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Work-Based Training in Smart Manufacturing and Its Influence on Engineering Graduates' Employability in the industry 4.0 Era in Lagos State-Nigeria.

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Abstract: - *This study examined work-based training in smart manufacturing and how it influences the employability of engineering graduates in the industry 4.0 era in Lagos State, Nigeria. The research was guided by two research questions and two null hypotheses. A correlational survey design was used to collect information from three main groups: engineering graduates, engineering educators or training coordinators (lecturers), and industry supervisors or employers. The total population of the study was 6,550 participants, made up of 4,200 engineering graduates, 1,500 lecturers from higher institutions (including the University of Lagos, Lagos State University, Lagos State University of Science and Technology, and Yaba College of Technology), and 850 industry supervisors or employers in Lagos State. From this population, a total of 1,080 respondents were selected using a multi-stage sampling technique, which involved two key steps: stratified sampling and simple random sampling. Data were collected using a well-structured questionnaire, which was carefully designed to obtain accurate and relevant information. The validity of the instrument was confirmed by three experts, one from the Department of Electrical and Electronics Engineering, another from the Department of Civil and Environmental Engineering, both at the University of Lagos, and a third expert from the School of Technical Education, Yaba College of Technology. The reliability coefficient of the instrument was calculated as 0.84, indicating a high level of consistency. The analysis was carried out using the Pearson Product Moment Correlation (PPMC) to answer the research questions and test the null hypotheses at a 0.05 level of significance. The analysis was performed with the aid of the Statistical Package for the Social Sciences (SPSS) software, confirming that the research instrument had strong reliability. The major findings of the study showed that engineering graduates who participated in structured and technology-driven work-based training developed better technical, digital, and problem-solving skills, which are highly valued in smart manufacturing industries. The results further revealed that there is a significant positive relationship between work-based training in smart manufacturing and engineering graduates' employability in the industry 4.0 era in Lagos State. Based on these findings, the study recommended that higher education institutions in Lagos State should form stronger partnerships with smart manufacturing industries.*

Key words: Work-Based Training, Smart Manufacturing, Engineering Education, Graduate Employability, Industry 4.0

Introduction

Since the First Industrial Revolution in the 18th century, the world has witnessed a steady growth in the need for people with technical and practical skills. As industries expanded and technology advanced, the demand for skilled workers became higher than the supply. This growing gap between the number of skilled workers needed and those available led to the establishment and promotion of Technical and Vocational Education and Training (TVET) as a means to close the skills gap and prepare a competent workforce.

TVET plays an important role in developing individuals who can meet the changing needs of modern industries. It helps learners build specific skills, knowledge, and abilities that are directly related to their future jobs. Unlike general education, which focuses more on theory, vocational and technical education is focused on employment and real work experiences. According to researchers such as Kaenong *et al.* (2023); Kantová *et al.* (2023), TVET helps students develop professional competence, work habits, and problem-solving abilities needed for success in the workplace. TVET covers many areas, including technical education, vocational training, apprenticeship programs, and on-the-job learning (Huang *et al.,* 2023). Throughout every phase of the industrial revolutions, from the first to the present, TVET has played a major role in producing the skilled manpower required for industrial development. Because of its importance, governments, educators, and policymakers across the world have continued to focus on improving TVET systems, especially by promoting work-based training (WBT) as a core part of learning.

Work-based training (WBT), often referred to as work-based learning (WBL), is an approach that allows students to learn in real work environments. This method helps them connect classroom knowledge with actual job experiences, giving them a chance to practice what they learn, build confidence, and develop essential employability skills. As explained by Mazlan *et al.* (2025), WBL merges theory and practice by enabling learners to apply what they have studied in real-life work situations. It also helps students gain experience that cannot be fully obtained in a classroom. Raelin (2008) describes WBL as a learning process that takes place within the work environment, where learners gain skills and knowledge through direct experience rather than through formal lectures. Because work environments are often complex and problem-oriented, students learn by doing and by solving real challenges (Schuh *et al.,* 2015). In addition to improving technical skills, WBL also helps students develop soft skills such as teamwork, communication, leadership, and adaptability. In polytechnic and engineering institutions, work-based learning programs are key to improving students' readiness for the workplace. These programs allow learners to experience real industry conditions, which enhances their technical competence, academic performance, and employability. Studies by Adan *et al*. (2021), Ahmad *et al*. (2019), and Mohd *et al.* (2017) show that such programs are especially useful in preparing students for smart manufacturing environments, where modern technologies and automation play vital roles.

