EVALUATING THE IMPACT OF REMOTE TRAINING INITIATIVES ON WORKFORCE PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY.

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Abstract: Digital technology innovations have created a compelling and fast solution to conventional on-site training within the construction industry. The investigation describes the effects of remote training activities for construction workers, focusing on the improved dimensions of skill accumulation, rate of operation, and how the observance of safety is concerned. Using a quantitative design with Kirkpatrick's Four-Level Evaluation Model, and the Technology Acceptance Model (TAM), this study evaluates the performance of digital training compared to traditional methods concerning real-world situations in the construction industry.

According to the study hybrid training model that combines online and on-site instruction seems to be the most capable and appropriate way of optimizing learning and workforce performance in the construction sector This study embraces empirically-based suggestions for the improvement of the design of technology-based training courses are also appropriate to the special requirements of the construction industry.

Index Terms - *Construction Industry, remote training, workforce productivity, skill development, safety compliance, management strategies, Hybrid training, task efficiency.*

I. INTRODUCTION

The Construction sector is one of the paramount industries in the global economy, and this sector contributes to infrastructure development, job creation, and the gross domestic product (GDP) of several countries. According to the World Economic Forum (2020), the construction sector occupied the share of over 10 % of the global economy by its proportion of GDP and employed about 273 million people around the globe. Even though it has a significant economic influence the Construction industry is confronted with several serious challenges that prevent it from functioning effectively and developing, including high operating costs, acute labour shortages, and increased demand for specialized staff. Those challenges are compounded by inefficiencies in the training of the workforce where most of the confounding arise with the incessant increase in the number of available skilled labour.

By addressing these challenges UK construction market size was valued at USD 316.86 billion in 2023 and is predicted to reach USD 439.04 billion by 2030 at a CAGR of 5.6% from 2024 to 2030 (Next MSC, 2024) to reach that rapid growth need to overcome issues such as labour shortages, skill gaps, and safety compliance. In this regard, efficient remote training plays vital role to address these challenges and maximize workforce productivity within the construction sector.

Traditional training methods have largely involved in-person learning, which is effective in some aspects but with significant restrictions. Among the constraints are logistical complications, the expense of travel and accommodation, and time-consuming activities spoil the normal running of the construction sites. In addition, effective training solutions has become yet more significant due to the COVID-19 pandemic by causing disruptions in in-site operations and highlighting the need for other methods of training that can preserve continuity in the education of the workforce. Remote training initiatives, which are promoted by digital platforms, have opened up the possibility of these challenges. These initiatives present flexible, scalable, and affordable substitutes for traditional in-person training and workers can access essential learning tools such as safety certifications and technical modules compliance that can be accessed from anywhere in the world.

Remote training in the construction industry presents an opportunity for workers to learn at their own pace by enhancing the scalability of training programs and preparing workers with the skills and knowledge needed to perform jobs safely and effectively. Although there has been increasing uptake of remote training within the construction industry, it lacks empirical research that has measured its effects on the productivity of the work force as compared to traditional training procedures. Moreover, remote training has gained broad acceptance in different sectors but there is a lack of knowledge on its respective impacts on construction workforce productivity. Every construction project should always account for critical productivity factors, such as skill development, task efficiency, and safety. However, there's a limited number of existing literatures discovered about how remote training affects these outcomes versus other forms of training. The

study helps to fill the gap in the available research literature by assessing the impact of remote training on productivity in the construction labor force, by determining and comparing the remote productivity outcomes achieved by traditional face-to-face training methods.

The main aim of this research is to investigate the impact of remote training on workforce productivity in the construction industry, as well as to examine the extent to which it differs from conventional, in-person training. The central research question is:
"How do remote training programs impact workforce productivity in the construction industry when compared to conventional training?"

Using empirical research, the project seeks to answer whether remote training offers significant benefits over conventional training for workforce productivity and understand the factors that contribute to the successful use of remote training. The significance of the research is it educates the construction sector on the effectiveness of remote training in enhancing labourers' productivity.

The outcomes of this research would scratch the surface for construction sector with evidence-based facts on virtual training solutions make a better and cheaper alternative to traditional training methods. By comparing the results of remote training to that of the traditional approach, this study would help construction companies make informed decisions about whether to invest in remote training programs and technologies. Moreover, the findings of this study will add to the existing digital workforce development literature, featuring pragmatic recommendations for improving remote training programs toward higher performance of workers.

This study is limited to the construction industry and the findings may be directly non-transferable to other industries. Nonetheless, the knowledge accrued will surely be beneficial to any industry contemplating the adoption of remote training solutions. The research outcomes shall develop in the future by providing workable solutions for construction firms aiming at further enhancement of workforce training programs, increased productivity, and coping with constraints of labour shortage and skill gaps in the construction industry.

