FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

ENHANCING THE ADOPTION OF OCCUPATIONAL HEALTH AND SAFETY IN THE NIGERIAN CONSTRUCTION INDUSTRY: COMBINATION OF DIGITAL TECHNOLOGIES AND TRADITIONAL APPROACH TO SAFETY

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Professor of Quantity Surveying

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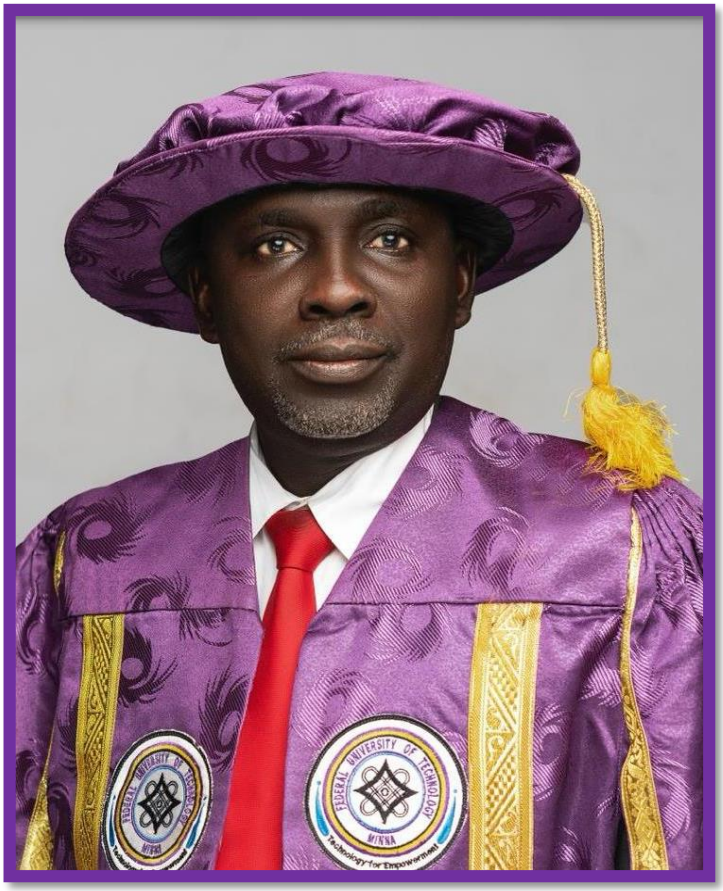

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PREAMBLE

Let me start by glorifying God Almighty, the Most Gracious and the Most Merciful. I praise God Almighty, the Cherisher and Sustainer of the Worlds; Most Gracious; Most Merciful and Master of the Day of Judgement.

Mr. Vice-Chancellor, Sir. I feel very honoured for the opportunity given to me to deliver this lecture to this distinguished gathering of scholars and highly respected personalities in the society. The topic of this lecture came as a result of the attitude of people, especially some of the relevant stakeholders, on the issue of health and safety management at workplace or occupational health and safety, as the case may be. People do not believe that health and safety is a serious issue and what is the outcome of this? It is obviously a disastrous and damaging outcome. To make matters worse in a bid to embrace technology, we think we could leave out human beings in the practice of health and safety management or occupational health and safety. Hence, the thinking is that man can be completely replaced with robots. My research over the past decade on health and safety management in construction has seen a different dimension into this thought. This gives rise to this inaugural lecture titled: "**Enhancing the Adoption of Occupational Health and Safety in the Nigerian Construction Industry: Combination of Digital Technologies and Traditional Approach to Safety**". Before starting the lecture, it is important to let us know that the lessons from this lecture is not only beneficial to the construction sector but to all sectors of the economy, including our great institution, the Federal University of Technology, Minna.

Mr. Vice Chancellor, Sir, Deputy Vice Chancellors, Registrar, Bursar, University Librarian, all principal officers, Deans, Directors, members of Senate, Heads of Departments, Professors, all the members of the university community, our great students, invited guests, gentlemen of the press, distinguished ladies and gentlemen. I welcome you as you listen to this inaugural lecture.

1.0 INTRODUCTION

Shelter is one of the basic needs of man in life and the housing sector is responsible for catering for man's need for shelter. Therefore, housing is paramount has it ranks among the top three needs of man (i.e., clothing, food and shelter) (Shittu, 2018; Islam *et al*., 2022). Housing is required to provide comfort, safety, satisfaction, experience, and convenience for its occupants. Hence, it is one of the essential social conditions which define the living standard of a country's citizens (Shittu *et al*., 2022). The construction industry is vested with the responsibility of ensuring that the housing need of man is realizable. The construction industry is a significant contributor to the economy of a nation, as it plays a vital role in every country's economic growth worldwide. The construction of buildings either for residential, commercial, industrial or educational purpose, takes place under an environment which is prone to safety threats leading to accidents, injuries and fatalities (Mohammed *et al*., 2022).

The adoption of building technology plays a critical role in providing a healthy environment in the construction industry. In spite of the adoption of technology to enhance the safety consciousness so as to reduce the rate of accidents, injuries and fatalities, the activities of the construction industry still pose severe threats to the stakeholders on construction sites, thereby increasing the rate of accidents, injuries and fatalities annually (Guo *et al*., 2021). Even with the embracement of digital technologies such as Artificial Intelligence (AI) and Computer Vision (CV) techniques, the rate of accidents is still alarming. This is because much attention has been focused on the application of digital technologies to address the safety issues in construction projects rather than combining digital technologies with issues that will address the root causes of the problem and find lasting solutions, such as the Behavioural-Based Safety (BBS) approach and Multi-Employer Safety Doctrine which are parts of the traditional approach to safety management.

1.1 Background to the Lecture

Traditionally, research effort has been focused on the policy, management, human and cultural issues of safety and there have been critical reviews on these dimensions, for example, human factors in construction safety (Guo *et al*., 2015; Goh *et al*., 2018) and strategic safety management (Zou and Sunindijo, 2015). Effective safety planning and hazard analysis are an essential prerequisite to accident prevention. It has been argued that traditional safety management practices in the construction industry have been manual, time-consuming, selective, and therefore inefficient and error-prone (Zhang *et al*., 2013; Zhang *et al*., 2015; Zou *et al*., 2017a). For example, Behavioural-Based Safety (BBS) programmes still rely on manual observations to collect unsafe behaviours (Guo *et al*., 2018). Manual observations and inspections are difficult to cover the whole site and monitor all workers.

The past two decades have seen increasing applications of digital technologies and techniques to help improve construction health and safety (H&S) management (Guo *et al*., 2017). Examples of digital technologies include, but are not limited to, Building Information Modelling (BIM) (Zou *et al*., 2017b), tracking and positioning technologies (Teizer *et al*., 2013), augmented reality and virtual reality (AR/VR) (Wang *et al*., 2013), and AI (Goh and Guo, 2018; Guo and Goh, 2017). These digital technologies have demonstrated great potential to improve safety management at a workplace. Comprehensive summaries of the research on this topic area can be found in past studies (Guo *et al*., 2017; Li *et al*., 2018).

1.2 Research Problem Identified

Seo *et al*. (2015) reviewed CV techniques for construction H&S monitoring. The study focused on evaluating unsafe behaviour from a technical and practical perspectives (e. g., image sensing devices, camera position, viewpoints, etc.). However, safety is a multi-faceted concept and consists of other important dimensions, like safety

culture, safety climate, and safety management system (Cooper, 2000), and it relates to not only human behaviour but also the surrounding environmental conditions such as moving machines, equipment and objects. In view of this, Seo *et al*. (2015) discovered the digital technologies alone cannot give the best result of minimal rate of accidents or zero accidents in the construction industry but a combination of digital technologies (e.g., AI, 4IR, CV, etc.) and the traditional safety science and management (e.g., BBS, H&S training, ergonomics, etc.) has the potential to do so. The BBS approach will ensure that stakeholders in construction projects comply with H&S procedures because they need to do so but not because they have to do so. Therefore, this study advocates for the adoption of the traditional safety science and management approaches in conjunction with the digital technologies so as to bring about affordable and enhanced adoption of H&S procedures in construction projects.

2.0 CONCEPT OF HEALTH AND SAFETY MANAGEMENT

Occupational health and safety (OHS) is one of the most important aspects of human concern. It aims at adaptation of working environment to workers for the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations. The question of OHS, as a global issue, is now taking a new turn (Tadesse and Admassu, 2006). Before discussion concept of OHS management, it is germane to understand some basic terms.

