intelligence will enhance individual and organizational development in Nigeria.

Kukoyi and Smallwood (2017) explored the perceptions of workers on health and safety practices on construction sites in Lagos state. The studied adopted a qualitative research approach. The findings of the studied revealed that workers view construction activities as hazardous to them, and are more interested in the monetary gains, these perceptions were linked to stakeholders' inadequacies in promoting health and safety practices, socio-economic realities, cultural beliefs, and inadequate training. The study recommended that the government and other stakeholders should develop strategies and policies that will foster commitment to health and safety on construction sites.

Oreoluwa and Olasunkanmi (2018) examined the health and safety management practices on construction sites in Akure. findings of the studied revealed that few construction companies have a decent level of safety practices captured in their company policies because health and safety issues are almost never factored in their bidding at the tendering stage thus, making it very difficult in earmarking funds to cater for the events of accidents. The studied recommended that building plans should not be approved without detailed health and safety documents indicating protective equipment provided by companies, Also, construction sites where work is carried out must be sealed when there is no provision of safety equipment.

Abass *et al.* (2019) evaluated the health and safety standards implementation on construction firms operating in Oyo State. The study revealed that there is no adequate provision of warning signs to appropriate places around the construction sites, most workers does not like training on safety precautions. The result from the study suggested that few health and safety standards are implemented by construction worker and management, the health enhance health and safety management in all the elements of health and safety management.

Isah (2019) examined the health and safety issues in the Nigerian construction industry. The study revealed that, safety issues in the Nigerian construction industry is not recommendable as the basic safety issues were not rated good. The study recommended that all workers in the construction industry must be insured with a good insurance health insurances coverage to take care of their medical expenses in the event of accidents and no contractor should be given any sort of project until his health and safety planned is approved by the concerned government body and closely be monitored for maximum compliance.

Adebayo and Emoh (2020) examined the application of health and safety plan on construction sites in Lagos State. The outcome of the study showed the need for constant re-evaluation of health and safety practices of the construction companies in the study area because of its vital contributions to economy development, Also, high demand for improvement of health and safety practices and use of prescribed safety wears on construction site, safety training must be taking serious most especially the site operatives that are more vulnerable to accidents, this will help them to know the safety demands of each construction projects. Safety inspections should be conducted on sites and any identified hazards should be taken care of as soon as detected. The study recommended that Government should intensify its effort towards health and safety implementation by partnership with professional bodies in the built environment to organizing special training on health and safety practice on construction site for the tradesmen.

Jimoh *et al.* (2020) explored the strategies for engendering health and safety culture in construction firms in Abuja. The component of the study included: management commitment, effective communication and stakeholders' involvement. The study revealed that external communication measures were given less attention and the implication of the study finding showed that there was high probability of accidents and emergencies which might result in disability or death of workers. The study recommended that management should be more committed regarding external communication, and there should be high commitment from the top management of the organizations which will in turn produce higher level of motivation and commitment throughout the organizations.

Eze *et al*. (2020) assessed the perception of construction tradespeople on the health and safety management on the construction sites. Study revealed that trades groups such as C oncreters/Mason/Bricklayers', 'Carpenters', and 'Steel benders/fixers/welders', are the trades groups that are more vulnerable to hazards and accidents on construction sites, and the most critical causes of accidents based on tradespeople perception are; inadequate training, drugs, and alcohol, horseplay by workers, excessive working hours resulting in mental fatigue, communication issues, unsafe act, /violations/ non-compliance behaviour, unsafe working condition, poor management practices, inadequate maintenance of tools and equipment, and hazardous machine operations. The study concluded that there is a low level of implementation of health and safety management practices on construction projects site by construction organizations.

Ugwu *et al.* (2021) evaluated the safety performance of construction companies in the Niger Delta region of Nigeria, findings of the study revealed that there is a medium level of safety performance in the construction industry in Niger Delta and there is a significant relationship between management commitment to safety and proactive safety performance in the construction industry in Niger Delta the study further recommended that top management should have safety policies in place, duly signed and ensure its implementation in the organization and these policies should be communicated and made available to their workers in an easy to understand language

2.4 Lean Construction as a Safety Tools in Construction Sites

Lean construction can be dated back to as far the late 1990s. Lean philosophy originated from the manufacturing industry and found its way into the construction industry due to the results observed in the Toyota mass production scheme (Bajjou *et al.*, 2017). Construction industry is a unique and dynamic process while manufacturing industry is movable and produce products in a fixed workplace (Pestana and Gambatese, 2016). Lean principles is the remover/reduction of non-added value activity (Koskela, 1992). Construction firm are now exploring new techniques, practices, and processes to make the industry less wasteful. Lean principles, when applied in the construction offer innovative ways to manage construction projects while reducing waste and improving safety, quality, efficiency, and performance of the production process (Maradzano *et al.*, 2019). Lean construction is a production management-based approach to project delivery a new way to design and build capital facilities. Pradeepkumar and Loganathan (2015) defined Lean Construction generally as a combination of original research and practical development in design and construction with an adaption of Lean manufacturing principles and practices to the end to complete design and construction process. Lean construction concept is a philosophy aimed at creating values for the client by eliminating waste, supported by collaborative project management tools, as part of a systematic and rigorous approach to continuous improvement. This concept has also been defined by the team of Construction Industry Institute (CII) as a continuous process of eliminating waste, reaching or exceeding all customer needs, focusing on the entire chain of value creation and seeking perfection in the performance of a construction project lean construction can also maximize value for the client, increasing quality and productivity, improving communications, improving health and safety conditions, and minimizes the direct cost of effective project delivery management (Sarhan *et al.,* 2017).

2.5 Background to Visual Management

VM is a managerial strategy and a fundamental element of the Toyota Production System that creates highly visual information fields from which people can pull information for an augmented self-management and control (Ohno, 1988; Shingo, 1989; Greif, 1991). The roots of VM can be found in the "Management by Seeing with Eyes" concepts of Taiichi (1988), and it has been widely used in advanced manufacturing plants (Liker and Morgan 2006). According to Tezel *et al*. (2015), VM goes beyond production management in factories, as it can be successfully adopted by commercial, educational, IT, healthcare and governmental services, and construction organizations. VM embodies an important close-range communication strategy based on cognitively effective information conveyance. This strategy has been frequently discussed in the production management literature. However, the current body of work lacks integrated focus and cohesion with an abundance of related terminology from scholarly works and consultant books (Tezel *et al*., 2015).

Tezel *et al*. (2015) developed an extensive literature review of VM role in production management, and they suggested that existing literature can be divided into five distinct categories:

i. Descriptions of Japanese originators and interpreters of the Toyota Production System

ii. Books by Western and Japanese consultants

iii. Scholarly papers on VM

iv. Scholarly literature in ergonomics and human factors that touches similar phenomena, but with different vocabulary

v. Diverse approaches discussing VM beyond production management

Tezel *et al.* (2015) posited that a distinction and clarification of the connections between the different terms is necessary to unify the fragmented discussions: VM is a managerial strategy that emphasizes close-range visual communication and is realized through different visual tools, including visual controls. A systematic implementation of those tools within the VM strategy at a work setting creates a visual workplace in which various benefits of VM can be observed.

2.5.1 Visual management and lean construction

Numerous studies suggested that VM is a key approach of Lean production implementation (Tezel *et al.,* 2016; Viana *et al.,* 2014; Formoso *et al.,* 2002). However, Galsworth (2005) clarified the VM and Lean work together. Neither is more important than the other they are of equal importance. VM builds the detail of work into the physical environment, enabling workers to operate precisely and with increasing self-regulation. Lean defines, extends, accelerates, and controls the flow of work that visual spells out, dramatically reducing lead-time, flow distance and improve safety.

Lean construction and consequently VM, has gained interest in the last twenty years (Bajjou *et al.,* 2017), mainly, influenced by the formation of the International Group of the International Group of Lean Construction (IGLC) and Lean Construction Industry (LCI) (Bajjou *et al.*, 2017). According to Koskela (2002), Lean Construction is a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. One way of seeing these errors and waste is through the application of the principle of transparency.

Koskela (1992) proposed six practical approaches for the implementation of process transparency in construction sites, which are closely related with Ohno's (1988) understanding in "Management by Seeing with Eyes"

i. Establishing basic housekeeping to eliminate clutter: 5S Method
ii. Making the process directly observable through appropriate layout and signage
iii. Rendering invisible attributes of the process visible through measurements
iv. Embodying process information in work areas, tools, containers, materials and information systems
v. Utilizing visual controls to enable any person to immediately recognize standards and deviations from them
vi. Reducing the interdependence of production units (focused factories)

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2.5.2 Visual management practices

VM refers to the managerial strategy of consciously integrating visual tools in workspaces with the aim of increasing transparency in construction sites (Tezel *et al.,* 2015). One of the major challenges in construction worksites deals with safety of workers, to be able to overcome this challenge, it is important for organisations to create a visual workplace by using visual tools such as signages to alert people about potentially hazardous situations, including preventing unsafe conditions in the workspace. The belief is that when this information is communicated visually in the workplace, workers and visitors to the site would not require any interpretation to understand them. Study from Egbele-okoro (2020) has established that indigenous construction companies in the Nigerian construction industry use visual tools mainly for accident prevention. However, not all these companies utilize the use of these tools to its full capacity. The reason for this may be that perhaps these companies do not have full awareness about what VM is (Tezel *et al*., 2011). If well utilized, the application of VM techniques in construction sites can yield better result in terms of accident prevention and thus greatly improve safety performance as seen by results from its implementation in previous studies (Jang and Kim, 2007; Awada *et al*., 2016; Abdelkhalek *et al.,* 2019). There are different types of VM tools (Tezel *et al*. 2016), different classifications of VM practices and devices exist.

Galsworth (1997) proposed a general classification of VM tools, in practice, these VM classification types commonly manifest themselves in the forms of some conventional VM tools such as: the 5s workplace structuring methodology, visual performance boards and obeya (big rooms). The visual workplace employs the idea of using visual devices situated within work settings to communicate with the doers, the actual people performing work within these settings (Liff and Posey, 2004).

A visual indicator is used to provide or share messages with receiving actors, but it is passive. In other words, whether the receiver of the message complies with the message is optional (Beynon-Davies and Lederman, 2017). Visual indicators pass crucial information from management to operational level intending to affect human's behaviour (Abdelkhalek *et al.,* 2019). Examples of visual indicators are charts, photos, value stream maps. Visual standards define what is supposed to happen in the work setting and are the responsibility of engineers and supervisors. Visual displays indicate the answers to the core questions of where, what, when, who, how many and how and are the responsibility of supervisors, managers and schedulers (Beynon-Davies and Lederman, 2017). Visual signal also provides a certain message to a receiving actor, but in this case, there is an expectation that the receiver takes attention and reacts to the message (Galsworth, 1997). Visual signals are used to provoke a response to the eyesight and interpret the surrounding environment enforcing high human control and directing human's behaviour They tend to grab attention for some essential points such as traffic light or and on boards (Abdelkhalek *et al.,* 2019). Visual controls show deviations and help people see how they do their jobs. They enforce full human control by limiting the response to a specific height, width, length, quantity (Abdelkhalek *et al.,* 2019). Visual controls attempt to impact upon the behaviour of the receiver directly by building the message into the physical environment. (Beynon-Davies and Lederman, 2017). Some examples of visual controls are road lines, maintenance, Kanban, colour coding, display of safety regulations.

Visual guarantees ensure that everything is done in the right way enabling only the correct outcome quantity (Abdelkhalek *et al.,* 2019). Visual guarantees are also known as mistake-proof, fail-safe, or Poka-Yoke devices. A visual guarantee is designed to make sure that only the right thing can happen. It prevents us from doing the wrong thing (Galsworth, 1997). Visual guarantees are normally devices designed explicitly to determine certain behaviours unequivocally (Beynon-Davies and Lederman, 2017).

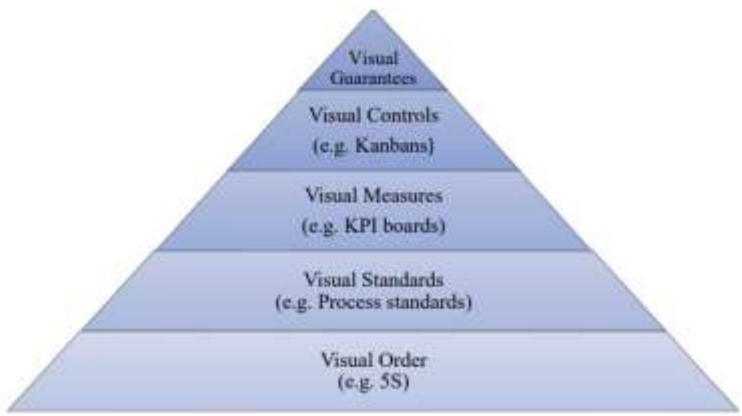

Figure 2.1: Visual workplace framework

Source: Galsworth (1997)

2.5.3 The 5s housekeeping (workplace organization)

The 5S is a systematic approach that focuses on organizing and standardizing the workplace and sometimes referred to the visual workplace or workplace organization. It is about a place for everything and everything in its place (Anerao and Deshmukh, 2016). It is one of the simplest lean tools. Workplace organization focuses on establishing visual order, organization, cleanliness, and standardization which leads to improved safety, creation of space, improved teamwork, and continuous improvement (Cudney *et al.* 2015). Good housekeeping is a well-known practice that leads to safer jobsites (Pestana and Gambatese, 2016). Adopting workplace organization improve ergonomics and reduces workers exposure to hazards which cause injuries. It reduces confusion, extra steps, and on-the-spot decisions, and therefore reduces motion and decreases trip and fall hazards (Pestana and Gambatese, 2016).

5S is a lean tool derived from five Japanese words: Seiso (shine), Seiton (straighten), Seiri (sort), Seiketsu (standardize) and Shitsuke (sustain), as a foundation for continuous improvement (Sarhan *et al.*, 2017; Pestana and Gambatese 2016; Cudney *et al.*, 2015).

i. **Seiri** (Sort): This refers to the separating of the needed tools and remove unneeded from the workplace (Anerao and Deshmukh, 2016, Cudney *et al.*, 2015, Ogunbiyi, 2014). As a result, cleanliness and safer working environment could be achieved (Salem *et al.*, 2005). This could minimize accidents caused by site congestion and makes circulation and movement safer on the site (Bashir *et al.*, 2011).

ii. **Seiton** (Straighten or set in order): it refers to arranging tools and materials for ease of use (Cudney *et al.*, 2015). It involves placing all materials and plants at their optimal location for ease identification and promote orderliness in the workplace (Ogunbiyi, 2014). This reduces congestion, promotes convenience and eases movement and circulation on the site (Bashir *et al.*, 2011)

iii. **Seiso** (shine): it means to clean up the site (Cudney *et al.*, 2015, Ogunbiyi, 2014). It involves removing all objects and materials from unwanted places and keeping away materials and machines/items that are not required to be used within that period. This could result in preventing accidents caused by site congestion and obstruction (Pestana and Gambatese, 2016).

iv. **Seiketsu** (standardize): is to maintain the first Ss. It is ensured that the workplace has common standards and ways of working (Tezel *et al*., 2016, Cudney *et al.,* 2015). It seeks to define standard procedures to maintain the working environment clean and organized (Cudney *et al*., 2015, Ogunbiyi, 2014). A significant level of cleanliness and orderliness is required to achieve the maximum safety on construction sites (Bashir *et al*., 2011). This could address poor safety culture among workers on construction sites, which is a determinant of accident (Bashir *et al.,* 2013).

v. **Shitsuk** (sustain): it refers to creating the habit of conforming to the rules (Anerao and Deshmukh, 2016, Ogunbiyi, 2014). It is about ensuring that the company continue to continually improve using the previous stages of 5S, maintain housekeeping, and conduct audits and so forth (Tezel *et al.,* 2016). It also about implementing methods to sustain the process (Cudney *et al.,* 2015) and make 5S a way of life and become part of the culture of the business and the responsibility of everyone in the organization (Tezel *et al*., 2016).