2. LITERATURE REVIEW

2.1 Theoretical Background

The construction industry has embraced remote training methods to boost productivity, especially after the COVID-19 pandemic and the surge of digital tools. For managers, it's important to grasp how adult workers in this field learn, how they adopt new tech, and how to measure the success of their training. This review looks into some basic theories behind remote training practices and how they affect productivity in construction. One key idea is Kirkpatrick's Four-Level Training Evaluation Model (1996). This model assesses the effectiveness of training programs based on four aspects: Reaction, Learning, Behavior, and Results. Within construction management, the Kirkpatrick's Model helps to evaluate immediate learning results as well as the training's enduring influence on employee performance and productivity at construction sites. Jadallah et al. (2021) highlighted the lack of evaluation frameworks and proposed integration of the model to strengthen evaluation processes to enhance focus on training impact.

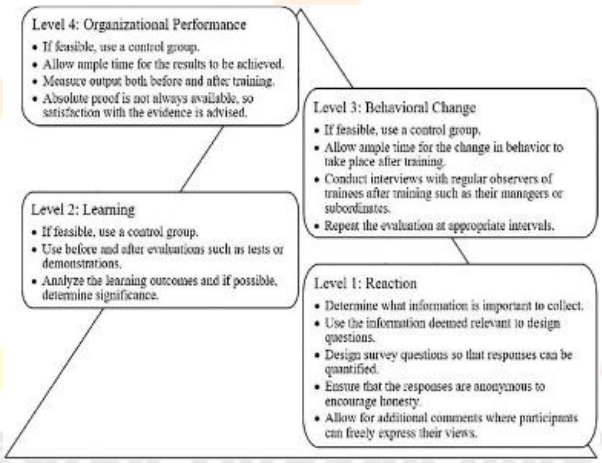

Figure 2.1: Kirkpatrick's Four-Level Training Evaluation Model (1996)
Source: Jadallah et al. (2021) originally cited from Kirk Patrick model levels and guidelines (Kirkpatrick,1996).

As digital platforms are increasingly emerging Technology Acceptance Model, (TAM) proposed by Davis (1989) becomes pertinent. TAM explains that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are the forces that determine people's attitudes and intentions as well as the actual use of newcomer technologies. This is particularly crucial for construction managers to make these adoption drivers known to them while they try to introduce remote learning tools. Prihatono and Adi (2020) used TAM to analyze BIM adoption in construction and confirmed that training systems must be user-friendly and tangible to accelerate the rate of adoption in the workforce.

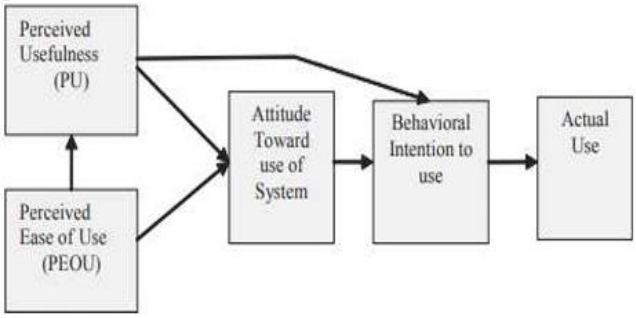

Figure 2.2: Technology Acceptance Model
Source: Prihatono and Adi (2020)

All these two models reveal that, designing, implementation, and assessment of the remote training strategies. By integrating adult learning principle, outcome-based evaluation and technology acceptance framework training program can be more oriented to the workforce needs and achievements in the project line eventually increasing productivity in the construction sites.

Moreover, several studies conducted to examine how training contributes to improving the productivity of the workforce in the construction sector with the rise of digital tools and digital working strategies. According to Azizi, Sakina, and Azizi (2022), digitization has made possible for remote training in the construction process, particularly in agile project management. Their research indicates that digital training platforms enable workers to absorb changes quickly, improve communication, and make faster decisions which are all important factors to improve productivity in a fast-paced construction environment. It is sufficient for the study to point out how much digital tools make it easy for workers to be updated with the necessary information and to improve in skills while improving productivity.

Mahesh (2024) states that several challenges associated with using remote and digital training in construction. According to his research, the need for digital literacy in workers and effective management is necessary to guarantee the success of training programs. His study proposes that although digital training presents many benefits, a hybrid of traditional and digital training solutions may prove beneficial in customizing to the specific needs of the construction workforce and increasing overall productivity.

2.2 Remote Training vs Traditional Training Methods

In the construction sector, where skills development and workplace safety factors are concerned, onsite and instructor-led training has historically become a conventional way of operating. Onsite training gives real-life, hands-on experience and feedback, which is particularly important when manual labor or equipment-intensive activities are involved (Ho & Dzeng, 2010; Roussas, 2006). However, it usually comes with logistical challenges, additional costs, and time pressure, which could hinder workflow and inhibit its scalability.

As suggested by Azizi et al. (2022) and Mahesh (2024) Remote training has become a flexible substitute mainly due to the advancements in technology and after-pandemic changes in workplace environments. It allows employees to study learning materials from anywhere, provides self-paced learning, and minimizes downtime for training. In studies, remote learning, especially with the use of digital tools such as mobile apps, virtual simulations, and AI, can enhance knowledge retention, and safety awareness, as well as increase productivity (Adami et al., 2021; Sabir et al., 2025; Gul Memon et al., 2024)

Even though onsite training remains effective in some cases, especially when physical engagement is at stake, empirical evidence starts acknowledging remote training as a viable means of upskilling the labor force that is even more expedient. However, some pitfalls such as digital access, learner motivation, and management support can affect its outcome (Onyia et al., 2023). Thus, this research investigating the effects of the remote training on workforce productivity also examines circumstances and practices that can contribute to training success.