2.1 Basic Definitions

The following are definitions of important terms in H&S management as given by the Industrial Accident Prevention Association (1999); Selçuk (2015); and ILO (2016).

2.1.1 Risk

Any event, activity or unplanned change that happens in the work environment and lead to injuries, illnesses or deaths.

2.1.2 Hazard

Hazard is a physical or psychosocial condition, object or agent that has the potential to cause harm to a worker and/or to cause damage to property or environment.

2.1.3 Accident

An unplanned event resulting in injury, illness or death.

2.1.4 Near miss

Near miss is an incident, which did not show a visible result, but had the potential to do so.

2.1.5 Incident

Incident is an unplanned, unexpected event which has the potential to lead to an accident although may not do so.

2.1.6 Fatality

Occupational accident or injury leading to the death of a worker. In order words, fatality can be referred to as death resulting from an accident.

2.1.7 Workplace

The workplace may be described as any place where people are at work.

2.1.8 Health

The World Health Organisation has defined health as a resource that enables people to achieve their own optimal potential of physical, mental, and emotional well-being.

2.1.9 Safety

The state of being away from hazards caused by natural forces or human errors randomly. The source of hazard is formed by natural forces and/or human errors

2.1.10 Safety attitude

Workplace safety attitude refers to the employee tendency to respond positively or negatively to a safety goal, idea, plan, procedure, prevention or situation.

2.1.11 Occupational health and safety

All factors and conditions that affect the H&S in the workplace, or affect the employees, contractors, visitors and any other person in the workplace.

2.2 Global Concept of Occupational Health and Safety Management

Interest in OHS started with the beginning of civilization, the researchers found that Hammurabi, the king of Babylon in the 18th century BC issued laws to protect the safety of workers, including the following: i) If a builder builds a house for someone and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death; ii) Punishment of the supervisors who cause damage as a result of failure to perform their work in a proper manner, for example, if a worker loses his arm as a result of the error or negligence of the supervisor, the supervisor's arm has to be cut likewise.

In the United Kingdom, labour and safety laws have begun to be issued since 1802 and in 1833 an entity was formed to inspect the factories (HM Factory Inspectorate) in order to inspect factories and ensure the prevention of occupational accidents of child labourers in textile sector. In the United States, in 1910, Allen Hamilton had been allocated as the first scientist in industrial toxins, and she was a leader in the field of toxicology and occupational health. The industrial renaissance occurred between 1920 and 1930 and was accompanied by the development and growth of industrial health in both public health and large private companies, which led to the formation of the American Conference of Governmental Industrial Hygienists (ACGIH) in 1938 and the American Industrial Hygiene Association (AIHA) in 1939, and they both included industrial/ occupational hygiene experts.

In view of the above background, OHS constitutes a system that deals with the prevention of injuries and illnesses related to work, as well as

the protection and improvement of the health of workers. It aims to improve the working conditions and the surrounding environment. Occupational health includes promoting and maintaining the highest degree of physical and mental health and social well-being of workers in all professions. In this context, the basic principles of the process of assessing and managing occupational hazards is based on the expectation, recognition, evaluation and control of the risks arising in or from the workplace and that are harmful to the health and well-being of workers. Therefore, application of OHS principles, which includes the mobilization of all social and scientific disciplines, constitutes a clear measurement of this complexity.

Unfortunately, it has been reported that OHS implementation is faced with several risks which result in severe consequences at a workplace and on workers. In the light of this, the International Labour Organisation's (ILO) (2016) statistics has it that 250 million workers around the world are exposed to accidents each year due to problems in securing the work environment. Economically, there are direct and indirect costs as a result of the ineffectiveness of the OHS system, including, for example: Cost of treatment; Decrease in the number of working days; Low productivity; Compensation costs; Training and re-training costs; Repairing the equipment damages costs; and Loss of contracts because the product does not meet the specifications. In order to address these challenges, Medicina (2020) submitted that the realisation that work will continue to change in the future requires that the field of OHS include but go beyond traditional concerns such as exposures to chemical, physical and biological agents and focus on an expanded paradigm that addresses the interaction of occupational and individual risk factors, the work-life continuum and ultimately on operationalising and implementing a concept for the well-being of workers. This holistic view will require new systems, thinking and transdisciplinary approaches to OHS in the future.

2.3 Occupational Health and Safety Management in the Nigerian Context

The ILO (2019) has developed numerous conventions, protocols, and recommendations on minimum labour standards. Some conventions have been promulgated and adopted by the ILO Member States, the majority of which relates to OHS systems. Nigeria is a signatory on two ILO (2019) conventions, including conventions on OHS since the country's formal affiliation with the international body in 1960. In the same way, Nigeria is a signatory to the Co45 underground work (women) convention (ILOC045, 1935) which came into effect on 17 October 1960. Nigeria is correspondingly a signatory to C155-occupational safety and health convention, (ILOC155, 1981), which came into force on 3 May 1994. Moreover, Nigeria presently has nine legislations on OHS (ILO, 2016) designed to support and protect workers in the manufacturing sector.

The promulgation of the safety ordinance of 1955 was the Nigerian government's first attempt to regulate industrial organisations (Uvieghara, 2001). OHS procedures were institutionalised by a series of legislations that were promulgated during the 1970s (Umeokafor *et al*., 2014a; Wekoye *et al*., 2019; Fuller, 2019; Manu *et al*., 2019; Simukonda *et al*., 2020). The Factory Act of 2004 (OSHP 2004) is the principal statute that regulates OHS in Nigeria. The Employees' Compensation Act of 2010 specifies the compensation of employees that suffer varying severity of work-related injuries. The Labour, Safety, Health and Welfare Bill of 2012 is the most recent legislation that seeks to repeal the Factory Act of 2004. The law was passed as a bill by the two national parliamentary assemblies in 2012 (Umeokafor *et al*., 2014b; Reuben *et al*., 2019; Wekoye *et al*., 2019; Omoijiade, 2019; Nkuhi and Benjamin, 2020; Umeokafor *et al*., 2020; Okoye *et al*., 2016). Unfortunately, this Bill did not see the light of the day as it never became a law in Nigeria. In view of this, scholars have reported that the enforcement of OHS laws in Nigeria is relatively inadequate (Idoro, 2011; Umeokafor *et al*., 2014b; Abubakar, 2015; Bamel *et al*.,

2020; Hallowell *et al*., 2019). In line with this, Olawepo *et al*. (2021) reported that based on the accident report from the Federal Ministry of Labour and Productivity (FMLP), evidence indicates that the food processing sector recorded 60% of all fatal cases between 2002 and 2012, as shown in Table 2.1.

Table 2.1: Record of Accidents, Injuries and Deaths in the Food Processing Industry

Period/Fatalities	1987-1996	2001- 2006	2002-2012
Accidents	-	490	9
Injuries	3183	-	20
Death	71	-	12

Source: Olawepo *et al*. (2021)

2.4 Occupational Health and Safety Management in the Nigerian Construction Industry

There is a consensus among scholars that the enforcement of OHS legislation in Nigeria is weak (Umeokafor *et al*., 2014b; Aniekwu, 2007; Adei and Kunfaa, 2007; Abubakar, 2015; Idoro, 2011, Shittu, 2016; Shittu *et al*., 2016), particularly in the construction industry, which has been omitted from existing OHS legislation in Nigeria. According to Umeokafor *et al*. (2014b), the enforcement of OHS regulations includes 'warning or notices to offenders and searching a defaulting factory. In line with this, the information in Table 2.2 displays the workforce analysis of the Inspectorate Department in the Ministry of Labour and Employment.

Table 2.2: Number of Registered Factories and Inspectors in the Six Geographical Zones in Nigeria

Geographical Zone	Registered Factories	Number of Inspectors
South-West	2,777	22
South-East	922	5
South-South	524	2
North-West	868	5
North-East	252	2
North Central	509	2

Federal Capital Territory	36	1
Total	**5,888**	**39**

Source: Umeokafor *et al*. (2014b)

In the light of this, Abubakar (2015) suggested the critical factors for an effective OHS system to include the following: Adequacy of the OHS law(s); Efficiency of the judicial system; Degree of independence of the OHS regulatory agency; Structure and placement of the regulatory and enforcement bodies; Adequacy of budgetary allocation; Accident history and government sensitivity; Good workforce-inspector ratio; and Activities of the civil society and human rights groups.

3.0 POSITION OF OCCUPATIONAL HEALTH AND SAFETY REGULATIONS ON CONSTRUCTION ACTIVITIES

In view of the fact that the state of OHS in Nigeria is poor, especially in the construction industry, it is imperative to identify the general OHS regulations that can be applied to construction activities in Nigeria. However, it has been reported that this contextual issue can make the difference (Umeokafor *et al*., 2014b).