2.5.4 Visual management taxonomy

Tezel *et al*. (2010) proposed nine (9) taxonomy for VM function which include; Transparency, Discipline, Continuous Improvement, Job Facilitation, On-the-Job Training, Creating Shared Ownership, Simplification, and Unification

i. **Transparency:** Transparency can be defined as the ability of a production process (or its parts) to communicate with people (Formoso *et al.,* 2002). Transparency involves a separation of the network of information and the hierarchical structure of order giving, in other words, an increase in self-control, which in classical organisation theory are identical (Greif, 1991). The goal is thus to substitute self-control for formal control and related information gathering. It is a dual mechanism working for both managers and employees through different messages. Moser and Santos (2003) summarised the practical impacts of transparency in a work environment as follows: the simplification and greater coherence in decision making, the stimulation of informal contacts throughout different hierarchical levels, the contribution to introduction of decentralisation policies, assistance in broadening employees' participation and autonomy in management, more effective (overlapping) distribution of responsibilities, an increase in employee morale, greater effectiveness in production scheduling, the simplification of production control systems, rapid comprehension (by making problems apparent) and response to problems (a controlled speed in decision making and responsiveness), increase in the motivation of workers for improvement and visibility of errors. Flexibility, versatility and mobility within work teams can also be included (Greif, 1991).

ii. **Discipline:** VM reflects people's adherence to the expectations of processes by transforming the abstract concept of discipline into directly observable concrete practices (Mann, 2005). Discipline can be defined as "making a habit of properly maintaining correct procedures (Hirano, 1995). Anyone, even a newly hired, inexperienced employee, should be able to distinguish between normal and abnormal conditions at a glance and start taking the correct steps, developing an intuitive, habitual correctness, without being dependent on another entity. Discipline means "following standardized procedures and is defined as making a habit of properly maintaining correct procedures (Tezel *et al.*, 2016).

iii. **Continuous improvement:** Continuous improvement (or kaizen in the lean terminology) is a highly dynamic capability and can be defined as an organisation-wide process of focused and sustained incremental innovation. VM serves as a base for continuous improvement and perhaps more importantly stimulates employee involvement to manage and improve quality (Greif, 1991)

iv. **Job facilitation:** Job facilitation can be defined as a conscious attempt to physically and/or mentally ease people's efforts in routine, already known tasks by offering various visual aids. VM facilitates routine job tasks for people by offering a quick, correct and holistic understanding of their job requirements (Galsworth, 1997). When the amount of information required to complete a task pushes the capacity of working memory, it must be made available in the physical world through visual displays (Norman, 1998). Human understanding consists of preconscious and conscious forms and visual graphical information processing is involuntary, like breathing (Rohrer, 2000). The right brain which processes visual information, creating mental images, can work faster, sometimes in the form of emotional reactions (Barry, *et al*., 2005). Moreover, repeated stimuli, with their frequent patterns, create the templates that people use to map and anticipate the reality (*Barry et al.,* 2005).

v. **On-the-job training:** On-the-Job training includes learning from experience integrating working with learning is a competitive imperative for organisations (Sumner *et al.,* 1999) Information in the environment enables on the job training, which is an effective way of learning, as it is integrated in actual work and helps employees learn by practical experience (Aik, 2005). It is a cost effective, less work disruptive, encouraging, and easy to assess organisational learning practice that employs VM (Aik, 2005).

vi. **Management-by-facts:** Management by facts is based on the use of facts and data based on statistics. VM is partially about opening the objective organisational reality to the relevant people through the flow of information (Greif, 1991; Liff and Posey 2004; Galsworth, 2005; Mann, 2005). This reality is free from personal bias or subjective experience or understanding of individuals. Openness, or willingness to share ideas and information willingly, frankly and accurately, is a condition for obtaining employees' trust in management.

vii. **Creating shared ownership:** Psychological ownership can be defined as a feeling of possessiveness and being psychologically tied to an object (material or immaterial). VM is used to create and designate territories and work teams (Greif, 1991) One other function of VM is image creation for stakeholders (Liff and Posey, 2004). It is particularly effective in creating a desirable organizational impression on potential/existing employees, customers and other shareholders (Greif, 1991). Visual elements are extensively used for internal marketing efforts and change management practices to convey a desired message, to persuade people and to alter the perception for creating ownerships (Tezel et al., 2016).

viii. **Simplification:** The management of information in dynamic and complex environments sometimes goes beyond the efforts and abilities of individuals. Organisations mainly use strategic information to make decisions, to make sense of changes and developments in their external environments and to generate new knowledge through organisational learning, in cascading strategic information from the upper organisational levels to lower levels, some mechanism is necessary for monitoring, processing and presenting the vast amount of information for people to make sense of (Choo, 1996).

ix. **Unification:** Organisations are constituted of interconnected socio-technical departments, with various layers (Tezel *et al.,* 2016). One of the managerial issues is to establish synchronization and harmony (shared understanding) between these layers. People may illusively think that they work in an isolated manner solely according to the departmental values and conditions to which they belong. In an organization, the vertical boundaries (the boundaries between layers), the horizontal boundaries (the boundaries between functional units), the external boundaries (the boundaries between the organisation and the outside world) and the geographic boundaries (the boundaries between different organisational units located in different geographic areas) can partly diminish with information sharing and dialogue creation (Ashkenas *et al.,* 1995). Creating a "boundaryless" organisation, where people act openly without status or functional loyalty and look for ideas from anywhere, is a major concern, especially in knowledge management efforts (Rastogi, 2000).

Furthermore, Tezel *et al.* (2015) also identified fourteen (14) VM practices on Brazil construction sites which include:

i. **VM by removing visual barriers:** The main principle behind removing visual barriers is to provide extended transparency to people by enabling observability on site (Tezel *et al.,* 2015). Process transparency is the ability of a production process (or its parts) to communicate with people (Formoso *et al.,* 2002). The approaches that can be used to improve process transparency: reducing the interdependence between production units, using visual devices to enable immediate recognition of process status, making the process directly observable through appropriate layout and signage, incorporating information into the process, maintaining a clean and orderly workplace and rendering invisible attributes visible through measurements. Tezel *et al.* (2010) suggested that those approach should not be understood as separate notions. For example, it is hard to observe something on a construction site, even with appropriate layout and signage, without maintaining a clean an orderly environment. Process transparency is achieved by using information giving, signalling, limiting or guaranteeing visual tools to communicate with people so that work settings expectedly become self-explanatory, self-ordering, self-regulating and self-improving (Galsworth, 1997).

ii. **VM for standardized identification and localization**: Standardization on construction site, refers to the arrangement of tools and materials on the construction sites for ease of use (Cudney *et al.,* 2015). It involves placing all materials and plants at their optimal location for ease identification and promote orderliness in the workplace. This reduces congestion, promotes convenience and eases movement and circulation on the site. The physical site environment needs to be standardized in terms of their identification and location by using visual clues, signs, tags, site maps, shadows, and colours (Tezel *et al.,* 2010). These standardization efforts often inclu ded the warehouses through material grouping, ordering and visual material tagging /identifying.

iii. **VM in systematic site order (5S)**: Systematic housekeeping efforts, widely known as the 5S programmes, 5S focuses on establishing visual order, organization, cleanliness, and standardization which leads to improved safety, creation of space, improved teamwork, and continuous improvement (Cudney *et al.*, 2015). The 5S efforts were sustained by using visually attractive communication means (e.g., mascots, signs, 5S boards)

iv. **VM in production control:** Production control is the process of introducing the improvements into the organisational and temporary aspects helps reduce non-value adding activities and increase production reliability (Bernardes and Formoso, 2002). Kanban according to Arbulu *et al.* (2003), is a lean approach developed in the automotive industry to pull materials and parts through the production system on a just-in-time basis. Kanban, which is a multistage production scheduling and inventory control system is a plastic card that contains all the information needed for production/assembly of a product at each stage, including details of its path completion. The cards are used for controlling production flow and inventory. The Kanban system according to Kumar and Panneerselvam (2007), facilitates high production volume and high-capacity utilization with reduced production time and work-in-progress.

v. **VM in production levelling:** Production levelling is also known as production smoothing or by its Japanese original term “heijunka”. Production levelling is construed as a method of determining product sequences to prevent from sudden changes in the quantity of manufactured products, which contributes to enhancing efficiency and flexibility, as well as to minimizing differences in workplace load

(Hüttmeir *et al.,* 2009). Production levelling is widely known as a method for defining the sequence of manufacturing various products in a mixed manufacturing model, mostly in order to balance production, enhance the efficiency and flexibility by eliminating waste and minimizing differences in the workstation loads (Liker, 2004). The main objectives of levelled production as identify by Araujo and Queiroz (2010) include: continuous flow throughout the entire supply chain, eliminating peaks in production, reduction of stock levels, avoiding work overload, maximizing efficiency of production resources, and enhancing production capacity. Without the production levelling an enterprise cannot accurately control and predict the production schedule and the stock of finished products and materials (Coleman, and Vaghefi, 1994). Heijunka boards is used on construction sites of concrete and mortar production. The levelling is always achieved by producing the concrete according to the demands of different crews (Tezel *et al.,* 2015).

vi. **VM in site signage**: The aim of VM is to enable anyone working in the workplace to be able to assess the current situation at a glance (Liff and Posey, 2004). Visually attractive and eye-catching signs, posters, sketches, mascots, and caricatures are commonly used to support the change management initiatives, internal marketing efforts, to underline best practices, to raise awareness on waste, to emphasize hygiene, health and safety, and to prevent ergonomic problems (Tezel *et al.,* 2015).

vii. **VM in work facilitators:** Visual facilitators are visual elements that have been designed essentially to facilitate the jobs of several workers (worker gangs) as visual aids (Tezel *et al.,* 2010). This category covers visual aids that is consciously created by management to help the workforce perform their tasks (Tezel *et al.,* 2015). Visual devices often serve as a reminder of the standard practices (often technical), providing additional knowledge in the work environment. Device should be eye-catching and easy to follow. Visual aids could be designed for anyone on the site, a crew, or a specific worker.

viii. **Improvisational VM:** Several improvisational visual aids had been integrated spontaneously by workforce into their work environments, particularly for quality control purposes (Tezel *et al.*, 2010). Visual signs are devised by workers and understood by people on the site as a mean of communication. Proper marking of the different elements in the workplace is important to avoid mistakes and increase efficiency and safety (Tezel *et al.*, 2015).

ix. **VM in performance management**: Performance management is a process in which the results achieved by an organization are evaluated together by means of the way in which it achieves its predetermined objectives and targets (Polese *et al.*, 2017). Performance management's goal is to create an environment where people can perform to the best of their abilities and produce the highest-quality work most efficiently and effectively (Kazaz *et al.*, 2019). Performance management tools help people to perform to the best of their abilities and produce the highest-quality work most efficiently and effectively. Different performance metrics are used by different parties, such as subcontractors, suppliers, and crews (Kazaz *et al.*, 2019).

x. **VM in station quality (Through the Andon).** The visualization of quality is indispensable for monitoring, evaluating and controlling the quality situation especially the constructions industry. Where production quality and product quality embody elementary competitive factors (Tezel *et al.*, 2010). For quality-related activities to be carried out efficiently and to contribute to the quality objectives quality management must use various methods of cause analysis, data compression and visualization (Shingo 1989). Quality visualization tools established in science and industry are easy to use and mainly work with numbers. Example of quality tools include: check sheet, Histogram, Ishikawa diagram, Pareto chart. In station quality is one concept which can be used to take all employees contribution to assure the quality in product. This is actually some kind of discipline which everyone wants to practice (Liker and Meier 2005).

xi. **VM in prototyping and sampling**: Prototyping is used in the form of displaying an example of a part or the whole of the end-product (e.g., a piping system or a complete room), enabling the workforce to visualize the end-product itself (Tezel *et al.*, 2015) Sampling is the practice of pairing different production elements (material/space or equipment/personnel) by using a real sample of the material and/or equipment in question, was also employed.

xii. **VM in distributing system**: Wide Information System, whether directly related to the production or not, is displayed to enhance transparency, and to raise awareness on the elements of the project system, such as regulations, evaluation of suppliers, company policies, and surveys with the customers (Tezel *et al.*, 2010).

xiii. **VM in mistake proofing systems**: Mistake proofing (also called poka-yoke) is as an improvement technology that uses a device or procedure, to prevent (or eliminate) defects or equipment malfunction during normal processing Mistake proofing devic es enforce correct operations by eliminating choices that could lead to incorrect actions (Shingo, 1989). Tommelein and Demirkesen (2018) reported that mistake proofing is an essential technique to detect mistakes before they turn into defects. The systems consisted of basic mechanical modifications on the material by the site management to guarantee a higher quality production consistently. The systems consisted of basic mechanical modifications on the material by the site management to guarantee a higher quality production consistently.

xiv. **VM in on-site prefabrication:** Site prefabrication efforts are carried out with the aim of achieving a higher level of end-product quality, eliminating interdependencies, and expediting a particular construction process (Tezel *et al.*, 2010).

Hao *et al.* (2014) identified four aspect of visual practices which include set management, board management, colour management and identify management as the main means of VM implementation.

i. **Set management:** refers to the placings of items scientifically in a purposeful, planned, methodical way, according to restriction condition, for the purpose of production activities, considering the efficiency of the production activities (Hao *et al.*, 2014). Set management set the production site as the main object, research and analyse the conditions of people, objects, places and the relationship between them, and promote combination of people, machines, materials, systems and environment by arranging, consolidating, improving the conditions of production site.

ii. **Board management**: Board management is a management method, which revealed project (information) that is hoped to manage through all kinds of management board, making the management status known to all (Parry and Turner, 2006). The particularity of environmental factors in production site determines the characteristics of the board management, which are striking, be clear at a glance, easy to use and manage (Liff and Posey 2004). As the board pointed out the spare parts, production, production time and methods, the name of the shipping and quantity and other relevant content, production site personnel can judge and handle problems independently (Hao *et al.,* 2014). The kinds of board include standardized operation state of board, management board, state board and temporary board.

iii. **Colour management**: Colour management is a management method using the psychological reaction and habits of people to colour and resolution and association ability. It covers the management activities within the enterprise and management of physical with a layer of colour coat. Staffs combine different colour with the traffic lights naturally and consciously, so that every one of us has the same understanding and interpretation of a problem (Hao *et al.,* 2014). When problems arise, they reach a consensus through language communication and determine the direction of the future. For example, the production progress status is distinguished with colour. Green stands for progress normally; Blue indicates production behind; Yellow indicates production to be expected, and red stands for mechanical failure (Hao *et al.,* 2014).

iv. **Identify management**: Identify management deals with the management of personnel, materials, and equipment mainly through the use of corresponding marks.

(Hao *et al.*, 2014). Job qualified and skilled employee identification and other types are usually distinguished by coat colour, epaulettes, tags and eye-catching signs. In terms of material identification, one of the most prone to errors project of the scene is material identification, which include name, number, quantity, origin, state recognition, good product and bad product identification, the identification of safekeeping conditions. Equipment identification mainly includes the equipment name, number, precision calibration management, operating personnel, maintenance personnel, operation condition, equipment, safety emergency escape, life device, operation flow signal in VM (Fu, 2010).

2.5.5 Awareness of visual management practices

Awareness can be described as the quality or state in which one is aware or have knowledge and understanding about the existence of something or occurrence of an event. It also means being conscious of the existence of something or an occurrence/event (Babalola *et al.*, 2018). Therefore, awareness in this context is used to describe the knowledge about the existence of VM practices. In Rogers' innovation diffusion theory (Rogers, 2003) awareness has been identified as the first stage in the adoption of an innovation, in the form of an idea, product or process of doing things. This has also been described as the knowledge stage when the potential adopter seeks to know about the innovation by acquiring knowledge and information about it. The knowledge sought at this stage of innovation-decision process is basically awareness knowledge, which may include knowing how the innovation works and how to apply or use it. The awareness knowledge involves the individual taking cognizance of the innovation, and this alone has the ability to make a potential adopter to decide to adopt the innovation or to get more knowledge on the procedure for using the innovation. In fact, the knowledge of how to use the innovation is essential in informing the adopter how the innovation can be used. This makes the potential adopter to have adequate knowledge of how the innovation operates and why it operates the way it does (Rogers, 2003).

VM practices is not well known within the construction industry, however, the importance of visualization is well recognized in the industry (Tjell *et al.,* 2015). Tezel *et al.* (2015) also posited that the use of VM is limited, particularly in terms of its deployment on the construction site, although VM has been practised for decades in various industries such as manufacturing, healthcare, and transportation (Bascoul and Tommeline 2017). It has however gained an increased attention in construction industry in recent times (Brady, 2014; Valente *et al.,* 2017). The concept of VM practices is becoming a reality more and more present in construction industry (Koskela *et al*,.2018). Its effectiveness in improving safety performance is becoming more and more acknowledged (Abdelkhalek *et al.,* 2019). However, Bascoul and Tommeline (2017) believed that currently VM practices is still in early stage of development Similarly, Sarhan *et al*. (2017) stated that the adoption of VM is still in a transition phase.

In USA and England successes have been recorded in level of awareness and making profit from the actual implementation of the VM in construction projects (Tezel and Aziz 2017). Studies from Brazil (Fernanda *et al.,* 2018), Saudi Arabia (Sarhan *et al.,*2017), Lebanon (Abdelkhalek *et al.,* 2019), Indian (Patel *et al.,* 2018), Morocco (Bajjou *et al.,* 2017) and Palestine (Enshassi and Abu, 2014) indicated that there was high level of awareness and usage of VM practices. A study by Ayalew *et al.* (2016) in Ethiopia indicated low level of awareness of VM practices among practitioners in the construction industry. Koohestani *et al.* (2020) also decried the low level of awareness of lean techniques in Iran construction industry, while Ahmed *et al.* (2020) revealed that less 65% of construction practitioners in Bangladeshi construction industry are aware of the VM practices. In Nigerian, the level of awareness and the extend of usage of VM practices in the construction industry is still low (Egbele-Okoro, 2020), this is corroborated by the study of Benedict *et al.* (2021) which ranked VM practices as of one of the least lean construction techniques adopted in Nigeria construction industry. One of the major challenges to the implementation of VM practices is lack of awareness of lean construction techniques (Sarhan *et al*, 2017), as a result, there is the need for more empirical evidence to maximize the benefits of lean construction techniques (Babalola *et al.*, 2018). Over the past years, many efforts have been made to raise awareness by providing guidance and sharing knowledge relating to lean construction by academics, researchers and practitioners (Bashir *et al*., 2015).

The establishment of the bodies has also helped to enhance awareness of LC techniques (Ogunbiyi *et al*., 2013). For instance, Lean Construction Institute (LCI), Construction Lean Implementation Program (CLIP), International Group for Lean Construction (IGLC), British Research Establishment (BRE), Construction Excellence (CE) (Bashir *et al.,* 2015), The Construction Industry Research and Information Association (CIRIA) and Construction Productivity Network. Additionally, seminars and conferences have been organized to increase awareness of lean techniques with real case studies of some construction organizations adopted VM (Valente *et al.*, 2017). According to Sarhan and Fox (2013), currently some organizations and universities offer lean construction education, which has been helpful in moving lean thinking into construction.