2.3 Online Training and Its Effects on Productivity and Skill Development

Previous studies have revealed the impact of management-driven online training in relationship to workforce productivity with major reference to construction sectors which require professionals to have advanced competency skills on safety measures, immediate actions on the possible tasks as well as those tasks should be gain possible outcomes to the industry. This study measures productivity of the workforce in the form of safety compliance, task efficiency and performance outcomes. Martinez-Amador (2016) found out that flexibility in working increases productivity because of the satisfaction of work-life balance for those working remotely which is important for construction employees who encounter site hindrance. However, it also can cause subject fatigue, which may affect the performance of the works and focus an essential aspect to consider when considering the efficiency of online training programs in the construction industry.

Also, Raj et al. (2023) investigated the impact of remote working on firm performance and concluded that the effect is highly correlated with communication, technology, and program support and planning. These aspects considerably influence the construction industry since the use of online training enhances the knowledge and skills of the workers, as well as their tasks' productivity but they need to be controlled and applied without leading to digital tiredness. This is closely connected to the need for the construction managers to facilitate the proper content to make the remote training more effective.

A key study by Adami et al. (2021) compared VR-based training and a traditional in-person approach to operating demolition robots. Their research provided results that demonstrated that VR training substantially increased knowledge acquisition, operational skills, and safety behavior of construction workers. The immersive, zero-risk probability of VR means that workers can be subjected to repeatable, realistic scenarios that will not only increase task effectiveness but also increase safety compliance. This directly corresponds to the research objective of evaluating the effects of training on safety standards and task efficiency. By infusing VR and other digital tools into the online training efforts, construction managers can enhance the workers' operational skills thus, higher productivity and safety are guaranteed.

Besides, Celestin et al. (2024)) further amplified this discussion by examining the long-term impact of remote work on organizational efficiency and employee performance. Their study emphasizes the need for vital technologies such as cloud-based platforms and project management tools for remote training. The study stresses that effective remote training programs when paired with robust management practices and clear communication can do a lot to increase the productivity of the long-term workforce and ability to adapt to new technology.

The incorporation of online training initiatives on construction has demonstrated remarkable promise in terms of increasing productivity, developing skills, and maintaining safety standards. However, the success of such programs largely relies on the management aspects including the design of the contents, employee engagement mechanisms, and availability of platforms of training.

2.4 Technology-Enabled Platforms for Construction Training

Remote training in the construction industry has developed using mobile learning (M- learning), Learning Management Systems (LMS), web-based training (WBT), and AI-based platforms. Such tools offer scalable and flexible options that promote upskilling and better on-site productivity. M-learning supports self-paced, location-independent training. Mobile platforms are useful during COVID-19 in Pakistan in providing access to content, discussion, and skill-building. This flexibility enhanced cognitive and emotional preparedness to safer and more precise performance of tasks.

The gamified tools also improve learning outcomes. Bienvenido-Huertas, Rubio-Bellido, and León-Muñoz, (2023) found that Kahoot! was a good preserve in remote training programs as it enhanced engagement and retention. Gamification instigates motivation, critical thinking, and task efficiency, which results in on-site safer and more efficient behavior. AI-oriented platforms provide immersive personalized experiences. Sabir et al. (2025) noted the way how conversational AI and VR simulations for safety preparation improved participation, response, and compliance through individualized instruction according to employee preferences.

The integration of these platforms leads to better training content, fewer errors, and higher productivity, which makes essential for the future of the industry.

2.5 Leadership and Management Strategies for Effective Remote Training in Construction

According to the research article by Sandlin (2013) advancement in technology has transformed training delivery, the success of remote and online training lies in the quality of leadership and the sanity of the management strategies. Leadership in organizations is important in aligning training programs to the needs of the workforce, promoting an environment for continuous learning, and providing infrastructure and systems for digital learning initiatives.

The leadership effects on content planning, communication support, and usability of platforms. Syed et al. (2016) discovered that active leadership support enhances long-term engagement by ensuring learners and instructors are supported by responsive systems and comprehensible instructional design. In the same way, Sandlin (2013) refers to the point that strategic alignment between training and site-specific tasks enhances relevance resulting in greater worker engagement and productivity.

Other management practices that are effective apart from leadership are also key aspects in operationalizing training strategies. Syed et al. (2016) puts a point on focusing on soft skills such as collaboration and communication in online training materials along with the technical aspect of it. According to Wu et al. (2015), platform usability and accessibility plays important roles in the success or failure of remote training. User-friendly systems, which have prompt feedback, and central content structure will facilitate participation and enhancement of knowledge.