3.1 Occupational Health and Safety Laws Applicable to Construction Activities

OHS in Nigeria has not received adequate attention and support. As a result, OHS statutory regulations and provisions are non-functional (Diugwu *et al*., 2012), while the state of OHS in Nigeria is poor (Diugwu *et al*., 2012; Okolie and Okoye, 2012). According to Diugwu *et al*. (2012), the failed OHS system in Nigeria is due to the weak statutory OHSR and provisions. Also, it has been argued that the appalling level of compliance with OHSR in Nigeria (Diugwu *et al*., 2013; Idubor and Oisamoje, 2013; Okolie and Okoye, 2012) contributes to the poor OHS in the construction industry. Meanwhile, the continued exclusion of the Nigerian construction industry by the existing Factories Act of 1990 (Diugwu *et al*., 2012; Idoro, 2008), and the inefficiency of the Federal Ministry of Labour and Productivity

Inspectorate Division in overseeing OHS in Nigeria as empowered by the Factories Act (Umeokafor *et al*., 2013) do not help compliance either, despite the higher likelihood of construction workers to be killed at work if compared with other industries (Odeyinka *et al*., 2005). Consequently, the construction contractors adopt regulations from the UK and the USA (Idoro, 2008; Diugwu *et al*., 2012) hence, compliance and enforcement are marginal (Umeokafor *et al*., 2013).

In view of the above background, it has been established that foreign construction firms have a higher likelihood of complying to OHS regulations than their indigenous counterparts (Shittu, 2016; Shittu *et al*., 2016). This is because the foreign construction firms and multi-nationals usually adopt the OHSR of their parent countries. In the light of this, Shittu (2016); Shittu *et al*. (2016); Muhammad *et al*. (2021); Muhammad *et al*. (2022); and Shittu *et al*. (2022) discovered that large size construction firms have a higher tendency to implement OHSR than small and medium size construction firms. Therefore, compliance with OHSRs increases with increase in construction firms' organisational characteristics. In addition, Muhammad *et al*. (2021); Muhammad *et al*. (2022); and Shittu *et al*. (2022) identified three (3) key areas where Nigerian construction firms can improve their level of compliance to OHSRs. These are: Formulating organisational OHS policy; Using OHS best practices from different construction firms who have demonstrated high-level compliance to OHSRs; and Strictly abiding by the clauses in the conditions of contract binding the parties to a contract in a specific construction project.

In the light of the above background, the Nigerian construction industry should try to draw strength from the clauses in the general OHSRs in order to formulate a customized organisational OHS policy which will be binding on the workers. Hence, the following are the OHSRs that are applicable to construction activities in Nigeria.

3.1.1 Workmen's Compensation Act

Workmen's Compensation Act is regulated by Ministry of Labour and Productivity. It is an Act to make provisions for the payment of compensation to workmen for injuries suffered in the course of their employment.

3.1.2 The Labour Act, Chapter 198 of the Law of the Federation of Nigeria 1990

The Labour Act, Chapter 198 of the Law of the Federation of Nigeria 1990 addresses extensively the welfare of workers in order to safeguard the health of the workers at workplaces. It also protects their right to a healthy, decent and conducive working environment.

3.1.3 The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 (Act No. 25)

The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 was enacted by the National Assembly of the Federal Republic of Nigeria on the 30th Day of July, 2007 and the National Environmental Standards and Regulations Enforcement Agency was established to: (a) be the enforcement Agency for environmental standards, regulations, rules, laws, policies and guidelines; (b) be a corporate body with perpetual succession and a common seal; and (c) to be in a capacity to sue and be sued in its corporate name.

3.1.4 The Insurance Companies Act of 1961

Insurance policies play a significant role in instilling H&S consciousness in the building sector, insuring workers against liability for injury arising from hazardous nature of building construction. Insurance policies employed in managing construction risks have been classified as: all-risk policies; builder's liability insurance; builder's risk insurance; equipment floater insurance; key man insurance; automobile insurance; and worker's compensation insurance; road traffic act policies; multi-risk policies; and specified peril policies.

3.1.5 Factories Act 1990

Factories Act is an Act to provide for the registration, etc. of factories; to provide for factory workers and a wider spectrum of workers and other professionals exposed to occupational hazards, but for whom no adequate provisions had been formerly made; to make adequate provisions regarding the safety of workers to which the Act applies and to impose penalties for any breach of its provisions. Factories Act 1990 was regulated by Factories Inspectorate Division of Federal Ministry of Labour and Productivity.

3.1.6 National Building Code 2006

In 1987, the Defunct National Council of Works and Housing directed that a National Building Code be evolved for Nigeria. All the stakeholders in the Building Industry were duly contacted for input. Thereafter, the defunct Federal Ministry of Works and Housing organised a National workshop at ASCON, Badagry - Lagos State in 1989. To further fine tune the Draft National Building Code, another workshop was held at the Gateway Hotel, Ijebu-Ode, Ogun State in 1990. The product of the Ijebu-Ode Code was approved by the then National Council on Housing in 1991 and the approved document was re-presented to the 2nd National Council on Housing and Urban Development held in Port-Harcourt, November, 2005. Consequently, the draft document underwent some restructuring. In view of this, the National Council on Housing and Urban Development deemed it necessary and initiated the process of evolving a National Building Code to put a stop to the ugly trends in the Building Industry.

3.1.7 The Nigerian Labour Safety, Health and Welfare Bill, 2012

The Labour Safety, Health and Welfare Bill, 2012 was presented to the National Assembly on the 27th of September, 2012. The bill seeks to address OHS challenges posed by industrial activities in Nigeria as well as that of the construction industry. The Bill addressed issues of occupational risks, hazards, accidents and diseases at work places,

especially for the Agricultural, Construction, Petro Chemical, and Oil and Gas industries. Unfortunately, the Bill was never passed into Law.

3.2 Responsibilities of Stakeholders in the Construction Business on Occupational Health and Safety

The responsibilities of governments, employers and workers should be seen as complementary and mutually reinforcing in the common task of promoting OHS to the greatest extent possible within the constraints of national conditions and practice (Ali, 2008).

3.2.1 Workers' rights

It is increasingly recognised that the protection of life and health at work is a fundamental workers' right; in other words, decent work implies safe work. Furthermore, workers have a duty to take care of their own safety as well as the safety of anyone who might be affected by what they do or fail to do.

3.2.2 Employers' responsibilities

Because occupational hazards arise at the workplace, it is the responsibility of employers to ensure that the working environment is safe and healthy. This means that they must prevent and protect workers from occupational risks. But employers' responsibility goes further, entailing knowledge of occupational hazards and a commitment to ensure that management processes promote safety and health at work.

3.2.3 Governments' duties

Governments are responsible for drawing up OHS policies and making sure that they are implemented. Policies will be reflected in legislation, and legislation must be enforced. But legislation cannot cover all workplace risks, and it may also be advisable to address OHS issues by means of collective agreements reached between the social partners.

4.0 MY CONTRIBUTIONS TO THE FIELD OF HEALTH AND SAFETY MANAGEMENT

My contributions have given birth to lots of research works in the field of H&S management by following the trend of development in the global and Nigerian contexts over the last decade. These research works have been reported in conference papers, journal papers, and students' projects, dissertations and theses at undergraduate and postgraduate levels. Most of these research works have identified the peculiar problems of H&S management in the Nigerian construction industry, the efforts made to address the problems, the extent to which the problems have been addressed, and the hindrances to the complete success of strategies proposed to solve the problems. This lecture provides the lasting solution towards effectively solving the problems of H&S management in the Nigerian context.

The following sub-sections give insights into the digital technologies and traditional approach to H&S management. Thereafter, the combination of the digital technologies and traditional approach to safety will be explored.

4.1 Highlights of Studies from My Contributions on Traditional Safety Approach

I hereby present a synopsis of four (4) most significant researches that I undertook on traditional safety approach.

4.1.1 Research on the appraisal of health and safety management practices of small and medium size construction firms (Shittu *et al*., 2015a)

This study identified fifty-eight (58) H&S management practices, of which forty-six (46) were very important. These 46 practices were sub-divided into five categories (Company's Commitment, Workers' Consultation and Participation, Communication, H&S Planning, and Education and Training). The study found that dominant H&S practice are: Provision of First Aid Facilities, Provision of Personal Protective

Equipment, and Keeping of Safety Record and Follow-up. Hence, the implementation of all the five categories of H&S practices are capable of improving the H&S performance of small and medium size construction firms (construction SMEs).