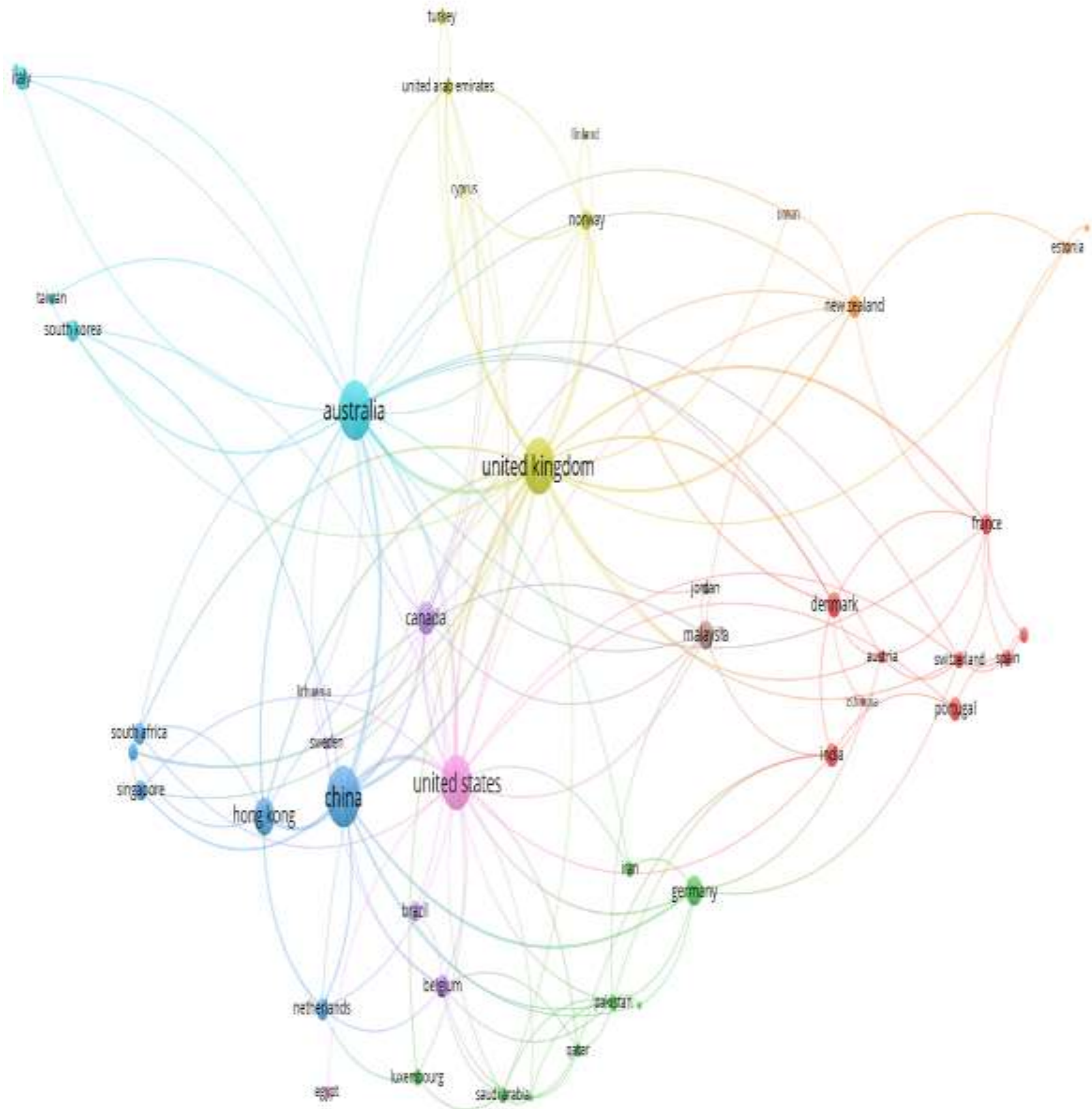

Figure 2.2: Co-authorship of country network

Source: Analysis from Vos viewer

The VOS viewer software program was used for more interpretive network visualization of co authorship of country countries to determine the level of awareness and extent of usage through the number of publications. A topic search was performed using the keyword

Visual Management and *construction sites* to obtain published literature on Scopus database. The keywords used to identify publications followed the logic of the research scope. Since the search was not restricted to any time span, it extracted the documents since the inception of VM. In total, 361 potential publications were found in Scopus database that were published in 54 Countries (see Table 2.1). Through network visualization using VOS viewer, the quantity of published literature is displayed in the circle. Circle size indicates the quantity of published paper in those countries; the higher the quantity of publications, the larger the circle (see Figure2.2). VM practices on construction sites is more profound in country like the United States, United Kingdom, Australia and China, though other countries are coming up, while there was no presence in many other countries. Hence, there is low level of awareness on visual management practices on construction sites. Nevertheless, VM practices has been gaining increasing attention in literature.

Table 2.1: Publication of literature on visual management

Country	Document	Citation
Australia	43	2061
Austria	2	197
Brazil	5	69
Canada	13	1732
Chile	1	2

Source: Analysis from Vos viewer

Table 2.1a: Publication of literature on visual management

Country	Document	Citation
Colombia	1	68
Croatia	1	25
Cyprus	1	33
Demark	8	450
Egypt	2	6
Estonia	2	42
Ethiopia	1	1
Finland	1	2
France	5	506
Greece	1	21
Hong kong	18	1373
Hungary	1	3
India	7	186
Iran	3	472
Ireland	3	344
Israel	1	35
Italy	7	297
Jordan	2	70
Lithuania	1	60
Luxembourg	3	23
Macau	10	76
Malaysia	1	34
Morocco	2	34

Source: Analysis from Vos viewer

Table 2.1b: Publication of literature on visual management

Country	Document	Citation
Netherlands	6	235
New Zealand	6	502
Nigeria	4	64
Norway	5	108
Oman	1	92
Pakistan	3	115
Poland	2	77
Portugal	7	429
Qatar	2	121
Saudi Arabia	3	101
Serbia	1	63
Singapore	5	107
South Africa	6	92
South Korea	6	688
Spain	4	403
Sweden	2	62
Switzerland	4	490
Taiwan	2	179
Turkey	3	146
United Arab Emirates	3	63
United Kingdom	39	1962
United States	37	3489

Source: Analysis from Vos viewer

2.5.6 Visual management implementation in the construction industry

A wide range of VM practices have been used in manufacturing, some of which have been adapted to construction sites (Fernanda *et al.*, 2018). Some visual devices are relatively simple, such as information boards containing procedures, drawings, and performance measures, while other practices require extensive planning, a certain level of readiness, and stability within the production system (Tezel *et al.*, 2015), such include kanban systems for pulling production or material supply, heijunka boards for levelling production, workplace organization, and andon systems for managing the help chain (Fernanda *et al.*, 2018). It has been pointed out that VM is the predominant mode of communication within organizations that seek to reinforce employee autonomy. In a traditional work environment, control and knowledge tend to be centralized, while in a transparent environment the network of information is independent of the hierarchical structure of order giving. Therefore, employees are allowed to control execution by comparing current conditions to given production objectives. Furthermore, visual management may increase the involvement of workers in continuous improvement efforts (Bernstein, 2012) because it allows for rapid understanding of and response to problems (Bateman *et al.*, 2016). Process control is simplified, reducing the propensity to commit errors and, most certainly, increasing the visibility of errors (Koskela *et al*., 2016).

2.5.7 Factors influencing the implementation of VM on construction sites

The empirical evidence on VM implementation remains scarce, only few studies report outside of their main findings on why VM implementation might succeed or fail Kurpjuweit *et al.* (2019). According to Verbano *et al.* (2017), the active participation and involvement of shop floor workers is important for the long-term effectiveness of VM. Poksinska *et al.*

(2013) noted that workers, not managers, should be responsible for updating the boards. These updates should be conducted in regular meetings and can involve selected customers and suppliers (Parry and Turner 2006). However, in their study on the design, implementation, and use of VM boards, Bateman *et al.* (2016) find that shop floor workers face difficulties designing and updating the boards due to their limited experience with the software systems, which constitutes an important barrier for VM implementation. They also emphasize the lack of commitment and resources, for instance in terms of physical installation of the boards, preparation of the data to populate the boards and coaching, as another important barrier. Hence, it is not surprising that scholars highlight the necessity of top management support (Eaidgah *et al.*, 2016; Parry and Turner 2006). Abdulkhalek *et al*. (2019) reported that resistance to change, cost, culture, time, overconfidence and lack of government regulation are the major barriers to implementation of VM practices while Tomasz and Jonnah (2021) highlighted that safety culture at a lower level, lack of support from top management, and lack of resources as the major barriers to implementation of VM practices. In a related development, Bateman *et al.* (2016) and Kurpjuweit *et al.* (2019) identified lack of construction skills workers, lack of resources, lack of commitment, missing top, middle management involvement and complexity of underlining process as barriers to VM implementation. Studies have also highlighted factors that promote VM implementation on construction sites, for example Kurpjuweit *et al.* (2019) reported eight movers of VM implementation, which are: pilot project, external consulting, standardization and control stepwise approach, training and coaching, knowledge transfer, management involvement and employee involvement. Bititci *et al.* (2016) reported that the top management of some companies is reluctant to share strategic information with shop floor workers, despite its importance in generating worker engagement. The study suggested a two-step implementation strategy to get managers to share information so that workers will be more engaged. Accordingly, firms should first introduce a light version of VM to familiarise the top management with the concept, before deploying it to other functional areas. Similarly, Verbano, *et al.* (2017) highlighted the usefulness of a gradual introduction of new tools and practices. Middle management is also important in the effectiveness of VM implementation. While area managers need to participate in implementation from the beginning to ensure sufficient ownership of the process, team leaders often have operator capabilities but lack the requisite leadership skills (Bateman, *et al.*, 2016). Besides general training on the use of VM Verbano, *et al.* (2017), Bateman, *et al.* (2016) suggested that team leaders need special mentoring and coaching for developing the leadership skills that are required for enabling continuous improvement. Bititci *et al.* (2016) noted that successful long-term implementation requires an accompanying change in organizational culture.

2.5.8 Barriers of implementation of VM on construction sites

i. **Management barrier:** Management barriers referred to various issues related to the support of the top management administers the construction firms. Since the successful implementation of lean tools or any new innovative strategy needs to be supported by top management (Attri *et al;* 2017, Small *et al;* 2017). Therefore, the role of management is a key factor that can enhance or hinder the effect of lean tools on safety performance (Camuffo *et al*., 2017). Barriers to the VM implementation in construction projects are identified in several studies and seemed to be related to management issues (Kurpjuweit *et al.*, 2019, Abdulkhalek *et al*., 2019, Tomasz and Jonnah, 2021). Poor project definition is proved to be a management barrier prevented the successful implementation of lean construction techniques in construction projects (Small *et al.*, 2017). Delegation strategy should be adopted by top managers to allow workers to participate in decision making and enhance work flow, too (Camuffo *et al.,* 2017) As a result, the approval procedure from top management can be shortened (Small *et al.,* 2017). Furthermore, lack of time for innovation is identified as a management barrier faced some construction firms in implementation of lean practices in construction projects (Zhou, 2012). In addition, Awada *et al.* (2016), identified lack of transparency as a management barrier prevented the successful implementation of lean tools in construction projects. Lack of communication among participants of the production process (managers, administrators, foremen, etc.) is another barrier hindered the implementation of VM in construction projects (Attri *et al.*, 2017). Kurpjuweit *et al.* (2019) identified lack of commitment of management as another barriers to implementation of VM practices on construction sites.

ii. **Attitude barrier:** Attitude refers to trend regarding intent, commitment and cooperation that need to be presented within the parties to successfully implement lean tools in construction projects. Attitude will consequently influence their capacity to work as a team. Abdulkhalek *et al*. (2019) posited that human attitude is one of the major factors affecting the implementation of VM in various construction industries. Poor leadership is one of the attitude barriers to lean tools implementation in construction projects (Attri *et al.,* 2017). Poor leadership may result into introduction of other barriers like employee resistance to change, inability to change the organizational culture and poor communication (Attri *et al.,* 2017).

To implement visual practice, it is fundamental to change the mind of the employees to manage their resistance to change (Attri *et al.,* 2017). Since employee support is very necessary for successfully implementing VM in construction projects. Cultural issues are also mentioned as barriers to the successful implementation of VM in construction projects (Abdulkhalek *et al*., 2019; Tomasz and Jonnah 2021; Kurpjuweit *et al.,* 2019). Moreover, lack of self-criticism limited the capacity to learn from errors which hindered the successful implementation of lean practices in construction. Fear of unfamiliar practices is another barrier to the implementation of new practice this is due to the misconceptions and misunderstandings of workers about VM (Bashir *et al.,* 2015).

iii. **Financial barrier:** Financial issues are among the most common barriers to lean practices across different organizations in various countries, but it varies across countries (Bashir *et al.,* 2012). The successful implementation of VM requires adequate fund to provide relevant resources, incentives and reward systems and sometimes to employ Lean specialist in the early stages to guide the organization in implementing the concept of Lean in safety improvement (Bashir *et al.,* 2012). Inadequate resources hindered developing and implementing an effective plan, and dealing with changes arising during the implementation of VM practice (Kurpjuweit *et al.* 2019). Cost of training, consultancy fees and cost to conduct workshops are considered as implementation cost of lean tool in construction projects (Bashir et al., 2015), Moreover, poor salaries of professionals do not encourage them to apply any innovative strategies (Small *et al.,* 2017) Lack of incentives and motivation is identified as financial barrier hindered the implementation of lean practice in construction projects (Attri *et al.*, 2017)

iv. **Education barrier:** Over the past years, many efforts have been made to increase awareness of lean practices by providing guidance and sharing knowledge relating to lean techniques by academics, researchers and practitioners. (Bashir *et al.,* 2015). The establishment of bodies like Lean Construction Institute (LCI), Construction Lean Implementation Program (CLIP) has also helped to raise awareness of lean practices (Bashir *et al.,* 2015). Despite these continuous efforts, it seems that educational barriers pose a great threat to the implementation of lean practices (Bashir *et al*., 2015) Educational barriers included lack of understanding of VM concept and inadequate knowledge of lean techniques (Awada *et al*., 2016,). Lack of technical skills is another barrier impede the implementation of VM in construction projects (Kurpjuweit *et al.,* 2019). Lack of technical skills hindered the conduction of pre task hazards analysis and accidents investigation program which are lean construction techniques used to promote safety. Moreover, technical skills of safety supervisors enabled them to define a standard procedure in order to maintain a clean work environment (Cudney *et al*., 2015). Furthermore, lack of education and training; and lack of awareness programmes are reported as educational barriers to the successful implementation of VM in construction projects (Kurpjuweit *et al.*, 2019). Without proper education and training, employees will not be able to know the basic concepts and benefits of implementing the VM practices. Employee working in the construction firms should have adequate knowledge about the programmes to be implemented (Sandeep and Panwar, 2016).

v. **Technical barrier:** Technical barriers have a direct impact on the application of certain VM principle and tools such as reliability, simplicity, flexibility and benchmarking (Koskela, 1992). Lack of agreed implementation methodology to implement lean practices is identified as technical barrier prevented the successful implementation of VM in construction projects. Moreover, complexity of VM implementation is another barrier to implement visual practices in construction projects. The complexity of construction projects, transitory nature of construction workplaces and changes in organizational personnel complicate the safety issues on construction sites). Since, VM does not just involve applying lean techniques on site, but also involves developing a culture among the staff for a continuous improvement across all units of the construction firm (Bashir *et al.,* 2015). Additionally, poor performance measurement strategies and fragmented nature of the construction industry are technical barriers hindered the implementation of VM in construction projects (Bashir *et al.,* 2013).

vi. **Government:** studies revealed that of one the barriers to implementation VM practices are due to government attitudes and support towards the construction industry in some countries (Kurpjuweit *et al.,* 2019, Abdulkhalek *et al*. 2019, Tomasz and Jonnah 2021). Government aspects that affect the project's development and the lean practices implementation are considered as external barrier in construction projects (Cano *et al.*, 2015). Governmental barriers are related to the government bureaucracy and instability of government policy (Small *et al.,* 2017). Inconsistency in policies was identified as government barriers to the implementation of lean practices which has a major effect on the plans of construction firms (Small *et al.,* 2017). Moreover, the unsteady price of commodities is another barrier prevented the implementation of LC in construction projects (Bashir *et al.*, 2015) Commodities needed in construction projects to improve safety are safety equipment as PPE, signs, boards, demarcations and alarms which are considered as LC techniques to promote safety (Sarhan *et al.*, 2017) The unsteady price of these commodities will affect the application of VM practices to improve construction safety.

2.5.9 Drivers of VM implementation on construction sites

i. **Government:** The success and failure of Lean application rests partly on the shoulders of the government (Shang and Pheng, 2014). Government should make reorientation in their approach to projects' execution. Government should prioritize lean in their national agenda and provide a clear direction for the construction firms to apply LC techniques on construction project (Shang and Pheng, 2014). Government agencies should introduce policies to encourage construction firms to engage in the application of LC techniques to improve safety in construction projects (Small *et al.*, 2017, Suresh *et al.*, 2017) The introduction of laws by the legislature, which is an arm of the government, is seen as another way of facilitating the full application of LC techniques among construction firms (Oladiran, 2017).

ii. **Management:** Management of construction firms has the main role to promote or hinder the implementation of VM practices in construction projects (Abdulkhalek *et al*. (2019). The successful application of LC techniques lies on the support and commitment of top management (Azyan *et al.*, 2017., Oladiran, 2017). Therefore, construction managers should develop and implement an effective plan to implement lean techniques successfully in safety improvement (Cano *et al.,* 2015, Bashir, 2013). Leadership is another important factor needed to overcome barriers to the application of LC techniques to improve safety in construction projects (Azyan *et al.,* 2017) good Leaders fosters effective skills and knowledge enhancement amongst its workforce. Also, Construction managers should cultivate honesty and trust between project participants (transparency) and be proactive in decision-making to apply LC techniques successfully in safety improvement (Cano *et al.*, 2015)

iii. **Education and training/skill development:** Education and skills improvement is about building human by providing education and training for the employees at all levels on the lean concept and tools (Azyan *et al*., 2017; Small *et al*., 2017). It is believed that continuous training is the key to change the organization culture and employees resistance to change during lean construction implementation (Azyan *et al*., 2017; Small *et al*., 2017). All the instructions, in the application of lean construction techniques should be simplified in order to achieve compliance and successful execution of the assigned tasks (Bashir *et al*., 2015). Furthermore, construction firms should enlighten their employees on the benefits of VM by engaging them in meetings, workshops and other events on the benefits of VM techniques (Tezel *et al.,* 2015). Comprehensive understanding of the Lean philosophy should be enhanced through awareness programmes to overcome the barriers to the application of lean techniques to improve safety (Cano *et al*., 2015). Awareness programmes could involve organizing a workshop or a training session with lean consultants to train the employees adequately to fully understand VM techniques. Moreover, awareness can be increased through research conferences to generate active, basic and applied research on VM to guide the application of VM practices in order to improve safety on construction sites.

iv. **Operation:** Operation success factors are needed to be considered during the application of lean practices in safety improvement like standardizing and ensuring complete designs to apply LC techniques in safety improvement successfully (Cano *et al.*, 2015). Additionally, workers should be involved and empowered to participate in the application of VM practices in safety improvement (Kurpjuweit *et al.*, 2019). Also, VM techniques should be applied gradually step-by-step in improving safety (Kurpjuweit *et al.*, 2019). Bashir (2013) stated that when the construction firms identify the tools that are relevant in achieving their targets, they should apply the tools in stages or one after the other, rather than many tools at a time. This strategy could help in addressing challenges like difficulties in changing working culture and complexity of Lean implementation. Moreover, establishing an improvement committee is important to be responsible for the application of LC techniques in safety improvement (Cano *et al.*, 2015). Construction firms should establish appropriate performance measurement approaches to measure the effectiveness of implemented LC techniques in safety improvement (Netland, 2016).

2.6 Safety Performance of the Construction Industry

The construction industry has faced a wide range of challenges especially due to the occurrences of accidents or hazard at the site. The main cause of accidents is poor safety performance of the workers from a combination of contributing causes (Nawi *et al.*, 2016). Therefore, a safety programme is needed to ensure and encourage better safety performance at construction sites. Safety programmes are key for avoiding work-related accidents and injuries Health and safety training and induction programmes for new employees are one of the ways to endure effective safety performance of construction industry. Sunindijo (2015) posited that the cost of training and compliance is a major impediment, especially to SMEs because of their limited financial strength and economic forces. health and safety training and induction programmes can improve safety consciousness and performance of construction site operatives. To ensure sustainable safety training in construction organizations, Sunindijo (2015) advocated for safety training incentives and supports. Companies with existing training programmes need to be assessed for effectiveness and to ensure that the practices are not neglected.