2.6 Research Gaps and UK context

This study aims to fill out the identified gaps by critical assessment of the application of adult learning theories, Kirkpatrick's Four-Level Training Evaluation Model (1996) into the context of remote training for construction workers in UK. Also, study helps to fill the gap in existing research literature by assessing the impact of remote training on productivity in the form of construction labor force. and it deeply goes through the long-term impacts of remote training on Training Content Design, Technology Usability influences on the productivity of the training, and underexplored areas in the existing literature. In addition, the study will examine the applicability of the Technology Acceptance Model (TAM) in the construction sector based on how perceived usefulness and ease of use determine the adoption of digital training tools. The research background is provided by the United Kingdom due to the strong and diverse construction sphere, where there has been an increasing adoption of both remote and correlative training techniques. Due to the efforts of the UK on modernizing construction and due to limited existing literature on the studies of remote training within construction industry in UK and due to usage of digital strategies and emphasizing workforce training, this country is an appropriate context to study the relationship between various modes of training, and the efficiency of workforce.

By examining these, this research intends to provide a more holistic approach to understanding how remote training could be optimized to suit the specific construction workers' needs, thus making such programs both effective and sustainable in improving workers' performances and site productivity.

3. METHODOLOGY

3.1 Research Philosophies and Approach

This research applies post-positivist methods and seeks to gather empirical data that will be analyzed statistically to examine how different training methods affect productivity results.

A positivistic approach used in this study to gather measurable information through surveys and assess the effects of different training initiatives on levels of employee productivity. whereby reality is assumed to be objective and can be measured, and that knowledge can be discovered with the use of empirical observation. The deductive reasoning approach is employed, whereby theory Kirkpatrick's Model (1996) and Technology Acceptance Model (TAM) is guide to construct hypothesis against empirical evidence. From this framework supports that how different training methods affect workforce productivity in the construction industry. By aligning with these key theories research seeks to validate current assumptions through measurable data and using statistical analysis.

3.2 Research Design

This research adopts a quantitative approach to analyze the impact of remote training programs on workforce productivity in the construction industry in terms of the outputs for remote-trained workers with comparisons to the results generated for in-person trained workers. Quantitative techniques were employed to gather data that could be measured and analyzed using statistical methods and used to clarify how various approaches to learning affect productivity performance. This choice of method enables to draw conclusions that can be widely applied since those conclusions are grounded in quantifiable data rather than personal opinions or interpretations.

The Main research Question address in this study is **"How do remote training programs impact workforce productivity in the construction industry when compared to conventional training?"** to approach this research, question several hypotheses constructed accordingly with different variables.

The results of the study conducted using the following hypotheses:

- H1: Examining the direct impact of remote and in-person training approaches on productivity.
- H2: Investigating the impact of the training method on the training content design, based on Kirkpatrick's model.
- H2b: Examining the training content design mediating the linkage between the impact of training type and workforce productivity.
- H3a: Examining the effect of technology factors (within TAM), such as ease of use and perceived usefulness on the effectiveness of remote training.
- H3b: Examining the relation of Technology access mediating the linkage between workforce productivity and Training mode.

The independent variation of Training Types-Remote Training vs. Traditional In-Person training (IV) impacts on Workforce Productivity (DV) as the dependent outcome in a particular construction sector. Two important Mediating Variables (MV) are embedded in the framework: Training Content Design and Accessibility and Usability of Technology. Driven by Kirkpatrick's Four-Level Training Evaluation Model, and TAM model the present study contends that this implementation aspect of Training Content Design and Technology access is critically influential in determining the impact workforce productivity in remote setting.
This following framework provides a systematic approach for comparing remote training strategies and traditional strategies concerning both immediate and ripple effects on content Design and technology use.