4.1.2 Research on the assessment of the implementation of H&S requirements in construction projects executed by small firms in Abuja, Nigeria (Shittu *et al*., 2015c)

This study found that firms with larger number of employees, larger turnover, and greater years of experience implement H&S requirements more than firms with lesser number of employees, turnover, and years of experience. In addition, civil engineering construction firms have higher level of implementation of H&S requirements than building construction firms.

4.1.3 Research on the implementation of emergency response safety procedures by small-sized construction firms (SSCFs) in Abuja, Nigeria (Shittu *et al*., 2017)

This study found that there exists a strong, positive and significant relationship between the number of accidents recorded on site and amount of compensation paid to victims. It was therefore concluded that SSCFs in Abuja averagely implement the emergency response safety procedures which are requirements in conditions of contracts.

4.1.4 Researches on the impact of organisational characteristics on H&S practices of construction contractors in Abuja, Nigeria (Shittu *et al*., 2015c; Shittu, 2016; Shittu *et al*., 2016; Shittu, 2022)

These studies evaluated the impact of organisational characteristics on H&S practices of Nigerian construction SMEs with a view to determining favourable conditions for effective safety performance. The Nigerian construction SMEs, who make up the highest percentage of construction firms in Nigeria, where classified with certain characteristics (see Table 4.1).

Table 4.1: Classification of Small and Medium-Size Firms

S/No.	Size category	Employment	Assets (=N= million) (excluding land and buildings)
1	Micro enterprises	Less than 10 employees	Less than 5
2	Small enterprises	10-49 employees	5 less than 50
3	Medium enterprises	50-199 employees	50 less than 500

Source: Small and Medium Enterprise Development Agency of Nigeria (SMEDAN) (2009)

The study established that organisational characteristics have significant impact on the H&S practices of construction SMEs. The study also discovered that there is low-level compliance with H&S requirements by construction SMEs due to the following important reasons in order of importance: Literacy level; Poor attitude of construction workers; Financial constraints; Environmental influences; Cost of H&S; Lack of basic facilities; Job security and continuity; Lack of awareness and orientation from government regulatory agencies; and Weather condition. An interview with the workers of the construction SMEs also revealed that poor attitude was one of the major reasons for the poor safety performance of construction SMEs. This is because one of the workers interviewed had this to say:

> *"Human beings generally are difficult to manage on site, especially when you remind them of safety on site; they will say "I know sir". Seeing you he will act immediately, but as soon as you leave, he removes his helmet and gloves"* (Respondent Number 152).

An owner/manager also gave his comment as thus:

> *"Some of our workers quarrel or fight with their colleagues over minor issues because they take alcohol or smoke Indian hemp before coming to work. These kinds of workers, most of the time, do not adhere to safety rules and they get injured. We*

dismiss such kind of workers with immediate effect as soon as they are noticed" (Respondent Number 11).

Site observations carried out also revealed some instances of unsafe work practices by workers on site even in projects where PPE were provided. These unsafe practices are shown in Figures 4.1 –and 4.2.

Figure 4.1: A Labourer Working at Height without Using PPE

Figure 4.2 Iron Bender Working Under an Unsafe Area without Using PPE

In view of the major findings of this study, the study developed the favourable conditions for attaining optimum H&S performance by construction SMEs as shown in Tables 4.2 and 4.3.

Table 4.2: Level of Implementation of Health and Safety Practices by Firms with Different Organisational Characteristics

Organisational Characteristics			Mean Score	Rank	Favourable Condition
Experience	A1	1 - 5 Yrs	2.33	4th	16 - 20 yrs experience
	A2	6 - 10 Yrs	2.32	5th	
	A3	11 - 15 Yrs	2.38	3rd	
	A4	16 - 20 Yrs	**2.63**	**1st**	
	A5	> 20 Yrs	2.49	2nd	
Age of Firm	B1	1 - 5 Yrs	1.98	5th	> 20 Years
	B2	6 - 10 Yrs	2.28	4th	
	B3	11 - 15 Yrs	2.30	3rd	
	B4	16 - 20 Yrs	2.51	2nd	
	B5	> 20 Yrs	**2.58**	**1st**	
Size of	C1	≤ 30 employees	2.07	3rd	71 - 200 employees
	C2	31 - 70 employees	2.47	2nd	

	C3	71 - 200 employees	**2.64**	**1st**	
Annual Turnover	D1	< N2 million	1.98	5th	N10 - 15 million
	D2	N2 - 5 million	2.33	4th	
	D3	N5 - 10 million	2.36	3rd	
	D4	N10 - 15 million	**2.64**	**1st**	
	D5	N15 - 20 million	2.53	2nd	
Growth Rate by Size	E1	0 - 10%	2.38	3rd	31 - 40%
	E2	11 - 2 0%	2.28	4th	
	E3	21 - 30%	2.47	2nd	
	E4	31 - 4 0 %	**2.80**	**1st**	
	E5	4 1 - 5 0 %	2.28	4th	
Growth Rate by Turnover	F1	0 - 5%	2.31	3rd	11 - 15%
	F2	6 - 10%	2.45	2nd	
	F3	11 - 15%	**2.69**	**1st**	
	F4	16 - 20%	2.08	5th	
	F5	20 - 25%	2.30	4th	

Source: Shittu (2016); Shittu *et al*. (2016); and Shittu *et al*. (2022)

Table 4.3: Favourable Conditions for Effective Safety Performance

Organisational Characteristics	**Size Band**	**Mean Score**
Experience	16 - 20 Years	2.63
Age of Firm	20 Years and above	2.58
Size of Firm	71 - 200 Employees	2.64
Annual Turnover	=N= 10 - 15 Million	2.64
Growth Rate by Size	31 - 40%	2.80
Growth Rate by Turnover	11 - 15%	2.69
Average Level of Implementation of	***H&S Practices***	***2.663***

Source: Shittu (2016); Shittu *et al*. (2016); and Shittu *et al*. (2022)

The mix of organisational characteristics in Table 4.3 (favourable conditions) gives an average level of implementation of H&S practices of mean score of 2.663 on a scale of 1.00 – 3.00. This indicates that this mix of organisational characteristics is capable of bringing about 89% improvements in the safety performance of the construction SMEs. Hence, the study concluded that for the safety

performance of a construction SMEs to be effective, the construction SME should have been in existence for about 20 years and above; employ a safety officer/supervisor/site manager with an experience of 20 years and above; have attained a site workforce of 71 employees and above; have attained an annual turnover of =N=10 Million and above; have a growth rate by size of workforce of 21% and above; and have attained a growth rate by annual turnover of 11% and above.

4.2 Highlights of Studies from My Contributions on Digital Technologies for Safety Management

This section gives a synopsis of four (4) most significant researches that I undertook on digital technologies for safety management.

4.2.1 Research on the application of information and communication technology (ICT) for the implementation of health and safety measures by construction firms in Abuja, Nigeria (Shittu *et al*., 2021c)

This study revealed that the H&S measures mostly requiring the use of ICT tools for proper implementation on construction sites are: Creating safety and health regulation and hazard identification, prevention and control. Site surveillance technologies (CCTV) is the ICT tools mostly required for monitoring the level of compliance to H&S measures on construction sites, as shown in Table 4.4. The impact of ICT tools on the level of compliance to H&S measures on construction sites was found to be significant. Therefore, the use of ICT tools has significant impact on the level of implementation of H&S measures by construction firms.

Table 4.4: Results of ICT Tools Mostly Required for Monitoring the Level of Compliance to H&S Measures on Construction Sites

Code	ICT Tools	RII	Rank	Decision
B1	Site surveillance technologies (CCTV)	0.98	1st	Very Important

B2	Remote Sensing (RS) standard cellular phones, smart phones or tablets.	0.96	2nd	Very Important
B3	Mobile Radio Systems	0.94	3rd	Very Important
B4	Electronic document management system (EDMS)	0.92	4th	Very Important
B5	Email and short message services (SMS)	0.90	5th	Very Important
B6	Radio Frequency Identification Device (RFID)	0.89	6th	Very Important
B7	GPS (Global Positioning System)	0.86	7th	Very Important
B8	Modelling and visualization (3D-CAD, 4D-CAD)	0.85	8th	Very Important
B9	Ultra-wideband (UWB)	0.84	9th	Very Important
B10	3D and 4D visualization technology	0.83	10th	Very Important
B11	Video conferencing	0.80	11th	Important
B12	IP Network Surveillance	0.78	12th	Important
B15	Ultrasound positioning system	0.77	15th	Important
B16	Artificial Intelligence Enabled BIM	0.72	16th	Important
B17	Unmanned Aerial Vehicles (UAV)	0.70	17th	Important
B18	Real-Time tracking system, RFIDs, automation and remote sensing technology	0.62	18th	Important
	Average RII	***0.83***		***Very Important***

Source: Shittu *et al*. (2021b)

4.2.2 Research on the utilization of artificial intelligence (AI) tools for monitoring compliance to safety practices on construction sites in Abuja (Adamu *et al*., 2022)

The study revealed that Site Sensors, Construction Wearable, Drones (UAV), Virtual Reality and Augmented Reality are the most important AI tools required for monitoring the level of compliance to safety practices on construction sites (see Table 4.5). The most significant benefit of AI tools on the level of compliance with safety practices on construction sites is "Enable management to avoid accidents and eliminate safety hazards so as to minimise employees' losses" (see Table 4.6) and the most significant strategy for enhancing the

utilization of AI tools for monitoring compliance to safety practices on construction sites is "Training employees with required skills, competence and confidence to implement the right technologies" (see Table 4.7). Hence, the application of AI tools would significantly improve compliance to safety practices on construction sites.