According to Nawi *et al.* (2016), there are four categories of factors affecting safety performance that should be focused on, which are: management, safety culture, behaviour, and awareness. On the other hand, Couto *et al.* (2017) highlighted time barriers as the factor affecting safety performance at construction sites. Safety performance can be influenced by factors including top management's and project managers' poor safety awareness, poor safety resource, lack of training, and reckless operations.

Health and safety improvement strategies identified by Belayutham and Ibrahim (2019) include; safety being considered as criteria during tendering, construction organizations should provide a suitable platform for exchanges of knowledge and experiences that will promote best practices, funding of OHS training to be taken over by the government, making safety one of the Key Performance Indicators, strict enforcement of safety regulation, creating more safety-conscious culture, rewards, and penalties for defaulters, effective communication system on-site, and health and safety training programmes.

2.6.1 Measurement of safety performance on construction sites

Measuring safety performance allows the organizations to take important decisions and appropriate actions towards their adopted safety management system (Elsebaei *et al.*, 2020). Measurements are very important as it determines the effectiveness of the safety management system on the overall safety performance, which can be either accident prevention strategies and/or safety practices and activities Some researchers suggest that measuring contractors' own safety performance is important to ensure their organizations are aware about their safety well-being. A study by Hinze and Gambatese (2013) concluded that contractor's safety performance was consistently influenced in part by several factors. In addition, the quality of project contractors is even more important because it has a direct bearing on the performance of the prime contractors on key elements of the work. Improving health and safety performance in the construction industry is crucial because it represents the excellence of the executed projects, and more importantly the protection of life for people who work in the field.

There are two types of safety indicators widely used in safety literature, which are "leading" and "lagging" (output measurement, or post-accident measurement) safety indicators. Leading indicators are preferred both in industry and academia. Traditionally, safety performance was measured by the goal setting and feedback method (known as lagging indicators) such as Incident Rate (IR), Accident Rate (AR) and Experience Modification Rate (EMR). In recent years, leading indicators have been highlighted as the method to evaluate safety performance of the construction project (Choudhry *et al.*, 2007). Safety performance measurement tool has been developed in other countries, for example ‘Safety Meter’ in Australia, SHASSIC in Malaysia, these tools are based on leading indicators that aim to involve the workforce in the method of measurement and raise site safety awareness (Abas *et al.*, 2020).

2.6.2 Lagging indicators

Traditionally, the construction industry has measured safety performance based on lagging indicators such as total recordable injury rate (TRIR) and fatality rate (Hinze *et al.*, 2013). According to Lingard *et al.* (2013), the reason for the popularity of these methods are: Easy to collect, Understood easily, comparable with each other, used in benchmarking, Useful in the identification of trends Lagging indicators record “after the fact” failures. Since the probability of occurrence of any recordable injuries or fatalities are low, they could not be able to identify any changes in the safety management system (Lingard *et al.*, 2013). Lagging indicators measure the absence of safety rather than the presence of safety Sometimes injury rates have been related to other things such as reward systems, bonuses, and manager performance appraisals (Lingard, 2013). These rewards can lead to perverse incentives causing employees to under-report. Near miss reports have been categorized as leading indicator and lagging indicator, Hinze *et al.* (2013) have investigated this problem and came up with characteristics for each near miss report.

1. **Osha recordable incident rate:** For many reasons in most organizations, they still use traditional safety measures like OSHA incident rate which is number of incidents per 200,000 man-hours worked in each organization. The other similar measurement introduced by American National Standard Institute (ANSI), is the number of incidents per 1 million man-hours worked. Based on OSHA, injuries that require a physician to treat them and cases where workers become unconscious during his or her job should be considered as recordable injuries (Elsebaei *et al.*, 2020).

$$TRIR = \frac{\text{No of OSHA recordable cases} * 200{,}000}{\text{Total labour hours worked a year}}$$ .... Equation (2.1)

2. **Lost time cases (LTC):** According to OSHA (2003), any injury or illness that results in the employee being unable to work as assigned work shift is considered as LTC. It should be noted that death is not categorized as LTC

$$LTC = \frac{\text{No of lost time cases} * 200{,}000}{\text{Total labour hours worked a year}}$$ ....Equation (2.2)

3. **Lost workday rate (LWD)**: According to OSHA (2003), Lost Work Day Rate (LWD) calculates the number of lost work days per 100 employees. The equation below shows the calculation of LWD rate:

$$LWD = \frac{\text{No of lost time} * 200{,}000}{\text{Total labour hours worked a year}}$$ **.....................** Equation (2.3)

4. **Days away, restricted or job transfer (DART):** This rate is an indicator for a number of incidents that had one or more lost day, one or more restricted days, or days that an employee was transferred to different tasks within a company.

According to OSHA (2003), below is the equation that shows the calculation of DART rate:

$$DART = \frac{\text{No of DART incident a year} * 200{,}000}{\text{Total labour hours worked a year}}$$ .... Equation (2.4)

5. **Incident rate (IR):** Total number of incidents per 100 workers (not necessarily working the standard OSHA hours) in a certain time (not necessarily a year)

$$IR = \frac{\text{Total incidents} * 100}{\text{Total workers}}$$ .... Equation (2.5)

6. **Severity rate (SR): T**he total number of lost days for every incident within a period of time.

$$SR = \frac{\text{Total lost days}}{\text{Total incidents}}$$ .... Equation (2.6)

7. **Risk rate (RR):** The total number of lost days for every 100 workers (not necessarily working the standard OSHA hours) in a certain time (not necessarily a year).

$$RR = \frac{\text{Total lost days} * 100}{\text{Total workers}}$$ .... Equation (2.7)

8. **Experience modification rate (EMR):** Workers' compensation insurance is a significant cost of any construction firms. This indicator is being widely used as an index for past safety performance of any firm. The experience modification rate is widely used indicator of a contractor's past safety performance.

According to Hinze *et al.* (1995), the equation for calculation of EMR will be:

$$EMR = \frac{\text{AP+Ee+b}}{\text{E+B}}$$ ....Equation (2.8)

Where Ap= actual primary loss; Ee= expected excess loss; E= expected losses; B= Ballast

Lagging indicators are reactive monitoring indicator that show when the desired safety outcome has failed, or when it has not been achieved (Oien, *et al.,* 2011). The use of lagging indicators involves identifying and reporting incidents to check that controls in place are adequate, identifying weaknesses or gaps in control systems, and learning from mistakes (Dagdeviren *et al.,* 2008). Lagging indicators have been widely used in the construction industry to measure and improve safety performance for decades, However, most of these methods are reactive or subjective approaches because accident statistics only show the performance of safety management in the past (Costin *et al.,* 2019) and are reactionary. In addition, these traditional safety metrics are out of date given the current ability to collect, analyse, and share safety data (Mahmoudi *et al.,* 2014). Since lagging indicators are reactive, they will not be used in this study to measure safety performance.

2.6.3 Leading indictors

The use of leading indicators has increased recently based on the number of organizations that have implemented as well as increased research with the focus on leading indicators. There are many advantages for using safety leading indicators. One of the advantages is that leading indicators provide a measurement on how well the organization is performing in terms of safety (Lingard *et al.,* 2013). It could give proper feedback to safety management for improvement before any accident happens (Hinze *et al.,* 2013). leading indicators are categorized as a passive indicator or an active indicator. Passive indicators are those that cannot be altered in a short period of time (Hinze *et al.,* 2013). Dilkhaz and Neamat (2019) identified ten leading indicators through a systematic literature review. Leading indicators identified include:

i. **Workplace organization:** Work place organization is considered a physical hazard indicator in the workplace (Guo and Yiu, 2016). Housekeeping is a comprehensive phrase restricting the cleanliness of a site. It comprises features such as waste removal, and material and equipment storage.

ii. **Attitudes and Safety climates**: Safety climates refers to the attitude of employees or managers in the workplace (Dilkhaz, and Neamat 2019). Safety climate is largely well-defined as the employee insights of safety in the job site, specifically as it related to manager opinions (Schwatka *et al.,* 2016).

iii. **Near Miss:** Near Miss: Is deliberated a close call incident. It may cause injuries or totally damaged, but no damage was caused as the navigation of how to manage and control the hazards and avoid it is occurrence in the workplace. Through using PPE, change in the task sequence and controlling of guards (Rajendran, 2013).

iv. **Site Inspections**: Site inspections, and their similar coordinate, site examining, are tests that evaluate the hazards number on the workplace. Rajendran (2013) used a scoring system where opinions were subtracted depended on the number of safety violations that happened on the site. Site checks are checklists prepared by some familiar individuals such as a supervisor or safety representative (Lingard *et al.*, 2017)

v. **Training/Job Safety Talks**: Safety instruction, and safety training for supervisors to edit safety conditions considered as safety practices (Guo and Yiu, 2015). Training has often measured a side of safety (Niu *et al.*, 2017; Schwatka *et al.,* 2016). Toolbox talks, or job safety talks, used to change the conversation between the management and workers on a steady base and can be seen as a type of safety communication (Lingard *et al.*, 2017).

vi. **Pre-task Safety Plan:** pre-task safety planning as the discussion of hazard controls to eliminate or manage hazards in the work tasks (Guo and Yiu, 2015). This planning is done by controls such as guards, change in task sequence, or use of personal protection equipment.

vii. **Worker Safety Behaviour**: Worker safety behaviour was dignified in lots of studies. It includes measures such as worker participation in safety (Schwatka *et al.,* 2016) employee safety inspiration, and worker safety capability (Guo and Yiu, 2015). Rajendran (2013) depended on using checklists instead of safety professional evaluation to evaluate workers' safety behaviour.

viii. **Safety Corrections:** Ng *et al.* (2012) measured the number of safety corrections as the number of non-compliance of project safety regulations made by the workers on an ad hoc basis. In contrast, Lingard *et al.* (2012) measured non-compliance as determined through site inspections alone.

ix. **Subcontractor Safety**: Subcontractor safety can be noticed at various levels. (Guo and Yiu, 2015) Focused on the subcontractor managing of safety as an indicator in the advance safety condition. Also, in project construction until now they did not offer a measurement methodology (Sparer *et al.,* 2015)

Cheung *et al.* (2018) also categorized safety indicator into 3 levels which are: Firm level, project level and group/ individual level. Cheung *et al.* (2018) identified 16 safety indicators through a systematic literature that can used to measure safety performance on construction sites on construction sites as shown below in Table 2.2.

Table 2.2: Leading indicators used to measure safety performance

Firm level	- Description	Source
Organisation commitment	Client, designer, principal contractor and subcontractor commitment to safety	Guo *et al.* (2017)
Safety auditing	The process of collecting independent information on the efficiency, effectiveness and reliability of the safety management system and drawing up plans for preventive actions.	Mictchell (2000)
Training and orientation	Improving skills, knowledge, attitudes and experiences of employees to effectively manage safety	Alruqi Hallowell (2019)
Project level		
Client engagement	Client is engaged in construction safety throughout a project.	Alruqi & Hallowell (2019)
Supply chain and workforce engagement	Subcontractors, suppliers and self-employed workers are engaged in construction safety throughout a project.	Guo *et al.* (2016)
Safety design	Preventing accidents during construction is considered as one of the objectives of design.	Mitchell (2000)
Plan for safety	Safety in construction is considered in the planning process	Agumba & Haupt (2012)
Hazard identification and control	The process and outcome of identifying and controlling hazards and risks in workplace.	Biggs &Biggs (2013)
Safety learning	Learning from accidents, incidents and relevant experiences.	Biggs & Biggs (2013)
Recognition and reward	Mechanisms to motivate workforce to comply with safety	Guo *et al.* (2017)
Site communication	Familiarising operatives with a job, informing risks and improving task specific competence to prevent accidents	Versteeg *et al*. (2019)

Table 2.2a: Leading indicators used to measure safety performance

Group and individual level	- Description	Source
Safety climate	Employees' perception of the priority an organisation and workgroup placed on safety-related policies, procedures and practices.	Chen *et al.* (2018)
Worker involvement	Workers' level of involvement in establishing, operating, evaluating, and improving safety practices.	Aksorn & Hadikusumo (2008)
Competence	Ensuring that employees have the skills, knowledge, and attitudes do the work .	Hinze *et al.*, (2013)

Source: Cheung *et al.* (2018)

Safety leading indicators were commonly recognised as measures of the safety management system, which consists of safety rules and resources as well as actors with the aim of creating and sustaining the safety of a workplace (Guo *et al.*, 2017). in construction, safety leading indicators measure safety management processes and practices of firms and projects. The measurements precede the occurrence of adverse safety outcomes. They provide early signals of situations that might increase levels of risk or lead to adverse safety outcomes (Leveson, 2015). Therefore, leading indicators can prompt proactive measures in response to the current state in order to address the deficiencies or further develop the safety management system (Hallowell *et al.*, 2013). Leading indicator will be adopted in this study because of its proactiveness in measuring safety performance, as it provides an early indication of impending adverse events and drive preventive actions.

2.6.4 Factors affecting safety performance

The construction industry is recognized as the most dangerous industry as it is often accompanied by accidents. These accidents that occurred on building sites lead to many drawbacks in project performance, like delay in completing the project, increasing project cost, reducing productivity, and creating passive perceptions of the organization. Thus, it is important for the worker to make sure that safety and health are taken care of in the workplace to avoid accidents (Abas *et al.,* 2020). Health and safety issues are extremely significant in all industries and particularly in the building industry. Although the construction industry always faces changes like adapting new methods and new equipment's as well as new machinery, however, it is always running into safety issues, including deaths. Therefore, health and safety problems are always considered important in the construction industry, particularly the problems regarding poor safety performance like injuries and health diseases could be the cost of accidents, both directly and indirectly. According to Shah *et al.* (2015), there are many factors that could be categorized into nine different major groups as follows:

i. **Cost factors:** Cost is the most considerable factor affecting any industry if it is construction or manufacturing. The major factors included in the cost group are prices escalation of material, project cash flow, materials cost, equipment's cost, project labour cost etc

ii. **Time factors**: Time is directly correlated to the performance of construction. Some of the time factors include average delay due to closure, lack of materials, project duration, the average delay in payments to the contractor, the ratio of orders delivered late, the time required to correct defects, time of site preparation and time required to execute change orders.

iii. **Quality factor:** quality is one of the important measures for the customer side. High-quality construction required a high amount of time to construct the amenities.

iv. **Productivity factor:** depend on labour, skilled personal and semi-skilled personal. So the productivity is influenced by labour and so on performance too.

v. **Client Satisfaction:** Client Satisfaction also affecting the performance of construction. Coordination of information between owner and project parties affecting client satisfaction.

vi. **Health and safety factor:** This group contain four cofactors; reportable accident rate, applications of health and safety factors in a company, assurance rate of projects, and ease of arrival to the site (project site).

vii. **Government policies:** Government policies affect the speed of construction as well completion of construction. The viewpoint of the contractor is also important.

viii. **Surrounding circumstances:** The environment is also an important aspect of the human body. It affects the productivity of construction as well as the performance of construction. Major factors are climate condition in the site, noise level, air quality, and waste around the site.

2.7 Bibliometrics Analysis of Safety Performance in the Construction Industry

In this study, the Scopus citation database was used for conducting the bibliometric analysis. Scopus is the world's largest and most wide-ranging collection of information resources (Xie *et al.,* 2020). Bibliometrics is the routine use of citation analysis and a systematized approach to the processing data repository (Thompson and Walker, 2015). A topic search was performed using the keywords "safety performance, construction industry" to obtain published literature in the Scopus. Since the search was restricted to ten years timespan, it extracted the documents from 2013 till 2023. The search was carried on January 18, 2023. It resulted in 1280 documents that were downloaded in csv format for analysis. The files were imported to VOS viewer software program. VOS viewer was used for more interpretive network visualization of keywords, journals, publications, authors, and countries.

The keyword co-occurrence is a bibliographical analysis applied to detect significant areas and classify those frequently co-occurring terms into theme-based clusters (Sharifi 2020). Bibliometric data reveals that this analysis included 7050 keywords. Results of keyword occurrence were carried out by co-citation analysis in VOS viewer for a minimum threshold of 25 keywords and the 282 representative co-occurrence links, as shown in Figure 2.3 The size of each node is commensurate with the frequency of the keyword. The proximate nodes indicate those have simultaneously occurred in multiple articles, and the thickness of the links that connect them is proportional to the strength of the link (Sharifi 2020). Keywords such as construction, construction industry, project management, sustainable development risk management and construction safety have high incidences, indicating a greater research focus, and are strongly associated with the other keywords. Since the keyword safety performance was included in the search string hence its high occurrence is predicted. Four clusters were identified, the largest blue cluster with 12 keywords including construction, construction industry, project management, construction management, is closely linked to keywords like construction industry. The second-largest cluster was the red cluster with 22 keywords mainly containing accident prevention, occupational risk, construction sites, construction safety and human resources management are linked with safety performance on construction sites. The green cluster contained 13 keywords, such as sustainable development, industry 4.0, waste management, supply chain and planning which can be seen as movers to safety performance on construction sites. Other keywords like BIM, office building, information management and design are in the yellow cluster, indicating their link with safety performance. Figure 2.3 shows the quantitative details relating to the top 10 highly occurred keywords ranked based on their strength.