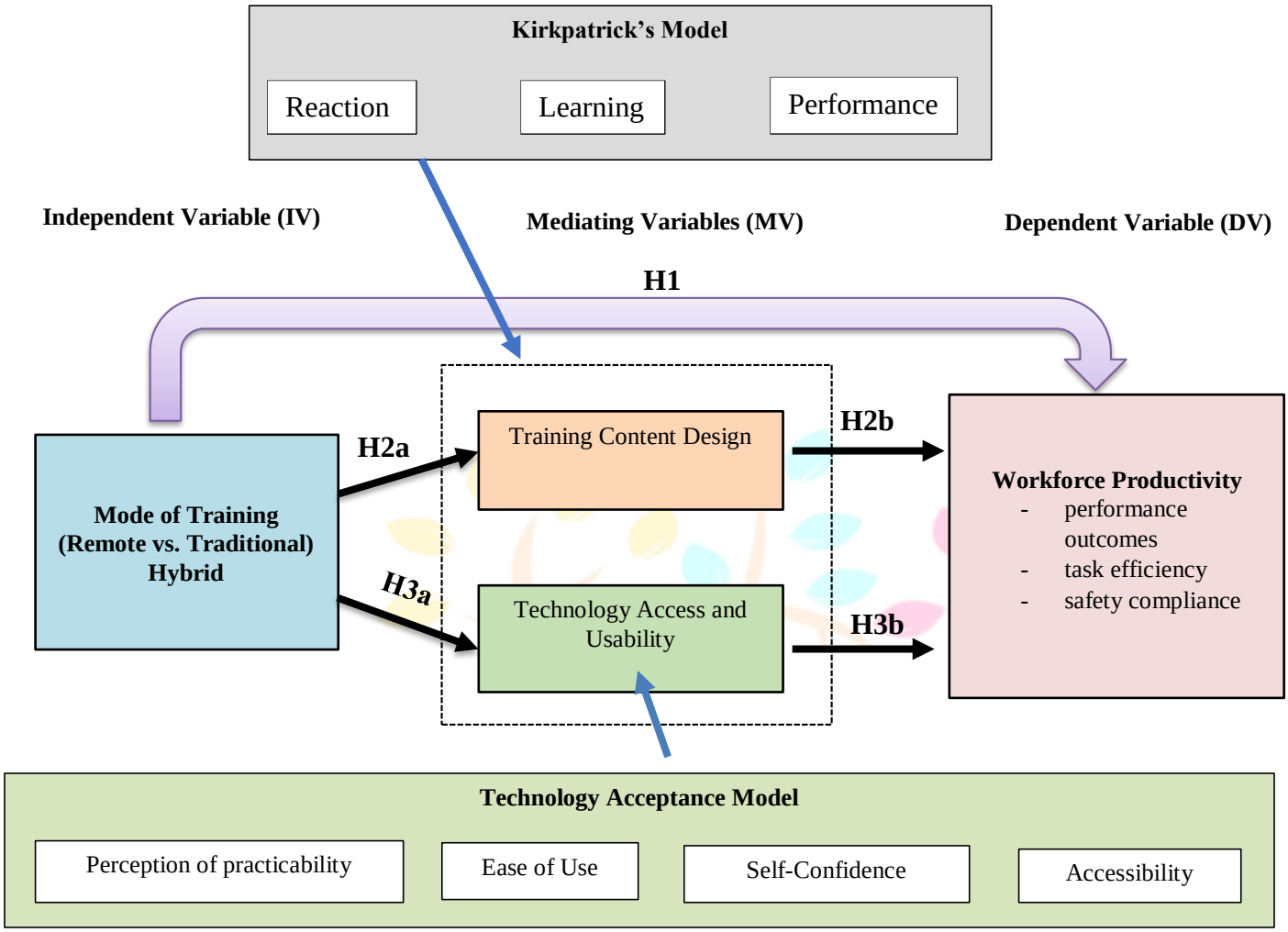

Figure 3.1: Conceptual Framework

3.3 Data Collection

This study applies a quantitative method, where a structured close-ended online questionnaire will be used to generate primary data from workers in the construction sector. Two validated resources have been applied to adapt the questionnaire: Ho and Dzeng, (2010) Construction Safety.

Training via e-Learning and Aroge (2012) Employee's Training and Development for Optimum Productivity: The Role of Industrial Training Fund (ITF), Nigeria. The choice of such instruments is based on relevance to the focal point of the study and reliability when used in a similar study.

The questionnaire consists of four different sections:
Section A: Demographic details such as Age, Gender, Experience, Job title, and mode of training attended.
Section B: Effect of training content design in relation with Kirkpatrick's Four-Level Model.
Section C: Effect of Technology Access and Usability in line with the TAM Model
Section D: Online training vs E-learning effects on workforce productivity.

Responses will be collected on a 5-point Likert scale (ranging from Strongly Disagree (1) to Strongly Agree (5)) which will be used to support quantitative analysis and statistical comparison. To conduct a validated survey, instrument a Pilot test of 15 respondents to be done before conducting the actual surveys to test clarity and reliability of items.
The online survey will be conducted through the Google Forms and the survey seeks to obtain responses from engineers, architects, construction managers and other professionals of the industry who are conversant with either remote or traditional training methods. This study is voluntary and all data collection will be done on a confidential basis, and with exclusive intent for academic research.

3.4 Sampling Technique

For this study, a non-probability purposive sampling technique will be used. It enables the researcher strategically to select participants based on their particular background or experience that is relevant to the investigation, particularly those involved in the traditional as well as remote training programs in the construction process. Since the research examines practices of training, purposive sampling enables the researchers to select individuals with practical training backgrounds resulting in valuable, insightful findings.

The targeted professionals in this study are those working in the Construction industry and include; Engineers, construction managers, Laborers, and stakeholders who embrace remote or traditional forms of training in the United Kingdom. To reduce the regional bias, and to improve geographical representation companies are selected from different regions in UK as England, Wales and Scotland through an online survey. It improves the uniformity and generality of the study.

A minimum of 135 professionals are targeted with a margin of error that is equal to 5%, as it is adequate to conduct correlation and regression analysis.

3.5 Ethical Considerations

This study adhered to strict ethical standards, ensuring informed consent, participant confidentiality, and the ethical use of research instruments. All necessary ethical approvals were obtained, and data were collected and processed with integrity. These measures ensured the research met academic and ethical rigor while contributing responsibly to the body of knowledge.