Table 4.5: Results of AI Tools Required for Monitoring Compliance to Safety Practices on Construction Sites

Code	AI Tools	RII	Rank	Decision
B1	Site Sensor	0.97	1st	Very Important
B2	Construction Wearable	0.92	2nd	Very Important
B3	Drones (UAV)	0.88	3rd	Very Important
B4	Virtual Reality (VR)	0.86	4th	Very Important
B5	Augmented Reality (AR)	0.83	5th	Very Important
B6	Autonomous Heavy Equipment	0.80	6th	Important
B7	CCTV	0.77	7th	Important
B8	Artificial Intelligence Enabled BIM	0.75	8th	Important
B9	Software & Mobile App.	0.72	9th	Important
B10	Artificial Neural Network	0.69	10th	Important
	Average RII	***0.82***		***Very Important***

Source: Adamu *et al*. (2022)

Table 4.6: Results of Benefits of Using AI Tools for Safety Compliance on Construction Sites

Code	Benefits of Using AI Tools for Safety Compliance on Construction Sites	RII	Rank	Decision
D1	Enable management to avoid accidents and eliminate H&S hazards so as to reduce the difficulty of employees as well as minimising their loss.	0.98	1st	Very Significant
D2	Increase the level of implementation of H&S measures by workers on construction sites.	0.96	2st	Very Significant
D3	Protect co-workers, employers, customers, suppliers and members of	0.95	3rd	Very Significant

	the public influence by the workplace environment.			
D5	Avoid the direct and indirect costs of worker injuries and illnesses, and promotes a positive work environment.	0.94	4th	Very Significant
D18	Decrease time for data processing and communicating information.	0.77	14th	Significant
D19	Avoiding the use of outdated equipment and plants during construction stages.	0.76	15th	Significant
D20	Improvement of site condition	0.75	16th	Significant
D21	Reduce the need for co-workers to be located in the same venue.	0.75	16th	Significant
D23	Aid operational improvement through communication of construction information for effective decision-making and coordination.	0.71	18th	Significant
	Average MIS	***0.78***		***Significant***

Source: Adamu *et al*. (2022)

Table 4.7: Result of Strategies for Enhancing the Utilization of AI Tools for Monitoring Compliance to Safety Practices on Construction Sites in Abuja

Code	Strategies for Enhancing the Utilization of AI Tools for Monitoring Compliance to Safety Practices	RII	Rank	Decision
E1	Training employees with required skills, competence and confidence to implement the right technologies	0.88	1st	Very Significant
E2	Creating awareness and knowledge about AI and creation of AI policies	0.87	2nd	Very Significant
E3	Develop a flexible development methodology allowing parts of the AI applications to be developed, built, and tested iterative	0.86	3rd	Very Significant

E4	Utilize skilled managers i.e., AI and ML teams should be led with project managers that can strictly enforce project management methodologies and best practices	0.83	4th	Very Significant
E5	Implementing training and re-training for workers on compliance to safety practices through the use of AI	0.81	5th	Very Significant
E10	Introduction of Risk Analysis in the Design Stage	0.73	9th	Significant
	Average MIS	***0.79***		***Significant***

Source: Adamu *et al*. (2022)

4.2.3 Researches on the assessment of effectiveness of fourth industrial revolution (4IR) technologies for effective health and safety practices in construction projects in Abuja (Kadi, 2024; Kadi *et al*., 2024)

These studies found that the most important tool of 4IR technologies required for effective H&S practices in construction projects are "Building information modelling (BIM)", as shown in Table 4.8. The most severe barrier to the adoption of 4IR technologies for effective H&S practices in construction projects is "Insufficient electricity" (see Table 4.9). The most significant driver for the adoption of 4IR technologies for effective H&S practices in construction projects is "Getting ready to adopt Digital drivers" (see Table 4.10). Therefore, in order for construction firms to enhance the adoption of 4IR technologies, there is a need to develop a mechanism which will be made up of both proactive and reactive measures based on the drivers identified in the study.

Table 4.8: Tools of 4IR Technologies for H&S Practices in Construction Projects

Code No.	Tools of 4IR Technologies for H&S Practices in Construction Projects	MIS	Rank	Interpretation
B3	Building Information Modelling (BIM)	4.28	1st	Extremely Important

B9	Nanotechnology	4.15	2nd	Extremely Important
B10	Sensors	4.12	3rd	Extremely Important
B1	Real-time locating systems (RTLS)	3.99	4th	Very Important
B14	Big Data and Cloud Systems	3.98	5th	Very Important
B4	GPS	3.95	6th	Very Important
B13	Cyber Physical Systems	3.93	7th	Very Important
B7	Internet of Things (IoT)	3.80	8th	Very Important
B15	Drones' technologies	3.79	9th	Very Important
B8	Automation and robotic construction (ARC)	3.74	10th	Very Important
B12	Virtual reality (VR)	3.60	11th	Very Important
B2	Ultra-wide band (UWB)	3.54	12th	Very Important
B11	Unmanned aircraft system/vehicles (UAS/UAV)	3.49	13th	Very Important
B6	Virtual annotation	3.39	14th	Very Important
B5	ZigBee	3.21	15th	Very Important
	Average MIS	***3.80***		***Very Important***

Source: Kadi (2024); Kadi *et al*. (2024)

Table 4.9: Barriers to the Adoption of 4IR Technologies for Effective H&S Practices in Construction Projects

Code No.	Barriers to the Adoption of 4IR Technologies for Effective H&S Practices in Construction Projects	MIS	Rank	Interpretation
C4	Insufficient electricity	4.55	1st	Extremely Severe
C17	Lack of top management and leadership support	4.17	2nd	Extremely Severe
C2	Lack of specialised professionals and technical skills	4.16	3rd	Extremely Severe
C24	Privacy of workers personal data is not guaranteed	4.10	4th	Extremely Severe
C23	No assurance of data security	3.98	5th	Very Severe
C6	Lack of access to the wireless broadband powered network	3.61	17th	Very Severe

C11	Lack of innovation in the construction industry	3.60	18th	Very Severe
C14	Fear of job losses	3.59	19th	Very Severe
C13	Lack of access to the wireless broadband powered network	3.58	20th	Very Severe
C15	Slim profit margins in the industry	3.54	21st	Very Severe
C21	Decision to use differs from client requirements	3.53	22nd	Very Severe
C20	Culture of the construction industry	3.30	24th	Very Severe
C19	Incompatibility of technology with current practices and current construction operations	3.27	25th	Very Severe
	Average MIS	***3.74***		***Very Severe***

Source: Kadi (2024); Kadi *et al*. (2024)

Table 4.10: Drivers for the Adoption of 4IR Technologies for Effective H&S Practices in Construction Projects

Code No.	Drivers for the Adoption of 4IR Technologies for Effective H&S Practices in Construction Projects	MIS	Rank	Interpretation
D10	Getting ready to adopt Digital drivers	4.16	1st	Extremely Significant
D17	More attention and investment for training and guidance	4.02	2nd	Extremely Significant
D13	Employment of high level of skilled manpower with digital literacy	4.02	2nd	Extremely Significant
D11	Getting ready to adopt Big data and cloud computing; Digital platform); Physical drivers (Autonomous Cars; 3D printing)	3.94	4th	Very Significant
D5	Provision of protections by the Government	3.86	6th	Very Significant
D9	Focusing more attention to attention given to training and guidance	3.81	7th	Very Significant
D16	Support and collaboration between government and other stakeholders	3.80	8th	Very Significant
D2	Training in advanced ICT infrastructures	3.79	9th	Very Significant

D4	Provision of supportive atmosphere by the Government	3.63	10th	Very Significant
D14	Acquisition of advanced ICT infrastructure	3.61	11th	Very Significant
D1	High level of skills acquisition for upcoming digital economies	3.59	12th	Very Significant
D7	Support and collaboration with relevant stakeholders	3.59	12th	Very Significant
D6	Provision of venture capital, and oversight necessary to educate and direct on future building projects	3.22	17th	Very Significant
	Average MIS	***3.72***		***Very Significant***

Source: Kadi (2024); Kadi *et al*. (2024)

4.2.4 Research on the utilization of BIM-integrated construction safety risk assessment (BIM-CSRA) practices at the design stage of building projects in Benue State (Oche, 2024)

The study established that despite the evident benefits (see Table 4.11), the widespread adoption of BIM-CSRA practices encounters hurdles that necessitate attention. These challenges include the Interoperability challenges, lack of awareness and understanding, limited technical skills, initial investment costs, and Cost implications. Hence, the need for collaborative efforts to foster the adoption of standardized BIM-CSRA practices.