Smart Manufacturing represents a new phase in the industrial world. It is the main driver of what is now called the Fourth Industrial Revolution (Industry 4.0). Smart Manufacturing combines people, machines, and digital technologies to improve how products are designed, produced, and delivered. It focuses on increasing productivity, efficiency, flexibility, and sustainability through the use of advanced tools such as automation, robotics, artificial intelligence (AI), and the Internet of Things (IoT) (Kang *et al.,* 2016). According to the National Institute of Standards and Technology (NIST), Smart Manufacturing involves "fully integrated and collaborative manufacturing systems that respond in real time to meet the changing demands of factories, supply chains, and customers." In simple terms, Smart Manufacturing uses advanced technologies that can automatically adjust to production needs, reduce waste, and improve quality. Countries such as Germany and the United States have been leaders in adopting Smart Manufacturing. They have integrated technologies like Cyber-Physical Systems (CPS), IoT, cloud computing, and data analytics into their production systems. These technologies have also found applications in areas such as healthcare, construction, and environmental management. For nations like Nigeria, Smart Manufacturing offers a great opportunity to modernize industries and improve technical education. However, to benefit fully from Smart Manufacturing, the education system especially engineering education must adapt. Engineering students must not only learn theory but also gain experience with modern technologies that are used in smart industries. This is where work-based training becomes essential.

Engineering Education refers to the process of teaching and learning scientific, mathematical, and technological principles that help individuals design, build, and maintain systems that improve human life. It aims to produce graduates who are both technically skilled and innovative (Cropley, 2015). Rather than following a fixed curriculum, engineering education allows each institution to design programs that best suit its students and local industry needs. According to Kamp (2023), modern engineering education should promote creative thinking, problem-solving, and teamwork while keeping students motivated through practical and relevant learning experiences. It must also include laboratory work, project-based learning, and work-based training to bridge the gap between classroom instruction and real-life applications (Amish, 2024). As new technologies like AI, robotics, renewable energy systems, and smart production tools continue to grow, engineering education must evolve to include digital literacy, entrepreneurship, and interdisciplinary learning. In this way, it not only equips students with technical competence but also prepares them to contribute to industrial development, innovation, and sustainable national growth. Graduate Employability refers to the ability of graduates to gain meaningful employment, succeed in their careers, and adapt to changing job markets. It goes beyond earning a degree to include personal attributes such as communication, teamwork, leadership, creativity, and adaptability (Bennett, 2019; Rothwell and Arnold, 2007). Graduates are expected to secure jobs that match their skills and education and provide fair economic returns for their efforts.

Employability is now a key measure of how effective higher education systems are. Many global institutions assess their success based on graduate employment rates and income outcomes (Thijssen *et al.,* 2008). As noted by Cin and Neave (2014); and Tomlinson (2017), governments and universities worldwide are increasingly focusing on how well graduates transition into the job market, as this reflects both the quality of education and its contribution to the economy. Thus, higher education today must ensure that students graduate with the right technical skills, digital literacy, and professional competence required by industries, especially in the era of Industry 4.0.

Industry 4.0, also known as the Fourth Industrial Revolution, refers to the digital transformation of industries. It changes how businesses operate by integrating advanced technologies into all aspects of production and management (Rajnai & Kocsis, 2018). This transformation includes automation, data exchange, and real-time decision-making through technologies like IoT, cloud computing, RFID, and enterprise resource planning (ERP) (Baur and Wee, 2015; Fonseca, 2018). However, many industries, especially in developing countries, still face challenges in adopting these technologies. Some leaders are unaware of Industry 4.0 or unsure of how to prepare their organizations for this shift (Rajnai and Kocsis, 2018). Transitioning to digital systems requires new strategies, retraining workers, and redesigning workflows all of which demand skilled professionals with practical experience. For this reason, this study seeks to examine the role of work-based training in smart manufacturing and how it influences the employability of engineering graduates in the industry 4.0 era. The study focuses on Lagos State, Nigeria, where industrial and educational systems are rapidly expanding and adapting to new technologies.