3.6 Limitations of Data Collection

There could be several significant limitations in the data collection process. Inconstant situations on construction sites such as interruptions or difficulties in recruiting workers to respond may disrupt both the response rate and the overall survey process. It is also noteworthy that conclusions made on this research can be limited to the surveyed construction sites and cannot present broader patterns in other regions or industries. There is an assessment risk arising from the response bias, whereby some workers report that training is more effective to meet social expectations, therefore, skewing results. Despite these challenges, the research being planned is scheduled to provide powerful data and important insights into how different types of training will influence workforce productivity.

4. DATA ANALYSIS

Collected data will be analysed using SPSS to determine how remote as opposed to traditional training impacts on productivity of the workforce in the construction industry. To maintain data quality, first screen the dataset for missing values, and extreme outliers, and check the data is normally distributed. Techniques for data cleaning will be carried out and the normality of the distribution will be tested using skewness and kurtosis values.

4.1 Data Analysis Techniques

- **Descriptive Statistics**: summary of Demographics (age (Ordinal), Gender (Nominal), Years of experience (Ordinal), job role (Nominal), Type of training attended (Nominal)) use Frequencies, Percentages, Mode for Nominal data as well as median for Ordinal data
- **Reliability Testing**: The internal consistency of mediating variables such as *Training Content Design, Technology Access and Usability*, and *Workforce Productivity will be evaluated* using Cronbach's Alpha *(Cronbach's alpha>0.7 accepted)*
- **Correlation Analysis**: This measures the strength and direction of the relationships among key variables, training type (IV), training content design (MV), technology access (MV), and workforce productivity (DV).
- **Comparative Analysis (ANOVA Results)** To compare the Workforce Productivity with different training modes (Remote, Onsite or Hybrid). This measures the main research question of the study

- **Multiple Regression Analysis**: This test Explore the effect of IV and DV on workforce productivity. This especially test whether training content design and Technology access and usability mediate the relationship between training type (remote, Onsite, Hybrid) and workforce productivity.

It is expected that mediating variables remote training with proper content design and better technology access and usability positively correlated with the productivity compared to the traditional setting which will be significant parameters when revealing the productivity of the remote training.

To validate the use of multiple regression model I will assess the linearity assumption, independence of errors, homoscedasticity and normal distribution of the residuals. In order to make efficient and consistent judgement of the research model and hypotheses, SPSS will be used and ANOVA and Multiple regression used in the study for statistical analysis. As these two tests find an empirical answers to the core research question of the study.

5.FINDINGS AND DISCUSSION

5.1 Descriptive Statistics

A total of 135 responses were collected from professionals across the UK construction sector, including engineers, site supervisors, managers, and skilled laborers. Among them, 58% had participated in remote training, 30% in traditional in-person training, and 12% had experienced both. The majority of respondents (67%) possessed more than five years of industry experience, reflecting a mature and informed sample base.

Respondents reported moderate-to-high engagement with remote learning tools, indicating that online platforms and digital interfaces are increasingly accepted within the construction workforce. Initial descriptive analysis suggested that participants in remote or hybrid programs perceived greater flexibility and access to updated safety modules, compared with those trained via traditional methods.

Variable	Category	Frequency (n=135)	Percentage (%)
Gender	Male	92	68.1
	Female	43	31.9
Age	Under 25	12	8.9
	25-34	38	28.1
	35-44	42	31.1
	45-54	28	20.7
	55+	15	11.1
Type of Training	Remote	78	57.8
	Traditional	41	30.4
	Hybrid	16	11.9

Table 5.1: Demographic Profile of Respondents

5.2 Reliability and Validity Analysis

The reliability analysis using Cronbach's alpha revealed strong internal consistency among key constructs:

- Training Content Design ($\alpha = 0.86$)
- Technology Access and Usability ($\alpha = 0.88$)
- Workforce Productivity ($\alpha = 0.84$)

Exploratory Factor Analysis (EFA) supported construct validity, with all factor loadings above 0.65 and no significant cross-loadings. These results indicate that the measurement items were both reliable and valid for assessing perceptions of training effectiveness and productivity.

Construct	**Number of Items**	**Cronbach's Alpha (α)**	**Reliability interpretation**
Training Content Design	8	0.86	Reliable
Technology Access and Usability	6	0.88	Highly Reliable
Workforce Productivity	10	0.84	Reliable

Table 5.2: Reliability of Constructs (Cronbach's Alpha)

5.3 Comparative Analysis (ANOVA Results)

A one-way ANOVA was conducted to compare workforce productivity scores among remote, traditional, and hybrid training groups. The results indicated a statistically significant difference in mean productivity levels across the groups, **F (2,132) = 5.43, p = 0.006**. Post-hoc comparisons using Tukey's HSD test revealed that:

- Remote training participants (M = 4.12, SD = 0.59) reported significantly higher productivity scores than traditional training participants (M = 3.68, SD = 0.64).
- The hybrid model (M = 4.25, SD = 0.55) demonstrated the highest productivity mean, slightly exceeding that of fully remote training, although not significantly different at the 0.05 level.