Table 4.11: Benefits of Components of Construction Hazards through Design (CHPtD) for BIM-CSRA Mechanism at Design Stage of Building Projects

Code No.	Basic Components of CHPtD for BIM-CSRA Mechanism at Design Stage of Building Projects	RII	Rank	Decision
B2	Safety design principles BIM apparatus	0.88	1st	Extremely Important
B8	BIM facilitates for data-driven decision-making	0.87	2nd	Extremely Important
B7	BIM facilitates for collaboration among stakeholders	0.85	3rd	Extremely Important

B10	BIM facilitates for adoption, interoperability, and awareness for successful implementation	0.84	4th	Extremely Important
B9	BIM facilitates for the visualization of the construction process	0.83	7th	Extremely Important
B5	3D BIM model for identifying potential hazards	0.82	8th	Extremely Important
B6	3D BIM model for identifying potential risks	0.81	9th	Extremely Important
B4	Ergonomics BIM apparatus	0.78	10th	Very Important
	Average RII	***0.84***		***Extremely Important***

Source: Oche (2024)

4.3 Suggestion for Enhancing the Implementation of OHS Requirements from My Contributions

It can be seen from my contributions through individual, collaborative and supervised researches presented in the previous sections that the use of the traditional approach and digital technologies to the implementation of OHS requirements are mutually exclusive. By implication, a single approach is not enough to give the best result but a combination of the two approaches to safety management should be explored. Therefore, this section will give a brief working procedure of the traditional approach and digital technologies to H&S management and a proposed model for the combination of the traditional approach and digital technologies to H&S management for enhancing the adoption of OHS in Nigerian construction industry.

4.3.1 Traditional safety management approaches

H&S principles are universal, but how much action is needed will depend on the size of the organisation, the hazards presented by its activities, the physical characteristics of the organisation, products or services, and the adequacy of its existing arrangements. Organisations that manage safety and health successfully invariably have a positive safety culture and active safety consultation programmes in place.

Successful organisations can establish and maintain a culture that supports H&S (Health and Safety Authority, 2006). These principles are governed by the OHS procedures. Studies have advocated for the use of three (3) traditional approaches to safety management for construction activities. These are the Behavioural Based Safety Approach; H&E Education and Training; and Ergonomics Management. This lecture will concentrate on these three traditional safety approaches.

4.3.1.1 Behavioural *based safety approach*

In enterprises, accidents happen mainly due to improper and dangerous behaviour of employees. The approach called Behavioural-Based Safety (BBS) assumes that the most effective attempts to modify dangerous employee behaviour are based on influencing people abuse. As a consequence, change in behaviour leads to a change in the way of thinking and attitude (Niciejewska and Obrecht, 2020). In other words, as a result of using BBS for a long time, employees create a safe attitude that in the future translates into further safe behaviour (Skowron-Grabowska and Sobocińsk, 2018). Therefore, one of the concepts that affects the elimination of undesirable behaviours in the work process is BBS. The BBS approach is thus providing specific behaviour management techniques to promote attitudes and values which support workplace safety (Toma *et al*., 2024), as shown in Figure 4.3.

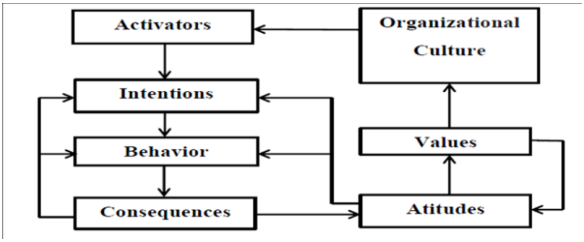

Figure 4.3: Influence of Behaviour Change Interventions in BBS Approach

Source: Toma *et al*. (2024)

4.3.1.2 H&E education and training

Intensive and extensive education and training is required to increase the level of awareness of workers about safe acts, unsafe acts and mitigative measures at construction sites (Health and Safety Executive, 2008; Niciejewska and Obrecht, 2020). The OHS law (Health and Safety at Work Act 1974) requires that you provide whatever information, instruction and training is needed to ensure, as far as is reasonably practicable, the H&S of your employees. Apart from written information, pictorial information (signs and symbols) can also be used for H&S education and training, as shown in Figure 4.4.

Figure 4.4: Use of Signs and Symbols for H&S Education and Training

Source: ILO (2016)

4.3.1.3 Ergonomics management

Ergonomics is a multidisciplinary activity dealing with the interaction between man and his total working environment plus such traditional environmental elements as atmosphere, heat, light, and sound as well as all tools and equipment of the work place (Tadesse and Admassu, 2006). Therefore, to achieve the desired results of work, both planning and design activities and control and evaluation activities must include ergonomics with its physical, cognitive and organisational domains in order to obtain a complete management system (ABERGO, 2021). Its objective is to develop, through the contribution of the various scientific disciplines that constitute a body of knowledge that, from an application perspective, should result in a better adaptation of

technological means, work and living environments (International Ergonomics Association (IEA), 2019; Texas Department of Insurance, 2024). Failure to observe good ergonomics leads to muscular disorder, affecting the posture and vital parts of the body as shown in Figures 4.5a 4.5g.

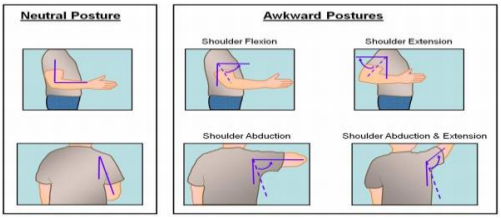

Fig. 4.5a: Neutral and Awkward Postures of the Shoulder

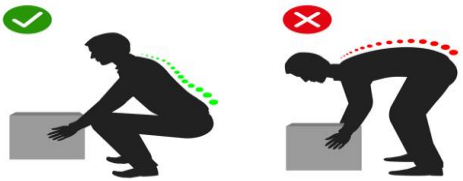

Fig. 4.5b: Good and Bad Postures for Lifting Loads

Fig. 4.5c: Bent posture and extended reach Fig. 4.5d: Tilt table brings work within reach

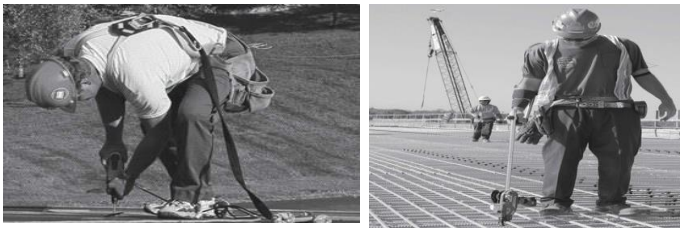

Fig. 4.5e: Bad Practice Trying Rebar by Hand **Fig. 4.5f: Good Practice Using Rebar-trying tool**

Figure 4.5g: Musculoskeletal Disorders (MSDs)
Source: Texas Department of Insurance (2024)

Muscular disorder results in injuries to the muscles, nerves, tendons, joints, cartilage, or spine. As shown in Figures 4.5a - 4.5g, examples of bad and good ergonomics practice (bad positioning of the body while at work) are shown in Figures 4a - 4f. Figure 4g, on the other hand, shows the consequences of bad ergonomics practice at work. It therefore takes a good education and training coupled with good BBS approach to build up understanding and positive attitude among workers to practice good ergonomics at a workplace. This is applicable not only to construction activities but any kind of activity of human endeavour.