Statement of the Research Problem

The world of manufacturing is changing very fast because of the arrival of Industry 4.0, also known as the Fourth Industrial Revolution. This new phase of industrial growth combines advanced technologies such as automation, robotics, artificial intelligence (AI), the Internet of Things (IoT), and big data. These technologies have completely changed the way industries design, produce, and deliver goods and services. Because of these changes, there is now a strong need for engineering graduates who have more than just basic technical knowledge. They must also have digital skills, problem-solving abilities, creativity, teamwork, and adaptability to work effectively in modern, technology-driven industries.

Work-Based Training (WBT) is one of the best methods to prepare students for such industries. Through WBT, students learn practical skills by working directly in real industrial environments while still studying. This training helps them connect what they learn in class with real job situations. WBT also helps them develop important employability skills, such as communication, teamwork, leadership, critical thinking, and digital literacy. These are skills that every employer in today's job market wants. In the era of smart manufacturing, WBT can help engineering graduates become more confident, skilled, and ready for employment. However, in many universities and technical institutions, especially in developing countries like Nigeria, teaching is still mostly theoretical. Many programs focus mainly on classroom lectures and do not provide enough practical, hands-on learning experiences. Students often learn from textbooks and simulations without real exposure to modern industrial technologies or work environments. As a result, many graduates finish their studies without the practical knowledge and real-world experience that employers expect.

This lack of practical exposure creates a skills gap between what students learn in school and what industries actually need. Many employers complain that new graduates cannot effectively handle the technologies and systems used in smart manufacturing. Graduates may also lack essential workplace attitudes, problem-solving ability, and technical flexibility. This mismatch leads to unemployment, underemployment, and poor productivity in the engineering and manufacturing sectors. In addition, industries are moving towards automation, data-driven production, and digital collaboration, but many engineering graduates are not trained to operate or maintain these smart systems. This makes it difficult for them to compete in the global job market. Consequently, there is an urgent need to bridge the gap between education and industry by introducing more work-based training that focuses on real manufacturing environments and smart technologies.

Therefore, this study aims to examine how work-based training in smart manufacturing influences the employability of engineering graduates in the industry 4.0 era in Lagos State, Nigeria. The study seeks to find out whether graduates who participate in structured work-based training become more employable, more innovative, and more productive than those who do not. Understanding this relationship will help improve the design of engineering education programs and ensure that higher institutions produce graduates who are fully prepared for the demands of smart industries.

Purpose of the Study

The main purpose of this study is to find out how Work-Based Training (WBT) in Smart Manufacturing affects the employability of engineering graduates in the industry 4.0 era in Lagos State, Nigeria. The study aims to understand whether practical, hands-on training in real industrial settings helps graduates to develop the skills and experiences they need to get and keep jobs in today's modern, technology-driven industries. More clearly, the study is designed to:

1. Find out the relationship between work-based training in smart manufacturing and the employability of engineering graduates in the age of Industry 4.0.
2. Examine how the level of exposure to Industry 4.0 technologies during work-based training helps graduates to gain the technical, digital, and soft skills needed to work effectively in smart manufacturing industries.

Research Questions

The study was guided by the following research questions:

1. What is the relationship between work-based training in smart manufacturing and the employability of engineering graduates in the industry 4.0 era?
2. What is the relationship between exposure to Industry 4.0 technologies during work-based training and the development of employability skills needed by graduates in smart manufacturing industries?

Research Hypotheses

The following null hypotheses were developed to guide the study:

H_{01}: There is no significant relationship between work-based training in smart manufacturing and the employability of engineering graduates in the industry 4.0 era.

H_{02}: There is no significant relationship between exposure to Industry 4.0 technologies during work-based training and the development of employability skills among engineering graduates.

Methodology

This study used a correlation survey design to collect and analyze information about how work-based training in smart manufacturing affects the employability of engineering graduates. The design was chosen because it helps to identify the relationship between two or more variables without manipulating them. It allowed the researcher to collect opinions and experiences from people directly involved in engineering education and the manufacturing industry.

The study involved three main groups of respondents: engineering graduates, engineering lecturers or training coordinators, and industry supervisors or employers. The total population for the study was 6,550 people. This included 4,200 engineering graduates, 1,500 lecturers from selected higher institutions (University of Lagos, Lagos State University, Lagos State University of Science and Technology, and Yaba College of Technology), and 850 industry supervisors or employers working in different manufacturing organizations in Lagos State.