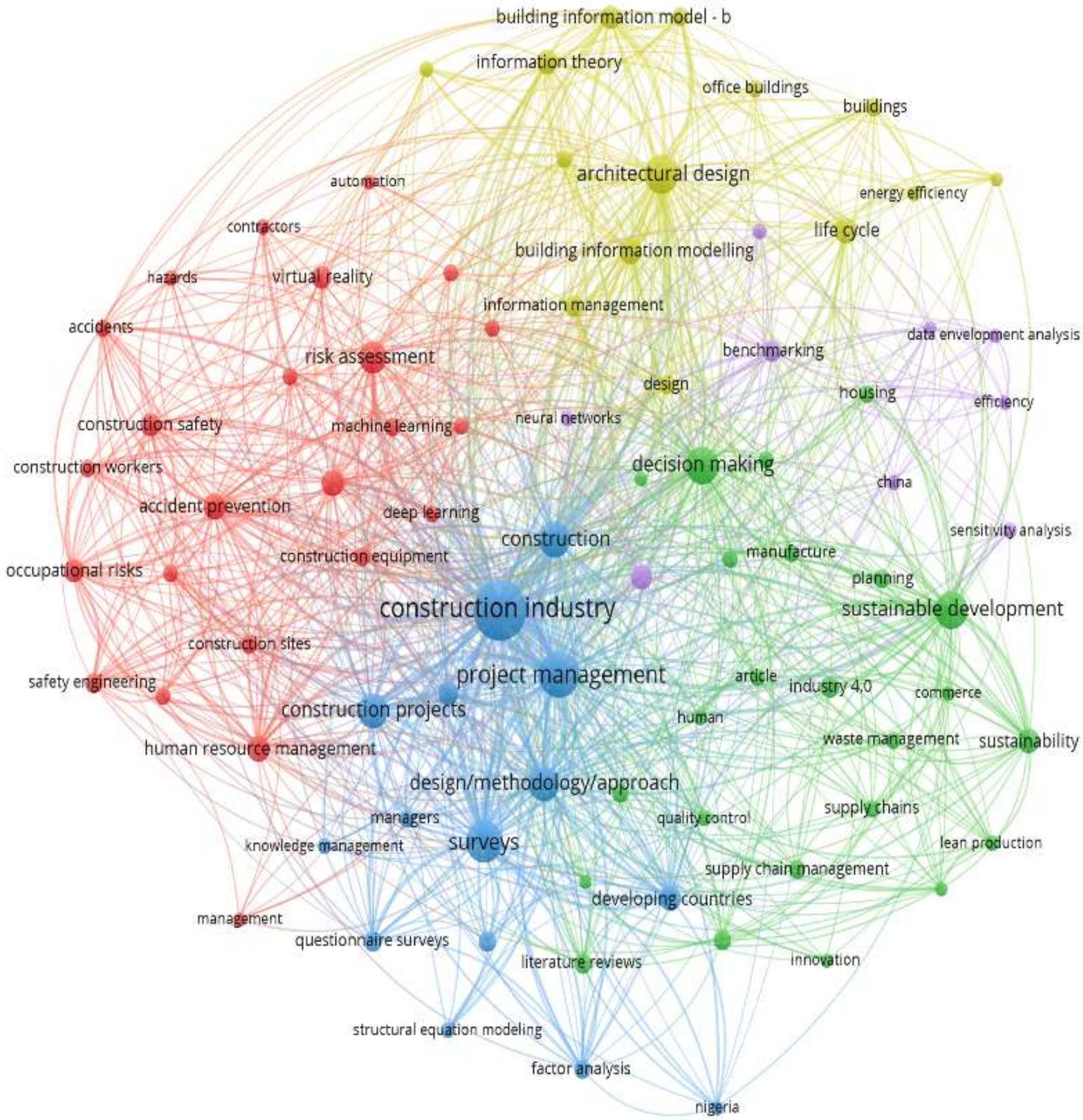

Figure 2.3: Co-occurrence analysis of all keywords network

Source: Analysis from Vos viewer

2.8 Influence of Visual Management Practices on Safety Performance

Effective VM practice is an antidote for improvement process that can significantly improve safety performance as it results in fewer losses (Tomasz and Jonnah 2021). Effective visual management practice on construction site can produce significant benefit and impact the overall project performance. VM practices promote systemic thinking that is aimed at improving the safety performance of workers on construction sites by stimulating human senses (Tezel *et al.*, 2009). This is achieved by making the construction process visible and comprehensible from start to finish through measurement and public displayed of information. (Koskela, 2002). The use of various VM tools makes the implemented processes understandable for all construction workers and managers through a clear visualization of the performed work done in a consistent manner (Kurpjuweit *et al.*, 2019). An important aspect of VM practices is that it is deliberate in pursuing the purpose of making it easy for everyone to quickly recognize and comprehend what is being communicated (Tomasz and Jonnah 2021). Hence, it improves the safety performance on construction sites.

The issue of work safety constitutes an important pillar in the operation of enterprises. Each employer is obliged to protect workers' health and life ensuring safe and hygienic working conditions, while making good use of the achievements of science and technology. In order to reduce the risk of accidents, the employer should equip workers with preventive solutions limiting the risk of accidents. VM is an effective solution for the improvement of the efficiency of processes that can also significantly improve work safety (Tomasz and Jonnah 2021). VM refers to the manner of visualization of work activities in order to improve the workflow (Beynon-Davies *et al.,* 2017) and it implies the support of processes in such a way that they are safer, more effective and ultimately result in fewer losses (Tomasz and Jonnah 2021). The use of various forms of VM makes the implemented processes understandable for all production workers and managers alike through a clear visualization of the performed work done in a consistent manner (Kurpjuweit *et al.*, 2019). The goal of Visual Management is to make communication simple and attractive. The simplicity and attractiveness of visualization facilitate communication (Tomasz and Jonnah 2021).

Scientific research on the use of VM shows that VM focuses on the transfer of information, facilitates the exchange of strategic information. throughout the enterprise and strengthens the involvement of production teams in improvement activities (Kurpjuweit *et al.*, 2019). Actions to improve work safety should also be treated as an improvement initiative, and the use of VM in the area of occupational safety and health may lead to a reduction in accidents at work and an increase in the safety culture (Tomasz and Jonnah 2021). It therefore seems necessary to identify the factors that facilitate the achievement of the goal and the obstacles that hinder it as so to make the conducted activities effective and improve work safety.

VM supplement work instructions through reinforcing the right way that things should be done at the point of action. It helps in ensuring that the right things are being done the right way by people. Visual devices enable someone to walk into the construction sites and know within a short period of time what’s happening regarding some elements as workflow, performance targets, and specific required actions (Sarhan *et al.,* 2017). Visual devices include signs related to safety, schedule, and quality (Enshassi and Abu, 2014). It could be used to provide immediate and visual information that enables people to make correct decisions and manage their work and activities properly (Chahal and Narwal, 2017).

Increased visualization can be identified as one of the key principles of promoting safety on the construction site (Patel *et al.*, 2018). The VM technique is used to monitor the construction workers and warn supervisor if they are not using safety devices. The boundary beyond works should be made very visible to the workers to prevent accidents caused by human error. This can be achieved by visual demarcations and boards (Bashir, 2013). A major strength of visual devices is that the information is promptly available to a wide range of employees (Sarhan *et al.*, 2017). It could communicate vital information to workers with low levels of knowledge and poor site awareness which could reduce the likelihood of accidents occurring. Safety signs and labels could potentially reduce accidents caused by poor communication (Bashir, 2013). Additionally, using safety signs and labels helps workers to identify workstations and pathways easily. It can assist in reducing chances of errors and mistakes which could lead to accidents (Sarhan *et al.*, 2017). One of the major causes of accidents is unsafe site conditions, which basically is due to inadequate supervision with poor visualization (Awada *et al.*, 2016). By improving visibility, effective visual workplace will be produced which lead to effective work conditions.

The application of VM on construction sites have shown promising result which has improved safety performance on construction sites. Awada *et al.* (2016) emphasized that the use of visual tools for communication of important safety instructions on sites is the major key for maintaining safe construction environment. Abdelkhalek *et al.* (2019) revealed that there was safety improvement on construction sites that slightly used safety visual on construction sites in Lebanon where accident was limited and not fatal and stressed the need for further improvement on VM application. Sarhan *et al.* (2017) also acknowledged that VM application has positive improvement on safety at construction sites in Saudi Arabia. Furthermore, Patel *et al.* (2018) also revealed that VM and its application on Indian construction industry have shown promising result. However, there are peculiarities in different countries and the level of adoption differ from one another. Hence, VM practices are effective and result in positive influence on construction sites that implement the practices.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

Research design has to do with plans and procedures used to conduct research (Creswell and Plano, 2018). There are three ways in which research can be investigated. It could be by qualitative, quantitative, or mixed approaches. Based on the merits and the demerits of the three approaches, no approach is better than the other. According to Kumar (2014), the approach a researcher decides to make use of depends on the objectives of the study. Many researchers have made the choice of a single method approach either qualitative or quantitative approach while some have used mixed methods approach for their research studies. A mixed methods research design was adopted in this study. Mixed methods research is a procedure for collecting, analysing, and "mixing" both quantitative and qualitative research and methods in a single study to understand a research problem (Cresswell and Plano, 2018). Dawadi *et al.* (2021) categorized mixed method research design into three namely, exploratory sequential design, explanatory sequential design, and convergent parallel mixed-methods design.

The study adopted a convergent parallel mixed methods design. Convergent parallel mixed methods is a form of mixed methods design in which the researcher converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem (Dawadi *et al.*, 2021). At first, two types of data sets were collected concurrently, and secondly, they were analysed independently using quantitative and qualitative analytical approaches (Schoonenboom and Johnson, 2017). It is an approach in which two data sets are combined to get a complete picture of the issue being explored and to validate one set of findings with the other (Creswell and Plano, 2018). In a convergent design, the integration of both data helped the researcher gain a complete understanding of the one provided by the quantitative or qualitative results. In this study, both questionnaire survey and observation methods of data collection were used to assess the influence of visual management practices on safety performance on construction sites in Abuja. The rationale for this research design approach was that it enabled the researcher to answer research- questions with sufficient depth and breadth. It also provided opportunities for convergence and corroboration of results that were derived from different research methods (Schoonenboom and Johnson, 2017).

3.2 Population and Sample Size

Population refers to the set or group of the units on which the findings of the research are to be applied (Shukla, 2020). In other words, population is a set of the units which possess variable characteristic under study and for which findings of research can be generalized. A sample size can be defined as a group of relatively smaller number of people selected from a population for investigation purpose (Alvi, 2016). The process through which a sample size is extracted from a population is called sampling (Alvi, 2016). The members of the sample are called participants. Sample size is used to fairly represent the target population. It is said to be representative when the characteristics of elements selected are similar to that of entire target population. The more the sample is representative of the target population, the higher is the accuracy of the inferences and better are the results generalizable (Alvi, 2016). There are different formulae that can be used for the determination of appropriate sample sizes (Shukla, 2020). The researchers should choose the formula according to their needs and convenience. The target population for the study included all active construction sites in Abuja. Data from FCDA shows that 902 approvals were given for foundation, ground floor, first floor, second floor and third in 4 districts in Abuja between the period of January to March 2023. This study considered only active medium and large sized construction companies/sites as the target population of the study. The reason for the rationale on medium and large sized construction companies was because VM practices will be effective and mostly found on those construction sites. Out of the 902 approvals that were given between the period January to March 2023. Only 260 of those construction sites were considered to be medium (50-199 workforce) and large sized (>200 workforce) firms, only 102 of those sites were active as at the time of data collection, the 102 sites formed the sample size of the study.

3.3 Sampling Techniques

Sampling is the process of selecting a statistically representative sample of individuals from a population of interest such that the inferences and study findings from the sample represent real associations in the population of interest (Shukla, 2020). Sampling methods are broadly categorized into two major types which are probability and non- probability sampling (Alvi, 2016). Probability sampling method, is a method in which subjects are selected without any bias or prejudice and in which all the units of population have equal or predetermined and certain probability to be selected in a sample (Shukla, 2020). Non probability sampling is also called as judgment or non-random sampling (Alvi, 2016). Non- probability sampling techniques are more conductive and practical method for researchers deploying surveying in the real world (Showkat and Parveen 2017). Gettings responses using non probability sampling methods is faster and more cost effective than the probability sampling methods because the sample is known to the researchers. The respondent responds quickly as compare to people randomly selected as they have a high motivation level to participate (Showkat and Parveen 2017).

The different types of non-probability sampling techniques are convenience sampling, purposive sampling, quota sampling, and snowballing sampling. Purposive sampling is also known as judgment, expert, selective or subjective sampling. Purposive sampling is a sampling technique in which researcher relies on his or her own judgment when choosing members of population to participate in the study and provide the best information to achieve the objectives of the study. One of the advantages of purposive sampling is that it ensures the research targets a specific population, increasing the chances of collecting accurate and relevant data (Saunders *et al*., 2016). As the number of the targeted population is not known, the non-probability sampling method was adopted. In order to achieve the research objectives, the purposive sample was taken from the study area, the unit of analysis was the active construction sites, hence the questionnaire survey was administered one per site. Both the observation and questionnaire survey were carried out using purposive sampling.

3.4 Data Collection Instruments

Accurate and systematic data collection is critical to conducting scientific research. Data collection allow us to collect information that we want to collect about our study. Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes (Kabir, 2016). The goal for all data collection was to capture quality evidence that translated to rich data analysis and allows the building of a convincing and credible answer to questions that have been posed (Mazhar *et al.,* 2021). Depending on research type, methods of data collection include: documents review, observ ation, interview, questionnaire, or a combination of different methods (Kabir, 2016).

Primary data for the study were collected using self-administered questionnaires survey and observation method. Hence, self-administered questionnaires and non-participant observation method formed the researcher's tools of data collection for the study.

3.4.1 Questionnaire

A questionnaire refers to an instrument for the collection of data usually in writing form, consisting of series of question in open ended and closed questions and other enquiries requiring a response from subject (Mazhar *et al.,* 2021). Questionnaire can be an effective means of measuring the behaviours, attitude, preference, opinion and intention of relatively large numbers of subjects more cheaply and quickly than other methods (Mazhar *et al.*, 2021). The language used was simple, adequate and ethnically ideal to enable the participants respond with ease and without fear of intimidation or violation of respondents' rights and privacy. Questionnaires were administered to the active construction sites sampled in the study area.

3.4.2 Observation method

Observation is a fundamental way of finding out about the world around us. As human beings, we are very well equipped to pick up detailed information about our environment through our senses (Kabir, 2016). Observation method refers to the act of using the five senses by an observer to note a phenomenon in the field setting. It is often carried out with a note taking instrument and recording it for scientific purpose (Creswell and Poth, 2018).

Things observed can include the participants themselves, their physical settings, their activities, their interactions, their conversations, including the behaviour of the observers themselves. There are four types of observation (Creswell and Poth, 2018). They include (1) Complete observation, in which the researcher is fully engaged with the people being observed. (2) Participant observation, in which the researcher partakes in the activities in the site. In this case the role of the participant is more noticeable than the researcher's role and as such helps the researcher to get insider views and subjective data. (3) Non-participant observation, in which the researcher is an outsider of the group being studied and watches and takes note from a distance. The researcher in this case can record data without direct involvement with the activities or people. (4) Disguised observation, in which the people being studied neither sees nor notice the researcher. For this study the researcher adopted the non-participant observation method because this method enabled the researcher to observe the surrounding environment of each sampled active construction site visited. Fifty (50) construction sites were visited and assessed to determine workers understanding and extent of use of visual aids, and the influence they have on promoting safety performance on construction sites.

3.5 Procedure for Data Collection

Researcher visited selected active construction sites with well-structured questionnaires, which were administered to site builders, in various active sites sampled. Also, the researcher observed and assessed the construction environment to determine the level of awareness and adoption of safety visual on construction sites by observing visual signs on construction sites, discrepancies between respondents' answers and the actual realities regarding safety visual implementation on construction sites.

3.6 Method of Data Analysis

Data obtained from the field were sorted, classified and organized into tables and charts. All data collected through the well-structured questionnaire and observation were analysed and presented in tables showing the mean item scores, Spearman correlation and linear regression analysis using Scientific packaged for social sciences version 26 and Microsoft Excel. Also, data obtained from observation method were presented in bar chart using Microsoft Excel. The mean item score and ranking was used for analysis of objectives one, two. three and four. Spearman correlation and Regression analysis was used for objective five to determined relationship.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Respondents Rate

Table 4.1 below shows the analysis of the questionnaires administered. 102 questionnaires were administered, eighty-two (82) were retrieved and 73 were deemed fit for analyses. The screening criterion to select a valid response that is fit for analysis was based on two (2) factors, firstly, any questionnaire with unanswered questions is not considered, and if the respondent provides more than one answer to the same question. Any questionnaire that falls under the listed categories was deemed unfit for analysis consideration. Hence, all the 73 responses considered for analysis were carefully and properly filled.

Table 4.1: Respondents rate

Category	Question sent out	Questionnaire received	Percentage used for analysis
Builder /Engineers on sites	102	82	73
Total	102	82	73

4.2 Demographic Information

The demographic information of the respondents is presented in Table 4.2, from the table, the characteristics of respondents according to their years of practice in the construction industry, organization years of practices in the construction industry, highest level of education, average cost of project handle by firm, organization workforce and nature of work undertaken by organization data were presented. It shows that 17.8% of the respondents have 1-5years experience in the construction industry, 21.6% have 6-10years experience, 14.9%

have 11-15years work experience, 43.2% of the respondents have 16-20year experience and 2.7% of the respondents have more than 20years experience in the construction industry. Twenty-three (23%) of the respondents' organizations have 6-10years practice in the construction industry, 33.7% have 11-15years of practice in the construction industry, 35.1% of respondents' organizations have 16-20 years of practice in the construction industry and 8.2% of respondents' organizations has more than 20 years of practice in the construction industry. The academic qualification of the respondents shows that 20.5% hold Higher National Diploma, 36.9% hold BSc/BTech degree, 17.6% hold Post Graduate Diploma, 25.2% hold master degree. It shows that 12.3% of the respondents' firm handle an average cost of project 50-449 million while 87.7% of respondents' firm handle average cost of project 500million and above. 2.7% of respondents' organisations have a work force of 1-49, 76.7% have workforce of 50-200 and 20.5% of the respondents' firms have workforce of 200 and above. It also shows that 21.9% of respondents' firms undertake building works while 78.1% of respondents' firms undertake both building and civil engineering works.