4.3.2 Digital technologies available for safety management

Digital technologies are primarily ICTs that engender effective production, storage, handling and display of different kinds of information, data and interactions between individuals and electronic systems using digital computer language. Digital technologies encompass stand-alone and integrated tools, applications and software packages used in creating, processing, storing, displaying data and exchanging information (Ibem *et al*., 2018). Recently, digital technologies have been used to enhance the implementation of OHS requirements in construction projects. To this effect, the various tools used for H&S management in construction had been earlier highlighted in this lecture. Most of the studies on the application of

digital technologies have advocated for the use of CV technologies; AR/VR; and AI among other types of digital technologies. Therefore, this lecture will concentrate on these three digital technologies.

4.3.2.1 Computer vision (CV) technologies

Technological developments aided by CV have been identified as a robust approach to automatically identify and recognise unsafe behaviour and conditions. As a result, a rich collection of images of people's actions and the work conditions that contribute to unsafe events have been accumulated. From an engineering perspective, CV aims to automate tasks that the human visual system is unable to perform. The ability to automate tasks has been enhanced by deep learning (Guo *et al*., 2021). In particular, Convolutional Neural Networks (CNN), a class of deep learning networks, have been used for analyzing visual imagery (e.g., processing images and video) and overcoming the issues associated with manual observation and recording of hazards (i.e., potential sources of harm) on construction sites. Advancements in the development of CV-based approaches have the potential to provide managers and engineers with the ability to improve the safety performance of their construction operations on-site. The general framework for the application of CV for H&S management in the construction industry is presented in Figure 4.6.

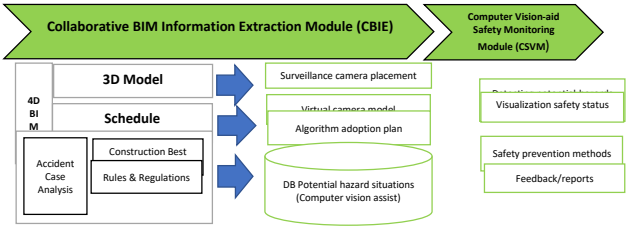

Figure 4.6: A Framework for Computer Vision-Aided Construction Safety Management

Source: Tran *et al*. (2022)

In practice, however, the application of CV has been limited due to an array of technical (e.g., accuracy and reliability) and managerial challenges (Fang *et al*., 2020). These challenges are a product of the dynamic and complex nature of construction, the difficulties associated with acquiring video surveillance data, and the cost of acquiring this technology.

4.3.2.2 Augmented reality and virtual reality (AR and VR)

According to Adamu *et al*. (2022), VR is applied on a specific construction for the purpose of motivating H&S training at the workplace in real time. VR comprises of both apparatus which provide real-time virtualisation to detect hazards and accidents. The technology enhances sites with safety training on a real-time based system. The system brings the real time activities on site to train relevant parties on safety. The safety training is made easier when VR works together with 4D CAD and BIM to identify possible hazards (Adamu *et al*., 2022). AR is another technology that can greatly improve safety on the construction site. Whether it is allowing for a more detailed safety plan to be developed or providing training on heavy equipment using actual equipment on real sites with augmented hazards, there are a number of ways that AR can be deployed on the jobsite (Oke, 2020).

4.3.2.3 Artificial intelligence (AI)

Artificial Intelligence (AI) does not exist in isolation. As a scientific discipline, AI has its roots in information and computing sciences, mathematics, logic, statistics, and engineering. It also has connections to many other fields. AI technologies are used in most industries and domains, and significant benefits are expected (Adamu *et al.,* 2022). The discussion about AI and the regulations governing its use also relate to morals, ethics, and values. The relationship of AI to other research disciplines, society, and domains using AI technologies is depicted in Figure 4.6.

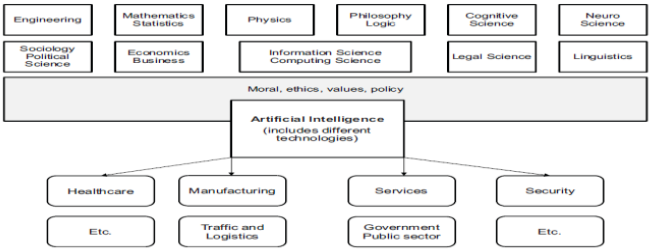

Figure 4.6: AI and Related Fields of Science
Source: Adamu *et al.* (2022)

4.3.3 Combination of digital technologies and traditional approach to safety

It has been established in this lecture that there are flaws in the traditional approach to safety management due to the fact that this approach has been manual, time-consuming, selective, and therefore inefficient and error-prone (Zhang *et al*., 2013; Zhang *et al*., 2015). Unfortunately, manual observations and inspections are difficult to cover the whole site and monitor all workers. In addition, paper-based hazard identification systems would impede timely risk communication on construction sites (Zou *et al*., 2017a). In view of this, in the past two decades, the digital technologies and techniques have been advocated for. These digital technologies have since then seen increasing applications which have helped to improve construction H&S management (Guo *et al*., 2017). However, when reviewing CV techniques for the construction H&S monitoring with major focus on unsafe behaviour from a technical and practical perspective, Seo *et al*. (2015) realised that safety is a multi-faceted concept consisting of other important dimensions, like safety culture, safety climate and safety management system. It also relates to not only human behaviour but also the surrounding environmental conditions such as moving machines, equipment and objects. Therefore, digital technologies alone cannot give the best result of minimal rate of accidents or zero accidents in the construction industry

but a combination of digital technologies and the traditional safety science and management has the potential to do so. In the light of this, a model for combining the digital technologies and the traditional safety science and management for enhancing the adoption of OHS management in the Nigerian construction industry is proposed in this lecture as presented in Figure 4.7.

The proposed model for enhancing adoption of OHS management in the Nigerian construction industry, presented as Figure 4.7, is made up of three (3) stages and an output mechanism which is expected to give a positive outcome of zero or minimal rate of construction site accidents. The first stage is the stage where the traditional safety approach is explored by implementing the required H&S procedures depending on the nature and size of the project as well as the size of the firm. This stage is mostly suited for construction SMEs who may not have the capability to afford the tools for implementing digital technologies. The second stage is the stage where the tools for the digital technologies are explored depending on the nature and size of the project as well as the size of the firm. This stage is mostly suited for the large size construction firms who can afford the cost and expertise to put up tools for digital technologies for construction site OHS management. Large size construction firms, or any such firm, who are buoyant enough can start their OHS management from the second stage. Once the construction SME firms have attained an optimum H&S performance level, as established by Shittu (2016), they can proceed to the second stage. Construction SME firms who are yet to attain the optimum H&S performance level can move from the first stage to the third stage. The third stage is the stage where workers who have been identified with poor safety performance are attended to by using the most important approaches to the traditional approach to safety based on the feedback mechanism. Successful outcome of the adoption of the model of combined digital technologies and traditional approach to safety for enhanced OHS

Management will lead to zero or minimal accident rate on construction site.

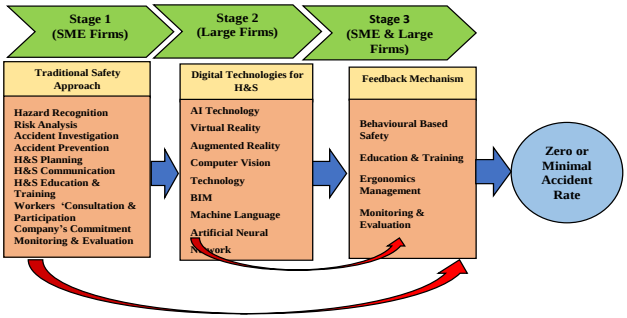

Figure 4.7: Proposed Model of Combined Digital Technologies and Traditional Approach to Safety for Enhanced OHS Management

The major benefit of this model is that it gives room for flexibility. This is because irrespective of the size of firm, the model can still be adopted and the model can be applicable to other sectors of the economy with slight modification.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

It has been established in this lecture that digital technologies can be applied to enhance current safety management systems by improving the efficiency of hazard identification and lifting the situation awareness of workers. It has also been revealed that the traditional approach to safety management involves lots of manual tasks which could be cumbersome and time-consuming. Hence, the digital technologies approach to safety has been embraced. However, the traditional approach to safety still has some unique features which the digital technologies are yet to be able to address in spite of the effectiveness, efficiency and time-saving capabilities of the digital technologies. These unique features are safety attitude, safety culture,

safety climate, and safety management system. In addition, the cost of acquiring digital technologies' tools is not affordable to the small and medium size construction firms that make up a sizeable proportion of construction firms in Nigeria. In view of this, a model has been proposed to combine the digital technologies and traditional approach to safety management so as to enhance the adoption of OHS requirements in the Nigerian construction industry for improved safety performance in terms of zero or minimal rate of accidents. The proposed model presented in this lecture will give room for flexibility because irrespective of the size of firm, the model can still be adopted conveniently and affordably. The flexibility of the proposed model can also be of benefit in the sense that it can be adopted to manage workplace safety in other sectors of the economy with slight modification.