To select participants for the study, a multi-stage sampling technique was used. This method involved two main steps: stratified sampling and simple random sampling. First, the population was divided into groups (strata) based on their categories graduates, lecturers, and industry employers. Then, from each group, respondents were chosen randomly to ensure that everyone had an equal chance of being selected. A total of 1,080 respondents were finally selected to participate in the research, representing the sample size for the study. A structured questionnaire was developed and used as the main tool for data collection. The questionnaire contained items that measured respondents' views on work-based training, exposure to smart manufacturing technologies, and employability skills. To ensure the quality and accuracy of the instrument, it was reviewed and validated by three experts: one from the Department of Electrical and Electronics Engineering, another from the Department of Civil and Environmental Engineering at the University of Lagos, and a third from the School of Technical Education at Yaba College of Technology. Their feedback helped to refine the questions and confirm that the instrument was appropriate and relevant to the study objectives. To test how reliable the questionnaire was, a pilot test was carried out, and the responses were analyzed. The reliability coefficient obtained was 0.84, which shows that the instrument was consistent and dependable for use in the main study. For data analysis, the researcher used the Pearson Product Moment Correlation (PPMC) statistical method to answer the research questions and test the null hypotheses at a 0.05 level of significance. This method helped to determine the strength and direction of the relationship between work-based training, exposure to smart manufacturing technologies, and employability skills among engineering graduates. All data collected were analyzed using the Statistical Package for the Social Sciences (SPSS). The results from the analysis confirmed that the questionnaire had a high level of reliability, and the statistical tests provided clear evidence of the relationships between the study variables.

RESULT

Table 1: Pearson's Product Moment Correlation on the relationship between work-based training and employability of engineering graduates in the industry 4.0 era in Lagos State.

Variable	N	Mean	SD	Pearson Correlation (r)	Remark
work-based training	1080	2.915	0.742	.610**	Strong/Positive
Employability of engineering graduates	1080	3.301	0.574		

Table 1 presents the result of the Pearson Product Moment Correlation (PPMC) analysis, which examined the relationship between work-based training and the employability of engineering graduates in the industry 4.0 era within Lagos State. The analysis revealed a correlation coefficient (r) of 0.610, which indicates a strong and positive relationship between the two variables. This means that as engineering graduates receive more structured and practical work-based training, their chances of becoming employable and successful in smart manufacturing industries also increase. In simple terms, the more graduates are exposed to real industry experience and hands-on learning, the better they perform in the job market. The positive direction of the correlation suggests that improvements in work-based training directly contribute to higher levels of employability among engineering graduates in the industry 4.0 environment, where advanced digital and technical skills are highly valued.

Table 2: Pearson's Product Moment Correlation on the relationship between exposure to Industry 4.0 technologies and graduates' acquisition of employability skills in smart manufacturing industries in Lagos State.

Variable	N	Mean	SD	Pearson Correlation (r)	Remark
Exposure to Industry 4.0 technologies	1080	2.934	0.490	.561**	Strong/Positive
Graduates' acquisition of employability skills	1080	3.303	0.572		

Table 2 presents the result of the Pearson Product Moment Correlation (PPMC) analysis, which examined the relationship between exposure to Industry 4.0 technologies and the acquisition of employability skills among engineering graduates working in smart manufacturing industries in Lagos State. The computed correlation coefficient was r = 0.561, showing a moderately strong and positive relationship between the two variables. This result means that the more engineering graduates are exposed to Industry 4.0 technologies such as automation, robotics, artificial intelligence, data analytics, and smart systems during their work-based training, the more likely they are to develop important employability skills. These include both technical skills, such as operating modern manufacturing systems, and soft skills, like problem-solving, communication, adaptability, and teamwork.

The positive relationship indicates that increased interaction with advanced digital technologies helps graduates become more prepared for the demands of modern industries. Graduates who gain hands-on experience with smart manufacturing systems during their training are more capable of applying what they have learned to real production settings. This enhances their confidence, productivity, and readiness for employment. Therefore, the finding suggests that integrating Industry 4.0 technologies into work-based training programs significantly supports the goal of producing graduates who can meet the evolving needs of the digital manufacturing sector in Lagos State.

Discussion of Findings

The findings presented in Table 1 showed the results of the Pearson Product Moment Correlation (PPMC) test, which examined the relationship between work-based training (WBT) in smart manufacturing and the employability of engineering graduates in the industry 4.0 era within Lagos State. The result showed a strong and positive correlation (r = .610), meaning that as the quality and level of work-based training increase, the employability of engineering graduates also improves. The statistical result, (r = .610, df = 1078, p < .05), indicated that this relationship is significant. Therefore, the null hypothesis was rejected at the 0.05 level of significance.