Table 4.2: Demographic information of the respondents

Respondent		Frequency	Percentage%
Years of practices in the industry	1-5yrs	13	9.5
	6-10yrs	16	21.6
	11-15yrs	10	14.9
	16-20yrs	32	43.2
	more than 20yrs	2	10.8
	Total	73	100.0
Organization years of practices in the construction industry	6-10yrs	17	23.0
	11-15yrs	25	20.5
	16-20yrs	26	35.1
	more than 20yrs	5	8.2
	Total	73	100.0
Highest academics qualification	HND	15	20.5
	BSc/BTech	27	36.7
	PGD	13	17.6
	MSc	18	25.2
	PhD	0	0
	Total	73	100.0
Average cost of project handle by your firm	100m-500m	9	12.3
	500milion and above	64	87.7
	Total	73	98.6
Organization workforce	1-49	2	2.7
	50-199	56	76.7
	200 above	15	20.5
	Total	73	100.0
Nature of work undertaken by your organization	Building	16	21.9
	Both building and civil Engineering	57	78.1
	Total	73	98.6

4.3 Extent of Usage of Visual Management Practices on Construction Sites

The first objective of this research was to assess the extent of usage of visual management practices on construction sites. Table 4.3 showed the extent of usage of VM practices on construction sites. Total of 43 VM practices were identified, analysed and ranked accordingly under each of the major individual constructs; 24 VM practices were ranked 1st with the high extent of usage. Also, another 10 VM practices were ranked 2nd with a moderate extent of usage. At the same time, the other 9 VM practices were ranked to be 3rd with a low extent of usage. The VM practices ranked to be in the high extent usage with their various mean score as indicated in Table 4.3 are keeping a clean and maintaining an orderly construction site (4.33), cleaning the workplace and removing materials and machines that are not required (4.29), clearing of unwanted materials from site (4.25), making the process directly observable.(4.21) fencing with transparent material to permit seeing and being seen through, along with providing a safe enclosure(4.18), material on sites is grouped and classified in an orderly manner (4.16), colour coded helmets with additional written information (4.15), separating needed tools from unneeded materials (4.15), identification of stocked materials using standardized stickers (4.10), board showing the planned dates of different activities on construction sites (3.97), calendar summarizing important project event in near future (3.95), monthly printed calendar showing events and important milestones (3.90), colour coded work aid for easy comprehension (3.86), signs indicating dangerous hazards (3.79), company policies visually presented (3.77), physical modelling give rough idea of possible problem that may occur during construction process (3.75), physical modelling give rough idea of possible problem that may occur during construction process (3.72), signs showing mandatory protective equipment for each working area (3.70), physical modelling assists in ensuring design accuracy by providing a visual representation of how the final product should function (3.68), safety signs indicating a possible danger (3.65), display of real time and planned time for each activity (3.64), writing on block wall for communication (3.62), Spray marking of electrical/ mechanical points of connection (3.58), spray marking of pipe for ease of connection (3.53).

Also, as presented in Table 4.3 are the mean score and standard deviation of fifteen VM practices major constructs and their extent of usage. The five most frequently high used visual management practices in the construction sites are visual management in workplace organization (4.24), VM practices by removing visual barriers (4.23), VM practice of standardized identification (4.13), VM practice of distributing system (3.94) and VM in prototyping and sampling (3.71). In contrast the five least VM practices used on construction sites are VM in performance management (3.01), VM in station quality (2.54), visual management in production control (2.49), VM in on site prefabrication (2.33) and visual management in mistake proofing system (2.24). It is evident from the Table 4.3 that the extent of usage of VM practices is still moderate, this research is consistent with the study Benedict *et al.* (2021) and Babalola *et al*. (2018) which ranked VM practices as of one of the moderately applied lean construction techniques adopted in the Nigerian construction industry. Therefore, there is urgent need to raise the level of awareness of VM among the construction practitioners as some of these practices have not been explored to the fullest

Table 4.3: Extent of VM practices usage on construction sites

Visual Management Practices	Mean	Std.D	Ranking	Decision
VM by removing barriers	**4.23**	**0.80**	**1**	**HE**
Fencing with transparent material to permit seeing and being seen through, along with providing a safe enclosure	4.18		3	HE
Keeping a clean and maintaining an orderly construction site	4.21		2	HE
Making the process directly observable.	4.13	0.96	3	HE
VM in safety management	**3.65**	**0.92**	**7**	HE
Project wide information put on display	3.72		1	HE
Safety signs indicating a possible danger	3.65		2	HE
Informative posters about work ergonomics	3.58		3	HE
VM in workplace organization	**4.24**	**1.03**	**1**	**HE**
Cleaning the workplace and removing materials and machines that are not required	4.29		1	HE
Separating needed tools from unneeded materials	4.15		3	HE
Clearing of unwanted materials from site.	4.25		2	HE
VM In Production Control	**2.49**	**1.11**	**13**	**LE**
Supplier assessment charts	2.81		1	ME
Control board showing the stock level of materials.	2.27		2	LE
Control board showing the stock level of tools	2.41		3	LE
VM in production levelling	**3.58**	**0.95**	**8**	**HE**
Boards showing the progress of the construction in bar graph format	3.68		1	HE
Display of real time and planned time for each activity	3.64		3	HE
Supplier assessment tables showing suppliers performance	3.44		2	ME
VM in site signage	**3.68**	**0.83**	**6**	**HE**
Signs indicating dangerous hazards	3.79		1	HE
Signs showing mandatory protective equipment for each working area	3.70		3	HE
Company policies visually presented	3.77		2	HE
VM in work facilitator	**3.45**	**0.91**	**10**	**ME**
Process chart providing visual representation of steps in a process	3.56		2	HE
Colour coded work aid for easy comprehension	3.86		1	HE
Visual work instruction providing relevant information at point of action	2.93		3	ME

Table 4.3a: Extent of VM practices usage on construction sites

Visual Management Practices	Mean	Std.D	Ranking	Decision
Improvisational VM	**3.57**	**0.90**	**9**	**HE**
Writing on block wall for communication	3.62		1	HE
Spray marking of electrical/ mechanical points of connection	3.58		2	HE
Spray marking of pipe for ease of connection	3.53		3	HE
VM in performance management	**3.01**	**0.62**	**11**	**ME**
Quality metric for scoring quality performance of project e.g. product conformance, cost, time etc	2.59		3	ME
Safety metrics for scoring/measuring safety performance of workers. e.g. safety auditing, use of personal protective equipment	2.98		2	ME
Overall construction progress board showing the progress of activities	3.47		1	ME
VM in station quality	**2.54**	**0.90**	**12**	**ME**
Colour coding to identify what action to take next	2.36		1	LE
Flowchart sequence of production operation	2.35		2	LE
Control chart to determine if the production process is within control	2.92		3	ME
VM in prototyping and sampling	**3.71**	**0.98**	**5**	**HE**
Physical modelling assists in ensuring design accuracy by providing a visual representation of how the final product should function	3.68		2	HE
Physical modelling give rough idea of possible problem that may occur during construction process	3.75		1	HE
VM in distributing system	**3.94**	**0.79**	**4**	**HE**
Calendar summarizing important project event in near future	3.95		2	HE
Monthly printed calendar showing events and important milestones.	3.90		3	HE
Board showing the planned dates of different activities on construction sites	3.97		1	HE
VM in mistake proofing system (removing error)	**2.24**	**1.10**	**15**	LE
Mistake proof device for pipe system	2.21		2	LE
Mistake proof for lift installation	2.19		3	LE
Reducing time cycle	2.32		1	LE

Table 4.3b: Extent of VM practices usage on construction sites

Visual Management Practices	Mean	Std.D	Rank	Decision
VM on site prefabrication	**2.33**	**0.52**	**14**	LE
Prefabrication mechanical (piping, fixture) with visual information	2.32		2	LE
Prefabrication electrical (piping, fixture) with visual information	2.34		1	LE
VM for standardized identification	4.16		1	HE
Material on sites is grouped and classified in an orderly manner	4.16		1	HE
Identification of stocked materials using standardized stickers	4.10		3	HE
Colour coded helmets with additional written information	4.15		2	HE

4.4 Effectiveness of VM Management Practice in Improving Safety Performance on Construction Sites

The second objective of this study was to access the effectiveness of VM practices in improving safety performance on construction sites. Table 4.4 showed the effectiveness of VM practices on improving safety performance on construction sites. A total of 43 VM practices were identified, analysed and ranked accordingly under each of the major individual constructs; 32 VM practices were ranked 1st with a high level of effectiveness in improving safety performance. Also, 11 VM practices were ranked 2nd with a moderate level of effectiveness in improving safety performance. The 32 VM practices ranked to be in the high level of effectiveness with their various mean score as indicated in Table 4.3 are clearing of unwanted materials from site (4.03), separating needed tools from unneeded materials (4.01), cleaning the workplace and removing materials and machines that are not required (3.99), making the process directly observable (3.99) material on sites is grouped and classified in an orderly manner (3.99), safety signs indicating a possible danger (3.95), keeping a clean and maintaining an orderly construction site (3.93), colour coded helmets with additional written information (3.93), monthly printed calendar showing events and important milestones (3.88), fencing with transparent material to permit seeing and being seen through, along with providing a safe enclosure (3.84), identification of stocked materials using standardised stickers (3.81), calendar summarizing important project event in near future (3.77), board showing the planned dates of different activities on construction sites (3.75), overall construction progress board showing the progress of activities (3.72) and signs showing mandatory protective equipment for each working area (3.70), prefabrication electrical (piping, fixture) with visual information (3.68), company policies visually presented (3.67) signs indicating dangerous hazards (3.66), boards showing the progress of the construction in bar graph format (3.66), prefabrication mechanical (piping, fixture) with visual information (3.64), spray marking of electrical/ mechanical points of connection (3.63), mistake proof for lift installation (3.63), project wide information put on display (3.62), representation of how the final product should function (3.59), spray marking of pipe for ease of connection (3.58), informative posters about work ergonomics (3.58), Writing on block wall for communication (3.57), physical modelling give rough idea of possible problem that may occur during construction process (3.55), control board showing the stock level of materials (3.55), Reducing time cycle (3.52) and marking of electrical/ mechanical points of connection (3.52).

Also, as presented in Table 4.4 are the mean score and standard deviation of the fifteen visual management practices major constructs and their extent on improving safety performance on construction sites. The five most frequently high used VM practices that improve safety performance on construction sites are: VM in workplace organization (4.01), VM by removing barriers (3.92), VM for standardized identification (3.91), VM in distributing system (3.80) and VM in safety management (3.71). Workplace organization is one of the simplest lean tools to implement because it is considered as the first step to be taken by the organization. Workplace organization focuses on establishing visual order, organization, cleanliness, and standardization which leads to improved safety, creation of space, improved teamwork, and continuous improvement (Cudney *et al.*, 2015). Visual devices include signs related to safety, schedule, and quality, it could be used to provide immediate and visual information that enables people to make correct decisions and manage their work and activities properly (Chahal and Narwal, 2017). In contrast the least five effective visual management practices that improve safety performance on construction sites are; VM in production control (3.48), VM in work facilitator (3.45), VM in performance management (3.44), VM in production levelling (3.43) and VM in station quality (3.36).

Table 4.4: Effectiveness of VM practices in improving safety performance on construction sites

Visual Management Practices	Mean	Std.D	Rank	Decision
VM by removing barriers	**3.92**	**0.82**	**2**	HE
Fencing with transparent material to permit seeing and being seen through, along with providing a safe enclosure	3.84		2	HE
Keeping a clean and maintaining an orderly construction site	3.93		1	HE
Making the process directly observable.	3.99		3	HE
VM in safety management	**3.71**	**0.77**	**5**	HE
Project wide information put on display	3.62		3	HE
Safety signs indicating a possible danger	3.95		2	HE
Informative posters about work ergonomics	3.58		1	HE
VM in workplace organization	**4.01**	**0.821**	1	HE
Cleaning the workplace and removing materials and machines that are not required	3.99		3	HE
Separating needed tools from unneeded materials	4.01		2	HE
Clearing of unwanted materials from site.	4.03	.	1	HE
VM In Production Control	**3.48**	**1.13**	**9**	ME
Supplier assessment charts	3.40		1	ME
Control board showing the stock level of materials.	3.55		3	HE
Control board showing the stock level of tools	3.41		2	ME
VM in production levelling	**3.48**	**1.13**	**9**	**ME**
Boards showing the progress of the construction in bar graph format	3.40		1	ME
Display of real time and planned time for each activity	3.55		3	HE
Supplier assessment tables showing suppliers performance	3.41		2	ME
VM in site signage	**3.66**	**.901**	**3**	**HE**
Signs indicating dangerous hazards	3.70		1	HE
Signs showing mandatory protective equipment for each working area	3.67		2	HE
Company policies visually presented	3.66		3	HE
VM in work facilitator	**3.45**	**0.93**	**10**	ME
Process chart providing visual representation of steps in a process	3.58	.	1	HE
Colour coded work aid for easy comprehension	3.37		3	ME
Visual work instruction providing relevant information at point of action	3.40		2	ME

Table 4.4a: Effectiveness of VM practices in improving safety performance on construction site

Visual Management Practices	Mean	Std.D	Ranking	Decision
Improvisational VM	**3.57**	**0.90**	**9**	**HE**
Writing on block wall for communication	3.57		8	HE
Spray marking of electrical/ mechanical points of connection	3.52		3	HE
Spray marking of pipe for ease of connection	3.63		1	HE
VM in performance management	**3.44**	**0.81**	**11**	ME
Quality metric for scoring quality performance of project e.g. product conformance, cost, time etc	3.31		2	HE
Safety metrics for scoring/measuring safety performance of workers. e.g. safety auditing, use of personal protective equipment	3.30		3	ME
Overall construction progress board showing the progress of activities	3.72		1	ME
VM in station quality	**3.36**	**0.85**	**12**	ME
Colour coding to identify what action to take next	3.29		3	ME
Flowchart sequence of production operation	3.45	.	1	ME
Control chart to determine if the production process is within control	3.34	.	2	ME
VM in prototyping and sampling	**3.71**	**0.98**	**5**	**HE**
Physical modelling assists in ensuring design accuracy by providing a visual representation of how the final product should function	3.59		1	HE
Physical modelling give rough idea of possible problem that may occur during construction process	3.55		2	HE
VM in distributing system	**3.94**	**0.79**	**4**	**HE**
Calendar summarizing important project event in near future	3.80		2	HE
Monthly printed calendar showing events and important milestones.	3.77		3	HE
Board showing the planned dates of different activities on construction sites	3.88		1	HE
VM in mistake proofing system (removing error)	**3.57**	**0.78**	**8**	HE
Mistake proof device for pipe system	3.44		3	ME
Mistake proof for lift installation	3.63		1	HE
Reducing time cycle	3.52		2	HE

Table 4.4b: Effectiveness of VM practices in improving safety performance on construction site

Visual Management Practices	Mean	Std.D	Rank	Decision
VM on site prefabrication	**3.64**	**0.89**	**7**	HE
Prefabrication mechanical (piping, fixture) with visual information	3.64	.	2	HE
Prefabrication electrical (piping, fixture) with visual information	3.68	.	1	HE
VM for standardized identification	**3.91**	**0.81**	**3**	HE
Material on sites is grouped and classified in an orderly manner	3.99		2	HE
Identification of stocked materials using standardized stickers	3.81		**1**	HE
Colour coded helmets with additional written information	3.93		3	HE

4.5 Drivers of Visual Management Implementation Practices on Construction Sites

For objective three (3) which is to determine the factors influencing implementation of VM practices on construction sites in Abuja. Table 4.5 showed the divers to VM implementation on construction sites. A total of 30 drivers were identified, analysed and ranked accordingly under each of the major individual constructs; all the 30 drivers factors were ranked 1st with high influence, on implementation of VM practices on construction sites.

Also, as presented in Table 4.5, are the mean score and standard deviation of the 10 major constructs drivers of VM implementation on construction sites. The three critical high drivers influencing the implementation of VM practices on construction sites are; attitude (4.16), training and coaching (3.95), management involvement (3.91). This is in consistent with the study of Abdelkhalek *et al.* (2019) and Kurpjuweit *et al.* (2019) which ranked attitude, management and training as the major drivers for VM implementation on construction sites. All the drivers of VM practices identified in this study all have significant impact on the implementation of VM practices on construction sites as this is evident in their high means score gained. In contrast the three least drivers of visual management implementation on construction sites are; operation (3.68), mentoring (3.64) and standardization and control stepwise (3.60).

Table 4.5: Drivers of VM implementation practices on construction sites

Visual Management Practices	Mean	Std.D	Rank	Decision
Attitude	**4.16**	**0.715**	**1**	**HI**
Cooperation among team members	4.18	.	2	HI
Good leadership	4.08	.	3	HI
Understanding of the concept of VM practices	4.22	.	1	HI
Standardization and control stepwise approach	**3.60**	**0.654**	**10**	**HI**
Improving communication among participant	3.70		1	HI
Ensuring compliance to routines.	3.63		2	HI
Improving production process	3.64	.	3	HI
Training and coaching	**3.95**	**0.77**	**2**	HI
Organising interactive workshops	3.88	.	1	HI
Involving senior managers in workshops	3.83		2	HI
Effective communication between supervisor and workers	4.16		3	HI
Employee involvement	**3.77**	**0.84**	**7**	**HI**
Understanding VM concept	3.75	.	2	HI
Listening to and acting on employee feedback on the use of visual tools	3.73	.	3	HI
Provision of appropriate visual tools	3.85	.	1	HI
Management involvement	**3.91**	**0.79**	**3**	**HI**
Developing and implementing an effective plan	4.03	.	1	HI
Ensuring support for continuous improvement	3.80		3	HI
Good leadership	3.88		2	HI
Government support	**3.90**	**0.80**	**4**	**HI**
Government should provide a clear direction to apply VM techniques by introducing policies	3.90	.	2	HI
Government should work closely with professional bodies	3.93		3	HI
Government should promote work site safety through worker safety inspector	3.88		1	HI

Table 4.5a: Drivers of VM implementation practices on construction sites

Drivers of VM	Mean	Std.D	Ranking	Decision
Operation	**3.69**	**0.79**	**9**	**HI**
Standardization of construction sites for ease of identification	3.69		2	HI
Worker's empowerment and involvement in decision making	3.51		3	HI
Application of VM techniques gradually step-by-step	3.86		1	HI
Workplace organization	**3.78**	**0.76**	**6**	**HI**
Awareness on the benefit of implementing workplace organization.	3.68	.	3	HI
Develop plan that clearly shows the responsibility of employees	3.82		2	HI
Commitment of both management and employee	3.84	1	1	HI
Mentoring	**3.68**	**0.75**	**8**	HI
Give guidance and direction to workers	3.68		2	HI
Motivate construction workers	3.63		1	HI
Shares knowledge and experience	3.73		3	HI
Education	**3.81**	**0.87**	**5**	HI
Continuous training	3.92		2	HI
Simplification of VM techniques	3.60		3	HI
Providing adequate education and training	3.93		1	HI

4.6 Barriers to VM Implementation Practices on construction site.

Table 4.6 shows the barriers to VM implementation on construction sites. A total of 27 barriers factors were identified, analysed and ranked accordingly under each of the major individual constructs. The 14 barriers ranked to be in the high influence with their various mean score as indicated in Table 4.6 are; absence of safety policy (4.26), absence of cost of training (3.71), absence of punishment /fine for defaulter of VM practice (3.69), lack of self -criticism (3.67), complexity of VM implementation (3.65), poor communication among construction participants (3.65), poor communication (3.60), non-involvement of workers in decision making (3.60), poor performance measurement strategies (3.59), absence of government enforcement officers/ inspectors to enforce VM practices (3.58), High cost of

VM implementation (3.57), lack of awareness of the programmes by government (3.56), inability to change organizational culture (3.52) and limited understanding of VM concept (3.50).