5.2 Recommendations

In the light of the findings and conclusion put forward in this lecture, the following recommendations have been made:

i. It is strongly suggested that future research should focus on the way to improve on the digital technologies framework to be able to recognise more safety behaviours so that the digital technologies techniques can be integrated into behaviour-based safety programmes to reduce the reliance on manual observation and analysis or a combination of both traditional of digital technologies for a more efficient adoption of OHS requirement in the Nigerian construction industry.
ii. Due to the flexibility of the proposed model of combined digital technologies and traditional approach to safety for enhanced OHS management, interdisciplinary efforts among the relevant stakeholders in all the sectors of the economy are needed to measure and monitor safety culture using the model. Such a move would significantly impact the digital transformation in construction H&S management and improve safety performance.

iii. Finally, the management of this great citadel of learning is encouraged to set up a large safety committee which will include a safety committee at the university level, schools/centers/directorate level and departmental/units' level. In addition, each member of the university community should see his/her safety as his/her responsibility. A staff does not have to wait for the university management to make laws before realizing that he/she should be safety conscious. On a final note, try to realise that your safety is your responsibility; stay safe!

CLOSING REMARKS

Mr. Vice- chancellor, Sir, I would like to end this lecture with the following quotes on safety: In a word of wisdom by Jackie Stewart, it was said that "*It Takes Leadership to Improve Safety*". In the same vein, Eleanor Everet stated that "*Safety is Not a Gadget but a State of Mind*". Also, in line with safety, Captain Scott Kelly stated that "*Safety Has to be Everyone's Responsibility*". In addition, Kina Repp stated that "*You are Your Own Last Line of Defense in Safety*". Don Brown also moaned that "*An Accident is Just the Tip of the Iceberg*". Finally, Dan Petersen asserted that "*Paper Doesn't Save People, People Save People*". From all these quotes, I so submit that '*Your Safety is Your Responsibility; Stay Safe*'.

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BRIEF PROFILE OF THE INAUGURAL LECTURER

Prof. Abdullateef Adewale Shittu was born in Minna on the 8th day of October, 1974 to the family of Late Alhaji Hamzat Olayiwola Shittu, and Alhaja Mulikat Funsho Shittu. He is the fourth of the eight children of the family. He is happily married to Mrs. Nafisat Adejoke Shittu and blessed with lovely children (Abdullahi, a graduate; Aishat; Abdulazeez; and Abdulrahman, all undergraduate students) and a grandchild (Sultan). He is a native of Offa in Offa Local Government Area of Kwara State. Prof. A. A. Shittu had his primary education at Limawa Primary School, Minna from 1979 – 1986 where he obtained the Certificate of Primary Education. He had his secondary school education at Ahmadu Bahago Secondary School, Minna from 1986 – 1992 where he obtained the Senior Secondary School Certificate. He later proceeded to the Federal University of Technology, Minna from 1995 – 2000 where he obtained a Bachelor of Technology Degree in Quantity Surveying. He had his National Youth Service (NYSC) at Mobil Producing Nigeria Unlimited, Eket, Akwa Ibom State from May, 2001 to May, 2002. He also attended the University of Jos, from 2006 – 2008, where he bagged a Master of Science Degree in Construction Management. Prof. A. A. Shittu moved further with his studies by attending the prestigious Ahmadu Bello University, Zaria, from 2012 – 2016, where he acquired the Degree of Doctor of Philosophy (PhD) in Quantity Surveying. In order to upgrade his career, Prof. A. A. Shittu passed all professional examinations, interview and screening which led to his induction as a Professional and Fully Registered Quantity Surveyor by the Nigerian Institute of Quantity Surveyors and the Quantity Surveyors Registration Board of Nigeria with Registration Numbers: 2200 and 1608 respectively in 2011.

Prof. A. A. Shittu started his work experience as a classroom teacher at Adiatullahi Islamic Nursery and Primary School Offa, Kwara State from 2002 - 2005. Alongside this, he also taught primary school pupils and secondary school students lessons at home. In addition, he

practiced the profession of Quantity Surveying as the principal partner of NAFLAT Cost Consult, Offa, Kwara State. He worked as a part-time lecturer at the Department of Quantity Surveying, Federal Polytechnic, Offa, Kwara State from 2004 – 2005. In November 2005, Prof. A. A. Shittu was employed as an Assistant Lecturer by the Federal University of Technology, Minna, Niger State. He rose to the rank of Lecturer II in November, 2008; the rank of Lecturer I in October 2012; the rank of Senior Lecturer in October 2017; the rank of an Associate Professor in October 2020; and the rank of Professor in October 2023.

Prof. A. A. Shittu has lots of posts of responsibility since his employment with Federal University of Technology, Minna. He was Level Adviser to 200 Level students of Quantity Surveying (2006 - 2008); Examination Officer of Quantity Surveying Department (2008 - 2012); Staff Adviser to National Association of Quantity Surveying Students, FUT Minna Chapter (2014 - 2023); Departmental BTech Project Coordinator (2021 till date), Assistant Examination Officer, School of Environmental Technology (SET) (2017 - 2018); Assistant Time Table Officer, SET (2017 - 2018); SET Representative; University Convocation Exhibition Sub-committee (2016 till date); SET Representative; University Board of Survey (2016 till date); SET Representative; University Seminar and Colloquium Committee (2021 till date); and Department of Quantity Surveying Alumni Relations Officer (2022 till date) among others.

Prof. A. A. Shittu has more than a hundred publications in local, national and international journals and conferences and has been involved in many community service activities within and outside Federal University of Technology Minna. Some of these activities are as follow:

S/N	TYPE OF COMMUNITY SERVICE	YEAR/SESSION
1	Tutor, NIQS Professional examination, Nigerian Institute of Quantity Surveyors, Niger State Chapter, Minna	2019
2	Member, Nyikangbe-Gurara Community Development Association, Minna	2010 - Date
3	Member (General Secretary), Executive Committee: Salam - Salam Islamic Society of Nigeria, Minna – Niger State Branch	2019 - Date
4	Invitation as a Guest Speaker at the 12th Annual Speech/Prize Giving Graduation Ceremony of Crystal Jewels academy, Minna. Topic: CULTURE & HERITAGE: Tools for Building a Solid Foundation in a Nation.	20/07/2017
5	Invitation as a Guest Speaker at the Speech, Graduation and Prize Giving Day of Treasure International Schools, Minna. Topic: Building a Solid Foundation through Culture and Heritage.	27/07/2019
6	Invitation as a Guest Lecturer, Ahmadu Bahago Secondary School, Minna. Topic: CHOOSING A CAREER AS A PROFESSIONAL QUANTITY SURVEYOR: The Pros and Cons.	28/05/2024
7	Resource Person: Federal University of Technology, Minna Degree Affiliated Programme, The Federal Polytechnic, Bida, Niger State.	2019 - Date
8	External Moderator: Department of Quantity Surveying, Niger State Polytechnic, Zungeru	2019 - Date
9	Member, Education and Curriculum Review Committee, Salam - Salam Quranic Schools, Salam - Salam Islamic Society of Nigeria, Minna – Niger State Branch	2021 - Date
10	Member, Maikunkele Completion of Mosque Project Committee, Salam - Salam Quranic Schools, Salam - Salam Islamic Society of Nigeria, Minna – Niger State Branch	2022 - Date

Prof. A. A. Shittu's Islamic Education started in 1994 when he enrolled (informally) at Organisation of Muslim Unity's (OMU)

Quranic School in Bosso, Minna and learnt the recitation of the Holy Qur'an under Late Alh. Abdullateef Lawal and Late Alfa Isah (may Almighty Allah be pleased with their souls - Amin). He also attended a training course in Da'awah and Dialogue organised by Muslim Students' Society of Nigeria (MSSN), Federal University of Technology, Minna Chapter in 1997. Prof. A. A. Shittu's Islamic Education gave rise to so many community service activities as he became a member of Salam-Salam Islamic Society of Nigeria in 2018 and was appointed the General Secretary of the Society, Minna Branch and Assistant General Secretary (National) in 2019. Prof. A. A. Shittu's hobbies are reading, writing, listening to music and carrying out research.

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