This means that work-based training in smart manufacturing directly influences how employable engineering graduates become. In other words, when students are exposed to real industry environments during their training, they gain the necessary technical and professional skills that make them valuable to employers. The finding supports the work of Mazlan et al. (2025), who explained that Work-Based Learning (WBL) is an approach that connects theory with practice by allowing students to apply classroom knowledge to actual work situations. This approach helps students build confidence, technical competence, and adaptability in real-world conditions. Similarly, Rothwell and Arnold (2007) noted that employability refers to a graduate's ability to get and keep a job that matches their skills and offers fair financial rewards for their education. This shows that structured and practical learning experiences are vital for improving graduates' job readiness and success in the modern industrial world.

The findings presented in Table 2 further examined the relationship between exposure to Industry 4.0 technologies and graduates' acquisition of employability skills in smart manufacturing industries in Lagos State. The analysis produced a moderately strong and positive correlation (r = .561), which indicates that increased exposure to advanced digital technologies such as automation, artificial intelligence, robotics, data analytics, and smart systems significantly improves graduates' employability skills. The statistical result, (r = .561, df = 1078, p < .05), also confirmed that this relationship is significant, leading to the rejection of the second null hypothesis.

This means that the more engineering students are exposed to Industry 4.0 technologies during their training, the better they develop essential employability skills including both technical and soft skills such as communication, teamwork, problem-solving, and adaptability. This finding aligns with Amish (2024), who emphasized that modern engineering education should focus on learning for work, at work, and through work, to ensure that students gain meaningful hands-on experiences that prepare them for their future careers. Similarly, Hamid *et al.* (2014) explained that employability skills often called transferable or generic skills are necessary for all workers, regardless of the job level. These include communication, teamwork, initiative, planning, problem-solving, and self-management, as described in the Employability Skills (ES) Framework developed in various countries (Suarta *et al.,* 2018; Rao, 2010).

The results from both analyses clearly show that practical exposure to real-world industrial activities and modern technologies during work-based training significantly enhances engineering graduates' employability. Graduates who receive such training are more confident, innovative, and adaptable to new challenges in smart manufacturing environments. They also develop the ability to integrate theoretical knowledge with real production systems, making them more valuable to employers.

Conclusion

This study concludes that work-based training (WBT) is a vital tool for improving the employability of engineering graduates in Lagos State, Nigeria, especially in the industry 4.0 era. The results revealed that graduates who participated in well-structured and technology-based WBT programs developed stronger technical, digital, and problem-solving skills, which are in high demand in today's smart manufacturing industries. The study also showed a significant relationship between work-based training in smart manufacturing and graduates' employability, meaning that WBT helps bridge the gap between classroom learning and industry expectations. On the other hand, the study found that limited exposure to modern industrial technologies remains a major problem for many engineering graduates. This lack of hands-on training makes it difficult for them to adapt to automated, digital, and data-driven workplaces.

To solve this challenge, there is a need for closer collaboration between higher education institutions and smart manufacturing industries. Such collaboration will help align academic curricula with industrial realities, introduce modern training facilities, and create internship or apprenticeship programs that expose students to Industry 4.0 technologies. By strengthening work-based training programs, Lagos State can produce engineering graduates who are job-ready, innovative, and capable of contributing to industrial growth. These graduates will not only meet the changing demands of employers but will also help sustain the state's and nation's industrial competitiveness in the era of digital transformation.

Recommendations

Based on the results of this study, the following suggestions are made:

1. Universities and polytechnics in Lagos State should work more closely with smart manufacturing companies. Together, they should create and run work-based training (WBT) programs that help students learn both in school and in real work settings. This will make what students learn in class match what is needed in industries.
2. Schools offering engineering programs should review and improve their courses so that they include new skills and knowledge needed in modern, technology-driven industries. This will help students become more ready for jobs in smart factories.
3. The Lagos State Government, together with professional groups like COREN (Council for the Regulation of Engineering in Nigeria) and MAN (Manufacturers Association of Nigeria), should create rules and give support or rewards to companies that take part in work-based training programs. This will encourage more industries to train students and help them gain useful job skills.

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