Also, as presented in Table 4.6, are the mean score and standard deviation of the 9 major constructs barriers of VM implementation on construction sites. The three critical high barriers influencing the implementation of VM practices on construction sites are; safety culture (3.63), lack of government support (3.61), technical barriers (3.60). This study is in in line with the studies of Egbele-Okoro 2020, and Abdelkhalek *et al.,* (2019) which identified cultural issues, lack of training, limited knowledge, lack of commitment and government issues as top barriers hampering implementation of VM practices on construction sites. In contrast the three least barriers of VM implementation on construction sites are education (3.44) and resistance to change (3.35).

Table 4.6: Barriers of VM implementation practices on construction sites

Barriers	**Mean**	**Std.D**	**Rank**	**Decision**
Lack of resources	**3.56**	**1.12**	**5**	**HI**
Absence of cost of training	3.71		1	HI
Limited skills workers who understand visual practices	3.39		3	HI
High cost of VM implementation	3.57		2	HI
Lack of management support	**3.53**	**1.07**	**8**	**HI**
Poor communication among construction participants	3.65		1	HI
Non-involvement of workers in decision making	3.60		2	HI
Poor coordination among construction participants	3.36		3	HI
Education	**3.44**	**0.91**	**7**	MI
Limited understanding of VM concept	3.50		1	HI
Limited education and training	3.41		3	MI
Limited technical skills	3.42		2	MI

Table 4.6a: Barriers of VM implementation practices on construction sites

Barriers	Mean	Std.D	Ranking	Decision
Resistance to change	**3.35**	**1.16**	**9**	MI
Not obeying visual rules	3.30		2	MI
Thinking it is time consuming	3.27		3	MI
Lack of trust in the system	3.49		1	MI
Lack of government support	**3.61**	**0.99**	**2**	HI
Absence of government enforcement officers/ inspectors to enforce VM practices	3.58		2	HI
Absence of punishment /fine for defaulter of VM practice	3.69		1	HI
Lack of awareness of the programmes by government	3.56		3	HI
Safety culture	**3.63**	**0.96**	**1**	HI
Absence of safety policy	4.26		1	HI
Inadequate engagement of safety managers on sites	3.28		3	MI
Lack of proper training on effective use of safety wears	3.36		2	MI
Safety culture	**3.63**	**0.96**	**1**	HI
Absence of safety policy	4.26		1	HI
Inadequate engagement of safety managers on sites	3.28		3	MI
Lack of proper training on effective use of safety wears	3.36		2	MI
Attitude	**3.59**	**0.86**	**4**	HI
Lack of self -criticism	3.67		1	HI
Inability to change organizational culture	3.52		3	HI
Poor communication	3.60		2	HI
Technical barriers	**3.60**	**0.98**	**3**	HI
Complexity of VM implementation	3.65		1	HI
Long implementation period	3.58		3	HI
Poor performance measurement strategies	3.59		2	HI

4.7 Safety Performance Measure on Construction Sites

The fourth objective of the study is to determine how various efforts put in place contributed to the safety performance measures in the construction firms. Table 4.7 summarizes the findings with respect to safety performance measures in construction sites. Total of 39 minor safety performance measures were identified, analysed and ranked accordingly under each of the major individual constructs; 37 safety performance measures were ranked 1st with the high extent on measuring safety performance on construction sites. At the same time, the other 2 were ranked 2nd with moderate extent. The safety performance measures ranked to be in the high extent on measuring safety performance with their various mean score as indicated in Table 4.7 are safety is given priority over time (4.14), site layout planning is done before start of work (4.04), safety rules and procedures are strictly followed by workers (4.03), materials on site are stored properly (4.00), training for new workers is compulsory (3.99), workers react strongly against any violation of safety rules by co-workers (3.97), sharp edges are covered/protected, like nails and steel bars (3.93), provision of information about work place (3.92), there is no work pressure on workers (3.91), safety compliance to signage (3.91), refresher safety training session are periodically conducted for all workers (3.91), identity health hazard (3.91) analyse hazard before work begins (3.91), safety planning by supervisor and workers (3.90), and organizing safety meetings (3.90) safety compliance to visual control (3.87), workers report safety and health concern (3.86), regular safety inspections are conducted by higher management (3.83), visual signage to inform, alert and control actions (3.83), monetary reward for complying with safety rules (3.83), perform work within hazard control (3.83), safety communication on construction sites (3.81), general management commitment to safety (3.76), working or operating machine at unsafe speed (3.76), not using personal protective equipment (3.74), presence of safety polices on resources (3.74), promotion of workers who comply with safety rules (3.71), company has an effective system for the issuance of PPE (3.71), inspect work place for safety hazard (3.67), and inspect work place for safety hazard (3.67). company has an effective system for the inspection of PPE (3.59), public praise to workers who comply with safety rules (3.57), working at height without a guardrail (3.54) and company has an effective system for the replacement of PPE (3.51).

Also presented in Table 4.7 are the mean score, standard deviation and ranking of the thirteen major constructs of safety performance measures in the construction sites . The four critical high safety performances measures are workplace organization (3.99), management commitment (3.96), worker's involvement (3.95) and training and orientation (3.93). It is not surprising that work workplace organization is the first step toward achieving safety at workplace, the necessity of both management involvement and workers involvement to cooperate is shown in the need to training and orientation of construction workers safety practice. In contrast the three low safety performance measures are pre-task planning (3.64). personal protective equipment (3.60), and Unsafe working condition (3.44).

Table 4.7: Safety performance measures on construction sites

Safety performance Measures	Mean	Std.D	Rank	Decision
Management commitment	**3.96**	**0.79**	**2**	HE
Safety is given priority over time	4.14		2	HE
There is no work pressure on workers	3.91		1	HE
Regular safety inspections are conducted by higher management	3.83		3	HE
Safety audit	**3.90**	**0.76**	**5**	HE
Safety compliance to visual control	3.87		1	HE
Safety compliance to signage	3.91		2	HE
Safety planning by supervisor and workers	3.90		3	HE
Training and orientation	**3.93**	**0.70**	**4**	HE
Training for new workers is compulsory	3.99		1	HE
Organizing safety meetings	3.90		3	HE
Refresher safety training sessions are periodically conducted for all workers	3.91		2	HE
Site communication	**3.72**	**0.76**	**8**	HE
Slogan to communicate dangers	3.67		2	HE
Visual signage to inform, alert and control actions	3.83		1	HE
Toolbox talks or safety talks	3.66		3	HE
Workplace organization	**3.99**	**0.81**	**1**	HE
Site layout planning is done before start of work	4.04		1	HE
Materials on site are stored properly	4.00		2	HE
Sharp edges are covered/protected, like nails and steel bars	3.93		3	HE
Hazard prevention and control	**3.84**	**0.78**	**6**	
Provision of information about workplace	3.92		2	HE
Inspect workplace for safety hazard	3.67		1	HE
Identity health hazard	3.91		3	HE
Worker's involvement	**3.95**	**0.81**	**3**	HE
Safety rules and procedures are strictly followed by workers	4.03		1	HE
Workers react strongly against any violation of safety rules by co-workers	3.97		2	HE
Workers report safety and health concern	3.86		3	HE
Personal protective equipment	**3.60**	**0.95**	**11**	HE
Company has an effective system for the issuance of PPE	3.71		1	HE
Company has an effective system for the inspection of PPE	3.59		2	HE
Company has an effective system for the replacement of PPE	3.51		3	HE

Table 4.7a: Safety Performance measures construction industry

Safety performance Measures	Mean	Std.D	Rank	Decision
Safety climate	**3.77**	**0.864**	**7**	HE
General management commitment to safety	3.76		2	HE
Presence of safety polices on resources	3.74		3	HE
Safety communication on construction sites	3.81		1	HE
Unsafe working condition	**3.44**	**1.67**	**12**	ME
Working at height without a guardrail	3.54		1	HE
Working at height on platforms not properly supported	3.46		2	ME
Using unsafe ladder on sites	3.33		3	ME
Unsafe action	**3.72**	**0.91**	**8**	HE
Not using personal protective equipment	3.74		2	HE
Unauthorized operation of equipment	3.66		3	HE
Working or operating machine at unsafe speed	3.76		1	HE
Recognition and reward	**3.70**	**0.80**	**9**	HE
Monetary reward for complying with safety rules	3.83		1	HE
Promotion of workers who comply with safety rules	3.71		2	HE
Public praise to workers who comply with safety rules	3.57		3	HE
Pre task planning	**3.64**	**0.82**	**10**	HE
Daily meeting before the commencement of work	3.64		3	HE
Analyse hazard before work begins	3.91		1	HE
Perform work within hazard control	3.83		2	HE

4.8: Relationship Between the Extent of Usage of VM Practice and Safety Performance

The fifth objective of the study was to establish the nature of relationship between VM practices and safety performance. To achieve this objective, Pearson correlation and regression analysis were adopted. The first hypothesis sought to investigate the relationship between the extent of usage of VM practices and safety performance on construction sites:

Ho: There is a significant relationship between the extent of usage of VM practices and safety performance on construction sites

$H_{1:}$ There is no significant relationship between the extent of usage of VM practices and safety performance on construction site.

This main hypothesis was to investigate whether the extent of usage of VM practices (independent) variables have a significant relationship with the safety performance dependent variables. The result in Table 4.8 showed that there is positive significant positive relationship at ($r = .662$ and p value $0.014 < 0.05$) the test shows there is significant relationship between the extent of usage of VM practices and safety performance on construction sites.

Table 4.8: Relationship between the extent of usage of VM practices and safety performance

		Extent of usage of VM practices	Safety performance
Extent of usage of VM practices	Pearson Correlation	1	.662*
	Sig. (2-tailed)		.014
	N	15	13
safety performance	Pearson Correlation	.662*	1
	Sig. (2-tailed)	.014	
	N*	13	13

*. Correlation is significant at the 0.05 level (2-tailed).

Also, a linear regression analysis was carried out to determine the extent of usage of VM practices on safety performance on construction sites. Also, to further examine the relationship between them and to justify whether the null hypothesis can be accepted or rejected. Table 4.9 showed the results of the regression model that the extent of usage of VM practices has a R2 value of (43.8%) which showed the percentage variance of the extent of usage of VM practices and this proved that there is a positive relationship between the extent of usage of VM practices and safety performance on construction sites. The model tested how the extent of usage of VM practices can predict safety performance on construction sites. The model offers a predictive power of 43.8% (R = .662; R2 = .438; F = 8.585 [with p = .014], with beta values (beta = .662).

This outcome revealed that the extent of usage of VM practices had a positive significant relationship with safety performance. Thus, the regression model implied that the extent of usage of VM practices have a significant contribution to the model measuring it on Pallant (2011) criteria which stated that variables are making significant contributions to a prediction of dependent variables when the significant value is less than .05 but if the significant value is greater than .05 then, the variables are not contributing significantly to the prediction of the dependent variable. However, the outcome from the regression analysis is not in support of the null hypothesis that there is no significant relationship between the extent of usage of VM practices and safety performance on construction sites. Thus, the null hypothesis is rejected.

We conclude that there is a well-established relationship between the extent of usage of VM practices and safety performance on construction sites. This is in line with the study of (Abdelkhalek *et al.* 2019) and Egbele-Okoro (2020) which posited that there is a relationship between VM practices and safety performance on construction sites

Table 4.9: Regression model summary on relationship between extent of usage of VM practice and safety performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.438	.387	33.462

a. Predictors: (Constant), visual management

Table 4.10: ANOVA relationship between extent of usage of VM practice and safety performance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	9612.324	1	9612.324	8.585	.014[b]
	Residual	12316.599	11	1119.691		
	Total	21928.923	12			

a. Dependent Variable: safety performance

b. Predictors: (Constant), extent of usage of VM practices

Table 4.11: Coefficient relationship between extent of usage of VM practice and safety performance

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	33.241	67.142		.495	.630
	Extent of usage of VM practices	1.007	.344	.662	2.930	.014

4.9 Relationship Between Effectiveness of VM Practices and Safety Performance

The hypothesis sought to investigate the relationship between effectiveness of VM practices and safety performance.

Ho: There is a significant relationship between effectiveness of VM practices and safety performance on construction site.

$H_{1:}$ There is no significant relationship between effectiveness of VM practices and safety performance on construction site.

Also, to further prove the regression analysis. Table 4.12 showed the regression analysis test on the relationship between effectiveness of VM practices and safety performance, Table 4.12 also showed that effectiveness of VM practices has a R2 value of (48.7%) showed the percentage variance of effectiveness VM practices and this proved a positive relationship between effectiveness of VM practices and safety performance on construction sites. The model tested how the effectiveness of VM practices can predict safety performance on construction sites. The model offers a predictive power of 48.7% (R = .698; R2 = .438; F = 10.454 [with p = .008], with beta values (beta = .698). The regression model implied that the effectiveness of VM practices have a significant contribution to the model measuring it on Pallant (2011) criteria. Thus, this outcome revealed that the effectiveness of of VM practices had a positive significant relationship with safety performance, thus, the regression analysis is not in support of the null hypothesis that there is no significant relationship between the effectiveness of VM practices and safety performance on construction sites. Thus, the null hypothesis is rejected.

Table 4.12: Regression model summary on relationship between effectiveness of VM practices and safety performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.698[a]	.487	.441	32.822

a. Predictors: (Constant), effectiveness

Table 4.13: ANOVA relationship between effectiveness of VM practices and safety performance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11261.541	1	11261.541	10.454	.008[b]
	Residual	11850.151	11	1077.286		
	Total	23111.692	12			

a. Dependent Variable: safety performance

b. Predictors: (Constant), effect

Table 4.14: Coefficients relationship between effectiveness of VM practices and safety performance

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	358.588	133.789		2.680	.021
	effectiveness	.559	.173	.698	3.233	.008

a. Dependent Variable: safety performance

4.10. Relationship Between the Drivers of Visual Management Practices and Safety Performance on Construction Sites

The hypothesis sought to investigate the relationship between drivers of VM practices and safety performance.

Ho: There is a significant relationship between drivers of VM practices and safety performance on construction site.

$H_{1:}$ There is no significant relationship between drivers of VM practices and safety performance on construction site.

Table 4.15 showed the regression analysis test on the relationship between drivers of VM practices and safety performance, Table 4.15 also showed that drivers of VM practices has a R2 value of (43.2%) showed the percentage variance of VM practices and this proved a positive relationship between drivers of VM practices and safety performance on construction sites. The model tested how the drivers of VM practices can predict safety performance on construction sites. The model offers a predictive power of 43.2% (R = .658; R2 = .432; F = 6.079 [with p = .039 < 0.5], with beta values (beta = .658). The regression model implied that the drivers of VM practices have a significant contribution to the model measuring it on Pallant (2011) criteria. which stated that variables are making significant contributions to a prediction of dependent variables when the significant value is less than .05 but if the significant value is greater than .05. then, the variables are not contributing significantly to the prediction of the dependent variable. The effectiveness of visual management practices has the most contribution to the prediction of the dependent variable (safety performance). Nevertheless, the outcome of the test revealed that the drivers of VM practices has a positive significant relationship with safety performance, thus, the regression analysis is not in support of the null hypothesis that there is no significant relationship between the drivers of VM practices and safety performance on construction sites. Thus, the null hypothesis is rejected.

Table 4.15: Regression model summary on relationship between drivers of VM practices and safety performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.658[a]	.432	.362	36.979

a. Predictors: (Constant), driver

Table 4.16: ANOVA relationship between drivers of VM practices and safety performance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	8336.974	1	8336.974	6.097	.039[b]
	Residual	10939.426	8	1367.428		
	Total	19276.400	9			

a. Dependent Variable: safety performance

b. Predictors: (Constant), drivers

Table 4.17: Coefficients relationship between drivers of VM practices and safety performance

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	133.842	265.026		.505	.627
	Drivers	.831	.337	.658	2.469	.039

a. Dependent Variable: safety performance

4.11. Relationship Between the Barriers of Visual Management Practices and Safety Performance on Construction Sites

The hypothesis sought to investigate the relationship between barriers of VM practices and safety performance.

Ho: There is a significant relationship between barriers of VM practices and safety performance on construction site.

$H_{1:}$ There is no significant relationship between barriers of VM practices and safety performance on construction site.

Table 4.18 showed the regression analysis test on the relationship between barriers of VM practices and safety performance, Table 4.18 also showed that drivers of VM practices has a R2 value of (21.2%) showed the percentage variance of VM practices and this proved a negative relationship between barriers of VM practices and safety performance on construction sites. The model tested how the barriers of VM practices can predict safety performance on construction sites. The model offers a predictive power of 21.2% (R = .461; R2 = .21.2; F = 1.884 [with p = 0.212> 0.5], with beta values (beta = -461). The regression model implied that the barriers of VM practices have no significant contribution to the model measuring it on Pallant (2011) criteria. The outcome of the test revealed that the barriers of VM practices has a negative significant relationship with safety performance, thus, the regression analysis is in support of the null hypothesis that there is no significant relationship between the barriers of VM practices and safety performance on construction sites. Thus, the null hypothesis is accepted.

Table 18: Regression model summary on relationship between barriers of VM practices and safety performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.461[a]	.212	.100	78.725

a. Predictors: (Constant), barriers

Table 19: ANOVA relationship between barriers of VM practices and safety performance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11678.203	1	11678.203	1.884	.212[b]
	Residual	43383.797	7	6197.685		
	Total	55062.000	8			

a. Dependent Variable: safety performance

b. Predictors: (Constant), barriers

Table 20: Coefficients relationship between barriers of VM practices and safety performance

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	1211.898	326.377		3.713	.008
	barriers	-.591	.431	-.461	-1.373	.212

a. Dependent Variable: safety performance

4.12 Observation of Visual Aids around the Construction Sites

Observation method of data collection was employed to corroborate the data gotten from the administered questionnaire to builders and engineers on construction sites. 50 construction sites environment were observed to check the extent at which visual aid was utilised on construction sites. 12 visual aids were identified and the extent of usage on construction sites is presented in Figure 4.1. Out of the 12 visual aids checked list, only few of the VM aids were available for use in the construction sites. Site layout, workplace organization, spray making and project performance board are the most adopted visual aids on construction site. This is followed by visual sign, standardization, which were adopted at a moderate extent. Safety sign and prototyping were employed at a low extent on construction sites. Production control board andon system and work facilitator were yet to be employed on the construction sites observed. It can be said that visual aids were employed at a moderate extent on the construction sites observed.