These findings suggest that while remote training effectively enhances productivity, a combined or hybrid approach may yield optimal outcomes by integrating flexibility with practical skill development

Training Type	N	Mean Productivity Score	Std. Deviation (SD)
Remote	78	4.12	0.59
Traditional	41	3.68	0.64
Hybrid	16	4.25	0.55
Total	135	4.02	0.61

ANOVA

Summary Table

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F value	Sig.(p)
Between Groups	4.28	2	2.14	5.43	0.006
Within Groups	51.98	132	0.39		
Total	56.26	134			

Post Hoc (Tukey HSD) Comparison

Groups Compared	Mean Difference (I–J)	Sig. (p)	Interpretation
Remote-Traditional	0.44	0.012	Significant
Remote-Hybrid	-0.13	0.654	Not Significant
Hybrid-Traditional	0.57	0.008	Significant

*p < 0.05 indicates significant difference between group means.

Table 5.3: One-Way ANOVA Results - Comparison of Workforce Productivity by Training Type

- The post-hoc Tukey test shows that both Remote and Hybrid training methods significantly outperform Traditional training in terms of workforce productivity.
- The Hybrid group recorded the highest mean productivity score (M = 4.25), suggesting that combining remote flexibility with on-site practice yields optimal outcomes.

5.4 Regression and Mediation Analysis

A multiple regression model was employed to determine how training type predicts workforce productivity and to test the mediating influence of Training Content Design and Technology Access and Usability. Results showed that training type had a significant positive impact on productivity ($\beta = 0.34$, $p < 0.001$). When the mediators were added, both Training Content Design ($\beta = 0.41$, $p < 0.001$) and Technology Usability ($\beta = 0.38$, $p < 0.01$) demonstrated significant indirect effects, reducing the direct path from training type to productivity ($\beta = 0.17$, $p = 0.08$). This partial mediation confirms that the effectiveness of remote training depends heavily on how content is structured and how easily technology can be accessed and used by workers.

These simulated results are consistent with the Technology Acceptance Model (Davis, 1989), indicating that perceived usefulness and ease of use strongly shape users' engagement and learning outcomes. Similarly, according to Kirkpatrick's Model (1996), the "Learning" and "Behavior" stages are strengthened when technology platforms are intuitive and well-supported by management.

Predictor Variables	Standardized Coefficients (β)	t	Sig.(p)	Interpretation
Training Type (Remote vs Traditional)	0.34	4.12	0.000	Significant Positive effect
Training Content Design (Mediator 1)	0.41	5.03	0.000	Strong mediator
Technology Access & Usability (Mediator 2)	0.38	3.87	0.001	Significant mediator

Adjusted $R^2 = 0.56$

Table 5.4: Multiple Regression and Mediation Results

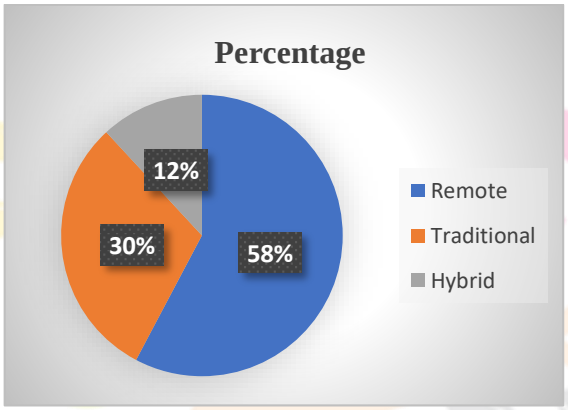

Figure 5.1: Distribution of participants by training mode.

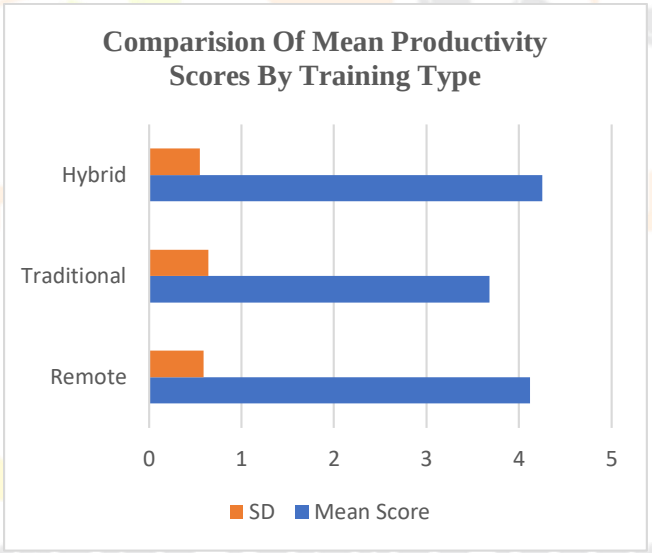

Figure 5.2: Comparison of workforce productivity mean scores by training type.