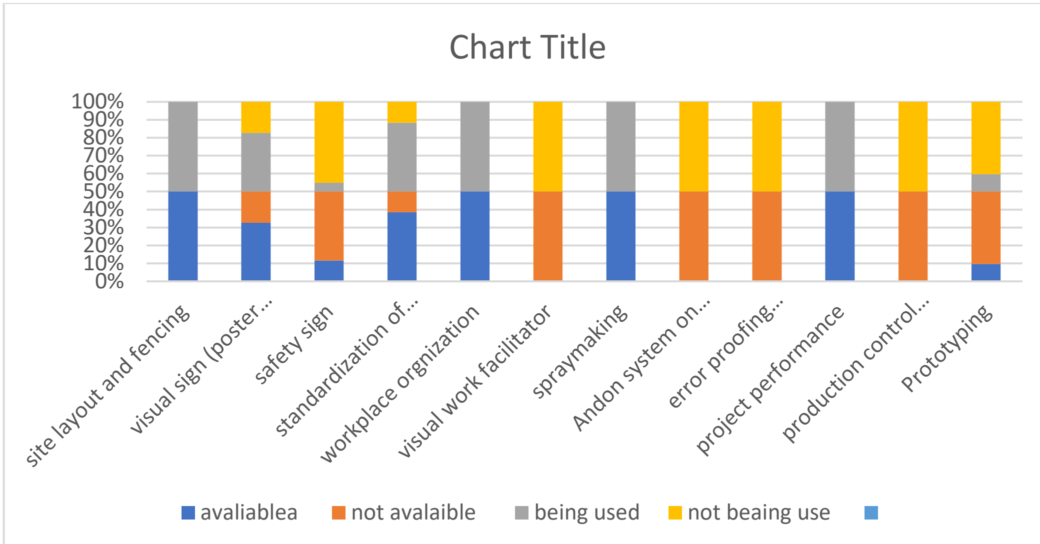

Figure 4.1: Observation Checklist chart
Source: Researcher Field Work 2023

4.13. Summary of Findings

1. **Objective one**: The first objective of the study was to determine the extent of usage of VM practices on construction sites. Both questionnaire and observation method of data collection was explored to obtained result. The results of the study from observation of visual aids available for used on construction sites revealed that out of the twelve 12 visual aids checked list site layout, workplace organization, spray making and project performance board are the most adopted visual aids on construction sites. Also, the five most frequently high used VM practices in the construction sites are; VM in workplace organization, VM practices by removing

visual barriers, VM practice of standardized identification, VM practice of distributing system, and VM in prototyping and sampling

2. **Objectives two**. The second objectives of the study was to assess the effectiveness of VM practices adoption in improving safety performance on construction sites. The five most frequently high used visual management practices that improve safety performance on construction sites are: VM in workplace organization, visual management by removing barrier, VM for standardized identification, VM in distributing system and VM in safety management.
3. **Objectives three**: The third objectives of the study was to examine the factors influencing the implementation of VM practices on construction sites. The study found that the movers of visual management implementation on construction sites are safety culture, lack of government support, technical barriers. In contrast the barriers to visual management implementation are workplace organization (3.99), management commitment (3.96), Worker's involvement (3.95) and Training and orientation (3.93).
4. **Objective four:** The fourth objective of the study is to determine how various efforts put in place contributed to the safety performance measures on construction sites studied. The findings with respect to safety performance on construction sites revealed the four critical high safety performance measures are workplace organization, management commitment, worker's involvement and training and orientation.
5. **Objective five:** The fifth objectives of the study was to establish the relationship between VM practices and safety performance on construction sites. The findings of

the study revealed the relationship between the extent of usage VM practices and safety performance at (r = 0.662 and p value 0.014< 0.05), effectiveness of VM practices and safety performance at (r = 0.698 and p value 0.008< 0.05.), drivers of VM practices and safety performance at (r = 0.658 and p value 0.039< 0.05.) which all indicated a positive relationship. The relationship between the barriers of VM practices and safety and safety performance showed a negative relationship at (r= 0.461 and p value 0.212> 0.05)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The aim of the study is to assess the influence of VM practices on safety performance on construction sites with a view to improve site management. The result showed that the most frequently high utilised VM practices in the construction sites are VM in workplace organization (4.24), VM practices by removing visual barriers (4.23), VM practice of standardized identification (4.13), VM practice of distributing system (3.94) and VM in prototyping and sampling (3.71). Only few of the practices (VM in production control, VM in station quality, VM in mistake proofing system (removing error) and VM in on site prefabrication) have not been explored. The observation method employed in the study also revealed that the extent of usage of VM practices is moderate hence, there is need to raise the awareness of VM practices to improve site management. The study also revealed that the 15 VM practices identified are effective in improving safety performance on construction sites with top VM practices as visual management in workplace organization (4.01), VM by removing barriers (3.92), VM for standardized identification (3.91), VM in distributing system (3.80) and VM in safety management (3.71). Findings also revealed that all the 10 identity movers of VM implementation on construction sites were significant with the top drives as attitude, training and coaching and management involvement. All the 9 identified barriers to VM implementation on construction were also significant with top ranked barriers as safety culture, lack of government support and technical barriers. The study further established that that there is a strong relationship between VM practices and safety performance by running a correlation and regression analysis test. The findings of the study revealed the relationship between the extent of usage VM practices and safety performance at (r = 0.662 and p value 0.014< 0.05), effectiveness of VM practices and safety performance at (r = 0.698 and p value 0.08< 0.05.), drivers of VM practices and safety performance a t (r = 0.658 and p value 0.039< 0.05.) which all indicated a positive relationship. The relationship between the barriers of VM practices and safety and safety performance showed a negative relationship at (r= 0.461 and p value 0.212> 0.05). The positive relationship of visual management practices on the extent of usage, effectiveness and drivers suggests the need for adoption of VM practice in the Nigeria construction industry

5.2 Recommendations

Base on the findings of the study the following recommendation were made:

1. The study therefore advocates for the usage of VM in removing errors, prefabrication on sites and production control on construction sites.
2. Safety culture should be cultivated to enhance the implementation of VM practices on construction sites, the study therefore recommend that safety culture should be entrenched in order to reduce safety mishaps on construction sites.
3. Human attitude is one the major drivers of VM implementation construction sites. Attitude of both employers and employees on safety issues is key, great emphasis should be laid on it to achieving safe working environment. The study therefore recommend that positive attitude should be imbibed by both the employer and employee regarding safety.
4. It is believed that continuous training is key to change the organization culture and employee's resistance to change during implementation of new practices.

Construction firms should enlighten their employees on the benefits of VM by engaging them in meetings, workshops and other events on the benefits of VM practices.

5. Management of construction firms has the main role to promote or hinder the implementation of VM practices in construction projects. The successful application of VM practices lies on the support and commitment of top management. Therefore, top management should develop and implement an effective plan to implement VM practices successfully in safety improvement.

6. The success and failure of VM practices rests partly on the shoulders of the government. Government agencies should introduce policies to encourage construction firms to engage in the application of VM practices to improve safety on construction sites.

7. Without proper education and training, employees will not be able to know the basic concepts and benefits of implementing the VM practices on construction sites. Employee working in the construction firms should have adequate knowledge on VM practices. Which can be gained through research conferences to generate active, basic and applied research on VM to guide the application of VM practices in order to improve safety performance on construction sites.

5.3 Contribution to Knowledge

The research has shown that effective VM practices improved safety performance on the construction sites in the Nigerian construction industry. The findings of the study revealed the relationship between the extent of usage visual management practices and safety performance, effectiveness of VM practices and safety performance, drivers of VM practices and safety performance which all indicated a positive relationship. The positive relationship of visual management practices on the extent of usage, effectiveness and drivers suggests the need for adoption of VM practice in the Nigeria construction industry. Hence, there is a need to shift the attention of construction practitioners towards implementing effective VM practices. The finding of the research will guide construction practitioners (architects, builders, engineers, etc) to the main barriers and the drivers to be taken to successfully implement VM practices in safety improvement in construction projects.

5.4 Area for Further Studies

1. Conduct a case study-based research to provide an integrated comprehensive understanding of the VM practices that are implemented with their benefits, barriers and success factors.

2. The study was limited to Abuja, and therefore would be beneficial to conduct similar studies in other metropolitan cites like Lagos and Port Harcourt.

3. A model should be developed using structural equation modelling to guide construction firms on the strategy to effectively implement VM practices in the Nigerian Construction Industry.

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APPENDICES

Appendix A: Questionnaire

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA
DEPARTMENT OF BUILDING
MAIN CAMPUS GIDAN-KWANO, MINNA, NIGER STATE.

Department of Building,
School of Environmental Technology,
Federal University of Technology,
P.M.B. 65,
Minna, Niger State.

Dear Participant,

Re: Influence of Visual Management Practices on Safety Performance of Construction Sites.

I Adio Kehinde Victor, a Master Student in Construction Management**,** Department of Building, School of Environmental Technology, Federal University of Technology Minna, Niger State conducting research on **Influence of Visual Management Practices on Safety Performance of Construction Sites''.** Your participation in responding to this questionnaire to the best of your ability and knowledge is highly needed in order to achieve the objectives of this research. It will take approximately 20 minutes to be completed.

The survey is purely meant for academic purpose and I wish to assure you that all information provided will be treated as confidential.

Thank you very much for your support, cooperation, and time.

Adio Kehinde Victor
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Prof. R. A. Jimoh
Project Supervisor (08036534507)
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SECTION A

1. Kindly state your years of practice in the construction industry:

   (a) 1 – 5yrs (b) 6 – 10yrs (c) 11 – 15yrs (d) 16 – 20yrs (e) more than 20yrs

2. Kindly state your organisation years of practice in the construction industry:

   (b) 1 – 5yrs (b) 6 – 10yrs (c) 11 – 15yrs (d) 16 – 20yrs (e) more than 20yrs

3. Kindly indicate your highest academic qualification:

   (a) FSLC (b) SSCE (c) ND (d) HND (e) B.sc/B.tech (f) PGD (g).M.sc/M.tech

   (h) Ph.d

4. Kindly indicate the average cost of the project handled by your firm:

   1m – 4m ( ) (b) 5m – 49m ( ) (c) 50m – 49m ( ) (d) 50m – 499m (e) 500m and above

5. Kindly indicate your organisational workforce (numbers of employee's):

   (a) 1 – 49 (b) 50 – 199 (c) 200 and above

6. Kindly indicate the nature of work undertaken by your organisation.

   (a) Building (b) Civil Engineering (c) Both Building and Civil Engineering works

SECTION B

From 5 (Very high extent) to 1 (No extent), what is the extent of usage of the following Visual Management practices on construction sites. From 5 (Very highly effective) to 1 (Not effective), what is the level of effectiveness of the following visual management practices in your construction sites?

S/N	Visual Management Practices	USAGE					EFFECTIVENESS				
		5	4	3	2	1	5	4	3	2	1
1	**VM by Removing Visual Barriers**										
	Fencing with transparent material to permit seeing and being seen through, along with providing a safe enclosure										
	Keeping a clean and maintaining an orderly construction site.										
	Making the process directly observable.										
2	**VM for Standardized Identification and Localization**										
	Material on sites is grouped and classified in an orderly manner										
	Identification of stocked materials using standardised stickers										
	Colour coded helmets with additional written information;										
3	**VM in workplace organization (5S)**.										
	Cleaning the workplace and removing materials and machines that are not required										
	Separating needed tools from unneeded materials										
	Clearing of unwanted materials from site.										
4	**VM in Production Control**										
	Supplier assessment charts										
	Control board showing the stock level of materials.										
	Control board showing the stock level of tools										
5	**VM in Production Levelling**										
	Boards showing the progress of the construction in bar graph format										
	Display of real time and planned time for each activity										

	Supplier assessment tables showing suppliers performance										
6	**VM in Site Signage**										
	Signs indicating dangerous hazards										
	Signs showing mandatory protective equipment for each working area										
	Company policies visually presented										
7	**VM in Work Facilitators**										
	Process chart providing visual representation of steps in a process										
	Colour coded work aid for easy comprehension										
	Visual work instruction providing relevant information at point of action										
8	**Improvisational VM**										
	Writing on block wall for communication										
	Spray marking of electrical/ mechanical points of connection										
	Spray marking of pipe for ease of connection										
9	**VM in Performance Management**:										
	Quality metric for scoring quality performance of project e.g. product conformance, cost, time etc										
	Safety metrics for scoring/measuring safety performance of workers. e.g. safety auditing, use of personal protective equipment										
	Overall construction progress board showing the progress of activities										
10	**VM in station quality**										
	Colour coding to identify what action to take next										
	Flowchart sequence of production operation										
	Control chart to determine if the production process is within control										
11	**VM in Prototyping and Sampling**										
	Physical modelling assists in ensuring design accuracy by providing a visual representation of how the final product should function										
	Physical modelling give rough idea of possible problem that may occur during construction process										
12	**VM in Distributing System**										
	Calendar summarizing important project event in near future.										
	Monthly printed calendar showing events and important milestones.										
	Board showing the planned dates of different activities on construction sites										
13	**VM in Mistake Proofing Systems** (removing error)										
	Mistake proof device for pipe system										
	Mistake proof for lift installation										
	Reducing time cycle.										
14	**VM in On-Site Prefabrication:**										

	Prefabrication mechanical (piping, fixture) with visual information									
	Prefabrication electrical (piping, fixture) with visual information									
15	**Safety Management**									
	Project wide information put on display									
	Safety signs indicating a possible danger									
	Informative posters about work ergonomics									

From 5 (Very high) to 1 (Very) what are the barriers to implementation of visual management on construction sites?

S/N	Barriers to Implementation of Visual Management Practices	5	4	3	2		1
1	**Lack of resources**						
	Absence of cost of training						
	Limited skills workers who understand visual practices						
	High cost of VM implementation						
2	**Lack of management support**						
	Poor communication among construction participants						
	Non-involvement of workers in decision making						
	Poor coordination among construction participants						
3	**Education**						
	Limited understanding of VM concept.						
	Limited education and training						
	Limited technical skills						
4	**Resistance to change**						
	Not obeying visual rules						
	Thinking it is time consuming						
	Lack of trust in the system						
5	**Lack of government support**						
	Absence of government enforcement officers/ inspectors to enforce VM practices						
	Absence of punishment /fine for defaulter of VM practice						
	Lack of awareness of the programmes by government						
6	**Safety culture**						
	Absence of safety policy						
	Inadequate engagement of safety managers on sites						
	Lack of proper training on effective use of safety wears						
7	**Complexity of underlying process**						
	Temporary and transitory nature of construction workplaces						
	Limited technical skill of workers						
	Fragmented nature of the construction industry						
8	**Attitude**						
	Lack of self -criticism						
	Inability to change organizational culture						
	Poor communication						
9	**Technical barrier**						
	Complexity of VM implementation						
	Long implementation period						
	Poor performance measurement strategies						

From 5 (Very high influence) to 1 (No influence) what is level of influence that these movers have in the implementation of visual management practices on constructions sites?

S/N	MOVERS OF VISUAL MANAGEMENT PRACTICES	5	4	3	2	1
1	**Attitude**					
	Cooperation among team members					
	Good leadership					
	Understanding of the concept of VM practices					
2	**Standardisation and Control Stepwise Approach**					
	Improving communication among participant					
	Ensuring compliance to routines.					
	Improving production process					
3	**Training and coaching**					
	Organising interactive workshops					
	Involving senior managers in workshops					
	Effective communication between supervisor and workers					
4	**Employee Involvement**					
	Understanding VM concept					
	Listening to and acting on employee feedback on the use of visual tools					
	Provision of appropriate visual tools					
5	**Management Involvement**					
	Developing and implementing an effective plan					
	Ensuring support for continuous improvement					
	Good leadership					
6	**Government support**					
	Government should provide a clear direction to apply VM techniques by introducing policies					
	Government should work closely with professional bodies					
	Government should promote work site safety through worker safety inspector					
7	**Operation**					
	Standardization of construction sites for ease of identification					
	Worker's empowerment and involvement in decision making					
	Application of VM techniques gradually step-by-step					
8	**Work place organization**					
	Awareness on the benefit of implementing work place organization.					
	Develop plan that clearly shows the responsibility of employees					
	Commitment of both management and employee					
9	**Education**					
	Continuous training					
	Simplification of VM techniques					
	Providing adequate education and training					
10	**Mentoring**					
	Give guidance and direction to workers					
	Motivate construction workers					
	Shares knowledge and experience					

From 5 (Very high extent) to 1 (Very low extent), to what extent do you apply the following leading indicators to improve safety performance on your sites?

S/N	Leading indicator for measurement of safety performance	5	4	3	2	1
1	**Management commitment**					
	Safety is given priority over time					
	There is no work pressure on workers					
	Regular safety inspections are conducted by higher management					
2	**Safety auditing**					
	Safety compliance to visual control					
	Safety compliance to signage					
	Safety planning by supervisor and workers					
3	**Training and orientation**					
	Training for new workers is compulsory					
	Organizing safety meetings					
	Refresher safety training sessions are periodically conducted for all workers					
4	**Site communication**					
	Slogan to communicate dangers					
	Visual signage to inform, alert and control actions					
	Toolbox talks or safety talks					
5	**Workplace organization**					
	Site layout planning is done before start of work					
	Materials on site are stored properly					
	Sharp edges are covered/protected, like nails and steel bars					
6	**Worker's involvement**					
	Safety rules and procedures are strictly followed by workers					
	Workers react strongly against any violation of safety rules by co-workers					
	Workers report safety and health concern					
7	**Personal protective equipment (PPE)**					
	Company has an effective system for the issuance of PPE					
	Company has an effective system for the inspection of PPE					
	Company has an effective system for the replacement of PPE					
8	**Safety climate**					
	General management commitment to safety					
	Presence of safety polices on resources					
	Safety communication on construction sites					
9	**Unsafe working condition**					
	Working at height without a guardrail					
	Working at height on platforms not properly supported					
	Using unsafe ladder on sites					
10	**Hazard prevention and control**					
	Provision of information about work place					
	Inspect work place for safety hazard					
	Identity health hazard					
11	**Unsafe action**					
	Not using personal protective equipment					
	Unauthorized operation of equipment					
	Working or operating machine at unsafe speed					
12	**Recognition and reward**					
	Monetary reward for complying with safety rules					
	Promotion of workers who comply with safety rules					
	Public praise to workers who comply with safety rules					

13	**Pre task planning**					
	Daily meeting before the commencement of work					
	Analyse hazard before work begins					
	Perform work within hazard control					

Appendix B: Observation Checklist

Observation check list of visual management practices

Items	Available	Not Available	Being used	Not being used
Site layout and fencing				
Visual Signs (posters and signboards)				
Safety signs				
Standardization of the workplace elements				
Work place organization				
Visual Work facilitators such as visual aids. Process charts colour coded work aids etc.				
Spray marking				
Andon system on equipment				
Error proofing device attached on equipment				
Project Performance board				
Production control board such as Kanban board				
Prototyping				