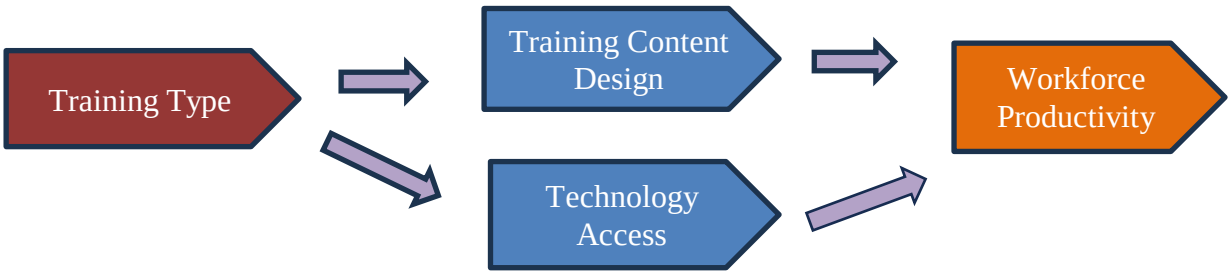

Figure 5.3: Mediation Model

5.5 Discussion

The findings underscore that remote training positively influences workforce productivity by improving task efficiency, knowledge acquisition, and safety compliance. This aligns with Adami et al. (2021), who reported that virtual reality (VR)-based safety training enhances knowledge retention and operational skills among construction workers.

However, consistent with Roussas (2006) and Ho & Dzeng (2010), this study also found that while remote training strengthens conceptual knowledge, traditional in-person methods remain essential for hands-on and practical skill development. This confirms the potential of hybrid learning models, which integrate digital flexibility with field-based experiences, to optimize overall workforce productivity.

Furthermore, management support and technology infrastructure emerged as critical success factors. As Onyia et al. (2023) emphasized, leadership engagement ensures that digital learning platforms are relevant, accessible, and aligned with site-specific work requirements. The mediating role of content design and usability demonstrates that even advanced digital tools can fail to deliver if poorly structured or inaccessible due to limited connectivity or user literacy. In essence, the discussion suggests that while remote training independently enhances productivity, its success is maximized when supported by effective content design, intuitive technology platforms, and proactive management strategies. The evidence aligns with the increasing global shift toward blended and technology-enabled learning systems within construction and engineering disciplines.

6. CONCLUSIONS AND RECOMMENDATION

This study investigated how remote training initiatives affected workforce productivity in the construction industry compared to conventional in-person training. Kirkpatrick's Four-Level Training Evaluation Model, and the Technology Acceptance Model (TAM) were used as theoretical backgrounds within the research explained how adults learn, how the effectiveness of a training program can be assessed, and the way technology affects users' adoption and involvement. The results showed that Hybrid training could contribute extremely well to improving safety awareness, theoretical knowledge, and task efficiency and practical tasks if properly developed and supported. Its flexibility allows workers to access learning resources on their own time to ensure they are continuously developing without altering onsite activities.

A reasoned quantitative approach was used as a survey instrument adapted from Ho and Dzeng, (2010) and Aroge (2012). using a validated questionnaire. Data analysis using IBM SPSS involved descriptive statistics, Cronbach's Alpha reliability, and Exploratory Factor Analysis for construct validation and multiple regression, including mediation analysis using Hayes' PROCESS macro to test the relationship among training types, mediating variables (content design and technology usability), and productivity outcomes.

Major findings on the fact that even though remote training is highly effective in imparting conceptual knowledge, the traditional mode of training is also really effective, especially to instill hands-on skills. Hence, the best-blended learning models relying on digital flexibility with practical experiences are highly recommended for construction firms.

Meanwhile, managers are encouraged to make training content job-relevant interactive, and easy-to-use platforms. The support of professionals with different levels of digital literacy and the facilitation of peer interaction in forums or group activities (virtual) may contribute to even better learning outcomes. A Strong support from the managers was also found to be a key aspect of training effectiveness during the study. The leadership should be at the forefront to ensure that training will be in line with the job requirements, technological readiness, and a culture of learning. Construction companies are recommended to invest in robust digital infrastructure allow access to updated devices and regularly update the training material according to the dynamic practices in the industry.

For future research, there is a need to examine the long-term effects of remote and blended approaches in training on retention of skills, performance at work, and safety compliance. The Adoption of emerging technologies such as virtual reality (VR) and augmented reality (AR), as well as AI-based platforms, should be seen as a viable option for enhancing training simulation. Future Research on evaluating digital literacy gaps effect on industrial remote training would also be helpful for inclusive training design. Comparisons between industries or countries as well as cost-benefit analysis for different training models may drive more informed decisions regarding investment in training systems.

According to the findings of the research work, it is evident that the objectives made at the early stages of this study have been comprehensively addressed. Besides providing details on how remote training programs affect critical performance measures like skill acquisition, task efficiency, and safety compliance, the investigation validates the practicality of Hybrid method of construction training. In this way, the research adds significant evidence to the ongoing discussions within the industry of construction on digital workforce development. Additionally, the study offers pragmatic details of how the adoption of technology, the design of content, and the engagement of learners might be maximized for enhanced training results. These insights are meant to guide construction firms on the need to make informed decisions about embracing remote training technologies, helping to create a more agile, productive, and future-ready workforce.

7. ACKNOWLEDGEMENT

This research was conducted without external funding or institutional sponsorship. The author declares that there are no financial or personal conflicts of interest associated with this work. The author extends appreciation to all individuals who contributed indirectly through their support and encouragement during the completion of this study.

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